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Report – Advancement of technology and economics of biogas production at Höganäs wastewater treatment plant

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REPORT WWTP

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1 Introduction

Biogas productions integrated with the WWTP indicated in calculations of the plan, have the potential for a positive economy. Therefore, it was decided that the option on WWTPs were deepened to search for synergies in the integration of new reactors with existing facility at the wastewater treatment plant in Höganäs. This memo presents the deepening of engineering, calculus and economics around the option. We seek to optimize the utilization of existing plant and equipment to minimize investment. Anaerobic digestion occurs in two lines, one for the sewage sludge and one for manure, crops and other residues from agriculture. In addition there is the upgrading of biogas to get the economy in the project to look as good as possible.

The design of this memo is such that we illustrate technical differences from earlier survey of the smaller facility located at the WWTP and the consequences it entails for the calculation.

2 Substrate

Substrate survey reported in the substrate-AM. Suggestions for substrate composition included in the cost and technology proposed in this box around the wastewater treatment plant (WWTP) are reported below.

The composition has been generated by iteratively whose cost constantly weighed against gas exchange and the overall economy. This is detailed in Chapter 4.

Table 1. Proposed substrate set for construction at the WWTP of 6-8 GWh

Substrate	**Volume, tone.**
Slurry, DS 8%	14 100
Solid manure, DS 25%	5 700
Tomato paste, DS 15%	1 080
cucumber paste, DS 15%	840
Fruit / veg, DS 15%	1 500
Rye paste, DS 25%	0
Other substrates, DS 15% *	3 000
Hay Silage unfit	0
Hay Silage feed	0
Corn / beet tops	0

* ex blast, Finax, etc

3 Technology

Technology section of this memo mainly handles the specifics of the proposed solution of biogas production integrated with activities at Höganäs WWTP. Within this chapter, Technology handled the proposal to establish a new biogas plant next to the existing business at Höganäs WWTP.

At Höganäs WWTPs, there is access to infrastructure and cheap heating and the production of biogas. This affects both the operating and capital costs and hence the project's economic buoyancy.

3.1 Construction Review

With the aim to find possible solutions to dismiss or identify plant parts on WWTPs that can be useful in an integrated biogas production has a more detailed review made at site visits. The review was carried out together with Fredrik Arthursson, VA Manager Höganäs Municipality, on 12 September 2012

3.1.1 Existing plant parts useful for receiving and pretreatment

In the eastern part of the plant is three final clarifiers, one of these is considered to be possible to release. In close proximity to office and laboratory building is a reject water tank about 250 m³, see Figure 1.

Figure 1. Reject water tank and thickener. In the background are the plant two reactors and the torch.

In these plant parts is the ability to release the final sedimentation tank and lead reject water for intermediate to that. This means that a change is likely only result in plumbing pipes and not land development. Completing the need is both piping as an additional pump for charging pre sedimentation with reject water.

In the reject water tank about 50-60 cm from the bottom an outlet in the form of a 150-stainless steel tube that opens into the pipes and from there is pumped through a centrifugal pump to the pre-sedimentation. All tubes are in a culvert and ends up in the final sedimentation. In this culvert it is possible to lead the reject water past reject water tank and pump it directly to the current final settler from where it can be pumped to the pre sedimentation, see Figure 2.
Through the wall behind reject water pump opens a 150 mm stainless legation pipes from reject water tank (Figure 2). Pipes in the back of the pump, angled at 45 °, is the supply pipes for the reject water from the sludge dewatering centrifuges.

Figure 2. Reject water pump. Dosing today the pre sedimentation with reject water.

Primarily, supplementing the need in terms reject water tank roof, displacements pump and mixers. Secondary may possibly additional ring to increase the volume of the receiving installation. However, this is not necessary in the first step. A few meters from the position where the outlet from reject water tank flows is a 90 mm PE / PVC pipes that previously provided centrifuges for sludge dewatering. This tube goes in the right direction and can be useful for sludge transportation to mix with solid substrates, see Figure 3.

Figure 3. Unused sludge pipe.

3.1.1.1 Receiving pumped waste

Just adjacent to the engineering building is an old converted sludge pocket with paved bottom of asphalt, Figure 4. The pocket is under roof and partially walls and two longitudinal compartments. Today, some of this is storage. When this is built over the position and the roof is suitable to supplement with walls and pipes for discharging the liquid material in one part, and unloading of the solid material in another part. With further supplementing the hard surface and collecting, washing of vehicles also could take place here.

Picture 4. Possible reception hall.

3.1.1.2 Receipt of non-pumpable material.

Part of non-pumpable material that cannot be considered to cause odor problems can be stored on existing sludge plate with L support in concrete, Figure 5. This creates a pocket suitable for storage. The material will be introduced to the plant via a Vogelsang solution containing a receiving pocket / lying silo that will be filled by a loader.

Picture 5. Sludge plate.

Since both daily operation and supervision that also records and the requirements of control for obtaining sustainability certification requires knowledge of material balances of the plant and also detailed records of deliveries required weighing of materials. It is available as an alternative to investing in their own weighing equipment. A contract with carriers to set a requirement for the supply of equipment in vehicles equipped with load cells.

3.1.2 Sanitization

A sanitization step is usually necessary to meet the Board's guidance on the subsequent spreading of digestate. We suggest traditional sanitation, pasteurization, which involves heating to over 70°C to be held at least 1 hour. Typically, the particle size maximum 12 mm. The simplest possible solution is, if the surface in the workshop building can´t be released for the purpose, is to place heat exchangers and sanitation tanks in one or two containers.

3.1.3 Heat Recovery

To recover heat from the sanitized material, which is 70°C, before it is pumped to bioreactor is necessary for two main reasons. First, the temperature optima for mesophilic digestion process, which we propose here, around 37 ° C, which means that sanitized materials, must be cooled in order to avoid the risk of overheating the process continues in the digester. It is also normal process economically viable not to take advantage of this amount of heat that must be switched away.

It is necessary despite the additional heat and we have credited counting the project surplus heat from Höganäs Sweden AB for 0.1 SEK / kWh.

3.1.4 Digestion/after digestion

A digester allowing sufficient residence time, with sufficient stirring and temperature on the sludge will be. To have residue storage with the option for additional gas production is a good way to ensure degassing of the digestate before fertilizer run-off. A double membrane gasholder on the digestate layer enables this. The ability to acquire used storage tanks occur now and then. This should be explored more deeply in the event of procurement of equipment.

3.1.5 Gas upgrade

We assume in the calculations that the upgrading of biogas takes place with a water wash technique. The facility included in the investment is of the brand Greenlane and has a top capacity of 300 Nm³ per hour. This is for the purpose of over-capacity, which allows an increased gas production. The alternative is a smaller plant with a maximum capacity of 130 Nm³ per hour, which would reduce investment by about 1.9 million SEK.

3.1.6 Distribution

Deployment can be done in several ways technically. Produced upgraded gas from a new biogas plant is 665 000 m³. The gas can be distributed to external distributor by entering into the natural gas grid. Nearest consumer is within about 300 m from the plant, which provides that the input to the gas grid could operate in the area. Deployment can also be done by flaking alternately on two swapbodies the bottle layer also acts as a gas storage or by building a pipeline of only biogas (without propane dosing). Distribution through swapbodies was waived in the memo “technology” as it becomes more costly than distribution through pipelines for this project when provision is made to the external distributor. Deployment can also be in local biogas management, which in the calculation is indicated to be the least expensive solution, see chapter 4.1.

3.2 Summary of technology

The facility is projected to handle both pumpable and non-pumpable wastes (Table 1). The pumpable waste should handle directly into a receiving tank and the non-pumpable waste is handed into the lying silo. A Vogelsang solution should mix the various factions. All materials must pass a pasteurized plant there except that the temperature of the material will be capped also a homogenization and load balancing occurs. The gas will then be upgraded to vehicle quality and then distributed to the filling station suggested by local biogas tube, as this looks to be the most advantageous to the project.

3.3 Mass balance and water needs

This mass balance shows material for co-digestion in a line separate from the sludge from the wastewater treatment plant and the existing raw gas production.

On received materials holds the total biogas potential corresponding to approximately 7.6 GWh, the expected outcome is of the order of 85% of this representing 6.6 GWh, equivalent to 665,000 Nm³ of upgraded gas / CNG (Figure 6).

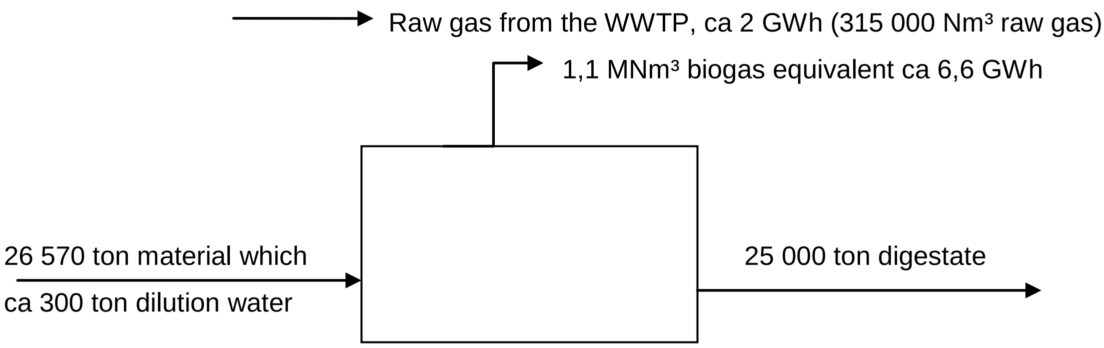

Figure 6. Mass balance for the current facility for a total of about 27 000 tones of substrate, dilution water addition of approximately 300 tones, resulting in about 25 000 tones of digestate.

3.4 Energy needs

Biogas production is energy-intensive and dependent on plant solution and technical design, the energy need could change. In this case, a simple and proven system is proposed in all alternatives. There are a numbers of alternatives solutions to the pretreatment / mixture stirring and gas upgrade. These alternatives, however, cause the specific cases have studied in depth with respect to the specific properties of the substrates, which can be implemented in a deeper investigation technique.

3.4.1 Installed power

To assess how much energy each plant can be expected to use, calculated the various component parts installed capacity (Table 2). A very large part of the energy is spent mixing of the various tanks in the system. The most energy-intensive part of the operation is the start time and the time until the operating speed of pumps and mixers. When the operating speed is achieved normally assumed that about 70% of the installed power is used. Added to this is the fact that some redundancy is typically built into key positions to prevent unnecessarily large service outages and disruptions. However, it is important to take in account these redundant systems in the compilation of the total installed capacity.

Table 2. Calculation of installed power

Installed capacity	Heat (kW)	Electricity (kW)
Additional system components at WWTP	100	450

Estimated energy requirements are presented in Table 3. The difficulty is to define the amount of electricity consumed, as this is dependent on the plant design and operating philosophy, additional amounts of substrate and gas, and more. We assume, however, from the experience of existing facilities to make as good estimate as possible.

Table 3. Calculation of energy needs for the current installation options.

	hygienisation (MWh/year)	Energy, electricity (MWh/year)
Distribution of natural gas / biogas locally	760	ca 850

Water wash has relatively low energy consumption and from plants in operation indicated consumption to about 0.3 kWh/Nm³ gas. Pressure raising a bottle stock requires further about 0.25 kWh/Nm³ gas.

3.5 Operational Aspects

The tasks available for a facility of this size should be allocated to the appropriate personnel. Given the plant's proximity to existing treatment plants, it should be possible to buy the hours and resources from there. This has been taken into account in the calculation. Given the below mentioned points, a full-time employee is considered sufficient in normal circumstances. However, in certain cases, services have to be purchased, because there are tasks that cannot be performed as a single work.

3.5.1 Daily operation

The use of a monitoring system with alarm system via e.g. SMS allows for a relatively short response time at a standstill, and also simple and manageable emergency services.

3.5.2 Administration and process monitoring

Administrative work in the form of receiving deliveries and their documentation, is daily / weekly reports. Although responsibility for the contractors in the area and inspections, tests, test sockets, handling of test results process monitoring and optimization is time-consuming tasks.

According to ABP Regulations is the requirement of a designated operator who will have an effective control over materials that are classified as ABP materials.

3.5.3 Substrate Collection and roared waste management

To coordinate and supervise the logistics of substrate downloads and digestate loading can be part of more administrative services as described above.

Certificate from the SP's side needed an appointed head of fertilizer quality is tasked to ensure that all handling ABP materials occurs under both current regulations and also the condition that the facility has.

3.5.4 Gas Manager

According to the Law of flammable and explosive goods (LBE) there shall be a gas manager attached to the plant. The person need not be employed at the facility, but must live and work close to the activities they are responsible for.

3.6 Dimensioning

Plant is designed for the selected set of substrates and then calculated the mass, energy and water balance. With a variety of incoming substrates of 27 000 tones and selected technical layout designed facility as shown in Table 4 and gas upgrade and gas stocks in order to receive the produced quantities of gas from your existing and future gas production.

Table 4. Dimensions and capacities presented set of substrates and plant layout.

	WWTP
Receiving tank	250 m³
Hygieniseringstank	3 * 4 m³
Power input sanitisation	100 kW
Digester	2 500 m³
After digestion tank	800 m³
Gas upgrading	300 Nm³/h raw gas
Gas storage	2 500 Nm³

3.7 Storage of digestate

Within this depression on WWTPs, no changes have been made that affect the earlier design and marketing of bio-fertilizer.

The calculations assume that existing pumping wells renovated or expanded and that a natural floating crust formed and or farmer using other methods approved by the County Board, such hydrograins or straw to prevent ammonia.

4 Provision

4.1 Provision of biogas as a vehicle fuel

Produced upgraded gas from a new biogas plant is 665 000 m³ / year. This is equivalent to 440 cars driving 1500 mil / year, Table 5. Existing gas produced from the WWTP would the upgrade to vehicle gas enough additional 130 vehicles per year. Total gas would be enough for about 570 cars per year. Upgraded gas can be compressed to 200 bar and can be flaked to nearby filling station, or used in place of dispenser installed, injected into the natural gas grid or distributed in local biogas tube.

Table 5. Quantity produced vehicle and theoretical number supplied vehicles

	amount of vehicle gas[1]	Equivalent, number of vehicles / year[2]
current production WWTP	200 000 Nm³	130
New facility at WWTP	665 000 Nm³	440

Upgraded gas can be allocated in several ways: either by distribution to external distributor or that the project itself is distributor. This affects the calculation to a great degree. Generally increases vehicle gas value the closer to the end customer it can be dismissed, why it is often advantageous to take it, in relation to the entire investment, less investment to establish a refueling station.

Pricing for entering the vehicle gas on natural gas grid is from case to case and is specific to the plant under the network owner (E.ON). The project accounts for wiring, as well as costs for the foundation and entry point on the natural gas network, which we have included in the calculation. The network owner handles propane metering and gas prices so this is included. With experience of projects in the region and a reconciliation with E.ON. is vehicle gas price for input online between 600-800 SEK / MWh. In the calculus, we expect 700 SEK / MWh.

The plant can sell the upgraded gas to the distributor in the network who want to buy and we suggest a discussion with several distributors then the price to end customers varies widely, from less than 14 SEK / Nm ³ to just over SEK 16 / Nm ³.

The option that the principal of the plant also is a distributor to the end customer is also available. This can be achieved in several ways, for example by establishing a new service stations or buy the existing in Lerberget. Establishment of a new filling station is estimated at around 5 million and the purchase of an existing one should be under it.

The station in Lerberget is supplied today by the natural gas grid. For the project, it may be advantageous to self-supply the refueling station through a local biogas grid. In this case this means to build a new biogas tube, which we have included in the calculation as a total investment of 1 500 SEK / m. The stretch WWTP - Skördevägen 2 where filling station is located is about 3 km.

The station in Lerberget is run by Preem and distributor of vehicle gas is Öresundskraft. The price to the end customer is 13.85 SEK / Nm ³ including VAT, which corresponds to approximately SEK 11 Nm³ or 1100 SEK / MWh. The sale of the vehicle gas at the existing service station is information Öresundskraft not disclose. For the project there is a positive synergy in that Höganäs Sweden can ensure full provision of the gas that cannot be sold as vehicle fuel. It also means that the plant is very rarely need to flare gas.

[1] Amount of biogas produced of vehicle quality, 97% methane, the calculation of the outcome has been digestion efficiency to 85%.

[2] Standard car, 1 5000 km / year, 1 Nm³ vehicle gas / 10 km

4.2 Provision of digestate

The calculations assumed that the trucks go with full returns of digestate to the different farms. It can reduce transport costs quite significantly. It also means that the farmer will get back the same volume of bio-fertilizer that is delivered to the plant.

4.2.1 Logistics and use of digestate

For a new facility at the WWTP that will produce 6-8 GWh per year the bio fertilization amount is about 25 000 tones, of which 10 to 12,000 tons can be stored in existing wells. For the other volumes, a new warehouse has to be built.

With the current demand for storage capacity it means an increase of about 8,000 m^3 more storage to be constructed.

Warehouse for a smaller amount of digestate is planned at the plant, about 1,000 m^3. External storage, satellite wells, amounts to approximately 7000 m^3. The costs of an internal and external layer are included in the calculation.

4.2.2 Allocation and actors

Besides livestock farms will require about 500 acres more for disposing of all the digestate. This represents approximately 10% of the available spreading area in Höganäs Municipality.

Average transport distance for digestate is estimated to about 5 km.

5 Economic calculation

Previously prepared spreadsheet for a new establishment of a biogas plant at the wastewater treatment plant revised here with respect to the results of site visits and opportunities for synergies in terms of equipment, infrastructure and operational coordination. Compared with the previous estimate for a facility at the WWTP will there also be an upgrading plant and the cost of a local biogas grid.

The estimate is calculated for an investment based on the synergies we have seen, and thus use what is going at WWTP and also complement the existing facility with new equipment. Occasionally, the opportunity to invest in used equipment, which we have not taken into account here. Used equipment is an opportunity that must be examined more carefully in case of procurement of a biogas plant.

5.1 Substrate Optimization

We have experimented with the different substrates, as decreased and increased the amount of slurry and analyzed the amounts of other agro-related substrates blast or unfit silage affect the overall economy to find the optimal substrate mix. Selected mix presented in the introduction to this report.

5.2 Calculation of a biogas plant integrated at the wastewater treatment plant in Höganäs

The calculation is based on the assumptions presented in terms of substrates and techniques of Chapter 2 and Chapter 3.1, the gas exchange of mass balance in Chapter 3.3, and adopted digestion efficacy as previously, about 85% of the potential and the price of gas, electricity, heat, water as before, gives investment costs of about 38 million SEK, Table 6, and operating costs as Table 7.

The entire investment is about 38 million, which also includes an upgrading facility and the consequences it entails, with a local gas tube and biogas filling station. Compared with the previous estimate for a facility at the WWTP, 26 million SEK gave the completion of the plant in place a reduction of the initial investment in the WWTP by over 20% to 20 million SEK.

Table 6. Estimated investment in a new digester and upgrading facility for integration at Höganäs WWTP. Additions also make local management and biogas filling station.

Investment costs SEK	
Reception and pre-treatment	5 800 000
Biogas plant, upgrading	15 500 000
Electrical and automation, air, odor	5 000 000
Buildings, residue storage	2 300 000
Infrastructure including biogas management	4 800 000
Fueling station	5 000 000
TOTAL	**ca 38 000 000**

Table 7. Operating and maintenance costs for a facility integrated with WWTPs.

Operation- och maintenance costs	
Biogas plant	500 000
Gas upgrade	300 000
Filling station	200 000
Staff, 1	500 000
Capital cost	3 700 000
Material cost and compensation to agriculture	300 000
Transports	1 200 000
TOTAL	**ca 6 700 000**

Revenue for vehicle fuel with a retail price to the end customer of approximately 14 SEK/Nm³ gets 7.5 million SEK including bio-fertilizer (90 000), which exceeds the operating costs of the facility. The design looks indicative seemed to work economically.