

# Waste to Energy in Urban Infrastructure

Experiences from Indo-Swedish collaboration  
2009-2011



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Illustrations: Bo Reinerdahl

Translation: Bugli

## **Positive experiences of Indo-Swedish biogas collaboration**

In the first week of June 2009, the Swedish delegation Biogas for Urban Infrastructure visited the Indian cities of Pune, Delhi and Bangalore. The visit was an initiative of the Swedish Energy Agency, which organised the delegation in collaboration with the Swedish Embassy in Delhi, the Swedish Trade Council and Invest Sweden. It subsequently proved to be the first step of a new programme on biogas technology, known as Waste-to-Energy.

Biogas was selected as the keyword for the delegation because it represents an area of technology that meets India's challenges, while providing examples of Swedish integrated solutions and technical cutting-edge competence. The initiative came about in response to the substantial interest in Swedish cleantech expressed by Indian stakeholders.

Sweden was an early mover in the field of waste management and in considering waste as a substantial energy resource. During the global oil crisis in the early 1970s, domestic forest industries were quick to substitute fossil fuels with their own residues. The gain was twofold: they cut fossil-fuel costs and enabled them to avoid paying for waste management. Since these early steps were taken, industrial bioenergy systems have become more sophisticated and efficient year by year. State regulations, taxation on fuels and various players have contributed to the development of an efficient system for utilisation of waste in Sweden.

The goals of local municipalities regarding waste disposal and the technical competence of private companies have drawn mutual benefit. Sweden's highly advanced expertise in the upgrading of biogas to vehicle fuel is one example. Substrate optimisation is another area where Swedish players are at the forefront.

India also has a long tradition of bioenergy use. The National Biogas Program, initiated in the late 1970s, was the first major step towards promotion of biogas in India. In fact, one of the world's first biogas plants was established in India, as a form of water management at a leprosy colony in the 19th century. Today, India's biogas efforts are more focused on the treatment of organic waste in biogas plants, which is often conducted on a small scale in rural areas – the result of which is known locally as gobar gas. Proven commercial technologies for biomethanation as part of urban waste treatment infrastructure remain new and need to be imported and adapted to Indian conditions.

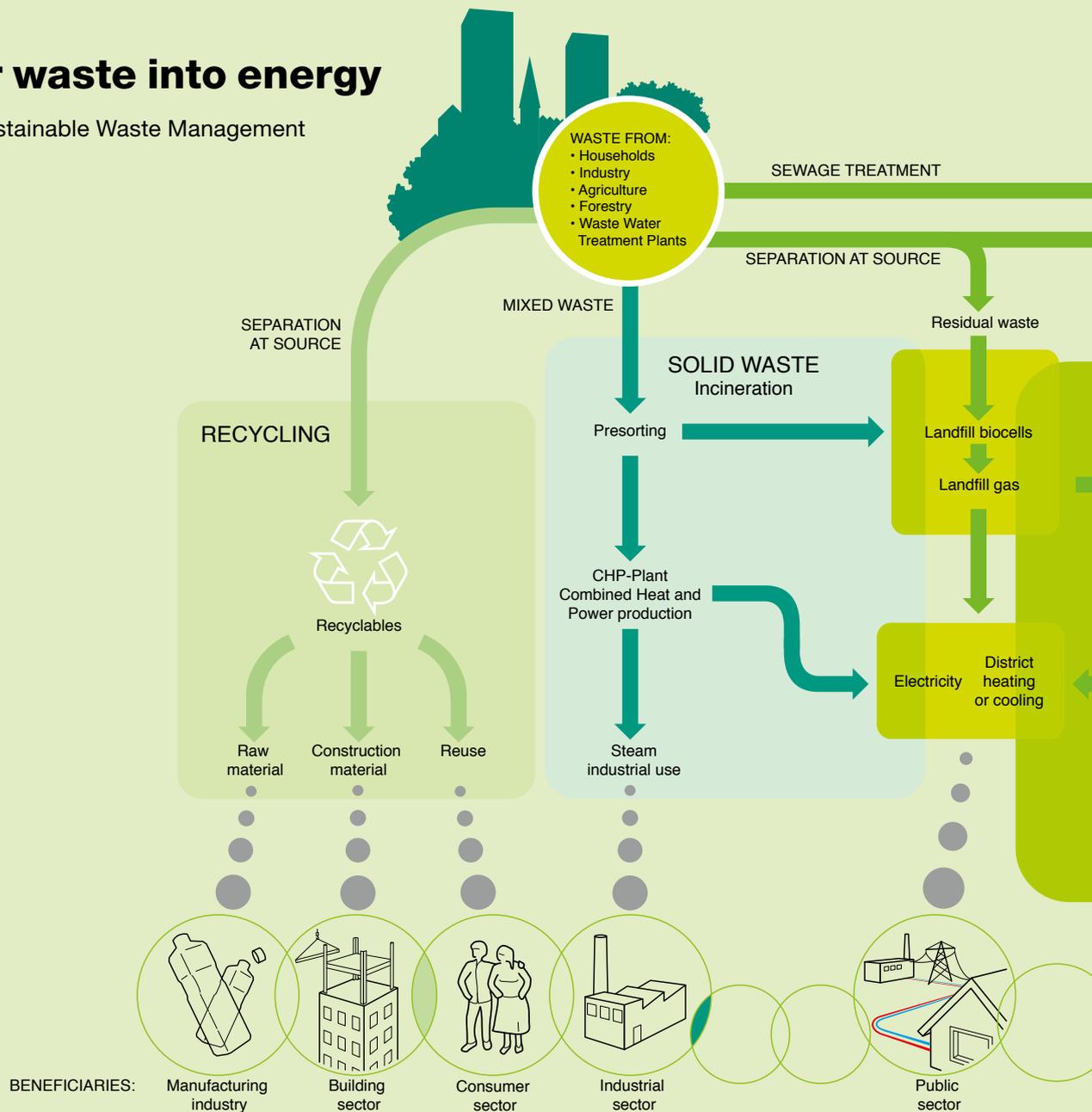
The Indo-Swedish collaboration with a focus on biogas was initiated based on an understanding of some major challenges facing India. Rapid urbanisation exerts high pressure on waste management, and on water supply and treatment. At the same time, rapid and necessary economic growth requires an increase in the supply of energy. Preferably, a supply that is sustainable and based on domestic resources. Urbanisation poses challenges and opportunities. India's rapid economic growth has resulted in an increasing amount of waste in its cities, which is often disposed at landfills or in the surface water. At the same time, the country's economic growth could theoretically create a basis for driving innovations and incentives.

A recent initiative by the Government of India is the Jawaharlal Nehru National Urban Renewal Mission (JNNURM), which was introduced in the Tenth National Plan. It serves as an instrument for improving municipal infrastructure and utilities, such as waste management.

By sharing experiences and technological solutions with Swedish partners in this programme, Indian cities can identify methods of developing their sustainable urban waste-management systems. Of particular relevance is the fact that the Swedish and Indian models are based on strong municipal actors and on being open to public-private partnerships. Some fundamental similarities and interesting differences provide opportunities for mutual learning and partnerships.

## Turn your waste into energy

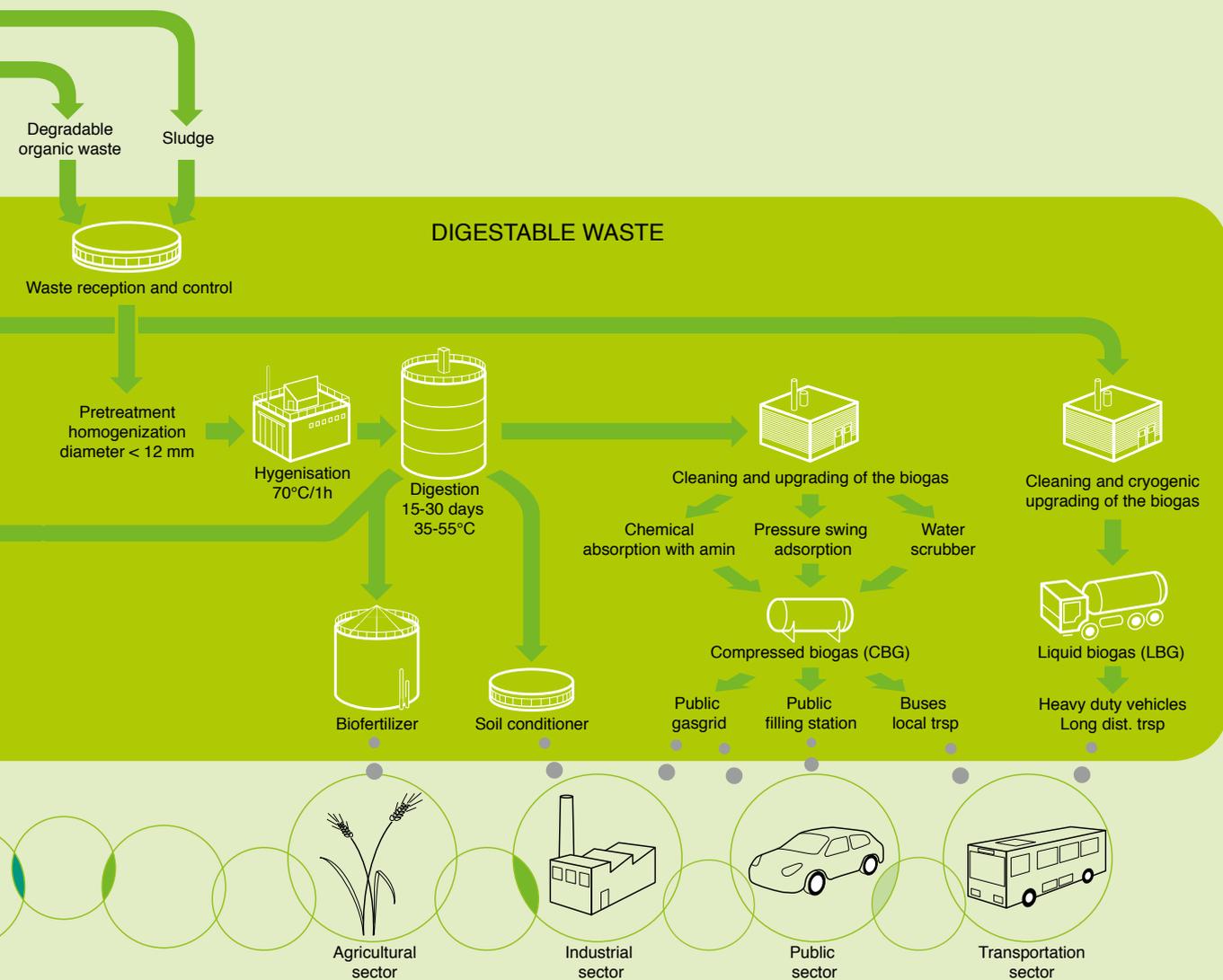
Integrated and Sustainable Waste Management in Sweden



## About the report

The purpose of this report is to present six different projects in the programme, their goals, partners and achievements so far. The ambition is to learn from what has been done, in order to get more prepared for future projects and challenges. We address both Indian and Swedish readers and hope that the report will be useful for both those who want a description the projects and those who would like to learn from them.

This illustration shows how waste and sewage water from different sources are handled in an integrated system; it is recycled, incinerated, digested and upgraded for various uses. Both compressed and liquid biogas is produced from solid and digestible waste and through the methanisation (upgrading) process. In Sweden, only 3 per cent of waste is deposited permanently at landfills.



## **The biogas delegation to India**

The Swedish delegation consisted of technology suppliers and consultants, municipal energy companies and business sector associations. The objective of the delegation was to establish contacts between Swedish and Indian players in the biogas field and thus ultimately to promote economic growth and the transition to a sustainable energy supply in both countries. In 2010, the delegation culminated in a new agreement between the Swedish and Indian governments, known as the Memorandum of understanding on new and renewable energy. This strengthens the commitments that were already made under the bilateral agreement on technological and scientific exchange in 2005.

The Indo-Swedish Environmental Facility, created at the initiative of the Swedish International Development Cooperation Agency (SIDA), was of great significance since it enabled Swedish players to seek support for project development together with partners in India. This provided the necessary support for long-term planning in which the various public authorities' tools could be combined.

The biogas delegation's trip generated substantial interest in continued discussions among both Swedish and Indian stakeholders. As a result, the Swedish Energy Agency initiated and partly funded a Project Secretariat including all members of the first delegation, which was organised under the Swedish Gas Association to develop the initial contacts for and design of the projects. In turn, this has led to a number of collaborative projects that include participants from the private sector and local government from both countries.

In autumn 2010, the Swedish companies participated in the Delhi International Renewable Energy Conference (DIREC), during which they were afforded the opportunity to deepen and develop contacts and, in cooperation with the Ministry of New and Renewable Energy, to continue discussions aimed at real demonstration projects. Both the Swedish Energy Agency and the Swedish Embassy in New Delhi have been highly committed to and involved in these discussions and projects, and SIDA has assisted with funding.

This report provides an illustration of the progress that has been made in Indo-Swedish biogas collaboration since the delegation Biogas for Urban Infrastructure initiated action in 2009. A number of Swedish government organisations and private sector organisations have worked together with Indian counterparts to develop the Indo-Swedish Waste-to-Energy cooperation. A mere two years later, we can now state that this has been a very fruitful venture. The Swedish-Indian cooperation that was formed in conjunction with the biogas delegation has already resulted in new knowledge, new methods, opportunities for new strategies and new business models.



# Ghazipur: Biogas from abattoirs and landfills

<b>Project:</b>	Biogas from Ghazipur abattoir waste
<b>Location:</b>	Delhi
<b>Swedish partner:</b>	COWI
<b>Indian partner:</b>	IL&FS Environmental Infrastructure & Services Ltd Municipal Corporation of Delhi
<b>External financier:</b>	Swedish International Development Cooperation Agency (SIDA)
<b>Project period:</b>	2010–2011

## Background

The landfill in Ghazipur, Delhi, covers an area of 300,000 square metres and is growing every day. A nearby abattoir, completed in 2009, has contributed to a further increase in inflows to the landfill in recent years. The abattoir generates about 80 tonnes of animal waste each day.

## The project

During the Swedish biogas delegation's trip to India in 2009, IL&FS established contact with the Swedish technical consultancy COWI, and in 2010, the two companies initiated a partnership project to assess the possibilities of using abattoir waste for biogas production instead of disposing of it at a landfill.

While COWI's study initially focused on the abattoir and its waste, the perspective soon expanded to also include other major organic waste flows to the landfill, in addition to abattoir waste.

“That was when the project truly gained traction, as a result of the opportunity to utilise various waste flows and to integrate the biogas facility with the waste-to-energy facility that is being constructed,” says COWI's Project Manager. “Creating biogas exclusively from abattoir waste is problematic: the animal waste must be mixed with vegetable-based mass to create the right conditions. When we examined the area around the landfill, we identified other organic waste flows – from sources such as nearby households and food markets – thus giving us the mix we needed.”

COWI conducted its preliminary study from November 2010 to September 2011 and was putting the finishing touches to a final report to IL&FS at the time this was written.

## Results

One of the project's results is a specific proposal for a future biogas facility in Ghazipur that is presented in the preliminary study. The proposed facility will have the capacity to receive 600 tonnes of waste each day, which is expected to generate a maximum biogas production of 31,700 Nm<sup>3</sup> (cubic metres at a normal pressure and temperature), or 38,000 kilograms per day. On an annual basis, production is expected to amount to 10.4 million Nm<sup>3</sup> of biogas, with an energy content of 60GWh.

The biogas facility is being constructed and situated to be compatible with surrounding facilities. It will be integrated with abattoirs and waste-to-energy facilities and will also have a positive effect on the landfill, in the form of diminished waste flows, as well as on the neighbouring wastewater treatment plants in the form of improved water quality. In addition, about 100 tonnes of bio-fertiliser will be produced each day as a by-product of the biogas production.

The project will also provide financial calculations of investment costs and operating expenses. An Indian delegation trip to Sweden to study Swedish biogas production is also being planned.

## Lessons learned

The head of COWI describes the mood of the project as highly positive. COWI was onsite in India for two weeks at the beginning of the project and for just over a week in March 2011 and during the autumn of 2011 in conjunction with the conclusion of the project. COWI's Project Manager believes that another trip would have been beneficial.

"Not specifically for the sake of information but to maintain relations and the tempo of the project," she says. "And in order to eliminate misunderstandings, which you can do when you sit at the same table and discuss matters from 8 to 5. The more you talk, the more you realise how much you have to discuss with each other. One conclusion that can be drawn from this is that you have to meet in person.



Without constant communication, the project loses momentum, she explains. Accordingly, the project participants in Sweden and India have held telephone meetings every week regardless of whether or not there were specific matters to address.

COWI also emphasises the importance of having a partner in IL&FS that is familiar with the Indian market and Indian municipal management.

The challenges faced by the project primarily involved the difficulties of gathering requisite information as a basis for COWI's analysis. For example, extensive efforts were required to determine the quantities and the composition of various waste flows on which the calculations should be based.

### **Looking forward**

If the preliminary study leads to the construction of a biogas facility in Ghazipur, this will have positive consequences in a number of areas such as:

- Diminished landfill inflows.
- Improved water quality from the neighbouring wastewater treatment plant.
- A positive impact on the climate: the production of biogas will reduce the consumption of fossil energy.
- Improved surroundings for people in the area.
- Economic advantages of deriving energy from waste and energy optimisation by integrating two facilities.
- Employment opportunities.
- Fertiliser as a by-product.

The realisation of a biogas facility in Ghazipur could ultimately inspire similar investments from other sources and thus accelerate India's transition to sustainable waste management.



# Bhairoba Sewage Treatment Optimisation Plan

<b>Project:</b>	Bhairoba Sewage Treatment Optimisation Plan
<b>Location:</b>	Pune
<b>Swedish partner:</b>	Läckeby Water AB – Division Purac
<b>Indian partner:</b>	Bharat Forge PMC, Pune Municipal Corporation
<b>External financier:</b>	Swedish International Development Cooperation Agency (SIDA)
<b>Project period:</b>	2010–2011

## Background

The Bhairoba Sewage Treatment Plant in Pune is one of many Indian sewage treatment plants where biogas is produced but not utilised. It would be economically and environmentally beneficial if the biogas could be upgraded and used as a source of energy, but this would require changes at the treatment plant.

Bhairoba was visited during the Swedish biogas delegation's trip to India in 2009, during which the possibilities of a Swedish-Indian partnership in order to optimise and upgrade the treatment plant were discussed. The Swedish Gas Association and Bharat Forge jointly developed the "Bhairoba Sewage Treatment Optimisation Plan" project.

The project received support from the Swedish International Development Cooperation Agency (SIDA) and was implemented by Läckeby Water AB, Division Purac, in partnership with Bharat Forge, the Swedish Gas Association and the Pune Municipal Corporation (PMC).

## The project

In 2010 and 2011, Purac and Bharat Forge analysed the operation at Bhairoba, focusing on sludge management and biogas production. The facility was visited in May and August 2010. The project involved a number of activities, including inspecting the installations and their capacity, examining operational data from the sedimentation tank and other sections of the facility, taking tests, evaluating various operational and management aspects, discussing a refurbishment of the plant and how variations in flows are to be managed and searching for gas leaks and the formation of gas outside the sedimentation tank.

The project issued a final report in August 2011.

## **Results**

The project resulted in recommendations on how to advance the management of the Bhairoba Sewage Treatment Plant and how to modernise the facility. The recommendations encompass the entire operation: the organisation, operational and maintenance procedures, security, supervision and documentation, structural changes to the sedimentation tank, the gas tank, thickeners and extensive renovations to major portions of the facility's mechanical and electrical installations.

In addition to technical requirements, the final report highlights the need for a holistic perspective, long-term plans and a lifecycle cost perspective in the operation. The recommendations of the preliminary study are intended to serve as the foundation for the next phase of the process: a detailed technical proposal, including cost calculations. The project also contains economic calculations concerning the cost of the proposed investments.

## **Lessons learned**

The partnership between Purac and Bharat Forge is described in highly positive terms. The clearest sign of the strong relationship is possibly that the two companies have expanded their shared interests and are now collaborating on other projects in



other Indian cities. The Swedish company Purac emphasises the difficulties for foreign players in understanding Indian public management and how the partnership with Bharat Forge was essential in the contact with the municipal management in Pune.

The challenges of the project that are mentioned primarily pertain to issues in the contact with the contractor currently operating the treatment plant on behalf of the city. This company had no economic incentives to be accommodating to Purac and Bharat Forge, which resulted in a laborious process of gaining access to information necessary to the analysis of the facility.

### **Looking forward**

The completed preliminary study demonstrates that developing Bhairoba into a modern treatment plant engaging in efficient biogas production that the city can either use itself or deploy for other purposes is entirely possible.

If this improvement project is successfully completed, Bhairoba could become a pilot project that demonstrates technical solutions and how to make them financially sustainable. This would provide important knowledge that could accelerate the upgrading of other treatment plants in Pune and throughout India.



# Improved biogas production in Pune

Project:	Development of sustainable waste management systems
Location:	Pune
Swedish partner:	Swedish Gas Association Sweco
Indian partner:	Bharat Forge PMC, Pune Municipal Corporation
External financier:	Swedish International Development Cooperation Agency (SIDA)
Project period:	2009–2011

## Background

Households and corporations in Pune generate about 1,400 tonnes of municipal solid waste per day. By 2020, daily waste production is expected to have grown to 2,400 tonnes, based on population growth and increased consumption. Previously, a significant portion of Pune's household waste was deposited at Urali Devachi, although waste delivered to this landfill has been halted since 1 June 2010, with certain exceptions. The Pune Municipal Corporation (PMC) has now implemented a more modern waste management system in Pune and is raising awareness among residents of the importance of waste sorting and recycling. The City has already introduced the mechanical sorting of a substantial portion of household waste at a privately owned sorting facility and is installing new small-scale biogas plants at a relatively fast rate. Currently, 12 to 14 small-scale biogas plants are in operation and the aim is to ultimately increase this number to about 40.

## The project

During the Swedish biogas delegation's trip in 2009, Bharat Forge and PMC came into contact with the Swedish industry organisation Energigas Sverige and the three parties formed a joint Waste-to-Energy project in Pune, financed by the Swedish International Development Cooperation Agency (SIDA). Sweco participated as the principal supplier to Energigas Sverige. Purac and MGE-Teknik AB participated as subcontractors.

The aim of the project was to evaluate the conditions for extracting landfill gas and to assess Pune's existing small-scale biogas plants, while analysing how Pune's future biogas-production needs can be met by small or large-scale plants.

Due to shifting conditions, the project has primarily focused on large-scale biogas plants, while the issue of landfill gas has not been given a great deal of attention.

Another key component of the project has been knowledge transfer. In September 2011, seven representatives from PMC travelled to Sweden for a week to study best available technology (BAT) within Swedish waste and sewage management and biogas production. Field trips were taken to destinations such as Stockholm's largest sewage treatment plant, Henriksdal, the Vätkraft biogas plant in Västerås and Fortum's incineration plant in Högdalen in Stockholm.

## Results

At the time of writing, the project had not been completed. It will preliminarily be in progress until year-end 2011.

The results of the project include evaluation of Pune's existing small-scale biogas plants. The conclusion reached is that the operation of these plants has considerable room for improvement: the systems have a tendency to back up due to sludge caused by inadequate management and maintenance, leading to reduced gas production and a foul odour.

Another problem noted in the evaluation was a lack of proper storage for the gas that was produced. While at all plants, the gas is used to generate electricity, this electricity can only be used internally at the plant and for street lighting in the area and may not be fed into the public electricity grid. During daylight hours, the gas is burned in a flare stack to no benefit.

Because of Pune's plans to more than double the number of small-scale biogas plants in the City, these are urgent matters to resolve. There are essentially two solutions: the City can either (i) invest in improved operations and better utilisation of the gas from small biogas plants or (ii) switch strategies and focus on large-scale biogas production systems.

The project intends to present two sets of calculations for Pune's biogas production, enabling comparisons of the performance of small and large-scale facilities and analyses of various business models (such as DBOOT, BOT, BOOT) for this operation.



### **Lessons learned**

The project has largely been a partnership between Bharat Forge, Sweco and PMC. Bharat Forge initially took primary responsibility for the communications with PMC and the relationship between PMC and Sweco has grown during the course of the project. The head of the project at Sweco believes that this has been a highly favourable structure since project efficiency has been dependent on knowledge of Indian public administration. The partnership between Bharat Forge and Sweco is described as effective and positive. This is attributed to the personal qualities of those involved and the fact that, as two major, international, commercial companies, Bharat Forge and Sweco are sufficiently similar to facilitate a fluid working relationship.

As mentioned above, the focus of the project became somewhat different than planned due to changes in real-world factors. The initial aim was to largely focus on landfill gas, but when SIDA financing was finally granted and the project could commence, it turned out that the landfill gas from Urali had already been evaluated to a certain extent by another consultancy.

Those interviewed for the project stated that it is not uncommon to be forced to adapt a project to changed real-world factors. In this case, the project plan included so many variables that many other aspects had to be focused on. At the same time, it illustrates that project plans have an expiration date and that short processing periods and quick project starts reduce the risk of a project plan becoming void.

### **Looking forward**

The project's evaluations and knowledge distribution have given Pune an enhanced platform for its future biogas operations. Considering its size – equivalent to about half the population of Sweden – and the City's extensively planned biogas build-out, the optimisation of this plant would entail major financial and environmental advantages.

The project also resulted in new contacts between the Swedish and Indian business communities, particularly between Bharat Forge och Sweco, which could ultimately lead to new partnerships.

# Knowledge transfer on biogas production in Mysore

<b>Location:</b>	Mysore
<b>Swedish partner:</b>	Eskilstuna Municipality
<b>Indian partner:</b>	Mysore City Corporation
<b>External financier:</b>	Swedish International Development Cooperation Agency (SIDA)
<b>Project period:</b>	2009–2012 (provisional)

## Background

The cities of Eskilstuna in Sweden and Mysore in India came in contact with each other through the offices of Sanson I.B.C. International and its Managing Director, Håkan Sandlund, who has collaborated with India for many years. In 2009, the two cities signed a collaboration agreement. A number of areas where collaboration is possible have been identified, including the environment, schools and education, as well as industry and health. The cities selected the environment and waste, with a focus on biogas production, as the first area in which to commence collaboration.

## The project

In conjunction with the signing of the collaboration agreement during a study trip made by Mysore's municipal management to Eskilstuna in November 2009, the two cities agreed that the area of the environment and waste should become the first area in which to initiate collaboration. On securing funding from the Swedish International Development Cooperation Agency (SIDA), Mysore and Eskilstuna started a project aimed at transferring knowledge regarding biogas production. Both cities have existing biogas production, but Eskilstuna has longer experience in this field, including many years of experience regarding the upgrade of biogas to vehicle fuel that is currently used to power the buses used in Eskilstuna's public transport system.

The project is still in the start-up phase. A study trip has been planned from Mysore to Eskilstuna but been postponed. Hopefully it will take place in October 2011. This time, the target group includes technical managers and experts in Mysore's administration. The programme will include a demonstration of Eskilstuna's waste management and biogas production, a visit to Mälardalen University Sweden and project discussions regarding how to proceed.

## Results

Since the project is still in the start-up phase, there are no results to report. In the long-term, the expected result is a functional biogas-powered public transport system in Mysore.

## Lessons learned

Both parties describe the project similarly: they perceive great commitment and interest in the collaboration from both sides. Yet, it has been difficult to gain impetus with the project – even on the points where the parties are in full agreement. The slow pace has resulted in a certain degree of frustration in some areas.

Unlike other Indo-Swedish collaborations, neither the Swedish Embassy in Delhi nor any other Swedish authorities have been involved in the collaboration between Eskilstuna and Mysore, and Eskilstuna has no other local representative in India.

Several interruptions in the process that arose from political elections in Mysore were also mentioned as contributory factors to the slow progress of the project.

At the same time, both parties stress the positive spirit and friendliness that characterise project communication, and express a hope that the forthcoming study trip to Eskilstuna will lay the foundation for more rapid progress with the project in the future.

## Looking forward

Mysore wishes to utilise the project to support the process of implementing biogas-powered public transport in line with the Eskilstuna model.

Both cities desire to extend their collaboration to include other areas. In this context, Mysore's commissioner mentioned in particular the transfer of knowledge regarding traditional Indian philosophies and teachings, including yoga and ayurveda, as well as the possibility of collaboration between Mysore University and Mälardalen University Sweden in Eskilstuna.



# Small-scale waste handling in “panchayats” in Tamil Nadu

<b>Project:</b>	Small-scale Waste Handling in Village Panchayats Treatment of Organic Waste in Tamil Nadu
<b>Location:</b>	Kancheepuram and others, Tamil Nadu
<b>Swedish partner:</b>	Sweco
<b>Indian partner:</b>	Hand in Hand
<b>External financier:</b>	Swedish International Development Cooperation Agency (SIDA) and the Swedish Agency for Economic and Regional Growth (formerly Nutek)
<b>Project period:</b>	2008–2011

## Background

The non-profit organisation Hand in Hand conducts extensive programmes to combat poverty in India and other countries. In Tamil Nadu, the organisation promotes environmental protection and improved sanitary conditions through 25 projects concerning sustainable solid waste management. These projects are mainly concentrated to the Kancheepuram district south of Chennai.

In these projects, Hand in Hand has arranged for the collection of recycled waste in villages and small cities (“panchayats”) in Kancheepuram. The collection is conducted by salaried “Green Friends,” who use three-wheeled cargo bicycles. Today, nearly 200,000 households are members of Hand in Hand’s waste-collection service.

Hand in Hand works closely with the local community. The waste-management services are ultimately intended to be transferred to the panchayats, allowing Hand in Hand to focus on introducing the model in new locations. In a number of panchayats, committees for environmental rights protection have been established for this purpose.

## The project

In 2008, Hand in Hand reached an agreement with Sweco, a technical consultancy, on two partnership projects to advance Hand in Hand’s waste-collection model. The partnership has focused on the technical and economic transfer of knowledge and the establishment of a small-scale demonstration facility for the production of biogas from food and kitchen waste.

Sweco and Hand in Hand analysed the conditions for a biogas plant in a preliminary study. With Sweco’s support, Hand in Hand subsequently conducted a



procurement process for the construction of such a plant. A contract was signed with the organisation Vivekananda Kendra in December 2009 and the work was completed in 2010.

A key element of the project was studying the financial aspects of waste management in further detail and providing Hand in Hand with a solid financial platform for the collection operation and biogas production activities.

## **Results**

### *Biogas production*

The project has supplied a technical and financial platform for the realisation of a biogas facility in Mamallapuram. This facility, with a 100-cubic-metre sedimentation tank, has been installed and has been in operation since September 2010. The energy from the biogas produced is converted into electricity using a 10kW generator and is used locally for purposes such as street lighting in the area. The cost of the construction project was INR 2 million.

### *Financial governance*

The project has delivered financial analyses to be used as the basis for Hand in Hand's collection operation. The project's reviews show that user fees are necessary for the operation to meet its financial obligations. It also shows that households' propensity to pay for waste collection tends to be on rise, but that there are considerable differences between locations. In the village of Mudichur, 85% of households accepted a fee hike to INR 30 per household and month, whereas in Nathapettai, 35% of households accepted a fee of INR 20.

The project has also developed a financial governance tool for its collection operations, which Hand in Hand can use to calculate and compare the financial implications of various activities. The tool was created using Microsoft Excel and can be applied to all panchayats.

### *Knowledge transfer*

The project has also included extensive training initiatives, and knowledge campaigns focused on the general public concerning the importance of sustainable waste management. Hand in Hand has trained employees, decision makers and non-profit staff. Hand in Hand's instructors also went on a field trip to Sweden to expand their expertise in topics ranging from recycling, the handling of biological waste and landfills to the handling of hazardous waste, institutional development and finances.

### **Lessons learned**

Those interviewed in the project gave a highly favourable impression of its efforts. Both sides describe the other party as skilled and hard working. The partnership climate has been positive and it has been easy to hold discussions in the project and to reach agreements. The project's problems include difficulties in producing reliable figures on which to base technical and financial calculations.

The project was not quite completed on time. The elections in India, at both the state and national level, which for a brief period encumbered local decision-making processes, were a key reason for the delay. The parties also experienced some misfortune in the procurement process for the construction of the biogas plant, since a preliminary contract was signed with a contractor that subsequently failed to submit the necessary additional information. This delayed the project and required additional work. The parties eventually came into contact with another contractor that was appointed and completed the project with a high level of quality.

### **Looking forward**

The project resulted in improvements in the collection operations for recycled waste that Hand in Hand conducts in Tamil Nadu.

Another result of the project is that Hand in Hand was able to construct a demonstration plant for biogas production from food waste. The plant is in operation and biogas production is reportedly working well.

According to Hand in Hand, the major gains from the project will not become visible until later. The organisation will apply its experiences and knowledge from the project to implement and improve waste management and biogas production in an increasing number of areas.

#### *A Hand in Hand representative says:*

“Since 2007, our model for waste management has expanded from 600 households to 200,000. We continue to expand our operations and spread these models to more locations. The small-scale demonstration plant for biogas production is pivotal since it provides us with practical experience, thus helping us to address larger projects. We are currently making plans for an approximately 500-cubic-metre biogas plant, which is sufficiently large to enable the gas to be compressed into cylinders.”

# Biogas as a vehicle fuel – pilot facility in Delhi

<b>Location:</b>	Delhi
<b>Swedish partner:</b>	Swedish Waste Management Association
<b>Indian partner:</b>	Government of Delhi, Delhi Jal Board
<b>External financier:</b>	Swedish International Development Cooperation Agency (SIDA) Swedish Energy Agency Government of Delhi Ministry of New and Renewable Energy
<b>Project period:</b>	2009–2011

## Background

In recent years, the Government of Delhi has taken extensive actions to improve the environment in the greater metropolitan region. Delhi currently has the world's largest gas-powered vehicle fleet and is working to reduce its ecological footprint in accordance with the Climate Change Agenda for Delhi 2009–2012. The Action Plan for Achieving Carbon Neutrality for Delhi, which is being prepared, will present Delhi's ambitious long-term aim.

The management of sewage and organic waste is a key factor in the project's effort to improve the environment and reduce the adverse climate impact. A biogas plan for Delhi is under development, which should encourage the use of organic waste in energy production instead of contributing to the City's growing landfills.

In conjunction with the Swedish biogas delegation's trip in 2009, the Government of Delhi established contact with several Swedish players in the area, including the Swedish Waste Management Association. In the discussions between various players (the Ministry of New and Renewable Energy, the Government of Delhi, SIDA, the Swedish Embassy, the Swedish Energy Agency and several Swedish and Indian stakeholders in the biogas area), the concept of merging Indian and Swedish biogas knowledge to enable the local production of upgraded biogas at vehicle-gas quality in Delhi was born.

The partnership initially encompassed exchanging experiences and field trips to Sweden and India. During the Delhi International Renewable Energy Conference (DIREC), a Joint Working Group meeting was held within the framework of the energy partnership between the countries, during which it was established that the next step would be identifying a site in Delhi that was suitable for demonstrating Swedish technology that had been adapted to Indian conditions.



## **The project**

The Swedish Waste Management Association was tasked with evaluating potential sites for a pilot plant to upgrade biogas to vehicle fuel in Delhi. The aim of this type of plant is to demonstrate that the processing of biogas from waste and sewage to genuine vehicle fuel is technically, economically and environmentally sustainable in Delhi and comparable Indian cities. The facility is to be operated pursuant to a business model that can subsequently be replicated at other facilities.

In addition to a detailed evaluation of the adequacy of existing sewage treatment plants, the project also entailed a review of the general economic and institutional conditions for a pilot plant, as well as recommendations concerning actions to eliminate obstacles in these areas.

Although the evaluation was based on a list of 18 existing sewage treatment plants, many of these could be eliminated at an early stage for various reasons and a limited number of suitable candidates were selected for closer examination.

The work was conducted between January and May of 2011 and the conclusions were presented and discussed at a meeting with the Government of Delhi on 13 May 2011, and in a final report in June 2011.

## **Results**

Following the evaluation, the Keshopur treatment plant was selected as the best option for the location of the pilot plant. The reasons supporting Keshopur included that:

- The treatment plant is currently being renovated.
- The renovated facility will have a new sedimentation tank with the capacity to produce more than 25,000 cubic metres of crude gas per day.
- Keshopur is located in the vicinity of Delhi's existing vehicle-gas grid, a gas-filling station and a car park for the City's gas-fuelled buses.
- The nearby vegetable market generates significant quantities of green waste, which can eventually become a valuable addition to the sedimentation tank.
- Keshopur is of a suitable size to function as a demonstration facility, which is relevant to other treatment plants.
- The plant is suitable for field trips since the site is located 15 kilometres west of the city centre, next to Outer Ring Road, which is relatively easy to access.

The report also indicates three locations suitable for additional biogas facilities. The investment cost for constructing the biogas plant is estimated at about SEK 35 million. A key matter to investigate further is how the costs of biogas production are to be compared with the natural gas that is sold in Delhi, which is subsidised by the government.

The next stage of the process was to form a Special Purpose Vehicle, comprising stakeholders aiming to advance the process into a commercial project. At this stage, the Swedish Export Credit Corporation – SEK Advisory Services charged the Swedish Energy Agency with advancing the detailed financial aspects of the process.

### **Lessons learned**

The Swedish reviewer's description is that his efforts were productive overall and that he received access to the interviewees and the information required. He states that this was due to having an Indian partner from the Government of Delhi assisting him in the project with practical arrangements and guiding him through the Indian management system. A total of 12 Indian and five Swedish organisations were interviewed, which in many cases submitted written material. Field studies were also conducted at three treatment plants. All of this would have been far more difficult without the help of aides who were fluent in the Indian management and corporate culture.

### **Looking forward**

The reviewer's conclusions were received with great interest in May 2011. Negotiations regarding the realisation of a pilot plant for biogas pursuant to the study's proposals were under way at the time this was written. Should such a plant be constructed, the following impacts are expected:

- The production of climate-friendly vehicle gas, equivalent to an annual reduction in carbon emissions of more than 10,000 tonnes.
- A reduction in the adverse climate impact caused by leaking methane.
- The economic benefits of waste being utilised as a resource.
- Evidence that it is technically and economically sustainable to invest in the production of upgraded biogas in Indian cities and that the plant thus paves the way for new biogas projects and contributes to a faster transition to sustainable waste and energy policies.



# Lessons learned

## Swedish experiences can be adapted to Indian conditions

The experiences from the projects that have been reported demonstrate that the Swedish and Indian parties had no difficulty in establishing relationships and initiating collaborations. They represent two corporate cultures that have discovered common denominators in respect of values such as expertise, friendliness and commitment. However, having a fundamentally sound partnership climate is not sufficient. The experiences from the partnerships also indicate the necessity of maintaining close and regular contact throughout the project in order to retain momentum and stay on course.

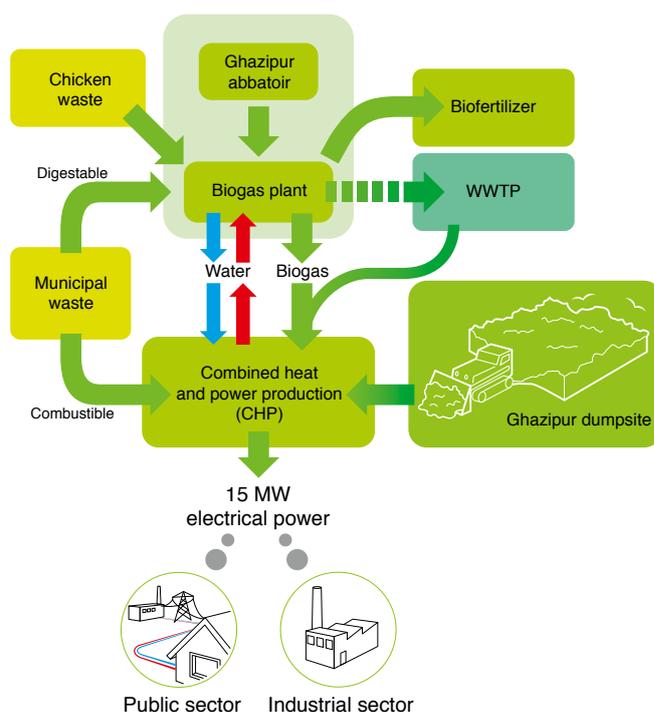
Many emphasise the major significance of the field trips. In addition to the actual transfer of knowledge, conveyance of context and broader understanding gained by the project participants, the field trips can contribute to maintaining and intensifying the relationships, thus leading to strong project results. This is the point at which the prerequisites to truly understand the conditions and needs in the relevant location are created.

## Three replicable solutions

The seven different projects in five different cities also demonstrate how various solutions were developed, all of which varyingly highlight, and are based on, a systematic approach. Listed below are three examples that provide an overall impression of the variety of the system solutions that were produced, which are based on how Swedish experiences can be developed to suit various contexts. The advantage is that the solutions can be replicated.

### 1. Ghazipur Abattoir

The project at Ghazipur initially focused on the abattoir and its waste, which was intended for use in biogas production. During the course of the project, the perspective soon expanded to also include other major processes in a comprehensive waste management and Waste-to-Energy system, in which biogas, bio fertilizer and electricity are produced. By integrating this system with a planned Waste-to-Energy plant and a CHP (combined heat and power production plant), the produced biogas will be burned and increase the capacity of the plant, thus resulting in a system capable of producing up to 15 MW elec-



trical power. The heat generated will, together with electricity, be used at the biogas plant for preheating the substrate.

Municipal waste that was previously sent to landfill can now be divided in a digestible and a burnable fraction. The latter is used directly in the CHP Plant and the digestible fraction will be included in the biogas production. The increase in organic waste being deposited at the dumpsite will stop, or at least decline significantly. After separation, the existing organic content could potentially also be used for energy production. The Waste Water Treatment Plant (WWTP) currently handles the untreated water from the abattoir. The biogas plant will reduce this pressure on the WWTP. Another possible synergetic integration is to also send the biogas produced at the WWTP to the CHP plant.

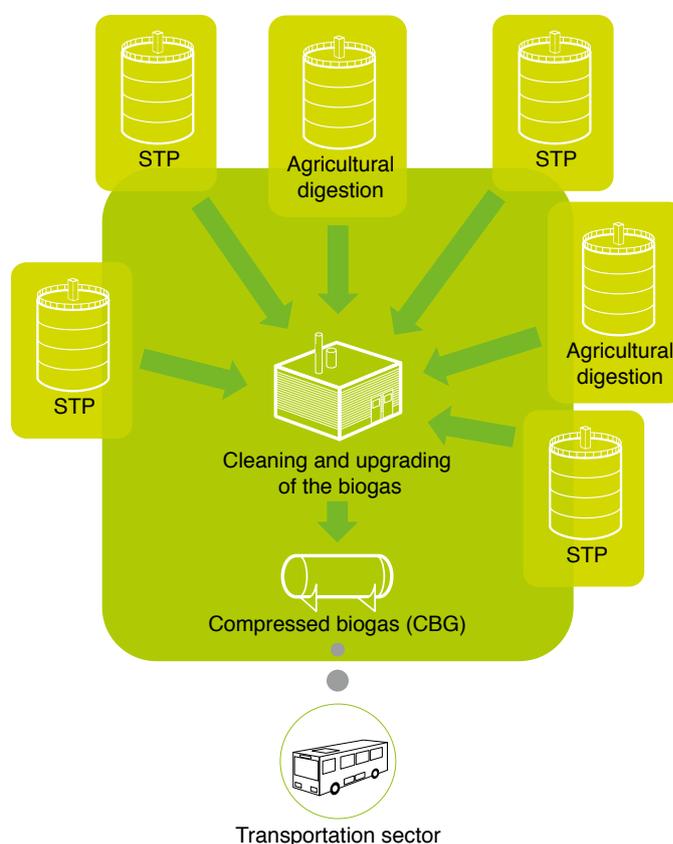
The project exemplifies an innovative process whereby a more limited project idea has been developed into a system solution utilising synergy potentials among different facilities and infrastructure in the area.

## 2. STPs in Pune

The project in Pune shifted focus from landfill activities, final covering and landfill gas extraction to instead concentrate on various concepts for large-scale digestion systems for solid waste, as well as the municipality's small-scale biogas production systems. The optimisation possibilities were studied for both the individual plants and the municipal system as a whole. A possible solution could be based on the digestible substrate raw materials being transported to a central digestion plant offering an upgrade or electricity production.

A combination of decentralised collection systems with central energy generation could provide major efficiency-enhancement gains. These solutions have proven highly reliable in Sweden. A comparable system was developed in Western Sweden and is based on decentralised production of crude gas, which was upgraded centrally and subsequently distributed for decentralised consumption. This could be located at a major STP and possibly also integrated with the forthcoming CNG grid.

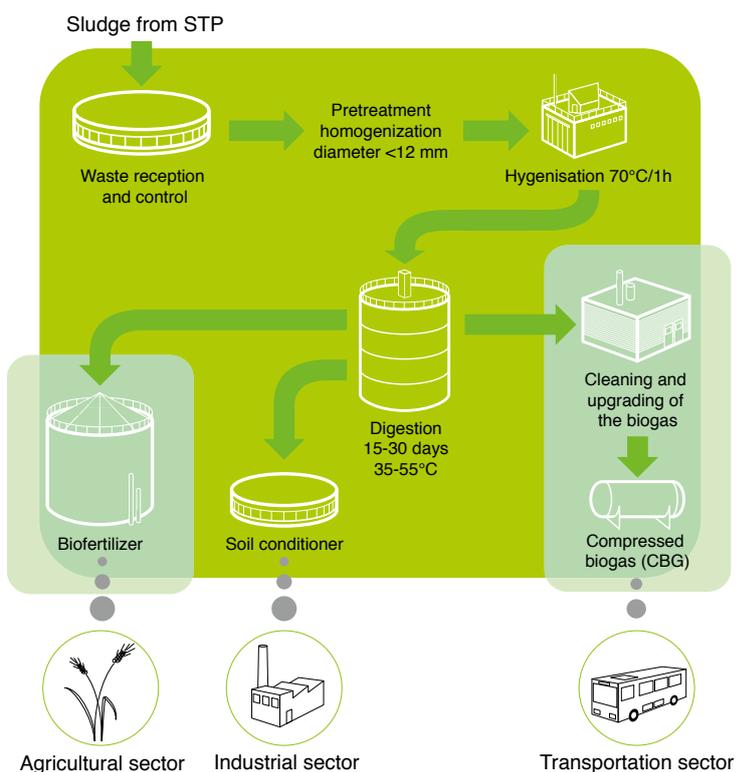
This prototype scenario is an example of decentralised crude-gas production, combined with a central, strategically located upgrade and decentralised utilisation.



### 3. The Keshopur STP

The Sewage Treatment Plant (STP) at Keshopur in Delhi is of suitable size to function as a demonstration facility, whereby Indian and Swedish biogas knowledge will be merged to enable the local production of upgraded biogas of vehicle-gas quality. The STP is located close to the CNG grid and to a bus filling station. The aim is to create value from the incoming sludge, which the municipality is obligated to treat at its sewage power plants, so that it can subsequently be used in the municipal transport sector. This system will serve as a relevant example to other waste treatment plants, and an example of how municipal obligations can be made more cost efficient, sustainable and climate neutral at no cost.

The project exemplifies a fairly straightforward systems opportunity to close the chain from sewage treatment to climate-neutral municipal transport.



### Knowledge exchange between Indian and Swedish partners

Since the first biogas delegation trip in 2009, Swedish and Indian players have shared a fruitful process. A number of solid experiences have been achieved, both internally among the Swedish players and in collaboration with Indian partners on site.

One of the internal, but major, gains is that the Swedish authorities have further advanced and intensified their mutual collaborations. Such horizontal collaborations between organisations promote resource-efficient partnerships.

Vertical structures between organisations can prevent resource-efficient partnerships and beneficial results. The recently established Environmental Office at the Swedish Embassy has played a pivotal role in the contacts between players in Sweden and India. The Environmental Office provides Indian stakeholders with a “One-stop shop” and access to Swedish players, while also allowing Swedish players to more efficiently maintain and develop contacts in India.

For the Swedish Energy Agency, the Swedish biogas delegation’s trip in 2009 was a new form of international collaboration and a new approach in the transition to a sustainable source of energy. The Agency had not previously pursued the concept of creating partnerships with the business community, municipalities and several government agencies to take joint action to demonstrate Swedish expertise. The programme allowed Swedish players to develop their ability to collaborate, while

working on individual assignments and with individual motives for their businesses.

The Swedish-Indian partnership project, which followed in the footsteps of the biogas delegation, has already resulted in new knowledge, new working models, opportunities to develop new strategies and new business models. The Memorandum of Understanding in 2010, between India and Sweden, will mainly focus on the development of new and renewable energy technology – such as in the project concerned – to adapt Swedish biotechnology to Indian conditions.

The Swedish experience in using waste and biomass to generate heat and energy has proven that there are major opportunities for turning Swedish and Indian visions into sustainable instruments for social and economic development.

One objective has been to identify pilot projects that have the potential to be further replicated throughout the Indian continent. One major challenge was, and remains, how to finance such projects in the future. We believe that we have made substantial progress in this matter, since these projects can be replicated and be applied to existing financial solutions in the Indian context.

A project that is totally dependent on subsidies and cannot be replicated would not be ideal to use as a sustainable business model.

The development of the Keshopur STP has been identified as a pilot project. It will show how to utilise a closed-loop supply chain between the municipal sewage treatment and the municipal transport sector. The same model is used in Stockholm, Sweden, and has resulted in a greener and more sustainable carbon footprint.

This solution creates a model for cost savings in the municipal economy. The raw gas is currently flared away, generating no revenue at all. Instead, the city could provide the gas at a low nominal cost to the upgrading plant, ensuring that the investment could be directly linked to the output price for vehicle gas. This would facilitate adjusting the price mechanisms around the end-user price for CNG.



### **Conclusions – conditions for intensified collaboration**

The various projects have contributed in different ways to building up a platform to advance Waste-to-Energy collaborations, including biomethanation. Several players claim that a platform is in place for further partnerships. At the same time, it has also become clearer that major challenges have to be faced.

#### *The difference between technical expertise and primary needs*

In many cases, the most suitable system solution does not necessarily require the most advanced technology, which is associated with high development costs. One way to reduce costs would be for Swedish suppliers to only provide key components, although to date, the Swedish players have been hesitant to such a model. One challenge is to define the boundaries of “key components” in a system solution; another is to identify equal incentives for joint technological development, which could benefit both parties. Some Swedish players have shown an interest to conduct a certain portion of their manufacturing in India. This interest could increase as a result from beginning to capture market shares.



*Lack of standards, policies and means of control to promote the best socioeconomic application of biogas*

A lack of clear guidelines and support for integrating biogas in the Indian system hampers both domestic development and the opportunity for foreign players to fully contribute expertise. Subsidies and other mechanisms for the pricing of CNG impact the market. The Swedish strategy for the development of the biogas sector in Sweden highlights that the entire production chain have to be optimised, and that the subsidy system should be technology neutral. Also in the Indian context, subsidies and policies should be designed to promote the production of vehicle fuel or electricity based on a socioeconomic perspective.

*Sufficiently competent to foresee the opportunities*

Urban Local Bodies (ULB), such as Municipal Corporations (MCs) also play a central role in order to implement the WTE systems. Some ULB has understood the opportunities to reduce municipal costs by properly designed municipal systems for handling sewage and solid waste. The experience from various cooperation projects shows that cooperation on knowledge transfer targeted at ULBs is needed. By becoming acquainted with the opportunities, an independent understanding and knowledge are developed, which can subsequently be applied to a player's own context. The experiences also indicate that a Swedish player does not necessarily have to form a partnership with a MC. It can be equally relevant to partner with a private Indian player or a NGO.

**Way forward**

The aforementioned challenges could lead to continued projects between Indian and Swedish partners.

*Analysis of success cases*

The Swedish Energy Agency could consider continued involvement in the projects that have already proven close to implementation. Such support should be designed in collaboration with Indian and Swedish partners. By examining the project more closely, we can identify the barriers that were project specific and those that were more general.

The Keshopur Project could also increase the understanding of how policies, standards and means of control can best be formulated and of how they can be implemented at the national level. The project could also provide a platform for various studies, such as calculating limits for the relationship between CNG and CBG, storage and distribution requirements, technical specifications for gas motors or on environmental toxins and other unwanted substance substrates.

In addition to the established partnership players, this effort could also include other organisations such as the Automotive Research Association of India and Bureau of Indian Standards.



#### *Establish and intensify contacts with dedicated cities*

Some 63 Indian cities are included in the Jawaharlal Nehru National Urban Renewal Mission (JNNURM). In several cases, these cities have an expressed sustainability agenda. It is important that they have access to the positive Indo-Swedish project results. There are potential partners at national and state level, in the ULBs and in the industrial sector. Swedish players with an expressed and verified interest could also participate.

#### *Research, Development and Innovations*

New networks can open doors for as yet unidentified partnerships, solutions and development tracks, in areas such as innovation or research. This would be highly suitable for Swedish Energy Agency assignments.

#### *Financial structures*

The key to success in the renewable energy solutions and sustainable systems is not only in the technology solution, but in the financing structure, both to secure investment, and to establish economy in operation and maintenance. This is essential so that positive results can be replicated and developed in new projects. In order to focus future efforts right, more knowledge about financial systems in India, including incentives, government initiatives and financial institutions needs to be developed.

This gathering of knowledge could advantageously be integrated with the aforementioned activities.

# Participants in the first delegation

The delegation of 2009 was designed provide a comprehensive picture of the overall Swedish competence in biogas field. For the Swedish Energy Agency, it was important to get experience from both providers and users of the systems. Therefore, both technology suppliers and consultants, as representatives of municipal operation and trade associations took part in the delegation.

Several of the participants in this delegation are engaged in the specific projects described in this brochure.

## SWEDISH PARTICIPANTS

### Technology suppliers

*Läckeby Water Group* is an independent, privately-owned Swedish group, specialised in design, supply and construction of systems for water and wastewater treatment as well as systems for renewable energy specifically biogas and biogas upgrading.

*Malmberg* is working with water treatment and biogas systems. The company's upgrade system is standardized and prefabricated in a special container building, for easy servicing and maintenance. The company has established itself within the geothermal system that uses natural heating and cooling of the ground water and mountains.

*MGE-Teknik AB* is a turnkey contractor that offers the best way to success with landfill projects. The competence and offer includes In-house technology, Planning, Design, Construction and Production.

### Suppliers of consulting services

These consulting companies offer services based on a portfolio that extends beyond waste management.

*SWECO* is one of the leading consulting engineering companies in Europe, with local offices presence in ten countries and extensive project exports worldwide. SWECO has project exports to some 80 countries worldwide on all continents.

*COWI* consulting company provide state-of-the-art services within the fields of engineering, environmental science and economics with due consideration for the environment and society.

*Ramböll Sweden* is organized in three divisions and one subsidiary. Division Engineering & Design, Energy Sector and Project Management Division. Subsidiary Ramböll Natura AB is active in service projects around the world.

## **Municipal utility companies**

*Göteborg Energi* is a municipal energy company that invests heavily in biogas, with both industry and agriculture. Their full-scale demo projects on gasification of wood wastes – GoBiGas has the potential to be the first of its kind in the world and has attracted substantial international interest.

*Trollhättan Energi* is a local supplier of energy. It produces and sells biogas as vehicle fuel. The municipality has also developed a system that combines small-scale production of raw gas with centralized upgrading to biomethane.

*Eskilstuna Energi och Miljö (EEM)* is a local supplier of energy, district heating, water and waste management. EEM offers assistance in running waste to energy plants.

## **Trade associations**

The two trade associations that participated together represent the entire Swedish “Waste to Energy” sector.

*Avfall Sverige* – Swedish Waste Management, is a stakeholder association with 400 members. It has most complete source of knowledge regarding current practice and trends in Waste Management in Sweden today.

*Swedish Gas Association* is the trade association dedicated to promoting a greater use of energy gases, such as biogas, CNG, LPG, natural gas and hydrogen. The organisation works with all issues related to energy gases, such as safety, training, certification, information and advocacy.

## **Government agencies**

*The Swedish Energy Agency* is a governmental authority for national energy policy issues. The Agency’s mission is to promote the development of the Swedish energy system in order to make it ecologically and economically sustainable. International cooperation and promotion of Swedish energy knowledge and cleantech are important tools.

*Sida (The Swedish International Development Cooperation Agency)* works according to directives of the Swedish Parliament and Government to reduce poverty in the world and achieve a sustainable development. The overall goal of Swedish development cooperation is to contribute to making it possible for poor people to improve their living conditions.

*The Embassy of Sweden* to India promotes relations between India and Sweden. The Embassy of Sweden is committed to working with India on research, design and deployment in the areas of energy and environment, in areas of mutual benefit and in line with India’s own development plan.

*The Swedish Trade Council* has the competence and resources to identify international business opportunities for Swedish companies. The dual ownership (government and industry) provides access at all levels throughout the world. It has offices in over 60 countries worldwide.

## **INDIAN PARTNERS**

### **Government bodies**

*The Ministry of New and Renewable Energy (MNRE)* is the nodal Ministry of the Government of India for all matters relating to new and renewable energy. The broad aim of the Ministry is to develop and deploy new and renewable energy for supplementing the energy requirements of the country.

### **Municipal bodies**

*The Delhi Jal Board*, constituted in 1998, is responsible for the Production and Distribution of potable water after treating raw water from various sources. The Chairperson of the Delhi Jal Board is the Chief Minister of the State government.

#### *About Municipal Corporations*

Municipal Corporations (Urban local bodies or local government) have been given the responsibility by the Centre and the State governments to oversee urban planning activities such as water, sanitation and public transport. Support for this is provided for by grants from the Central government. However, increasingly it is expected that urban planning interventions will be financed through locally collected sources i.e. land taxes and v.a.t.

### **Utility company**

*Indraprastha Gas Limited (IGL)* is responsible for the Delhi City Gas Distribution Project since 1999. The objective is to lay the network for the distribution of natural gas in the National Capital Territory of Delhi to consumers in the domestic, transport, and commercial sectors.

CNG shall replace diesel vehicles for public transport, following a Supreme Court Order. Today IGL has over 200 filling stations in Delhi that run 400,000 vehicles on natural gas. The project is backed by Gas Association India Limited (India) Ltd. and Bharat Petroleum Corporation Ltd. (BPCL).

### **Industrial partners**

IL&FS Waste Management & Urban Services Ltd (IWMUSL) has been promoted by Infrastructure Leasing and Financial services (IL&FS), a premier non banking financial institution of India. Focus areas include among prioritised areas integrated municipal solid waste management.

*Bharat Forge Limited (BFL)*, the flagship company of the USD 2.4 billion Kalyani Group, manufactures various forged and machined components for the automotive and non-automotive sector. Kalyani Group has started developing a portfolio in the renewable energy business, focusing on renewable businesses like wind power, bioenergy, solar, energy storage etc.

## The biogas programme Waste to Energy

This report describes the Indo-Swedish collaboration on biogas since, 2009 when the Swedish delegation “Biogas for Urban Infrastructure” visited India. Biogas represents an area of technology that meets India’s challenges, while providing examples of Swedish integrated solutions and technical cutting-edge competence. Several projects within the programme “Waste-to-Energy” are now underway in India.

*The Swedish Energy Agency* is a governmental authority for national energy policy issues. The Agency’s mission is to promote the development of the Swedish energy system in order to make it ecologically and economically sustainable. International cooperation is essential in achieving this target. The promotion of Swedish energy knowledge and cleantech is also an important tool.

With the support of the Swedish  
Embassy in New Delhi and Sida



EMBASSY OF SWEDEN



SWEDISH INTERNATIONAL  
DEVELOPMENT COOPERATION AGENCY



Swedish Energy Agency, Box 310, SE-631 04 Eskilstuna  
Telephone +46 16-544 20 00, Fax +46 16-544 20 99  
E-mail [registrator@energimyndigheten.se](mailto:registrator@energimyndigheten.se)  
[www.swedishenergyagency.se](http://www.swedishenergyagency.se)