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Resource check for selected treatment plants

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1. Summary

Observations from visits to eight treatment plants in Denmark

In Denmark, treatment plants make varying contributions to increased utilisation of resources and reduced impact on climate. This is something that Danish utility companies have proven at the treatment plants they run and continually invest in. From both the authorities' perspective and the water sector's perspective, there is a desire for more treatment plants to become more efficient with resources; with this in mind, and to inspire more plants to increase utilisation of resources, key individuals from the sector visited eight selected treatment plants.
During the visits, the individuals recorded a series of observations of the plants, their operations, opportunities and challenges faced in relation to increased resource usage, as well as proposing measures that could be useful and examined in greater detail. A summary of all of this is provided in the table at the end of the chapter; likewise, more detailed descriptions of the visits can be found in the appendices at the end of this report.

1.1 Introduction

To a certain degree, some of the observations and conclusions from the visits to the eight treatment plants are generally applicable to similar treatment plants in Denmark. There is clear indication, for example, that the smaller treatment plants have limited options when it comes to making profit on biogas energy production: too little sludge is produced, and the cost of setting up digestors, gas engines etc. is too high. In addition, many of the energy-saving options do not have a sufficiently short payback time for the smaller treatment plants, as there is too little potential saving and the cost of the equipment is too high. In some cases, centralisation of the smaller treatment plants may be the best option when it comes to achieving the necessary economies of scale in energy production and in terms of the savings made, with several utilities having examined such opportunities for a number of years. The evaluation of water sector law in 2012-13 also provided observations in this area (Deloitte, 2013).
As the waste water is not in compounds or concentrations, a number of specially designed treatment plants were visited. Some of the plants are set up in a certain way for historical reasons, with this set-up still determining how the plant can be run today. With this in mind, it is not possible to change the capacity, plant type etc. for this and several other treatment plants, which would be built differently nowadays if new and in the current conditions.
When looking at the configuration of the plants, it is also important to bear in mind that their main purpose is to treat waste water and that developing options to produce or save energy is secondary to this.
For some of the treatment plants visited, the opportunities available by adding organic waste and with it increasing biogas and, therefore, energy production, are also being considered. If done, and provided that the organic waste takes the form of source-sorted organic household waste, a string of conditions may need to be fulfilled, however. Some of these have already been covered in other investigations, such as (SK_Forsyning, 2017), which include, for example, considerations in relation to the Danish Water Sector Act and what a waste water company must finance via the tariffs.
In the past, much of the treatment plants' and the sector's attention has been directed exclusively towards energy production and savings. Some, however, have been focusing on greenhouse gas emissions from waste water treatment, including nitrous oxide and methane, for a long time. Reduction of the greenhouse gas emissions overall does not have any direct commercial potential, however, as proven previously in (among others) various investigations of the technical possibilities available for energy production and streamlining at Danish treatment

plants (DHI, 2015). Despite the lack of commercial potential, there are socio-economic grounds on which to implement certain measures in some cases thanks to a rather large amount of potential lying waiting to be tapped in the reduction of greenhouse gases. This incongruity has been covered in previous studies, such as (NIRAS, Energipotentialer og CO2-skyggepriser for energibesparende og energiproducerende teknologier i spildevandsrensning, 2016).

One of the eight treatment plants visited, the plant in Helsingør, has already installed equipment for struvite production that will potentially increase the utilisation of phosphate as a resource in waste water. Some of the other plants visited are considering similar equipment. The sale price of the phosphorus product created, struvite, will be a central decision-making parameter for the treatment plants. This was also the conclusion in other previous investigations, such as the second part of this project; see (NIRAS_1, 2019). This conclusion is lent further support by the fact that the treatment plant in Helsingør had the struvite plant decommissioned at the time of visit, because the market price of the phosphorus product was too low.

Generally speaking, the impression from the visits to the eight treatment plants is that legislative framework has a major bearing in decisions to increase energy efficiency, energy production and resource usage, e.g. with regard to financial regulation and benchmarking of the waste water companies, rules set for the companies when they produce and export energy in the form of, for example, electricity or heating, regulation of waste water company options when it comes to development costs, and so on. The main challenges faced as regards regulation are outlined in more detail in section 1.3.2. This has also been the finding in other situations in the past; see for example (Basse, 2014).

1.2 Status of the plants

In general, it was felt that the operations staff at the eight treatment plants visited had a firm focus on the options available for increasing energy production, energy optimisation and resource usage. They also displayed quite a lot of insight and interest in the opportunities available to their own plants; in other words, none of the plants visited are ill-prepared for future opportunities.

A number of the plants are already making use of advanced online controls, which may be suitable as a tool for meeting emissions targets while simultaneously meeting the desire to increase usage of resources.

Several of the plants visited are implementing or preparing measures intended to increase energy production, improve energy efficiency and improve usage of the resources in waste water. The measures include development of digestors, new gas engines, new equipment for aeration and systems for struvite production. All of these measures are clear indication that the plants continue to focus on improving their plants and increasing the number of options available for usage of resources.

Optimising operations and investments in new equipment aside, some of the plants visited have also reaped the benefits of centralising waste water treatment and sludge treatment already. In these plants' experience, centralisation has enabled them to stabilise operations more, optimise use of equipment and increase energy production and utilisation. Several of the other plants visited are also focusing on the benefits of centralising waste water treatment; a number of these are actively looking into their options here.

1.3 Challenges facing the plants

For the operations staff at the plants visited, it is not just about new opportunities and potential, however – they are also faced with a series of challenges that are limiting their options, on multiple occasions, with regard to increasing usage of resources at their own plant. Some of the challenges faced relate to operations, while others stem from issues and problems with the regulatory framework.

1.3.1 Operations and framework conditions

Some of the plants and the utility companies that own and run these face challenges in terms of their geography i.e. finding a suitable option for centralising waste water treatment. Quite simply, it will be very difficult to make one single location for both production and treatment of waste water pay off.

At the same time, some of the plants are also faced with operational challenges, e.g. due to limited capacity, fluctuations in load or bottlenecks in production. With effluent emission standards taking precedence, energy optimisation and increased usage of resources do, of course, become secondary considerations.

Some of the treatment plants visited have surplus heat from biogas engines, while others could even increase heat production by (for example) having heat pumps at the outlet. There are, however, limited opportunities available when it comes to disposing of the heat, because the district heating network is either too far away for it to be financially viable to put the necessary infrastructure in place, or the local district heating company prioritises other heat production rather than the treatment plant's potential supplies.

Uncertainty around key future areas is also a challenge for the operations staff at some of the eight treatment plants visited and the utility companies that own and run them. Firstly, there is market uncertainty around the sale price of the energy that the treatment plants use and produce. It would appear that the utility companies are capable of managing this uncertainty. Fluctuations in the price of (for example) struvite are also being dealt with – e.g. at the treatment plant in Helsingør, struvite production is being discontinued while the sale price does not balance with the production costs.

Uncertainty around the future plant structure is, however, also having a significant constraining effect on investment at the plants visited: Understandably and sensibly, there is less investment being made in plants that will potentially be centralised and decommissioned in five to ten years' time. Although the decisions about future plant structure may be an exclusively internal matter at each waste water company, they may also be influenced by organisational structure and collaboration across different waste water and utility companies, including consolidations in the sector, and collaborations between the local authorities who own the companies.

1.3.2 Regulation

Regulation of the waste water companies and other relevant legislation can also play a role in the options available to the treatment plants and in the incentives available for (for example) increasing energy production or energy efficiency. Several of the treatment plants visited and the utility companies that own them have found regulation to be a hindrance with regard (for example) to exploiting heat from the treatment plants.

There may be certain challenges faced in relation to Section 19 (1) of the Danish Water Sector Act (Vandsektorloven), which specifically requires the company to separate waste water supply from electricity supply, heat supply and gas supply. As separating – or setting up – a company involves a number of more or less fixed annual costs, the income from the sale of energy will be sufficient to offset the costs involved in setting up a separate company. Although exemption from the company separation requirement was possible, had it been implemented, the income – and the costs – from the energy production would have been factored into the income limits. The waste water company might therefore not 'profit' from the energy production, but any surplus could benefit the consumers by lowering waste water tariffs. Whether or not the energy production division is a separate company from the main business (the waste water company) will depend on several circumstances, including the size of the waste water company, whether or not organic resources are being supplied from outside and whether or not energy production was established before or after 1 January 2017 cf. Regulation on economic framework for water companies (Bekendtgørelse om økonomiske rammer for vandselskaber)[1].

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[1] Reg (BEK) number 938 of 28/06/2018

The challenges relating to the aforementioned company separation, main business and affiliated business aside, some plants also feel that the regulation can put obstacles in the way of opportunities to increase biogas production at the plant via organic waste. Pertinent issues in this respect are highlighted, among other things, in the 'Handbook on treatment of SS-OF-MSW biopulp in digestors' (Danish: 'Håndbog i behandling af KOD biopulp på rådnetanke') together with possible organisational structures and model solutions (SK_Forsyning, 2017) (Slagelse Forsyning A/S, 2019). In terms of regulations, the handbook lists the Danish Water Sector Act (Vandsektorloven), the Danish Heat Supply Act (Varmeforsyningsloven), the Danish Gas Supply Act (Gasforsyningsloven), the Danish Environmental Protection Act (Miljøbeskyttelsesloven) and the Danish Sewage Sludge Order (Slambekendtgørelsen) as being relevant to utility companies and use of source-sorted organic fraction of municipal household waste (SS-OFMSW) in the treatment plant's biogas production.
The aforementioned regulations aside, there may also be some more general uncertainty surrounding future need for investment and for a financial framework – including the streamlining requirements calculated by the Forsyningssekretariatet, the Danish Utility Company Secretariat. ~~the constant amendments to legislation that may decrease the return on investment in the plant~~.
Overall, the financial regulation does incentivise waste water companies to produce energy for their own consumption, if it is cheaper than purchasing it from external suppliers, or if supplements can be obtained through the economic framework to cover additional costs during energy production. The waste water companies do not have any financial incentive to sell energy to external customers, because any surplus is offset in the income framework if energy production is not done via a separate independent company. As such, it is only if the waste water company wishes to reduce the tariffs by selling energy, or if the production and sale of energy in themselves are a target set by the companies, that they have an incentive to sell energy, or if other specific circumstances at the individual company apply otherwise.

1.4 Conclusions from the visits

Although the operations staff at all eight of the treatment plants visited were already aware of the options available for increasing energy production, further energy efficiency improvements and optimisation of resource usage, positive and productive discussions of shared experiences and options for improvement were still possible during the visits. This has given the operations staff at the plants and their utility companies the inspiration they needed to implement suitable measures for the future.
Suggestions that were discussed during the visits included options for optimising new and existing equipment, including gas engines and digestors, as well as possible ways of optimising sludge treatment as a whole, and energy optimisation for fans and aeration. A summary of the conclusions from the visits:

- New gas engine and digestor: More opportunities for optimisation and potential for more stable operations are the main benefits of investing in a new engine and tank
- Central sludge treatment: More efficient handling of the sludge and the possibility of increased energy production
- Exploitation of struvite: Significant struvite precipitation, which can then be exploited for phosphorus-containing fertiliser products
- Other uses for sludge: Various options in which sanitised sludge is used for a non-agricultural purpose
- Process optimisation with external biogas plant: Conversion of the processes would potentially influence the quality of the sludge and, with it, the biogas potential for the external recipients of the sludge
- Skills development: Increased exploitation of energy may require new and more complex processes, whereby operations staff have the skills to match this increase in complexity

- Increased heat production: Heat pumps and more efficient gas engines may facilitate increased heat production. It must, however, also be possible to sell the heat (e.g. for district heating)
- Aeration energy savings: Smaller treatment plants can also save energy on (for example) aeration. The savings may, however, be too small to offset the costs associated with the necessary investments and operations

For more detailed descriptions of some of the technologies listed here, please read the background report from the ‘Net energy production in the water sector’ (Danish: Nettoenergiproduktion i vandsektoren) partnership’s report (NIRAS_2, Maj 2018). Exploitation of heat production is a recurrent theme and a subject that has proven to be relevant to a number of the plants. Many plants, however, are not in a position to dispose of the heat on the district heating network and in doing so exploit the heat in a reasonable fashion.

A number of the plants already have their focus firmly on process optimisation and control; likewise all of the plants visited seek to reduce their energy consumption on an ongoing basis. A number of the plants are aware of the climate impact from nitrous oxide and methane, which is why they are attempting to reduce these emissions by, for example, optimising aeration and tightening controls against the background of sensor data, among others. There are also several who are considering struvite at their plants, despite some potential warning signs from the plant in Helsingør, which has suspended its struvite production because the market price of struvite is too low.

The options for centralising waste water treatment, which several of the plants visited are considering or have already reaped the benefits of, may not only necessitate skills development, but also facilitate increased specialisation at the plants and at the waste water companies. Many of the plants, particularly the smaller ones, only get to avail of these opportunities to a limited extent today, but could potentially benefit from them more if they merged with other companies.

The plants visited face many challenges, both operationally and in a regulatory context, if they are to significantly increase energy production, energy efficiency and general usage of resources. Operations staff and utility companies are often capable of dealing with operational challenges, whereas the regulatory challenges can be more difficult to overcome.

TABLE 1. General conclusions and suggestions emerging from visits to plants

Treatment plant	Capacity and load	Status	Challenges	Conclusions
Slagelse	Designed for 125,000 PE, loaded to approx. 60,000 PE	Desire for improved energy profile Biogas and electricity production expanded Plan for bottom aeration to be established Centralised sludge treatment with economies of scale	The utility company's plants are dispersed geographically, making centralisation difficult A lack of subsidy options and the regulatory environment are preventing utilisation of heat from gas engines and heat pumps The plant operates below capacity, so some equipment is oversized at times	A new engine and digestor are providing more optimisation options and will potentially lead to more stable operations Many opportunities potentially but not all of them are financially viable
Holbæk	Designed for 60,000 PE, loaded to approx. 55,000 PE One of FORS' 22 treatment plants	Special SBR plant No focus on energy neutrality in the plant's design	Uncertainty around the plant's future and location means that possible measures are on hold	Awareness of the opportunities available with energy optimisation and central sludge treatment, but also uncertainty around the structure of the plants in the future
Fredericia	Designed for 420,000 PE, loaded to approx. 60,000 PE	Major focus on energy neutrality at the plant Process optimisation and control are one measure of several Awareness of nitrous oxide Potential for SS-OFMSW Potential for struvite precipitation	Heat production restricted by lack of market opportunities No option to receive organic waste	Energy neutrality within reach, but better options required if the heat is to be disposed of as district heating Exploitation of struvite should be considered Other ways of disposing of sanitised sludge
Holstebro	Designed for 180,000 PE, loaded to approx. 125,000 PE	Receives large volumes of COD Interaction between treatment plant, external biogas plant and three food producers Focus on aeration and fans	The utility company's plants are dispersed geographically, making centralisation difficult	Process optimisation at the plant has to be done in collaboration with the external biogas plant

Skanderborg	Designed for 47,000 PE, loaded to approx. 50–60,000 PE on some parameters	Preparations for increased biogas production and exploitation in gas engines Energy optimisation conducted wherever expedient	Surplus heat cannot be sold for district heating More stringent requirements regarding emission of phosphorus to recipient Extraneous water places a strain on the plant at times Load is increased significantly during festival times	Focus on increased usage of resources at the plant Awareness of need for skills development to cover increased complexity Desire for CO2 neutrality, including focus on nitrous oxide and methane
Helsingør	Designed for 76,000 PE, loaded to approx. 32,000 PE	The plant has advanced online controls and struvite precipitation 1/3 of the plant's electricity consumption is covered by the plant's own production Large amount of pumping necessary	Ongoing changes to regulation creates uncertainty Load from cruise ships may increase load significantly At present, the struvite produced cannot be sold at a sufficient price	New gas engine may increase electricity production Heat pump at outlet may increase heat production for district heating Up to 40% of the total volume of phosphorus at the inlet may be converted to struvite
Nivå	Designed for 22,500 PE, fully loaded	Smaller plant which used to produce biogas and electricity Close to full load Focus on optimisation of operations and energy savings	Limited spare capacity Narrow physical conditions for the plant	Energy optimisation may be possible for fans The plant is barely big enough for cost-effective biogas, electricity and heat production – even with SS-OFMSW
Fårevejle	Designed for 26,200 PE, loaded to approx. 20,000 PE	Sludge mineralisation plant established for this reason; no energy production Low energy consumption	Limited flexibility at the plant	Fewer energy savings on aeration and pumping may be possible if treatment requirements can be met simultaneously The options available for centralising the plant with the plant in Holbæk may open up the option of increased usage of resources

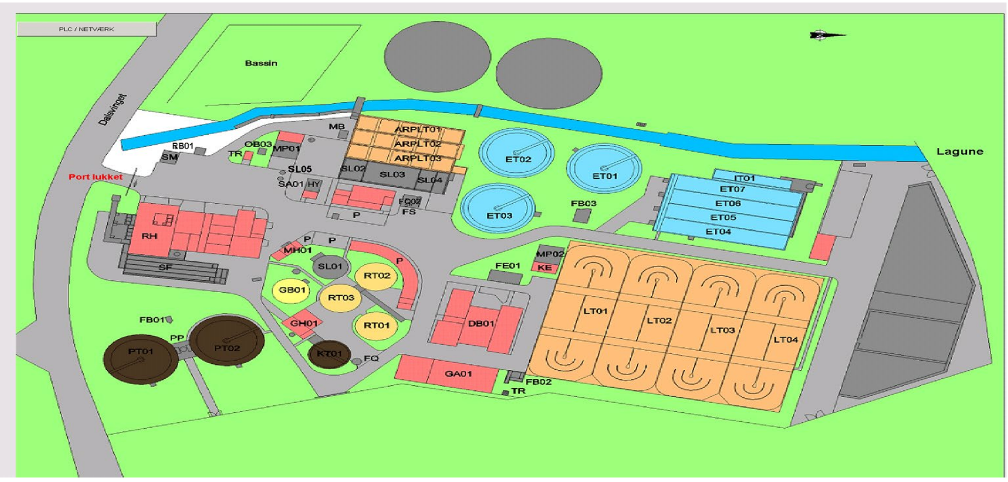
Appendix 1. Visit reports

Appendix 1.1 Slagelse Treatment Plant

“The plant has major potential with regard to increasing the supply of district heating and producing more electricity”

1.5 Introduction to the treatment plant

Slagelse treatment plant has a very effective new intake structure, which is upstream of the primary tanks. The biological section of the plant consists of a double aeration tank and is also fitted with a so-called ARP tank.
The plant has three digestors and is currently undergoing renovation to get all three tanks up and running. Electricity and heat are produced in the plant’s gas engines and boiler plants.
The plant was constructed over several years, with optimisations and adjustments consequently made over time. This also means that the water has been elevated several times, placing demands on efficiency. The plant has made efforts to exploit the existing buildings as best it can, with several installations re-used in new configurations over time.
The plant has set itself a clear target: to significantly improve their energy profile and to work on further elements, including establishing a new gas engine and an improved gas system.
Proactive efforts are being made to change the plant’s surface aeration to more energy-efficient bottom aeration.
Like many other plants, the plant is having problems with the heat exchangers used to heat the sludge in connection with the digestors.



1.6 Key figures for the treatment plant

Although the plant is designed for 125,000 PE, the load in the inlet to the plant is only around 60,000 PE; some of the load comes from the food industry, which means a high level of organic content. The utility company has chosen to centralise the sludge treatment for all of its plants at Slagelse Treatment Plant, enabling it to achieve considerable economies of scale and, in particular, making it possible to improve the usage of resources.
The plant has a high level of awareness around improving the plant's energy production and expects to be producing energy soon, thanks in particular to its implementation of energy-efficient bottom aeration.
The plant's catchment area is a combination of separate and shared sewerage, with a significant industrial load. At maximum hydraulic load, it is possible to control loading and unloading so that treatment is optimised and that the most contaminated waste water is treated.
The plant is conforming with effluent emission standards by a good margin and is capable of handling large hydraulic loads during rain. The plant's ARP tank makes it possible to ensure that the sludge concentration is relatively low in the aeration tanks while also ensuring that sufficient nitrification capacity is maintained.
Hydraulically speaking, the plant receives up to 10,000 m^3 a day on average, with around 4,000 kg dry matter produced each day, about half of which comes from external sources (Skælskør and Korsør).
The sludge is dewatered in centrifuges and delivered to farms.

1.7 Observations and proposals emerging from the visit to treatment plant

1.7.1 Proposed changes at the plant

Work is being done at the plant to increase the electricity and heat production capacity in the form of a new gas engine installation, which is expected to significantly improve the energy balance. It is important to focus on the efficiency of the machinery (a 1% change can increase electricity production by 3%).
Treatment of the gas before it is used in the gas engine is also frequently overlooked. Using heat to prevent condensation rather than using electricity for refrigerator drying can save energy.
Condensation of flue gas (cooling to below 80 degrees) is another option that should be considered, as relatively large quantities of energy can be obtained through doing so.
Improving the utilisation of heat from the gas engine installation is another area with untapped potential. Due to subsidies and the legal framework, exploitation of this heat potential is not

optimal; use of heat pumps has been considered but this solution is not thought to be viable. If the heat production is increased, this will be done to sell the heat to external consumers e.g. the local district heating company. At present, there is no – or only limited – financial incentive in this for the company; you may wish to read section 1.2 for further background.
The current endeavours to get all three digestors up and running are a step in the right direction with regard to improving gas production and, of course, also improving the energy profile. There is a large amount of awareness around process-related optimisation at the plant and, although major steps have already been taken towards automation, targeted efforts are still being made to continue work along this path.
Advanced online controls are already established at all of the utility companies' plants, with process optimisation taking place on an ongoing basis. It is recommended that the ongoing work on ammonium controls and further reduction of aeration on the plants be continued.

The existing primary tanks can be optimised, with possible consideration given to trying primary sedimentation as an option, and improve withdrawal of sludge in so doing, which may lead to increased gas production. It would, however, be necessary to upgrade the digestor system first. Keeping the sludge content of the primary tanks as low as possible is recommended, in order to obtain as much carbon for the digestors as possible before circulation begins.

At utility companies, ochre sludge from the drinking water supply is used to reduce problems with hydrogen sulfide. Too little attention used to be paid to the inbound pumping in the digestor system, but this is changing and the improvements are clear to see. It is recommended that work continue on making the load uniform for the digestors, as well as focusing on maintaining a uniform temperature in said digestors.

1.7.2 Other observations and perspectives on the plant

The utility company is committed to development work and currently has a pilot plant in operation, in which work is ongoing to reduce micro-pollutants in the treated waste water. The pilot plant consists of a filter, which is located upstream of active carbon and UV treatment. The analysis work is a major element of this project, which is receiving EU funding via Interreg. The plant is not grappling with the major challenges posed by struvite precipitation, so the considerations around struvite production are not relevant. The utility company prefers to keep as much phosphorus as possible in the sludge being delivered to farms.
As the plant is not loaded to capacity, the equipment can be oversized, i.e. it is not being utilised in the best way possible in all situations.

1.7.3 Description of external challenges

'SK-forsyning' supplies a very large area, so centralisation has been evaluated but since abandoned in relation to water treatment; decentralised expansion of the catchment area is currently ongoing. Sludge treatment and resource usage have been centralised to a large extent, with Slagelse Treatment Plant as the central unit.
As the centralisation of the sludge treatment across the entire utility company may pose a risk if there are ever any problems with sludge treatment at Slagelse Treatment Plant, making a decision on any emergency situations and creating a back-up plan is recommended.

1.8 Conclusion

Legislation regarding utilisation of alternative sources of organic waste/materials poses a challenge and to some degree is an obstacle hindering optimisation of energy production at the Treatment Plant. See section 1.2.2 for further background. Although the utility company collaborates very well with the authorities and the industries that are associated with the plant, the large fluctuation in the industrial load can pose a challenge.

Via process optimisation and fewer physical measures, it is anticipated that Slagelse Treatment Plant will be producing energy before not too long. As with a number of other plants, there is a very large amount of spare capacity, especially on the waterline. This means that pumps etc. are oversized in some cases and therefore use a lot more energy than if the size were optimal.
There are a series of measures in place in the form of process optimisation and some smaller-scale measures; the challenge is a lack of time, with financial conditions also having a negative effect.

Appendix 1.2 Holbæk

"Achieving clarity around future requirements and wishes is proving a major challenge generally and is making it difficult to make the right decisions…"

1.9 Introduction to the treatment plant

Holbæk Treatment Plant is an SBR (Sequencing Batch Reactor) plant, which is not typical of plants in Denmark. The large amount of operational experience built up has ensured that the plant delivers very good treatment results, however. The plant has a (typically) high-performance grate and sand/grease trap upstream of the SBR system consisting of a series of cells, in which both nitrification and denitrification are controlled in one cycle. It is not possible to set up a clarification tank to withdraw carbon when SBR technology is being used and, actually, it is even necessary to add external carbon to ensure full denitrification. This addition is restricted to a bare minimum in terms of amount, however. Although the biological excess sludge is digested and the gas utilised in a gas engine, production is restricted because only biological excess sludge is utilised by the plant.
The SBR plant can struggle with rain events, so an equalisation basin has been set up to counter this.
A plan is in place to optimise control of the plant via more dynamic controls that will potentially make it possible to both save energy and reduce the amount of carbon to be added.
At both Bjergmarken and Holbæk Treatment Plants, there has been a focus on installing up-to-date equipment to utilise energy from biogas production.
Holbæk Treatment Plant is just one of 22 treatment plants in Fors, the largest of which is Bjergmarken in Roskilde, with many other smaller plants spread across a large geographic area otherwise.
In Fors, intensive efforts have been made to centralise and shut down many of the smaller plants, but a string of various political and bureaucratic challenges have resulted in the physical changes not taking place. This in turn has meant that a series of less efficient plants are still being run while they wait and see what happens. With the situation unresolved and the future of the individual plants very uncertain, making significant investment is not an obvious choice. Some of the plants are loaded to their maximum as a result of extensive urban development in some areas. There are plans afoot to move all of Holbæk Treatment Plant, due to its very attractive location, to make way for urban development in the area, which is also curbing opportunities for significant plant upgrades.
Fors is an amalgamation of the utility companies servicing three municipalities, where work is ongoing to consolidate the operations. There are different tariffs for the original utilities, with practical streamlining of the consolidation remaining a challenge.

1.10 Key figures for the treatment plant

The plant has a full load of approx. 55,000 PE and maximum capacity of 60,000 PE.
The plant's sludge treatment has been optimised with mechanical pre-drainage and thermophilic digestion, which ensures maximum exploitation of the digestion process. The plant is fitted with a deammonification system that prevents impact stress from the stream of ammonium returning from the sludge dewatering. The plant has replaced its previous compartment-type filter press with a screw press and, in doing so, also reduced shock loads from the sludge dewatering.
Biogas is produced here, which in turn produces green energy via a gas engine installation and heat, which are sold to the network.
The digestor plant uses thermophilic digestion and has a short retention period of approx. 12 days; the plant strives to run the digestor with a relatively high concentration of sludge. Energy optimisation of the stirring in the digestor has been carried out at the plant.

The reject water from the sludge dewatering is treated in a deammonification system with a capacity of 110 kg/N day.
A new control system was put in place when the deammonification system was set up, effectively making it possible to reduce energy consumption substantially.

The plant's set-up means an improved energy profile will be impossible unless the plants undergoes extensive renovation.

1.11 Observations and proposals emerging from the visit to treatment plant

1.11.1 Proposed changes at the plant

Bjergmarken is working towards a heat pump being set up at the outlet from the treatment plant, with the possibility of district cooling also being considered for one customer. Technologies and collaborations of this kind would also be obvious choices for Holbæk Treatment Plant, although again this would be on the condition that the plant's short-term future is known and agreed.

There are plans in place to improve the controls for the SBR system, with a view to optimising energy consumption and streamlining the treatment process, including minimising the addition of carbon that is necessary. This optimisation is being given careful consideration, as is a change to the fan installation, which poses a challenge due to its age. Uncertainty about the future of the plant is posing a challenge in this regard too.

Work is actively ongoing to investigate the possibility of using pre-filtration at both Holbæk and Bjergmarken, the aim of which would be to improve pre-treatment; this would need to take account of the carbon balance in the subsequent steps, however. At Holbæk, problems could obviously crop up if too much carbon is removed and subsequent treatment is in line with the SBR principle.
Work is currently ongoing to renovate and potentially optimise the sand filter at the outlet from the treatment plant.

1.11.2 Other observations and perspectives on the plant

Bjergmarken's use of solar cells on a large scale has helped to ensure that the plant is energy-neutral at times. Although it would also be possible to install solar cells at Holbæk Treatment Plant, there is some uncertainty around how long the plant will remain at its current location and, consequently, also some risk associated with investing in solar cells at the plant in the long term.

In general, sludge treatment from the utility company's 22 treatment plants is decentralised, so consideration should be given to whether full or partial centralisation is possible for the sake of streamlining. The utility company has sludge mineralisation in place at a total of six plants; in this case, too, centralisation would be difficult to achieve, of course. The utility company is very aware of the challenges faced with sludge and is actively seeking innovative solutions for management and utilisation thereof in the future.

Fors supplies an area centred around Roskilde and Issefjorden, discharging to a series of small and sensitive recipients. As such, there is potential for a number of conflicts of interest in relation both to the load and to maintaining the flow of water for these recipients. Furthermore, significant challenges are faced in relation to flooding from recurrent events when the water level is high in Roskilde fjord. For this reason, it has been necessary to build extensive reinforcements for the low-lying sections of the plant, with an outlet pump station set up at Holbæk treatment plant.

The utility company also has its focus firmly on treatment and micro-pollution in the waste water outlet, in the form of microplastics and medical waste.

The utility company is also focused on process optimisation and has been using modelling tools that enable it to model different scenarios, resulting in changes actively being made to operations, leading in turn to energy-related improvements.

1.11.3 Description of external challenges

Fors and Holbæk treatment plant have been working on developing structural plans that will ensure a more centralised solution for the treatment plant structure in the utility company’s area, but it has not been possible to implement these plans for political and bureaucratic reasons. In the desired structure, importance is attached to usage of resources, and it will, granted, be possible to improve utilisation thereof significantly if centralisation is implemented.
At Holbæk treatment plant, a series of external factors are creating challenges: the plant is very close to maximum capacity, the plant is not built for energy neutrality and therefore faces challenges in this respect, and it is also unclear whether the plant will be moved to another location in the relative short term and is limiting the options available for extensive optimisation and renovation.

Several of the company’s treatment plants are close to maximum load as a result of positive urban development, underlining the need to implement the structural plans aimed at re-thinking the plant location and design. Implementing a new structure would open up the possibility of focused improvement and optimisation of resource usage.

The utility company’s system has been automated to a very high level. There is also awareness in the company that attracting the necessary labour to the sector may prove a major challenge in the long term.

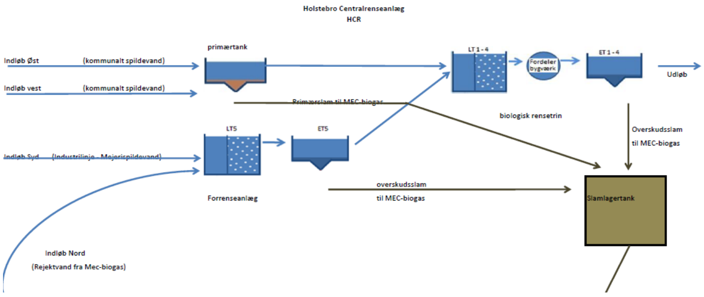
1.12 Conclusion

Holbæk Treatment Plant is a highly effective operation and achieves good treatment results. The plant has a full load, so any further increase to the load would pose challenges. Extensive automation has been carried out, freeing up significant manpower and leading to streamlining and optimisation of operations.
With the outlook for the treatment plant somewhat unclear, it will be difficult to justify any significant improvement of resource usage at the plant. It would, however, make complete sense to implement the centralisation as outlined by shutting down a number of the smaller treatment plants and setting up a new plant, where the focus can be on extensive usage of resources.

"Over-arching decisions have limited opportunities for resource utilisation locally"

1.13 Introduction to the treatment plant

Holstebro treatment plant has a classic set-up with an activated sludge plant and is fitted with bottom aeration. The plant receives its load from several separate lines, which could be exploited in any future utilisation of resources. A significant proportion of the industrial load is treated separately, involving both waste water at a high temperature and a high level of organic content.



The pre-treatment plant, consisting of an aeration tank with recirculation and a clarification tank, receives industrial waste water and reject from Måbjerg Biogas (MEC Maabjerg Energy Center). The excess sludge is extracted and pumped to MEC. The primary tanks receive the municipality's waste water. Sludge is then extracted and pumped to the MEC. The water from the pre-treatment plant and the primary tanks is transported to the aeration tanks, which are recirculation systems in terms of design, then transported to the clarification tanks, which extracts excess sludge and pumps this to MEC. The water then drains out into the Storå Creek via a pond. Reject water from MEC is treated in a deammonification plant from Paques (approx. 130 mg ammonium/litre).

1.14 Key figures for the treatment plant

Holstebro Central Treatment Plant has a relatively large industrial load. The plant has a capacity of 180,000 PE, with the industrial load accounting for 60% of the total load of 125,000 PE. The plant has an average water volume of 12,800 m^3/d and an annual water volume of 4.7 million m^3, with efforts made to reduce the extraneous water, which in turn has helped with the plant's hydraulic challenges.
The plant only has sludge treatment to a limited degree because all excess sludge is pumped onwards for treatment and energy utilisation at Måbjerg Biogas. Vestforsyning is a co-owner of this plant, which also receives sludge from other utility companies (Struer) and generally treats a range of different fractions.
As the entire sludge proportion is taken care of externally, resource utilisation (energy or other products) is not a potential option at Holstebro Central Treatment Plant. Having a heat pump in the relatively warm industrial waste water (25 degrees C) is realistic, however, if there are options for selling the heat. As Vestforsyning has excess heat in abundance from the combustion plant, there are no such options for selling the heat at present.
There is awareness of machine optimisation at the plant, with interest in optimisation of the fan installation in particular most evident.

1.15 Observations and proposals emerging from the visit to treatment plant

1.15.1 Proposed changes at the plant

Holstebro Central Treatment Plant receives very large volumes of COD, potentially making it possible to optimise the process at MEC's plant if making the most of this is targeted in the collaboration between the two companies. As the contractual conditions and agreements between MEC and Holsterbro Central Treatment Plants do not support this optimisation, it ought to be investigated whether any changes can be made to the settlement between the two companies.
Likewise, dewatering from the sludge that is pumped to MEC could also be increased; this would lead to a higher sludge concentration in the digestors and, in turn, to a better gas yield.

Work is currently ongoing to improve and optimise the bottom aeration, with the expectation being that energy-related improvements can still be made. The plant has had positive experiences with bottom aeration and rarely has to carry out de-acidification.
Introduction of more advanced controls, with ammonium as the control parameter, is one recommendation.
Replacing and optimising the fan installation has been done on an ongoing basis; continuing this optimisation, to minimise energy consumption, is recommended.
Primary sedimentation of the relatively large volumes of organic material has been one area of focus; likewise work has been done to look at the possibility of biosorption or a-stage technology; these efforts have been thwarted by a lack of subsidies for development work, however. It is recommended that this initiative be revisited and that an attempt potentially be made even without funding e.g. in collaboration with other utility companies.

1.15.2 Other observations and perspectives on the plant

The plant receives its industrial load from two slaughterhouses and one food producer (milk).
Their strong and constructive collaboration with local industries ensures ongoing opportunities for optimisation and also helps to avoid shortcomings.
Introduction of heat pump technology is not thought to be an option immediately because there is no demand for alternative heat sources in the area.
There is no specific emphasis on reducing nitrous oxide or methane from the waste water system at the plant.

1.15.3 Description of external challenges

The geographical conditions pose a challenge for centralisation; the utility company has automation and streamlining firmly in focus, but it will be difficult to actually consolidate plants.
Many of the smaller plants are also struggling with large volumes of extraneous water, which has to be addressed before centralisation can be considered.

1.16 Conclusion

All sludge treatment takes place at Måbjerg Biogas Plant MEC, so it is not possible for Hostebro Central Treatment Plant to make any headway in relation to resource utilisation directly – this would only be possible working in close collaboration.
There are a series of measures in place at the treatment plant with potential for usage of resources at the biogas plant. It would obviously also make sense to work towards optimised collaboration wherever there are financial incentives for optimisation of operations at the treatment plant.
The different wishes and options for continued process optimisation are valid, especially if usage of resources can be improved in collaboration with MEC.

"Skills development will be necessary in the long term given the increased complexity of treatment in the future" Jens Munk-Poulsen, Skanderborg

1.17 Introduction to the treatment plant

Skanderborg Central Treatment Plant has a fairly traditional set-up, with an inlet pump station followed by a grate and sand trap. Biological treatment is conducted in a one-step system, which is upstream of sand filters, before discharge to a very sensitive recipient. There used to be a digestor in the plant, but this is no longer used for digesting. The excess sludge is centrifuged to approx. 25–26% dry matter, then delivered to farms.
The plant has a capacity of approx. 47,000 PE but is overloaded for some parameters with the current load (actual load 50–60,000 PE). The plant also serves some smaller industries, namely slaughterhouses and a brewery. Significant urban development is taking place in the area, with proactive efforts being made to put a centralisation strategy in place, which is why it is necessary to expand the plant.
The utility company is planning centralisation on an extensive scale, which would see a series of smaller plants shut down to make way for a central treatment plant; it will also be necessary to conduct major renovation work and open up opportunities for resource utilisation, especially with regard to energy.
With the utility company serving an area containing significant natural assets, standards for emissions from the waste water system are much more stringent; the requirements set with these standards may cause conflict with a desire to mine energy at the plant to a not insignificant degree.
The design of the inlet to the treatment plant is cause for some concern at maximum load, creating a bottleneck for the plant to some degree.
Likewise, the biological plant struggles during rain, calling (in particular) for optimisation of the return sludge pumping; the design of the inlet section in the clarification tanks itself could be improved as well.

1.18 Key figures for the treatment plant

In 2018, 1.6 million m^3 of water was treated, which is a low volume compared to previous years.
With a matter load of 60,000 PE and capacity of approx. 50.000 PE, the plant has a very heavy load and is at times overloaded. The requirements of emission standards are met in general but there are few reserves in the existing plant.
Although the plant no longer makes use of digestors or (consequently) gas utilisation, re-establishing gas utilisation does form part of the plant's expansion strategy.

1.19 Observations and proposals emerging from the visit to treatment plant

1.19.1 Proposed changes at the plant

Consistent with the utility company's own view, this report recommends that a two-step plant with primary sedimentation be set up – or re-established – making it possible to extract carbon-rich primary sludge, which will then be digested and potentially make energy production possible. This report also recommends that capacity be created in the future digestor system to accommodate suitable waste from a typical food industry and guarantee that digesting the biological excess sludge will be possible. Within the immediate future, the most obvious option would be to harness the biogas for energy production at the plant, while another option

could be to upgrade the biogas to higher quality natural gas; the natural gas network is not located particularly close to the plant, however, so upgrading is not thought to be an obvious choice.
The plant’s clarification tank has a very traditional design, which is proving challenging in terms of sludge escaping and in turn leading to increased post-filtration costs. Various other return sludge pumps and the controls for these are also options for optimisation. The utility company is aware of this challenge and is working on a solution.
The utility company also has a clear understanding of energy optimisation for existing installations via frequency converters and smart controls, which are used whenever it makes financial sense to do so.

1.19.2 Other observations and perspectives on the plant

Construction work has started on a filter to further reduce phosphorus and suspended matter in the outlet from the treatment plant. The filter will make use of the very latest in technology and is expected to become a technological showcase. A great deal of importance has been attached to low energy consumption and high efficiency.
It is going to be possible to extend the area where aeration is set up, which will increase capacity and flexibility. The plant will operate with a sludge content of between 3 and 5 kg pr. m^3; with more targeted controls, it will potentially be possible to improve treatment or minimise energy consumption.
Contact has been made with the local district heating supplier, who is yet to show direct interest in purchasing excess heat from future energy production at the plant. This may prove an obstacle elsewhere too if excess heat cannot be incorporated into the local energy supply.

1.19.3 Description of external challenges

The plant is facing a series of challenges, the most significant of which is that the effluent is discharged to a sensitive recipient that can only accommodate up to 1.3 kg of phosphorus per day. This in turn means more stringent requirements and very restrictive conditions in relation to the overflow from the waste water system.
For some time, the utility company has focused heavily on separate sewerage to reduce impact from the system and, in turn, to remove extraneous water.
The environmental case processing in particular is creating dilemmas in relation to how to utilise resources. The very sensitive recipients mean that the requirements set for treatment are very stringent and, all things being equal, means that more energy is consumed in the treatment to achieve such low values and that overflow to the recipients is unacceptable.
As urban development mushrooms, many of the utility company’s resources are tied up in this work, so there is less subsidisation of more long-term energy optimisations etc.
One not insignificant challenge facing the plant and its operations is the annual ‘Smuk Festival’, which places very heavy demands on the plant in terms of load. Special operating conditions are required in the lead-up to the festival, and, in particular, while the festival is being held.

1.20 Conclusion

There are plans in place at the plant to significantly improve resource usage in connection with the planned expansion of the plant. The plant recognises that there will be a need for new skills training internally in the future as the plant becomes more complex.
The utility company attaches importance to reducing emissions and is focusing on controls that will counter nitrous oxide emissions in its work, while also keeping an eye on methane emissions from the plant and waste water system.
The utility company also aims to become CO_2-neutral in the long term, which will require a targeted approach to be taken – especially if its own energy production operation is to be established.

The treatment plant at Skanderborg has a full load, making it necessary to expand the plant; the considerable natural assets in the area also play a role here. Expansion of the plant will make major improvements to utilisation of resources possible and prepare the utility company for the challenges it will need to address in the near future.

Appendix 1.5 **Nivå Treatment Plant**

“The location of the plant and the limited possibilities for physical expansion make it very difficult for the plant to expand enough to be able to utilise resources efficiently”

1.21 Introduction to the treatment plant

Nivå Treatment Plant is a relatively old plant that has undergone a series of changes over time. Originally it was a two-step plant that utilised energy.

Historically the plant has struggled with very light sludge, which has often resulted in sludge escape and/or reduced capacity. After switching to a one-step plant, operations stabilised greatly and treatment results were excellent.

The plant has a capacity of approx. 22,500 PE and a full load at present, with very limited spare capacity. The plant does, however, feel that there is still some potential for optimisation. Sludge is treated with a centrifuge and then delivered to farms.

The plant is working on expansion plans to cover a smaller load from Kokkedal, which is currently being sent to the neighbouring utility company but which is expected to be sent to Nivå Treatment Plant instead. With the current load close to max. capacity over the winter, it will be necessary to adapt the plant.

1.22 Key figures for the treatment plant

The plant treats more than 4000 m^3 water a day, with treatment almost at the biological capacity of 22,500 PE. As the plant was previously converted to a one-step system, there is no biogas production or electricity production at present. Its digestor and clarification tank operation used to cause problems with carbon/nitrogen, which in turn caused problems with light sludge and meant that the plant struggled to meet emission standards.

Due to the challenges faced historically, the plant has its focus firmly on optimisation of operations, with equipment in place to provide extensive automation and enable the plant to use online controls.

Having switched to bottom aeration, and with its ammonium control and a relatively low sludge content in the aeration tanks, the plant has taken some successful steps towards minimising electricity consumption.

The catchment area for the plant has a relatively high degree of separate seweraging, which makes it possible to stabilise operations as well as opening up the opportunity of expansion and extension of the catchment area (Kokkedal).

1.23 Observations and proposals emerging from the visit to treatment plant

1.23.1 Proposed changes at the plant

Energy optimisation may be a possibility for the fans for the biological treatment, so consideration should be given to whether replacement is an option in connection with the planned expansion of the plant; as a minimum other types of fans should be considered when the current ones are at the end of their life cycles. It would be possible to expand the aerated volume in the existing aeration tanks and, by doing so, increase capacity.

One of the plant's original digestors is still available for use, but it would require extensive renovation, particularly with regard to hardware. It could be an option to re-start operation of the digestor, possibly by adding external carbon in the form of SS-OFMSW; the plant is, however, barely large enough to be cost-effective; likewise, it is not possible to supply the excess heat that would typically be part of gas utilisation directly to a district heating system. If a decision is made to commission the digestor system again, it would make sense to expand the plant with actual reject water treatment to reduce the process volume in the biological plant. Pyrolysis of sludge has also been discussed. Aside from minimising transportation of sludge from the plant, this option could also replace the natural gas purchased to heat buildings.

1.23.2 Other observations and perspectives on the plant

The utility company has been looking into the idea of adding SS-OFMSW, but it would be difficult to make this viable given the size of the plant and its space constraints.

The expansion of the plant to accommodate the increased load from the Kokkedal area would make it necessary to review the plant carefully to map and remove the bottlenecks that a 25–40% increase in load would cause. In this respect, importance should be attached to simultaneously minimising the energy consumption of the new components and processes.

1.23.3 Description of external challenges

With constant urban development ongoing in the plant's catchment area, the narrow physical framework may very well prove to be an obstacle to further expansion.

The plant is located in a protected area of considerable recreational value, which means that renovation and major expansion for energy neutrality purposes will be impossible or very expensive to implement.

1.24 Conclusion

Nivå Treatment Plant struggles partly due to its limited size, meaning that energy utilisation options are not optimal, and because the very constrained physical conditions make extensive redevelopments impossible or very difficult. Over time, the plant has undergone substantial optimisation and streamlining in the form of extensive automation and introduction of online controls. This produced good treatment results, with very limited demand placed on operations staff in daily operations.

There are other options for optimisation as well, with the utility company very aware of these, not least in connection with replacement and expansion.

The utility company is working on a holistic approach to the expansion necessary to accommodate the increased load; the expansion process is currently at a clarification stage ahead of a decision being made on expansion in practice.

Appendix 1.6 Fredericia Central Treatment Plant

"Our plant needs to be agile and always have space for increased industrial load"

1.25 Introduction to the treatment plant

The plant has a traditional set-up i.e. a one-step system with biological phosphorus conversion, but used to have a two-step set-up. Work is currently ongoing to re-establish the previous clarification tanks and with it improve the energy profile. Sludge treatment takes place in digestors but, rather unconventionally, the plant also uses thermal hydrolysis to improve digestion and increase the capacity of the digestor system.
The plant has bottom aeration, with measures having already been put in place for optimisation purposes; likewise the plant is equipped for extensive use of online meters that ensure ongoing process optimisation.
The sludge undergoes its final dewatering in the decanter and is then delivered to farms.
Some of the biogas from the digestion process is used in a biogas engine that generates power and heat, and some in an upgrading plant that makes it possible for the gas to achieve a quality that can be supplied to the natural gas network. Upgrading the biogas is subject to certain technical challenges and does not maintain stable operations on a constant basis.
The plant is located very close to the nearest town, which poses a series of challenges when it comes to dealing with its neighbours.
Like for many other plants, inflow of rainwater is an issue and this, together with variation in the very high industrial load, make the plant difficult to run and optimise.

Process and plant optimisations, consistent with the utility company's stated aim to become energy neutral, take place on an ongoing basis.
The plant is predominantly industrial in character, which poses operational challenges in the form of unstable influent and, in some cases, leads to more or less acute inhibition of the biological processes.

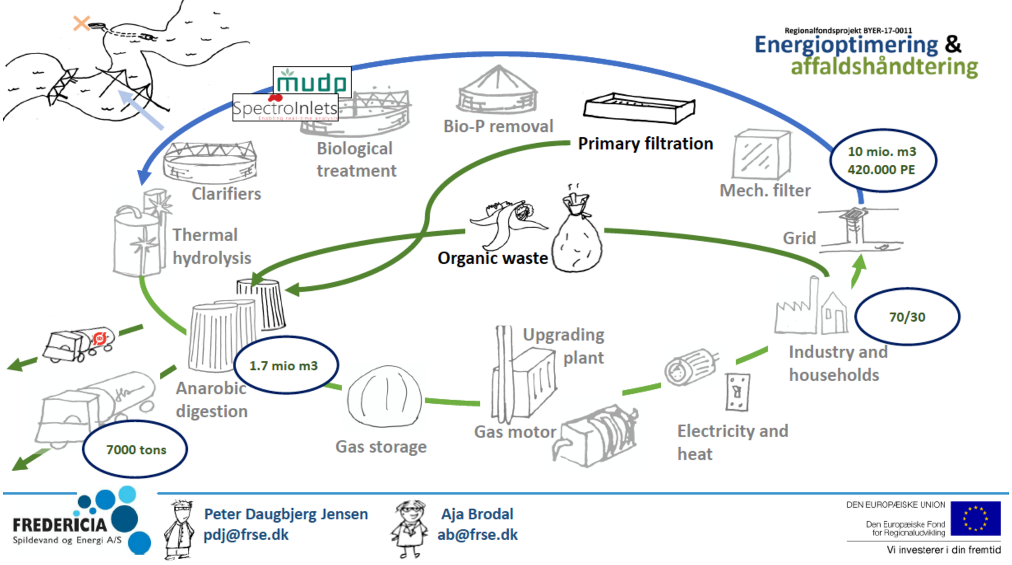
1.26 Key figures for the treatment plant

The plant treats up to 10 million m^3 waste water per year and has a considerable industrial load from dairies, refineries, breweries etc. The industrial load accounts for 60–80% of the overall load. The plant's total capacity is calculated as being 420,000 PE, but the large size of the industrial load means the plant's load is somewhat atypical. The plant receives a relatively large organic load that has the potential to be converted into energy. A unique feature of the plant is the upgrading plant that converts the biogas to natural gas quality; this plant is subject to technical issues, with operational stability also proving a problem. There are also gas engine systems established in parallel with this, which convert biogas to electricity and heat; uncertainty around the upgrading plant is also creating uncertainty around future expansion plans, however.
The plant drains into a highly robust recipient, so there has been no need to tighten emission standards. Despite this, work is actively ongoing internally to keep emissions much lower than the official requirements.
The sludge treatment process includes thermal hydrolysis (installed in 2001), which means, in practice, that the sludge is sanitised and therefore has more uses than is typical for waste water sludge. The sludge is drained in centrifuges to around 25% dry matter, which is lower than desired. There have also been some difficulties obtaining a suitable quality (SS concentrations below 1000 mg/l) from the reject water that is returned to the biological plant. The plant had been considering the introduction of sidestream treatment for the reject water, but given the challenges faced since, this idea is not relevant at the moment.

1.27 Observations and proposals emerging from the visit to treatment plant

1.27.1 Proposed changes at the plant

The plant is currently working on specific plans to become energy neutral, with a series of projects in the pipeline.



One area of major focus is potential use of organic residual waste, the advantages and disadvantages of which are currently being actively looked into.
The plant was originally designed as a two-step plant, in which the primary sludge is extracted and digested. The plant was simplified as part of an earlier renovation, with the primary tanks taken out of service. This is now under review, however, with the primary tanks set to enter into service again after some minor renovation. This is expected to have a very positive effect on the plant's energy profile. The plant's location very close to the nearest town means that there is great awareness of possible odour complaints, with much of the plant under cover as a result. A series of possible options have been investigated in relation to re-establishing the primary step, with the plant opting for a flexible solution and the option for an active by-pass 'dynamic pre-separation'. The plant is considering whether the potential for odour complaints can be reduced through appropriate use of precipitants (ferric chloride) in the primary section of the plant.
Significant struvite precipitation is experienced at the plant, but regularly removed; exploitation of the struvite is being considered instead of merely disposing of it like at present.

1.27.2 Other observations and perspectives on the plant

The plant pays a large amount of attention to ongoing process optimisation and is implementing a number of exciting initiatives pertaining to use and development of online controls and sensors. This has achieved very positive results, so work on optimisation and fine-tuning is set to continue using this approach. The plant has bottom aeration equipment and pays a lot of attention to reducing energy consumption during aeration in particular.
The plant also pays attention to nitrous oxide emissions and is planning initiatives to increase understanding and measurement of these challenges. The plant is interesting because of its large industrial load, meaning it could generally help to improve understanding of nitrous oxide emissions from treatment plants.
Despite the major industrial load, operation of the plant is relatively stable; this is due, in particular, to the extremely good collaboration with industries and authorities.

1.27.3 Description of external challenges

One dilemma facing the plant is that its relatively warm industrial waste water makes investigating the possibility of heat utilisation an obvious thing to do; this could be done if capacity were increased in the gas engine system or if a heat pump were used in the effluent water. The lack of consensus around heat production in this area means that investing in the supply of heat to the town is not an attractive option financially, however.

The treatment plant is interested in receiving more organic material but would struggle to make the most of its potential because of current legislation and conditions; waste management laws are considered a hindrance. See section 1.2 for further background.

The plant has the capacity to handle the urban development that is happening in the area, but industrial influent may pose capacity-related problems in the longer term.

1.28 Conclusion

With the right investments and process measures in place, Fredericia Central Treatment Plant is making good progress towards its goal of energy neutrality; the plant certainly has the potential to become an energy supplier. There may be some issues with supplying heat to the town, such as the supply gap and current legislation, which could hinder the plant as it tries to tap the obvious potential it has as a heat supplier.

With the quality of the sludge from the plant improved (sanitised), consideration should be given to whether the residual product can be assigned more value than today, i.e. no longer just delivered to farms. This report also recommends that work continue on possible utilisation of the struvite precipitation at the plant.

Thermal hydrolysis plant at Fredericia Central Treatment Plant

Appendix 1.7 Helsingør Treatment Plant

"We believe that we are prepared for the regulation, but it keeps changing. Not knowing the framework is a major challenge for us."

1.29 Introduction to the treatment plant

Helsingør treatment plant is located in the centre of the city, with efforts made to improve its visual appearance. The plant has a traditional set-up, i.e. a two-step system, with clarification and digestion of the sludge. The plant has generally had advanced online controls through its history and has undergone extensive automation. It receives waste water from the city of Helsingør and has no, or very little, industry connected.
Work is currently ongoing to optimise the plant to meet regulations, with frustration expressed at how constant changes to the operational framework are impacting on long-term planning. See section 1.2 for further background.
Helsingør Treatment Plant is one of the few plants in Denmark that has equipment for struvite production.

1.30 Key figures for the treatment plant

The plant has a nominal capacity of 76,000 PE and is loaded to approx. 32,000 PE. It must be pointed out, however, that reaching full capacity would pose certain challenges for the plant. In real terms, the plant can biologically treat around 40,000, PE but after this bottlenecks start to appear. The digestor system does have a good capacity, however, and increasing the load has been considered. The plant has looked into ways of adding fat to be able to increase gas production and, in turn, electricity production too.

With the existing plant, approx. 1/3 of the plant's electricity consumption can be covered by the plant's own production. It should be emphasised, however, that the need for so many pumps poses a challenge due to the large amount of energy consumed in running the plant.

1.31 Observations and proposals emerging from the visit to treatment plant

1.31.1 Proposed changes at the plant

The plant has an older and partly worn gas engine which is due for renovation or replacement. This report recommends that the gas engine capacity be increased in the long term so that it is possible to optimise the whole energy production process; likewise it might be useful to introduce standby capacity in the gas engine installation.

With plans afoot to welcome a number of cruise ships to the city, the plant is anticipating an increased load and looking to establish a plant that will be able to equalise the load. Consideration should be given to how best to utilise this fraction, given the high concentration that is expected and its potential to increase gas production.

There are also plans in place to investigate the possibility of introducing heat pump technology; but a lack of support for this work is hindering the plans; work to develop the ideas is continuing, however. The heating supplier in the city has chosen to invest in wood chips as a source of energy.

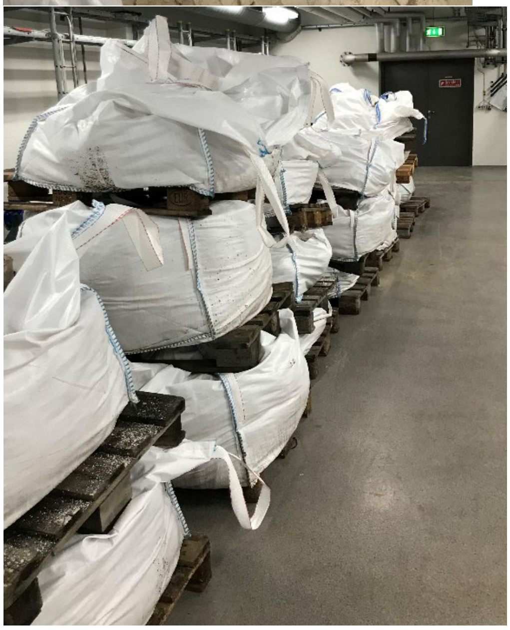
As the plant has bottom aeration, our recommendation would be to investigate whether energy optimisation is possible for the fan equipment.

Helsingør introduced online controls as part of its process optimisation – one of the first to take this approach.

1.31.2 Other observations and perspectives on the plant

Helsingør Treatment Plant began to utilise phosphorus from waste water, in the form of a struvite plant, from a very early stage. This plant uses a simple technique to extract struvite from the reject water after sludge dewatering. The system is located in a basement at the plant; its positioning was slightly difficult for the plant, but the location has proven to be an elegant solution. Commissioning the plant was a challenge, but the collective effort made by the supplier and operations staff means that it is now possible to produce approx. 400 kg of struvite per week. It has, however, proven almost impossible to sell the product, so the plant has shut down for the time being as there is no more space at the plant for the end product. As there are certain costs associated with struvite production, and given the lack of options for disposal, it is not financially viable at the moment to keep the plant running.

Intensive efforts are being made to resolve the issues with sales and production will be able to resume if it can be made financially viable to do so. It has been demonstrated that the plant is capable of extracting up to 40% of the total volume of phosphorus in the influent and converting this into struvite.

1.31.3 Description of external challenges

The utility company is faced with the issue of having three treatment plants of roughly the same size, the two others being Sydkysten in Espergærde and Nordkysten Nordvest for Helsingør. The combined load on the three plants may mean economies of scale and more resource-orientated operation will become possible. With the current infrastructure, it does not make any financial sense to merge the three plants, however. The location of two of the plants make expansion impossible; it would also be very difficult to link all the plants. Politicians have therefore decided to retain all three.
Although the plant in Espergærde is working on expansion, it faces major challenges in terms of area, limited options for the expansion and having to consider its neighbours in the process too. The Espergærde plant is also a small two-step system.
At the Nordkysten plant, small digestors were previously introduced to optimise energy production as well, but they found that the energy needed to heat the tanks was excessively disproportionate to the volume produced and consequently reverted to a one-step plant.
Centralisation of several plants in the region has been considered, but it is thought that there is no desire to do so politically; the existing collaboration between the operations team at the different utility companies is excellent, however.

1.32 Conclusion

Helsingør's utility company (Helsingør forsyning) has three different treatment plants of equal size, but which are structured in a way that would make it very challenging financially to merge them; the conclusion, following investigation of this possibility, is that all the plants must be kept. More long term, it could be considered whether one shared plant could be established for sludge processing and exploitation of resources, possibly located at Nordkysten, where there are better options for expansion than at the other two plants, which are both located very close to town and as such have few options when it comes to expansion.

Although Helsingør began utilising struvite very early on, it is disappointing to see that the plant has had to discontinue production because of a lack of struvite sales. For a utility company, the clear lack of private stakeholders available to support this evidently responsible exploitation of a finite resource, whether due to lack of desire or lack of ability to do so in a financially responsible way, poses a major challenge.

Appendix 1.8 Fårevejle Treatment Plant

"The anticipation of a new treatment plant has meant savings for many years…"

1.33 Introduction to the treatment plant

Fårevejle Treatment Plant has a traditional set-up as a so-called OCO plant, where matter undergoes biological processing as one collective volume. The plant conducts highly effective biological treatment and is fitted with a sludge mineralisation system that also works very well.
Resources are not exploited in terms of energy, because the plant has too little capacity for this. Additionally, since the sludge is dewatered/undergoes final treatment during mineralisation, the sludge is only spread from the mineralisation plant at very long intervals. During the winter months, the sludge is dewatered with a screw press and delivered to farms.
The size of the plant and its location makes sludge mineralisation possible; it is expected that emptying will take place in the near future. There is always some risk associated with this sludge treatment method because it can be impossible to use in agriculture should isolated pollution ever occur and will thus cancel out several years of sludge production.
It also somewhat surprising that the plant drains into the Ise Fjord rather than west into Sejerø Bugt bay.
For many years, the plan had been to build a new central treatment plant for the utility area; this investment is now thought to be unrealistic, however, if Fårevejle Treatment Plant is going to be kept. The plans, i.e. not expanding or renovating Fårevejle Treatment Plant, would have led to savings, but the changes mean that the plant will be updated.
For many years, the utility company struggled to manage sewerage for summer cottage areas from an economic perspective, due to heavy fluctuation in the load and consumption in these areas.

Figure 1 OCO plant

Figure 2 Clarification tank

Figure 3 Sludge mineralisation plant

Figure 4 Jan Viebjerg Larsen, Per Henrik Nielsen, Otto Jensen, Ib Pedersen

1.34 Key figures for the treatment plant

The plant is designed for a load of 26,200 PE and is loaded to approx. 20.000 PE.
The plant sees a water volume of around 1.2 million m^3 annually.
Energy consumption is relatively low in relation to the plant's load and treatment results, indicating that the plant is being run well. At a plant of this particular size, establishing biogas production and with it electricity and heat production too is not financially viable with the technology available.
Sludge is treated in two different ways: sludge mineralisation during the growing season and sludge dewatering with a screw press in the winter months, with the sludge from the screw press then delivered to farms.
There is no actual industrial load at Fårevejle Treatment Plant. No major change is expected to this either, nor to the population.

1.35 Observations and proposals emerging from the visit to treatment plant

The plant faces a series of operational challenges, including pipelines (return sludge) that require extra attention. The plant is relatively compact, with a design that restricts flexibility. This is because all the biological processes take place in one tank, which makes it somewhat difficult to adapt the plant to varying loads. The plant is achieving really strong results from its operations and operates at a high level of certainty as regards emission standards.
The utility company and operations team take a large amount of interest in alternative sludge disposal methods and are closely monitoring the sludge pyrolysis as an alternative to the existing sludge mineralisation process. This is in the hope of overcoming the challenge that the sludge would pose in connection with a possible central treatment plant.

1.35.1 Proposed changes at the plant

The plant has highly effective ammonium controls for the aeration. In terms of optimisation, fan efficiency is one area that could be improved, especially now that replacement is due.
As the sand trap is heavily aerated, it immediately became evident that it would be possible to make some savings on air consumption; this, however, might potentially lead to other challenges, and the savings would be marginal. Replacing the air-powered air-lift pump for sand extraction with a centrifugal pump might also lead to a smaller energy saving.

The plant operates with a relatively high biological sludge content in its process tanks, so reducing this amount may be worth considering in order to reduce the need for aeration. Any change of this kind would obviously need to be implemented slowly and carefully so as not to be detrimental to the strong emissions results.

1.35.2 Other observations and perspectives on the plant

Given the plant's very agricultural setting, consideration could be given to making use of the treated waste water from any future plant to water selected crops in periods with limited rainfall. Other factors would, of course, need to be taken into consideration here, but the idea could have a lot of potential in this area of the country.

1.35.3 Description of external challenges

The work previously done to establish a new central treatment plant is now being revisited to determine whether a merger with Holbæk is possible. Holbæk Treatment Plant's location is posing problems, so the expectation is that the plant will be relocated in the foreseeable future. This will open up the possibility of a merger (one consolidated plant), which might be of major significance to the centralisation of the utility company and possibly ensure that the plant built is a size whereby resource utilisation is viable. Taking this approach would also make it possible to move some load from the Ise Fjord to a more robust recipient. If a decision is made to go ahead with a merger and expansion, it would be useful to look at the options for expansion of Fårevejle Treatment Plant, where there is adequate space and an ideal distance from neighbours. One option that has been touched upon is utilising water meadows for subsequent polishing before being discharged into the Sejerø Bugten bay from a relatively large consolidated plant; this kind of solution is thought to be environmentally friendly, as well as very attractive financially, and would provide an innovative solution.

1.36 Conclusion

As the current plant is well-run, it would be difficult to make any major improvements in terms of resource utilisation. Setting up biogas production at the plant would not be viable with the restricted load. There are a series of further 'tweaks' that could potentially reduce energy consumption by a marginal fraction.

The utility company is very focused on setting up one central consolidated plant, but this is not economically feasible for the utility company on its own. A more promising solution might be to treat the waste water from Holbæk, which is struggling greatly due to its current location. A new consolidated plant or a major expansion of Fårevejle Treatment Plant would of course open up the possibility of resource utilisation. In this case, another challenge faced is the fact that the real volumes of waste water available in the utility company's own supply are too limited for actual sustainable resource utilisation; the obvious answer to this would be a merger of utility areas.

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Resource check for selected treatment plants - Water sector resource utilisation partnership

In Denmark, treatment plants make varying contributions to increased utilisation of resources and reduced impact on climate. This is something that Danish utility companies have proven at the treatment plants they run and continually invest in. From both the authorities' perspective and the water sector's perspective, there is a desire for more treatment plants to become more efficient with resources; with this in mind, and to inspire more plants to increase utilisation of resources, key individuals from the sector visited eight selected treatment plants.

During the visits, the individuals recorded a series of observations of the plants, their operations, opportunities and challenges faced in relation to increased resource usage, as well as proposing measures that could be useful and examined in greater detail.

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