

## Procuring 230 Football Fields of Membrane - Strategy, Results and Lessons Learned

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### Abstract

Stockholm is currently one of Europe's fastest growing cities, with its population increasing by approximately 1.5% per year, corresponding to 15,000 to 20,000 people. Sweden's commitment to the Baltic Sea Action Plan and the EU Water Directive will lead to more stringent effluent requirements (6 mg-Tot-N/l, 0.2 mg-Tot-P/l and 6 mg-BOD<sub>7</sub>/l), and wastewater treatment in Stockholm will require major investment to handle these challenges. As Stockholm Vatten's two wastewater treatment plants (WWTPs) – Bromma, 320,000 people, and Henriksdal, 780,000 people – are both located in or near residential areas in the city, plant development must be coordinated with its needs on economic, political, sustainable and long-term bases. Both WWTPs being facilities located underground also pose a challenge for any extension works.

**Key words:** membrane, procurement, wastewater

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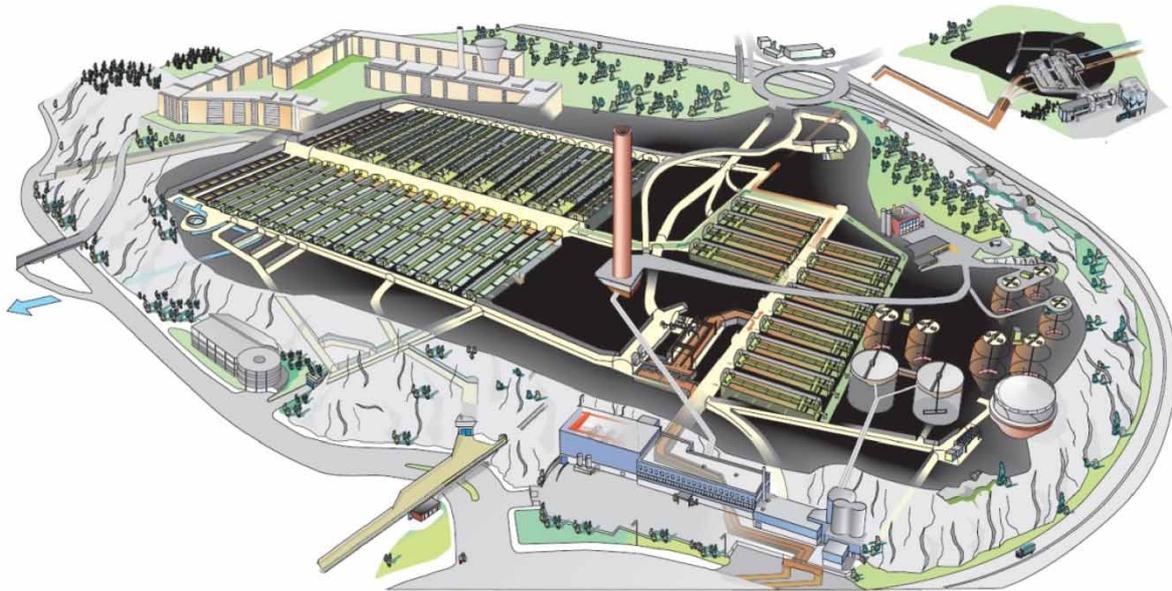
### INTRODUCTION

The Project 'Stockholm's Future Wastewater Treatment' includes decommissioning Bromma WWTP and transferring all of the wastewater usually treated there, via a new tunnel, to Henriksdal WWTP, which is to be expanded with membrane filtration.

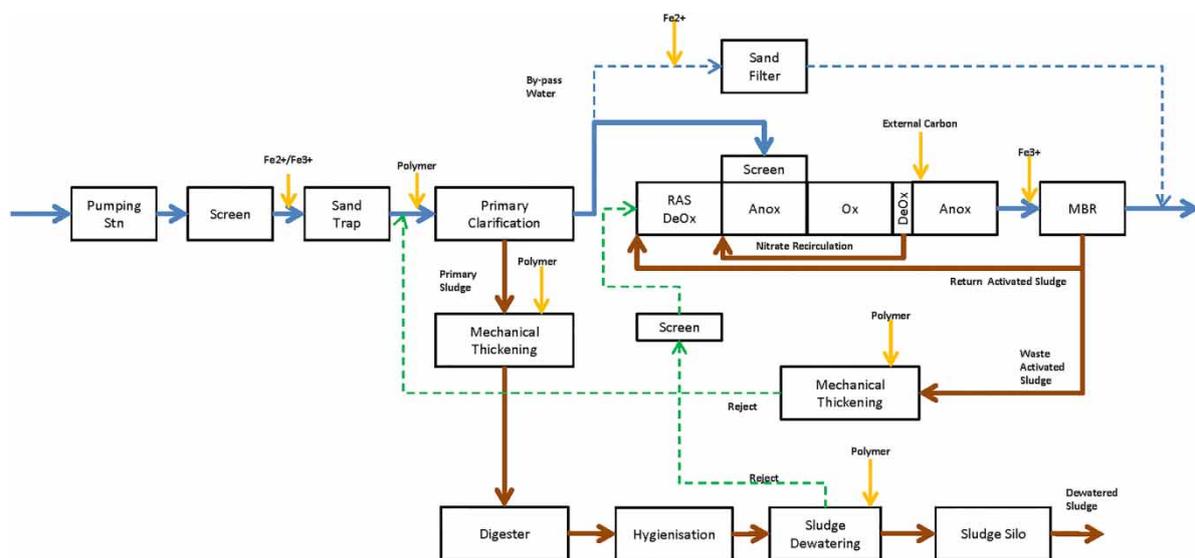
The design horizon for the extended Henriksdal WWTP is the year 2040, with a design load of 1.6 million people, corresponding to an average flow of 535,000 m<sup>3</sup>/d with a maximum of 1.6 million m<sup>3</sup>/d. The maximum design load on the biological treatment and membrane systems is 10 m<sup>3</sup>/s or 864,000 m<sup>3</sup>/d, making Henriksdal WWTP (Figures 1–3) the world's largest MBR-plant in development. The ability to maintain a high quality effluent output during wet weather and snow-melt resulted in a minimum design operating temperature of 8 °C. The total membrane area was projected at 1.6 million m<sup>2</sup> or approximately 230 football fields.

Stockholm Vatten has committed to a project called "Stockholm's Future Wastewater Treatment". The project includes decommissioning the Bromma WWTP, constructing a tunnel for conveying all wastewater treated at the Bromma WWTP to the Henriksdal WWTP which is expanded within the existing facility. The Henriksdal WWTP is completely underground in rock caverns. By implementing membrane filtration in the biological treatment stage the Henriksdal WWTP can be expanded to meet all project requirements.

The membrane system is a key component for the project. For the design work establishing the membrane system is needed in order to provide input to all other design disciplines. Stockholm Vatten decided on a two stage procurement procedure with the aim to create a good competitive situation and finding the best membrane supplier on the market. Weighing in pros and cons for different forms of contract and Scope of Works the decision was made to procure the membrane supplier via ABT06 (corresponding Fidic Yellow). The Scope of Works was limited to supply of membranes and



**Figure 1** | Schematic view of Henriksdal WWTP in the underground cavern.

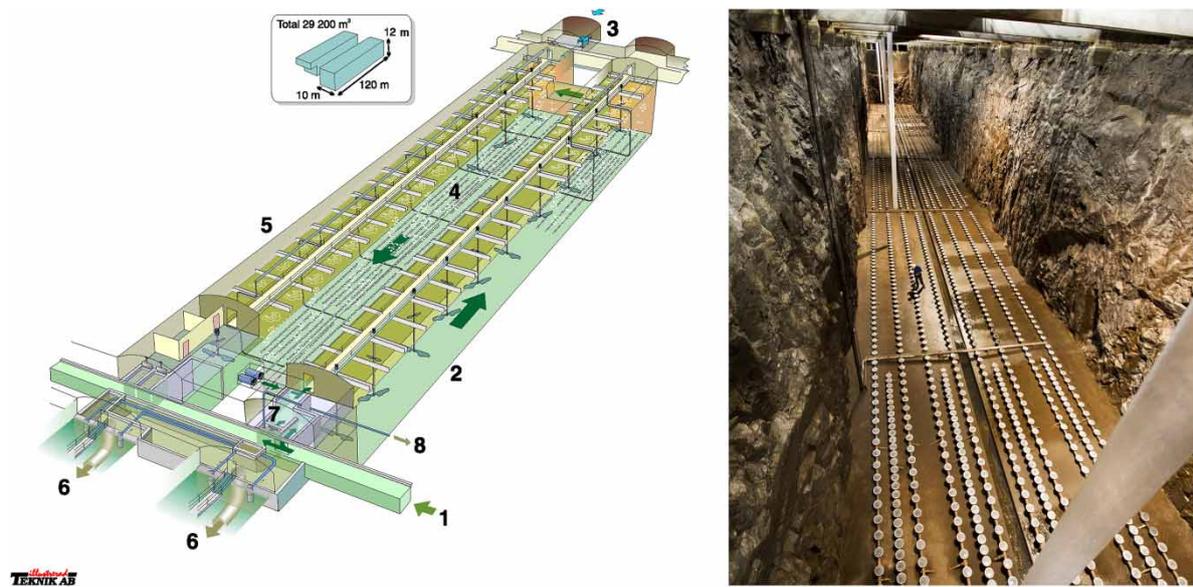


**Figure 2** | Schematic operating diagram of Henriksdal WWTP.

ancillary equipment, installation of membranes and participation during start-up and commissioning. The procurement process was commenced in February 2014 and the final contract was signed with GE Power and Water by 23 February 2015.

## SCOPE OF WORKS AND PROCUREMENT STRATEGY

The reconstruction works for the project extend over several years, with an even longer operating time for the plant. This puts great demands on all involved with regard to longevity, economic stability and commitment. The procurement goal was to find a suitable membrane supplier with high competence, and experience of large projects and membrane plants, as well as economic stability, ensuring its presence in the project over several years. Based on the overall procurement strategy for the project, work



**Figure 3** | Schematic of aeration tanks in operation (left) and picture of the empty aeration tanks (right).

packages, previous experience, etc., a decision had to be made on the form of contract and scope of works, and several options were considered:

- **Option 1:** Purchasing only the membranes from the membrane contractor, with a process/mechanical consultant doing the whole design according to AB04 (corresponding to Fidic Red Book) and thus procuring a general contractor to do all works.
- **Option 2:** Purchasing everything from a membrane contractor according to ABT06 (corresponding to Fidic Yellow Book), in other words, making this a turn-key contract. This was considered for both the membrane facility on its own and with the biological treatment lines making one large package.
- **Option 3:** Purchasing the membranes and ancillary equipment, plus the design and some installation as well as participation during start-up, from a membrane contractor. Another contractor, to be procured separately, will be responsible for the aeration tanks as well as installation work on the membrane facility, according to the membrane contractor's design. The contract with the membrane contractor will be developed from ABT06.

Option 3 was selected as the best for the project, the main reasons being:

- The membrane contractor selected is expected to have extensive knowledge of membranes and biological treatment, not being, primarily, a works contractor.
- The contract and all warranties are to be directly with Stockholm Vatten. Option 3 makes it possible for many different types of contractor and/or supplier to tender, not requiring resources for civil works, etc.
- Stockholm Vatten will have direct contact with a supplier holding all of the expertise required during commissioning and operation.
- A good competitive situation will emerge enabling different membrane suppliers to tender.
- Minimizing the number of works contractors operating on site and thus minimizing the risk of collisions.
- The membrane contractor will supply membrane cassettes and ancillary equipment. Another contractor is responsible for the biological treatment as well as installing equipment in the membrane facility. This allows for good coordination during commissioning.

## Procurement procedure

Procurement was done according to The Swedish Act (2007:1092) on 'procurement in the water, energy, transport and postal services sectors'. The contract selected for membrane supply was ABT06 and the procurement method was a two-step negotiation, with pre-qualification and tendering with negotiation.

## Pre-qualification phase

The purpose of this stage was to ensure that suitable applicants were qualified for tendering. By setting requirements to allow for a good competitive situation, Stockholm Vatten hoped for several applicants to qualify, ensuring sound competition subsequently. Setting requirements for large reference plants is difficult, however, if combined with a requirement for a good competition. Combining the number of MBR-references and their flow capacity, and the financial strength of the potential supplier, allowed Stockholm Vatten to complete the pre-qualification phase with the following requirements:

- Previous year's annual turnover: 1.500 Million SEK (180 Million USD). Approximately 100% of the expected contract sum. Credit rating at least BBB on Standard & Poor's Rating Services or equivalent.
- Supply 500.000 m<sup>2</sup> of installed membranes within 9 months of call off from Stockholm Vatten.
- At least 3 municipal MBR-WWTPs with a capacity of at least 1.000 m<sup>3</sup>/d each and at least 2 years in operation.
- At least 3 reference projects where contractor's scope was at least 75 Million SEK (9 Million USD).

On the basis of the pre-qualification requirements, a total of seven contractors were qualified for tendering. They included membrane suppliers, as well as EPCs (Engineering, Procurement, Construction) in joint offers with one or more membrane suppliers.

## Tendering phase

The scope of works for the contract was specified with regard to the project as a whole, especially looking to optimize coordination with other contractors on site. MBR-contractor supply included the design, membranes and ancillary equipment. Installation work was limited to membrane cassettes only, with all other installation to be conducted by others. This approach gives a clear definition of interfaces between contractors and works, ensuring clear boundaries of responsibility.

The basis of warranty according to ABT06 is 5 years on all equipment supplied. Looking further, searching for the actual membrane life-time, Stockholm Vatten decided on two options for prolonged warranty for an additional 5 years each. Warranty costs for a total of 15 years were thus included in the tender price, allowing Stockholm Vatten to plan ahead for any costs associated with membrane exchange over a 15 year period. This was also one of the key aspects of the procurement strategy. Stockholm Vatten wants a long-term partner, for the duration of the project and beyond.

The tender period extended from 7 July to 27 October 2014, plus a one week extension because of new information provided by Stockholm Vatten. Three tenders were submitted, which, bearing in mind the project's complexity, can be considered a very good outcome.

## Tender evaluation

Tender evaluation was conducted by a committee comprising seven people including consultants, plant maintenance staff and technical experts, as well as procurement specialists and contracting

lawyers. No prices were available to the committee prior to tender evaluation. The tenders were divided into two main parts:

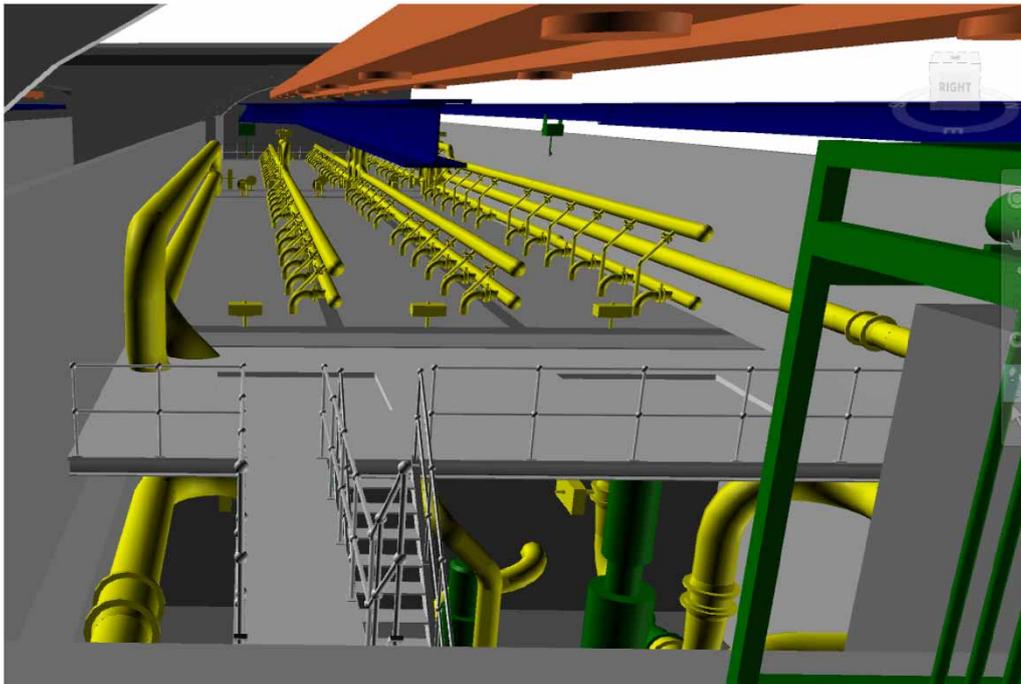
1. **Costs as provided by the tenderer:** Design, supply and installation of membranes and ancillary equipment, including participation at startup, etc., replacement membrane cassettes, costs for options 1 and 2 regarding extended warranties, civil cost for MBR-plant design and operating costs with respect to energy and chemicals. Energy and chemical consumption was calculated as a present value factor based on 15 years and an interest rate of 4%.
2. Costs associated with the civil work for the membrane facility were also calculated and included in the tender, based on rates provided by Stockholm Vatten.
3. **Price deductions based on Stockholm Vatten's evaluation:** Stockholm Vatten evaluated the tenders using a scoring model of added value and room for improvement. A final deduction of price was made for each tender for the following categories:
4. **Technical standard of tender:** This criterion includes risk assessment and management, detail of tenders with regards to placing mechanical equipment and drawings, and to what extent the tenderer provides a reliable and robust technical solution. Total value 45 Million SEK (5.3 Million USD).
5. **Design of MBR-facility with regard to operation and maintenance:** This criterion includes aspects such as the work environment, the placing and accessibility of equipment, noise reduction, redundancy, possible extensions of the MBR-facility, and its need for service and maintenance. Total value 125 Million SEK (14.6 Million USD).
6. **Project implementation:** This criterion involves aspects of organization, experience of provided personnel time schedule for implementation. Total value 80 Million SEK (9.4 Million USD).

The price deductions based on the tender evaluation, a total of 250 million SEK (29.3 million USD), were selected to promote good and innovative design solutions, putting emphasis on the work environment, as well as operation and maintenance. This is mainly due to the inherent constraints in the facility, where ceiling height must be considered as the WWTP has been built in a cavern. Figures 4 and 5 show the layout of the existing secondary clarifiers and the membrane facility, respectively, from the winning tender.

The final tender price was calculated as the 'Tender Price – Deductions from Tender Evaluation'.



**Figure 4** | Existing secondary clarifier, view from effluent channel (showing the cavern roof at the top).



**Figure 5** | GE membrane facility from tender, as viewed from the effluent channel.

## RESULTS AND LESSONS LEARNED

The initial meeting for the tendering process was conducted in February 2014. Pre-qualification was completed by May 2014, as planned. The tender documents were published in July 2014 and tendering was completed by 27 October 2014. Tender evaluation, negotiation and award to GE Power and Water were completed by 23 February 2015. The total time from the initial meeting to the finalized contract was about one year, in line with schedule.

The procurement outcome for the project is considered successful. The winning tender received the highest score unanimously from the evaluation committee, thus the best technical solution was selected.

Some important success factors are noted:

- Full support from Stockholm Vatten Project Management for the MBR-procurement team to follow through with the best outcome.
- Marketing of the project to ensure participation from committed tenderers. All major membrane suppliers participated at some point in the tendering.
- Committed decision from the Management of Stockholm Vatten and Stockholm City Council. All decisions to proceed with the project were made early by the City Council.
- The MBR-procurement team, consisting of people with different relevant experience, participated from the very beginning of procurement.
- Tender evaluation was done swiftly and stringently by a committed, well prepared evaluation committee following a strict evaluation procedure.
- Professional and very dedicated commitment from all tenderers.

All in all the procurement met all of the goals stated for the project, but some lessons were learned that could have improved or otherwise had an impact the outcome.

- The tender documents stated that the contract should be signed with one entity, being the tenderer. In hindsight, permitting a Joint Venture to be the contract partner could have opened the process to more tenderers.
- In the tender evaluation, section 2, the criteria concerning maintenance were evaluated as a price deduction, based on the tenderer's technical solution and the subsequent scoring from the evaluation committee. Stockholm Vatten considered whether this could have been done in some other way, e.g., by committing the supplier to a service program for all membrane lines, with an associated cost. This approach was not implemented in the tender documents as the final structure of such a mechanism was not clear.