Decentralised Waste Incineration Plant R.Vandhoo in the North of the Maldives

– Project Experience, Energy Use and First Operation Results –

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Environmental pressures in the Maldives raised from the fragile geography of the country coupled with rising population densities, increased tourism and changing consumption patterns. The country faces growing problems with solid waste management and pollution from sewage and other effluents emanating from urban settlements, hotels, fish-processing plants, ships and other sources. The quantities of solid waste generated exceed disposal and treatment capacity. Most wastes are dumped onto the island foreshore and burnet at low combustion temperatures. Uncontrolled waste disposal and floating debris at tourist resorts is the most visible threat to the country´s reputation as a pristine high-end tourist destination.

Uncontrolled disposal of solid waste (foreshore dumping and open burning) currently accounts for 15 percent of the greenhouse gas (GHG) emissions in Maldives. Proper solid waste management will help the country achieve its target of carbon neutrality by 2020. Ocean dumping of waste can lead to the degradation of coral reefs. Improper waste disposal into coastal vegetation is a major contributor to the degradation of the vegetation belt. Ad hoc disposal of waste of inhabited islands increase the risk of

vector borne diseases by creating vector-breeding sites. The establishment of effective solid waste management system in the country would reduce the impact of climate change and improve community health.

1. Project background

1.1. General information on the Maldives

The Maldives are a chain of nine islands groups in the Indian Ocean. It extends over 871 km in north-south direction. Only 220 of the 1.196 islands are inhabited. The Maldives have about 330,000 inhabitants, of whom about 130,000 live in the capital Male.

Tourism is the main source of income in the Maldives. Every year approximately 1,000,000 tourists are visiting the Maldives. Approximately 85 resort islands are used for tourism.

1.2. ASPIRE project

The Government of the Republic of Maldives has received grant funds from the multi-donor Climate Change Trust Fund, which are administered by the International Bank for Reconstruction and Development IBRD and executed by the Ministry of Environment and towards Preparation of the Accelerating Sustainable Private Investment in Renewable Energy (ASPIRE) Project.

The Maldives, as a conglomerate of Islands, is very particular and needs special adapted solutions. The challenging geography, the fragile ecology, the restricted space availability and the development of tourism activities, makes the project more complex with specific criteria for site selection, engineering, technology choice and management.

The development and scale up of renewable energy technologies for power generation is a high priority for the GoM. The Government envisages the deployment of renewable energy technologies to be in form of a Design Build Finance Own Operate Transfer (DBFOOT) model or similar where power supply arrangements would be made through a standardized Power Purchase Agreement (PPA).

Preparing Outer Island Waste-to-Energy Projects will be a key component under the ASPIRE program which will address the growing need for energy as well as sustainable management of waste in selected regions of the Maldives.

Taking into account the special geographical circumstances of the Maldives, the government has planned the construction of four waste incineration plants within the ASPIRE program.

They should desserve the

- Upper North province,
- North province,
- Male-Region,
- South province.

In the Upper North Province, the plant is planned to be built in Kulhudhuffushi. This plant generates electricity that is fed into the local grid and substituted the power of the diesel power plants as well as cold water for cooling purposes.

The disposal of the North Province is via the facility in Vandhoo, which was built as the first plant.

For the Male-region a facility is planned to be built on the island Thilafushi, which is known as *garbage island*. This plant is designed for the disposal of the waste of approximately 200,000 residents and tourists.

The incineration plant in the southern province is planned to be built in Addu City.

For the three locations Kulhudhuffushi, Vandhoo and Addu City the development of waste quantities, the waste composition and the utilization of the combustion heat has been investigated as a part of a feasibility study and carried out the feasibility studies for the optimal system configuration (electricity, production, cooling water, potable water).

2. Actual state of waste disposal

The waste disposal in the Maldives is still in the beginning. In the cities, the waste collection is carried out by private companies. The collected waste is transported to uncontrolled dumpsites. Main example is the island of Thilafushi in South Male Atoll, where the extension of the dumpsite has created an artificial land reclaim with waste and leachate flowing into the sea. On this resulting artificial island, industries and tank farms for diesel fuels have now emerged.

Figure 1: Actual status of waste treatment

Due to spontaneous combustion or even targeted burning of waste, there is a strong environmental pollution by smoke.

On the smaller islands a composting of organic waste in the garden is partly done. The remaining waste is brought to uncontrolled landfills that are burned regularly.

The resort islands have their own *small incinerators*, which are operated as batch plants without flue gas treatment.

The famous resort operators have implemented an extensive waste separation. Thus, beverage bottles, mainly PET bottles, cans and paper are collected and marketed separately.

In order to introduce an environmentally friendly waste treatment on the sparsely populated islands, three decentralized

waste incineration plants will be built. In parallel with the establishment of incinerators the construction of *Island Waste Management centres* on the islands is carried out.

These fulfil the function of sorting and transfer stations. Here metals, plastics, paper and cardboard are sorted out. The recyclables and residual waste will be transported by ship to the three regional waste management centres. The sorted recyclables are collected and disposed of there centrally for the respective region. The residual waste is incinerated, the bottom ash and flue gas cleaning products are deposited in the respective incinerators in newly built, base sealed residue landfills.

3. Vandhoo project

3.1. Design features

An island scoping study has identified Vandhoo in Raa Atoll as the preferred island on which to locate the Regional Waste Facility for the north region. Vandhoo is now gazetted as an industrial island to be shared for boat building and waste management. Approximately 15 ha have been made available for the construction of the RSWMF. The catchment for the Regional waste management system consists of 46 inhabited islands within, Baa, Raa, Noonu and Lhaviyani Atolls. There are also 15 resorts currently operating in the catchment, which have responded positively to the opportunity of participating in the RWM system. North Maalhos-madulu (Raa) Atoll is a large and complex atoll with many reefs, faros, channels and islands. The island of Vandhoo belongs to North Maalhos-madulu (Raa) Atoll.

To determine the amount of waste that will be processed in Vandhoo plant an increase in population from 47,666 in 2014 to about 62,300 in 2034 was assumed. It is also planned to increase the number of resort from 15 to 25 in the region, which corresponds to an increase in the number of beds from currently 4,700 to about 9,100.

Per inhabitant arise 0.9 kg/d, in the resorts is the amount of waste 3 kg/bed/night. The total amount charged in the north province, is 20,800 Mg/a.

The waste incineration plant is designed for the following parameters:

Throughput:	40 t/d
calorific value:	8,500 to 11,000 KJ/kg
ash content:	20 to 30 percent
humidity:	10 to 30 percent
max. Grain Size:	500 mm
Cl-Content:	0.35 to 1 percent
S-Content:	0.16 to 0.22 percent
combustion temperature:	850 °C
Waste oil throughput:	50 l/h
average ambient temperature:	25 °C
humidity:	90 percent

Waste composition	percent	Trend
Organics	70	constant
Garden waste	30	
Kitchen waste	30	
other organics	10	
Paper and cardboard	7	constant
Glass	3	decrease by 1 percent
Plastics	5	increase in the next years probably by 2-3 %
Metals	4	constant
Hazardous wastes (including clinical)	2	constant
Other (inert and dust)/mixed waste	9	decrease
Total	**100**	
Organics	74	constant
Garden waste	19	
Kitchen waste	45	
other organics	10	
Paper and cardboard	9	constant
Glass	5	constant
Plastics	5	constant
Metals	2	constant
Hazardous wastes (including clinical)	0,5	constant
Other (inert and dust)/mixed waste	4.5	constant
Total	**100**	

Table 1:

Waste composition of the household and the resort islands

The flue gas cleaning system is designed to achieve the limit values of the 17th BImSchV German regulation.

Based on the limits of the IFC/WB Environmental Health and Safety Guidelines, an environmental impact study was carried out; on the results of the stack, height was set to 22.0 m.

4. Project description

The regional waste management centre Vandhoo was built on an uninhabited island. The overall project includes the following individual measures:

- Construction of a transit channel through the reef,
- Construction of a harbour with quay wall and ramp,
- Coastal protection (by the construction of the transit channel the reef loses its function as a breakwater).

Service area, consisting of:

- Rainwater collection and storage,
- Tank Farm (diesel),
- power generator,
- social building,
- workshop,
- weigh bridge,
- Standing surface for collection containers,
- simple waste sorting (manually),
- Incinerator (1-line),
- landfill for the ash and flue dust.

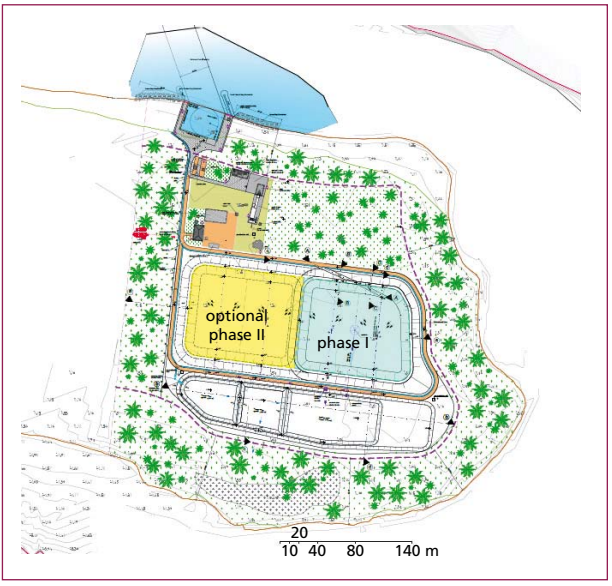

Figure 2:

Regional waste management centre Vandhoo

4.1. Landfill

The landfill site was built for Phase I with an available volume of 27,000 m³. The design of the landfill and the leachate collection show the sections through the landfill.

Because no clay is available due to the geological formation of the Maldives, the locally available coral sand is mixed with water and compacted.

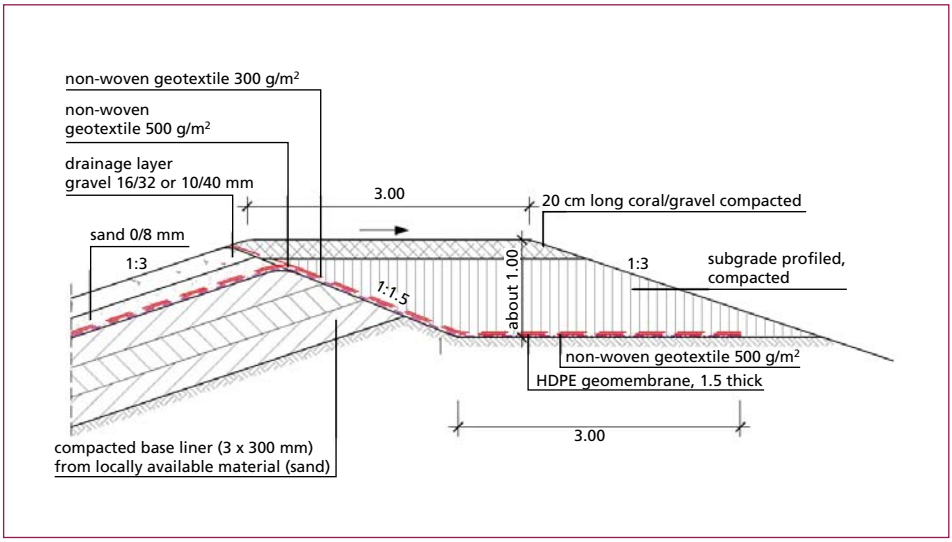

Figure 3: Construction of the landfill dam

Figure 4 shows the construction of the base seal. The leachate from the site will be collected and stored in the reservoir. The stored water is rained out in the dry season in the landfill, where it evaporates, so that no water has to be discharged to the environment.

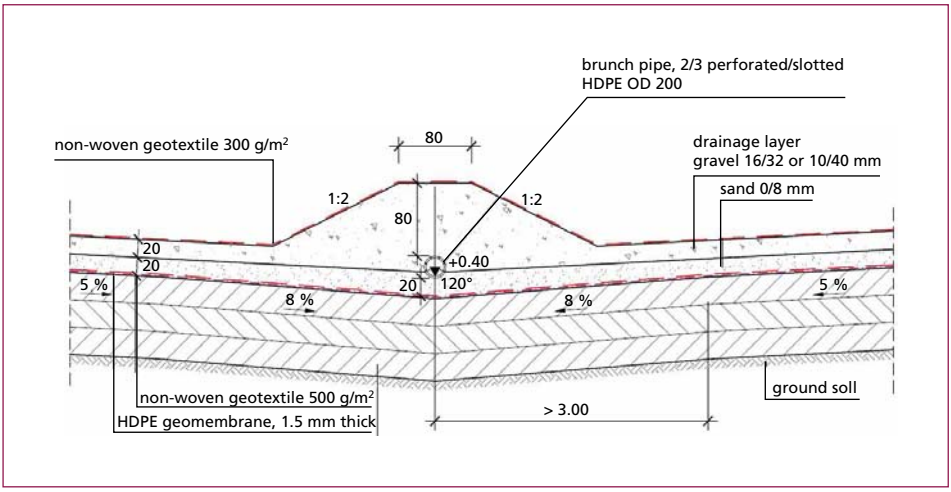

Figure 4: Construction of the base seal

The company Kocks Consult GmbH, Koblenz, Germany, which carried out also the overall design of the project, carried out the engineering of the landfill.

4.2. Combustion system

The combustion system, consisting of the components

- feeding system,
- incinerator,
- waste heat utilization,
- flue gas cleaning,
- stack

was advertised worldwide.

SPS Energie GmbH, Munich, Germany, carried out the basic engineering and the preparation of tender documents.

The contract for the construction of the incinerator received the company Michaelis from Würzburg, Germany.

Local construction companies carried out the necessary construction work on the foundations and the roof of the plant.

Figure 5:

Incineration plant Vandhoo

Figure 6: View to the incinerator, back house filter and air cooler

The plant is shown in Figures 5 and 6.

The waste is delivered by ship and stored back on the covered area in front of the feed conveyor. The feeding of the feed conveyor is done by wheel loader. A conveyor belt passes the waste through a lock entry in the combustion. This is designed as a grate combustion. The combustion air is supplied from the side below the grate.

At the end of the grate of the burned waste is discharged into a wet slag removal, from which the slag is thrown off in a transport container. This container is transported by wheel loaders for unloading.

On the first combustion stage, the post combustion chamber adjoins for the complete burnout of the flue gas. The post-combustion chamber is designed for a temperature of 850 °C and a residence time of two seconds.

On the post combustion chamber an emergency stack is arranged, which opens in case of failure of the heat recovery or the flue gas cleaning in order to leave the plant safely.

On Vandhoo are no possibilities of use of the recovered heat available. Because the future industrial development of Vandhoo is not yet decided, the flue gas is cooled down by a hot-water heat exchanger. The flue gas is cooled to a temperature of 180 °C, before it enters the flue gas cleaning. The flue gas cleaning is carried out with sodium bi-carbonate and activated coke as an absorbent. The absorbent is injected through a lance into the hot flue gas.

The separation of the reaction products and the fly ash is carried out in a filter with ceramic filter elements. The filter cake from the additives that forms on the surface of the ceramic elements ensures the sufficient contact time for the absorption of the acidic flue gas components and the organic flue gas constituents.

The filter elements are periodically cleaned with compressed air, the filter cake falls into a discharge system and is discharged with a screw in big bags. The big bags are sealed and discharged on the landfill part.

At the beginning, the hot water from the flue gas cleaning will be cooled down by an air cooler because now there is no possibility of using. In the course of industrial development of the island, Vandhoo the hot water will be used for the production of chilled water by means of an absorption chiller or for the production of portable water by a MEP-process.

5. Realization

The realization of the project is carried out in two stages, in step one the construction of the port, the landfill and the construction of social buildings and workshops was carried out. This phase of construction was completed in the 4th quarter of 2013.

The global tender for the incinerator was carried out in June 2013 after final clarification of the financing of the project by the World Bank.

The tenders were opened in August 2013, the commissioning of the system installer in January 2014th.

In the beginning November 2014 the readiness for shipment took place, and then the transport of the plant to the Maldives.

From February 2015 was carried out the installation of the system, start-up (first waste fire) took place in July 2015.

6. Results

Due to the delayed completion of the civil works such as the roof of the plant currently under construction, no results from the start up of the Vandhoo plant are available. Therefore, the table below shows the operating data of a comparable plant in Germany. The results of the Vandhoo plant will be presented on the conference in Vienna.

Table 2: Operating data of a comparable plant in Germany

	unit	value
annual operating hours	h/a	6.130,0
waste through put	t/h	1,2
average calorific value	MJ/kg	11,5
consumptions		
average fuel consumption (incl. start up and shot down)	l/h	28,7
average electrical power consumption	kW	150,0
sodium bicarbonate	kg/h	40,2
activated carbon	kg/h	0,68
compressed air	m³/h	6,4
residuals		
ash	kg/h	77,6
fly ash and FGT residuals from filter	kg/h	50,4

Table 2: Operating data of a comparable plant in Germany (continuation)

	unit	value
emissions		
In the gaseous emissions, the following values were measured:		
Nitrogen oxides	mg/Nm³	193,0
C_{total}	mg/Nm³	2,29
S	mg/Nm³	0,44
HCl	mg/Nm³	1,5
total dust	mg/Nm³	0,24
PCDD/F	mg/Nm³	0,005
HF	mg/Nm³	< 0,24
heavy metals (Cd + Tl)	mg/Nm³	< 0,008
heavy metals (Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V + Sn)	mg/Nm³	< 0,0091
Hg	mg/Nm³	< 0,001

7. Summary

With the project, *Incinerator in Vandhoo* the government of the Maldives has taken the first step towards an environmentally friendly waste disposal. The plant in Vandhoo will process the waste of approximately 50,000 residents of the northern region and 15 resort islands in the future.

Parallel to the construction of the incineration plant the development of formerly uninhabited island will be expanded into an industrially used range.

According to the further industrial use of the island, Vandhoo the type of heat utilization will be decided. Currently, the environmentally friendly disposal of household waste is a priority.

The expected emission levels represent a significant improvement of the present state of the waste disposal with uncontrolled deposition and incomplete combustion.

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