Institut für Kreislaufwirtschaft

Project concept

Renewable energy production from organic waste on Phu Quoc island, Vietnam

Institut für Kreislaufwirtschaft GmbH
(Institute for Recycling and Environmental Protection)
Neustadtswall 30
28199 Bremen, Germany
Tel.: +49 (0)421 5905 2311
Fax: +49 (0)421 5905 2349
Mail: IKrW@hs-bremen.de
Hompage: www.IKrW.de

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1. Introduction

Energy is a key component in Vietnam's recent industrialisation process. In the period of 1995-2000, the electricity consumption increased at a quick pace at an average rate of 14,7% per year. During the past two years, the yearly power demand has increased at a rate of 16,6%. So far, the development of power sources has been limited mainly to large central power plants using hydropower and traditional fossil fuels.

Vietnam possesses abundant renewable energy resources that can be utilised for decentralised power generation. Small hydropower potential (under 10MW per site) is estimated at 800-1.400 MW, while biomass cogeneration could supply an additional 250-400 MW. Furthermore, recent energy policies, such as the Renewable energy action plan (REAP) place emphasis on the increasing promotion and exploration of renewable energy. Until now, however, the utilisation of renewable energy sources for power generation has been limited to sporadic application with a combined installed capacity of 160-215 MW (mostly hydropower and biomass combustion).

Despite several initiatives by national and international organisations, considerable barriers and challenges to developing renewable energy in Vietnam remain. The main barriers to a widespread application of renewable energy are:

- Lack of adequate policy and regulatory framework (e.g. power sector law)
- Inadequate information about renewable energy technologies
- Limited access to financial sources for investment
- Lack of attractive feed-in tariffs renewable energy projects (resulting low profit margin)
- Highly subsidised power sector
- Lack of demonstration projects in the field of renewable energy

Comprehensive investigations in Vietnam revealed that the island of *Phu Quoc*, situated in the Golf of Thailand, features very favourable framework conditions for renewable energy production. In particular, the application of biogas processes for electricity production was evaluated as promising. A pre-feasibility study was carried out in co-operation with local experts to further develop and substantiate the project concept.

2. Framework conditions for application of biogas technology for renewable energy production on the island of Phu Quoc

General

The island of *Phu Quoc*, *Kien Giang* province, South Vietnam, is the biggest island of Vietnam with a total area 568 km² and 76.585 inhabitants. The two major cities on the island are the capital *Duong Dong*, located in the island's centre and the fisheries port *An Thoi* at the southern tip of the island. Recently great efforts are undertaken to promote eco-tourism (Decision 97/TTCP from the Prime Minister 2000). Thus the political aim is to **promote a sustainable development** and to "keep the island green".

The provincial government plans to develop *Phu Quoc* into one of the countries most exclusive tourist destinations. The anticipated steady rise in number of tourists and the resulting demographic increase will lead to considerable infrastructural developments. The annual growth of population is estimated at 15% over the next decade. Consequently, appropriate measures will be required to avoid adverse impacts on the environment.

Current energy supply system

The island is located approx. 30 km from the mainland. The option to connect the island's electricity system to the mainland electricity grid was abandoned, because it was found to be not economically

Neustadtswall 30
28199 Bremen
Tel.: 0421/5905-2326
Fax.: 0421/5905-2349
email: IKrW@hs-bremen.de
www.IkrW.de
Sparkasse in Bremen
BLZ 290 501 01
Konto: 162 59 46
Geschäftsführer: Dr. Martin Wittmaier
Handelsregister Bremen: HRB 19582
UST-ID-Nr. DE 210064016

feasible. It was rather decided to expand the existing diesel-based decentralised power generation facility. In 2004, a new power station was built and took up operation to complement the unreliable electricity production of the old generation system. The new power station, located ca. 8km north of the island's capital, is equipped with two diesel-fuelled generators (genset) of 2,5 MW nominal electrical capacity each In order to cover the increasing electricity demand, the commissioning of two additional generators is planned in 2005, resulting in a total installed electrical capacity of 10MW. Currently, the demand for electricity is much higher than the supply, resulting in frequent power cuts. Therefore, the old generation site will be kept in operation until the demand can be covered by the new generators (figure 1).

Figure 1: Power generation on Phu Quoc island: New power plant near the capital Duong Dong a- Diesel generators at the old generation site

In 2004, the total electricity production amounted to approximately 23 Mio kWh. Due to the anticipated demographic growth and development of the tourist and industrial sectors, it is foreseen that the electricity demand will increase with a constant pace in the future. In addition, the island's north will be linked up to the main grid network within the next couple of years resulting in a further increase in electricity demand.

The average tariff for end consumers connected to the island's grid network amounts to the equivalent of 7.2 € cents/kWh. Taking into account the relatively high specific generation cost of diesel generators it is assumed that the long-term marginal costs are not covered by the current tariff. Consumer tariffs in remote areas without access to the island's grid network can be as high as 1 €/kWh. In those areas, electricity is produced by small-scale diesel generators or supplied by ice-making works. Supply of electricity is highly unreliable and only available at particular times of the day. An extension of the island's grid network to remote areas will lead to a considerable improvement of living standard rural residents (figure 2).

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Figure 2: Electricity transmission on Phu Quoc: The end of the grid network – Rural electrification in remote areas. A substantial part of the inhabitants only have access to expensive energy from small -scale diesel generators

Solid waste management

The household waste from the cities *Duong Dong* and *An Thoi* constitutes the major part of the island's total waste production. The daily waste generation in semi-urban areas can be estimated at 0,53 kg per capita. Taking into account the anticipated demographic growth, the annual quantity of household waste produced can be calculated to 15,5 million kg in 2005. In addition, approx. 1,5 million kg of food leftover and kitchen waste are produced annually in the major hotels and restaurants at the island's west coast.

At present, the waste collected is disposed off without prior treatment in an unmanaged disposal site located in the north of the island's capital (figure 3). The current waste handling practice is leading to local environmental hazards such as rodents, smell and ground water pollutions. Furthermore, resulting uncontrolled emissions of methane (CH_4) have adverse environmental impacts on global climate change. The provincial government initiated plans to build a managed landfill in the island's north near to the locality of *Xa Bai Thom* within the next years. The introduction of environmental sound waste handling practices is ranked high on the agenda of local as well as regional politicians, who want to promote eco tourism. Initiatives in the field of waste management will be boosted by the perceived urgent need to improve the island's environmental conditions.


Figure 3: Current practice of uncontrolled waste dumping – Planned area for new managed waste disposal site in the island's north

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Demand for fertilizer

Agriculture plays a vital role in Phu Quoc's economy. The area under cultivation amounts to 860ha for pepper plantations, 1.000 ha for fruit trees, 200 ha for vegetables, 570 ha for cashew nuts and 270 ha for coconut trees (figure 4). The extensive agricultural activity of the island is leading to a high demand for fertiliser. Besides livestock manure, a great amount of conventional mineral fertiliser is used to cover the demand.

Figure 4: Pepper plantations on Phu Quoc

Attitude of market actors and stakeholders

Interviews in a participatory workshop held in December 2004 revealed that both, the provincial government of *Kien Giang* as well as the local government of *Phu Quoc* highly support the introduction of renewable energy and waste treatment technologies on the island. The establishment of environmental sound practices in the field of energy production and waste management is regarded crucial to ensure a future sustainable development.

The responsibility for production, distribution and sale of electricity on Phu Quoc lies with the Power Company 2 *in Kien Giang* Province, a regional subsidiary of the national state-owned utility Electricity of Vietnam (EVN). The initiative to complement the island's electricity system with renewable energy technologies was received well by the Power Company 2.

3. Project concept

The framework conditions on the island of *Phu Quoc* were found to be very favourable for the application of renewable energy by biogas processes. The prevailing relatively high electricity tariff (compared to 5,1 € cents/kWh on the mainland) is expected to provide attractive returns for the project. The production of bio-fertiliser will result in additional revenue that further improves the project profitability. As side benefit, the problems related to the current waste handling practices will be addressed leading to a considerable improvement of local environmental conditions. This combined and integrated approach is in line with the development goals set by the local and regional governments, and the project will thus receive support from all relevant project stakeholders.

Comprehensive on-site investigations were carried out in order to identify the most suitable location for the biogas project. By considering both, energy and waste-related factors, the location near the new *Phu Quoc* power station was selected as the most promising site for the project (figure 5).

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Figure 5: Selected site for the biogas plant next to the new power station near to the capital Duong Dong (extract of map of Phu Quoc)

The household waste collected in the cities *An Thoi* and *Duong Dong* was selected as main feedstock for the biogas system. The solid waste is characterised by a relatively high organic content that makes it a suitable substrate for biogas processes. Based on the average dry substance content of the substrate that amounts to approx. 50%, a dry fermentation process was selected as main process type. In general, dry fermentation systems enable the processing of substrates such as household waste without prior treatment or separation. During processing in the biogas system, the organic substance of the substrate is degraded into biogas.

Different utilisation paths for the biogas produced were evaluated in relation to their effectiveness and practicability. Co-firing of the biogas in the existing diesel generators of the new power station is regarded as the most promising option. The diesel generators can operate under full load conditions even in case of limited biogas availability, resulting in high overall system efficiencies. Existing facilities and infrastructures can be used and no additional expenditure is required for cost-intensive components such as gas engine, transformer and grid interconnection. Therefore, this complete integration of the biogas system into the existing power generation system will lead to a considerable reduction in initial investment costs.

The residues obtained after processing the waste in the biogas system are stabilised and problems inherent in untreated waste such as smell, spreading of pathogens etc. have been minimised to a large extend. Residues are refined further in a down-stream composting process in order to produce a high quality raw material fertiliser that can be applied to agriculture. Interfering matter is separated in a screening process and disposed off in the landfill. A flow chart of the plant concept is shown in figure 6.

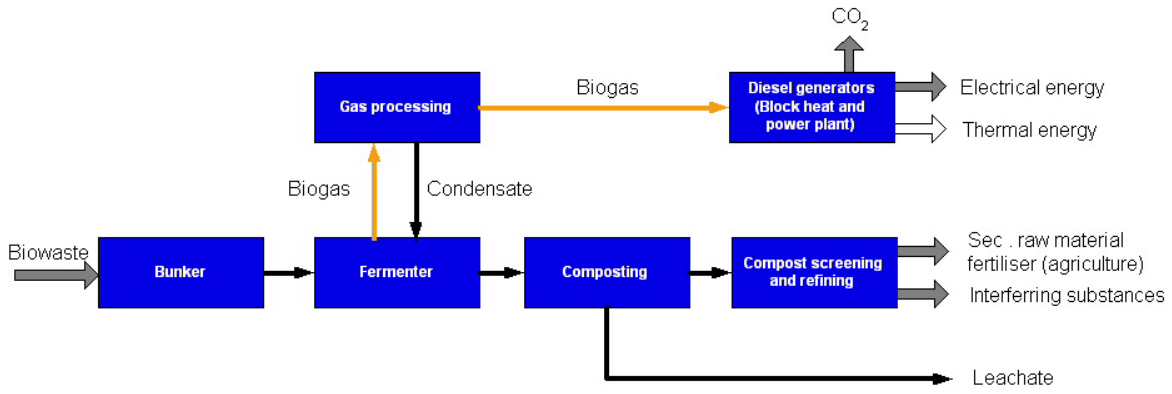

Figure 6: Flow chart of the plant concept for the biogas plant (dry fermentation process)

4. Expected project impact

Production of electrical and thermal energy

By processing the 15,5 million kg waste in the biogas system, approximately 1,8 million m^3 of methane will be produced every year. The equivalent energy content of this methane production amounts to 18 million kWh/a. Taking into account the overall system efficiencies of the existing diesel generators, the annual electricity production from biogas can be calculated to 5.400 MWh/a. This production would be equivalent to a nominal electrical capacity of ca. 675 kW_{el}. On the basis of the current electricity production the substitution ratio of conventional energy supply by renewable energy production amounts to approx. 23%.

Besides the production of electricity, an annual quantity of more than 9.000 MWh/a of thermal energy (hot water) is generated that can be used for a variety of applications (drying of fish, cereals, etc.)

Abatement of CO_2-emissions through project implementation

The implementation of the project will lead to a twofold reduction in CO_2-emissions:

- Avoided methane emissions from solid waste disposal (considered as CO_2-equivalents)
- Avoided CO_2 emissions from the substitution of conventional energy supply

The avoided emissions of methane **from solid waste disposal** were estimated applying the proposed default methodology of the revised IPCC 1996 guidelines. A managed landfill without utilisation/flaring of landfill gas was selected as appropriate baseline for waste disposal on *Phu Quoc* (likely scenario in the absence of the project). Compared to this baseline, the processing of waste in the biogas system followed by an utilisation of residues as fertiliser will result in a reduction of more than 12.000 t CO_2 equivalents per year.

The use of biogas for generation of energy is CO_2 neutral. By substituting fossil fuel-derived **energy production** with biogas, reductions in CO_2 emissions can be achieved. The production of electricity in diesel-fuelled generators (medium efficiencies) was selected as baseline for power generation on *Phu Quoc*. By utilising the produced biogas in the existent generators approximately 1.800m^3 of conventional diesel fuel can be replaced every year. This replacement leads to an annual reduction in CO_2 -emissions of about 4.700 t.

When compared to the selected baseline scenarios, the total abatement of CO_2 emissions through project implementation will be about **16.700 t/a**.

Production of secondary raw material fertiliser (bio-fertiliser)

As additional benefit, more than **12.000 t** of high quality fertiliser will be produced every year. By applying this bio-fertiliser to agriculture, the use of conventional mineral fertiliser can be cut down.

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