Winnie Poon

POSITIONING GRUNDFOS DOSING AND DISINFECTION IN NORDIC WATER UTILITIES

Applications,

Market demands & sales drivers,

Sustainability portfolio,

Recommendations

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DESCRIPTION

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Positioning Grundfos Dosing And Disinfection In Nordic Water Utilities

- Applications, Market demands & sales drivers, Sustainability portfolio, Recommendations

Abstract

This thesis is conducted for Grundfos and Mikkeli University of Applied Sciences between February and August 2014. It is commissioned by Grundfos.

The research aim was to identify chemical dosing and chlorine disinfection potential in water treatment systems that are driven by EU water directives and local legislations. Subject of the thesis was to realize the current and future market position of Grundfos 'dosing and disinfection' product range and to create it a 'greener' portfolio. The ultimately goal was to give Grundfos recommendations on enhancing its D&D position in the Nordic water utilities market.

The study scope is focused on drinking waterworks and wastewater treatment plants in four Nordic countries – Denmark, Norway, Sweden and Finland. The content is applications and market focused, which consists of technical, commercial and social aspects of chemical treatment. It covers aspects from general dosing applications, improved drinking water disinfection for legionella prevention, to nutrient recovery in wastewater treatment.

The study findings and recommendations can be utilised by Grundfos for reinforcing its position in the Nordic water utilities market, along with further product development and sales management.

Subject headings, (keywords)
Grundfos, positioning, dosing and disinfection, Nordic water utilities, applications, market demands, sales drivers, sustainability, recommendations

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Tutor	Employer of the bachelor's thesis
Aila Puttonen (MAMK) Karin F. Abel, Per Krøyer Kristensen (Grundfos)	Grundfos

TERMS, ABBREVIATIONS AND EXPLANATIONS

D&D	: dosing and disinfection
Nordic	: Denmark, Norway, Sweden and Finland
WW	: wastewater
DW	: drinking water
WWTP	: wastewater treatment plant
DWTP	: drinking water treatment plant
WU	: water utilities
IND	: industrial / industry
OEM	: original equipment manufacturer
CAPEX	: capital expenditure
OPEX	: operating expenses
TOTEX	: total expenditure
EWGLI	: The European Working Group for Legionella Infections
ECDC	: The European Centre for Disease prevention and Control
PI-diagram	: piping and Instrumentation diagram, a figure that illustrates the inter connection of process equipment and the instrumentation used to control the process.
GWI	: Global Water Intelligence
WSI	: water stress index
Q	: flow rate/ capacity
p	: system pressure
TOC	: total organic carbon
THMs	: trihalomethanes
NOM	: natural organic matter

CONTENTS

1 INTRODUCTION

'Vesi, vanhin voitehista'
– Water, the oldest paste on Earth (Finnish quote) /1/.

Managing water resources in a sustainable manner is not just a philosophy, but also a global challenge. Although water is abundant on Earth, fresh water only account for less than one percent. Also that one percentage is most suitable for human consumption. /2/. You might ask 'Doesn't the water cycle take care of it all?' – Yes it does, but mother-nature also has its limit and capacity. The ever growing world population is putting the greatest pressure ever on common resources that sustain life, water is not an exception.

'Gå ikke over åen efter vand'
– Don't cross the stream to get water (Danish quote)
= Easy does it /3/.

The question is how water should be managed, what method is the best to manage it and who has the know-how to manage it, without instigating further disturbance to the eco-system and most importantly to our next generation. There is a saying – 'We do not inherit the Earth from our ancestors, we borrow it from our children'/4/. It might sound cheesy, but the connotations behind is humbly true and inspirational.

Grundfos is one of the global leading pump manufacturers with an annual pump unit production of more than 16million. It was founded in Bjerringbro, Denmark in 1945, where it is headquartered today. The group is represented by 80 companies in more than 55 countries, employing approximately 18000 employees globally. /5/. The company has an outstanding reputation and is highly recognised in the water industry. It is well-known for its high quality products, service and holistic solutions. Besides, sustainability is a focal point both internally and externally. In terms of international standards, Grundfos is certified on ISO 18001 OHSAS – Occupational Health and Safety Management Standard, ISO 14001 Environmental Management Standard, and EMAS for environmental quality assurance /5/. Along with being a full-line supplier, Grundfos is trying to gain its share in the water treatment sector as a specialist.

Water utilities refer to drinking water treatment plants and wastewater water treatment plants. They can either be privately or publicly owned. Competition-free is a special market circumstance of water utility companies. It is impossible for the utility companies to compete against each other because pipelines are designed to channel water from households to specific wastewater treatment plants in municipalities. The exceptional market situation of no competition allows collaboration and knowledge sharing among the utility companies for continuous improvements in terms of solution efficiency and technology. /6/. Therefore, what drives the initiatives of water utilities in adopting certain treatment methods? It can be EU and national legislations, targets on cost saving and etc, which we are going to be discussed later on in the thesis.

As a former intern in Grundfos, I was given precious opportunities to work across different functions in the organisation and to experience different roles in business, from back office to sales support. It was challenging yet eye-opening to take on this comprehensive research study on dosing and disinfection in water utility. The overview of the technical aspect of this product range and market research in positioning it in the Nordic region was interesting to me. Throughout the research, I was also invited to several internal Nordic meetings to understand how utility business is executed, to share findings and to point out the needs for further improvement. My goal in this thesis research is to give Grundfos constructive and realistic recommendations on enhancing Dosing and Disinfection position in Nordic water utilities market.

The thesis is focused on the applications of D&D, market demands, sales drivers and environmental aspects in the Nordic water utilities. Details on products and issues regarding measurement and control will be left out. Information regarding competitors is contained within the customer survey. Confidential information and comments are left out for the sake of business secret protection.

In terms of materials and methodology, a literature review is carried out regarding products, applications, and part of sales drivers. Some relevant technical information obtained from the Nordic Drinking Water Conference 2014 in Helsinki is also included. Besides, a study regarding current business practice, customer's perception and environmental portfolio has been carried out through market research, survey and customer visits. The thesis research process is supervised by senior lecturer Puttonen.

2 DOSING AND DISINFECTION - PRODUCTS AND APPLICATONS

Dosing and disinfection, in short D&D, is one of Grundfos most extensive, sophisticated and a state-of-art product ranges, covering all-inclusive applications from drinking water disinfection to water treatment in highly sensitive industrial processes /7/. The terms ‘dosing’ and ‘disinfection’ are referring to dosing pumps and chlorine disinfection systems respectively. The difference is that dosing pumps only transport a precise amount of liquid (water, chemicals, solutions, etc.) from a place to another in a given time period providing an accurate flow rate, while disinfection systems prepare, produce and dose the chlorine compound solutions.

Dosing pumps are classified into three different types base on operational principle /7/:

- Diaphragm / digital dosing pumps
- Mechanical diaphragm dosing pumps
- Hydraulic piston diaphragm dosing pumps

Whereas, the chlorine compounds based disinfection includes /7/:

- Chlorine gas (Cl_2)
- Sodium hypochlorite (NaOCl)
- Chlorine dioxide (ClO_2)

As a pump manufacturer and a water treatment specialist, Grundfos supplies dosing pumps in many different ways, from boxes selling to customized-dosing system for small or large volumes, and based on different applications purposes. The most common dosing applications in water utilities include flocculation/ coagulation, chemical precipitation, pH adjustment and disinfection. /7/.

As a full-line supplier, Grundfos also supply measurement and control system along with the D&D, in short M&C, which is a range of electronic and electrochemical accessories that offer complete control of the dosing and disinfection processes. These control devices can be integrated into an existing system without a glitch. /7/.

‘Kast ikke barnet ut med badevannet’

– Don’t throw out the child with the bath water (Norwegian quote) /8/.

The meaning of this proverb means, not to take a drastic step of abolishing or discarding something in its entirety just for its small errors.

One of the inherent drawbacks of chemical dosing and chlorine disinfection, in comparison to physical treatment and biological processes, is that they are additive processes /9/. This means additional products are added to water in order to achieve the removal of a specific element, which often results in a net increase of the dissolved constituents in the water. An example would be chlorite formation resulted from chlorine dioxide disinfection. Likewise, dosing of flocculants to optimise the removal efficiency of sedimentation will increase the total dissolved solids in the sludge content. The dissolved constituents will have to be removed ultimately, which may further complicate treatment processes. /9/.

When selecting disinfection method, effectiveness is one of the key parameters in comparing disinfectants. Among chlorination, chlorine dioxide has the highest disinfection effectiveness based on its residence time and pH dependency /10/. Its depot time is the longest even when comparing with other disinfectant, such as ozone.

Most disinfectants generate by-products, yet chlorination generates the most. Ultimately, there has to be a solution to removal by-products to minimise their negative effects in health. UV disinfection has been a popular alternative for chlorination in many places. One of its advantages is its ability in killing bacteria that are resistant to chlorination /11/. However, its residence time is too short for distribution system with long distance (Table 1).

No one disinfectant is perfect. Some might be effective in doing the job, yet expensive. Some might have the most generation of by-products, yet effective and cheap. In the end, it is the priority that matters when selecting the best method.

TABLE 1. Comparison of disinfection methods /10/.

Disinfection agent	Disinfection effectiveness	Depot effect	pH dependency	By-products	Investment cost	Advantages	Disadvantages
Chlorine gas	+	Hours	High	▪ Chloramines ▪ Chlorphenoles, ▪ THM ▪ AOX	++	Low-cost agent	▪ Chlorine resistant germs, ▪ Storage for chlo-rine gas
Chlorine (electrolytic)	+	Hours	High	▪ Chloramines ▪ Chlorphenoles ▪ THM ▪ AOX	+	Low-cost salt (NaCl)	▪ Chlorine resistant germs ▪ Space required for storing salt
Chlorine dioxide	++	Days	Moderate	▪ Chlorite, ▪ Chlorate	+	No germ re-sistance	Minimum 2 chemi-cals to handle
UV	+	None	No	▪ Evtl. nitrite	+	No chemicals	Risk of germ regeneration after LP radiation
Ozone	+++	Minute	Moderate	▪ Aldehydes ▪ Bromate	++	Removal of odour, colour organic substances	Must be removed from drinking water

2.1 Applications in drinking water treatment

In terms of applications, chemical processes for drinking water treatment include /12/:

- Pre-oxidation/ oxidation
- Chemical precipitation - coagulation and flocculation
- Water softening
- pH adjustment / neutralization
- Re-carbonation
- Disinfection (e.g. legionella prevention)

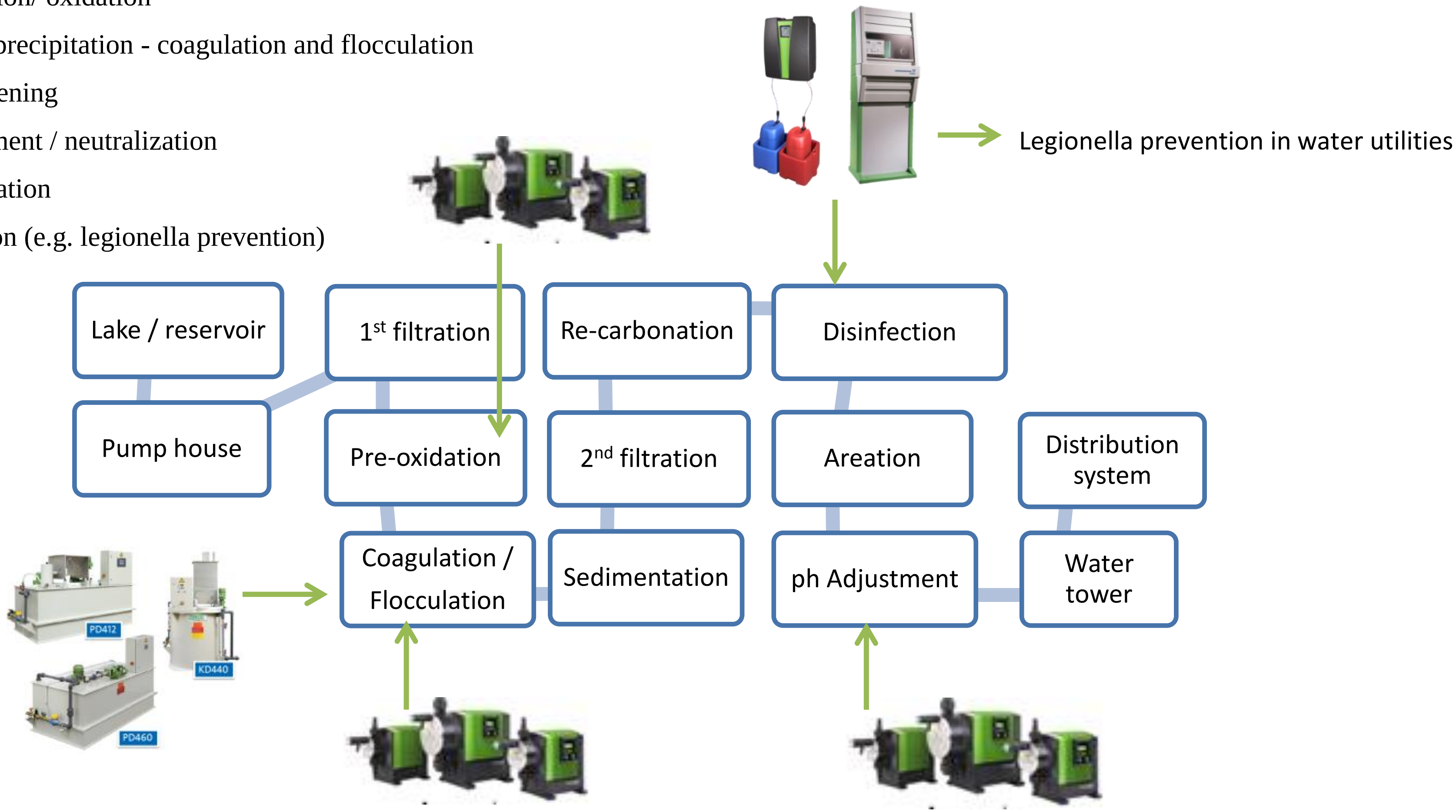

FIGURE 2. Dosing and disinfection applications in drinking water works. Modified according to Grundfos /13/.

Pre-Oxidation/ oxidation

Pre-oxidation can take place either at the intake stage or at the treatment plant, depending on the temperature and transport distance. The applicable chemical oxidants for dosing include chlorine, chloramines, chlorine dioxide and potassium permanganate. /14/.

Pre-oxidation by chlorine also refers to pre-chlorination. It is typically applied for reducing organic matter, eliminating ammonium ions or to oxidise ferrous iron to ferric iron in water. This process is best to be placed at the early stage of a treatment system for greater efficiency in organic material removal. Yet, it can also be applied at the filtration stage for biofilm prevention. One condition for this process is that water to be treated should contain low amount of organic material to limit its reaction with chlorine for Trihalomethanes formation. Besides, Dosing of chloramines is applicable if raw water contains no ammonia. And chloramines can be produced via the reaction of chlorine with ammonia or ammonium sulphate. In addition, pre-oxidation with chlorine dioxide is another way of chemical oxidation. This method neither oxidises ammonium nor forms THMs. Yet, the downside would be the reaction with natural organic matter and the formation of chlorite that needs to be removed eventually. /14/.

Chemical precipitations - coagulation and flocculation

Chemical precipitation is a conversion process of dissolved or colloidal substance in water into solid insoluble form, by chemical dosing to enhance the relevant precipitation process. It can be performed either by coagulants or by precipitants. /15/.

Coagulations and flocculation procedures are to facilitate the removal of suspended solids and colloids in water that are too tiny to be removed by sedimentation or filtration. By adding coagulants particles clump together to form larger flocs, which can be sedimented or filtered afterwards. /15/. Principally, a coagulant is for destabilising the colloidal particles in the water so micro-floc formation can take place to, whereas, a flocculent is an organic substance for enhancing the flocculation to form macro-flocs. The most common coagulants and flocculants are mineral salts, natural or synthetic organic polymers. Aluminium sulphate is the most common for treating groundwater. These clarification steps are to rectify some of the impurities in water caused by inert or living organisms. Moreover, the process removes part of the organic matter, some heavy metals and micro-pollutants that response to flocculation. /15/.

A study done by Kemira suggests that hydrogen peroxide dosing enhances iron coagulation in DWT, in which advantages include /16/:

- Higher floc formation efficiency that accelerates sedimentation
- Lower residual iron concentration and increase organic matter reduction after sedimentation
- Lower dosage of ferric sulfate that lower pit corrosion index
- Lower dosage of alkalisation chemical

The EU drinking water directive (98/83/EC) has set out a parameter to limit humus content in water for human consumption and chemical treatment such as dosing of iron, aluminium and polymers is mentioned for lowering the humus concentration to acceptable levels /14/. Chlorination is also recommended for controlling microorganism production in the distribution system. However, the formation of chlor-organic compounds from the reaction among the residual humus and chlorine was considered as a drawback. /18/.

In Norway, Sweden and Finland, majority of the population drink surface water from the lakes. Conceivably one of the most relevant purposes of these processes for Nordic drinking water would be the removal of humid acid that causes the colouring of surface drinking water. A joined /19/ study about the climate effects on dissolved organic carbon in Nordic surface waters was carried out by the Nordic Council of Ministers, Swedish University of Agricultural Sciences, the Finnish Environment Institute and the Norwegian Institute for Water Research. It was shown that the problem is most significant in South Sweden and Finland where TOC concentration often exceeds 20 mg/l. The aquatic humic substance has always been an issue to high quality drinking water supply, because it provides bacteria and fungi nutrients that accelerate their growth in the distribution system. This consequently leads to taste, odour and diseases issues. In Finland, the practice of chemical treatment with the purpose to lower humus content has started in 1908 in Helsinki DWTPs. Iron salt was dosed to the coloured and turbid water from river Vantaa for precipitating the humus and clay substances. /19/.

Most simulations suggest that humus leakage will rise by the effect of climate change, with increased temperatures and higher precipitation. Global warming also means milder but mistier winters and drier summers. Furthermore, the study also illustrates that forestry activities have elevated the carbon pools in the soils that result in humus leakage to surface water. /19/.

Water softening

Scales caused by hard water can be problematic for cleaning and piping system, so water softening is considered an important step for many water supply utilities. Water hardness is depending on the content of calcium and magnesium. The softening process is categorised into temporary and permanent. /20/.

Temporary water softening is carried out by dosing a strong base to increase the pH that will precipitate carbonate from water. Possible dosing includes /20/:

- Calcium hydroxide
- Sodium hydroxide

Permanent water softening includes the dosing of:

- Sodium carbonate (soda)

, that allows calcium and magnesium to be balanced by chloride and sulphate anions. /20/.

pH level plays a vital role in water softening. The elevated pH required during the process must be reduced to a value lower than 8.5 so as to comply with water quality regulations /20/. Thus, these conditions are making room for the dosing applications.

pH adjustment / neutralisation

In most cases, acidic groundwater indicates soft water, where pH ranges between 5-5.6 and contains 10-60 mg/l aggressive carbon dioxide. Hence, neutralisation is performed by dosing:

- Calcium hydroxide
- Caustic soda

Caustic soda can be applied for water which is not extra soft. The purpose of this is to eliminate aggressive carbon dioxide entirely as well as to extract elevated calcium carbonate in the water. One thing to keep in mind is that the treatment process should be thoughtfully designed to guarantee a good mix in the water, along with an adequate reaction time for chemical reaction. Attention should also be paid to the possible precipitation that may occur due to large quantity dosing of chemicals. /20/.

Re-carbonation

Re-carbonation is needed if water is too soft with less than 4°dH. The process increases water alkalinity as well as to stabilise pH. It also increases bicarbonate and hence increases water hardness. /20/.

Disinfection for preventing legionella

Legionella is a gram negative bacteria with special cell wall structure, with size between 0.2-0.70μm in diameter. It can be airborne and hence inhalable due to its tiny size. The optimal growing temperature is between 30 to 40°C. It has a fast reproduction speed that it can multiply double of its amount within 6 hours. It only transmits via respiration with contaminated aerosol smaller than 5μm, but not through human contacts. The hazardous germ quantity that threatens health and life is 10germs/ml. /21/. It is vulnerable for those with weaker immune system, such as the elderly and babies. In WUs system, biospheres for legionella include water supply systems, hot water systems in building installations and cooling circuits where condensation can occur. Besides, legionella also reproduce in biofilms and amoebas, which amoebae offer legionella protection in biofilm. /21/.

In building installations and water utilities, effective solutions to prevent or to tackle legionella include thermal disinfection, chemical disinfection or UV treatment. Thermal treatment refers to the use of hot water up to 70°C for approximately 15 minutes, and that water flow is running in circulation followed by a 3 minute flushing. UV treatment is to kill legionella with continuous exposure of UV light. Chemical treatment involves direct dosing of chemicals such as hypochlorite. /21/.

Among all, chemical treatment is the most effective in combating legionella disease, chlorine dioxide in particular. ClO_2 is an oxidising disinfectant. It kills micro-organism by irreversible oxidative destruction of the transport proteins. Its disinfection efficiency is 2.5 times higher than chlorine. It has a wider targeted germ range, longer depot time, lower pH independence and no chlorinated by-products are formed. Longer residence period also means less chances of regrowth. Yet, the change in taste and smell of water can only be avoided if dosing is between 0.5 to 3ppm. /21/. The handling of ClO_2 system is also a common concern as operators need to be technically trained to ensure work safety. This also means ClO_2 systems can be applied to prevent or to against legionella disease in water utilities.

2.2 Applications in wastewater treatment

In terms of applications, chemical processes for wastewater treatment include /9/:

- Hydrogen sulfide prevention
- Coagulation and flocculation
- Chemical precipitation (e.g. H_2S removal in collection systems)
- Oxidation / advanced oxidation
- Ion exchange
- pH adjustment / neutralization/ Stabilisation
- Disinfection (e.g. sludge / effluent treatment)
- Control of scale

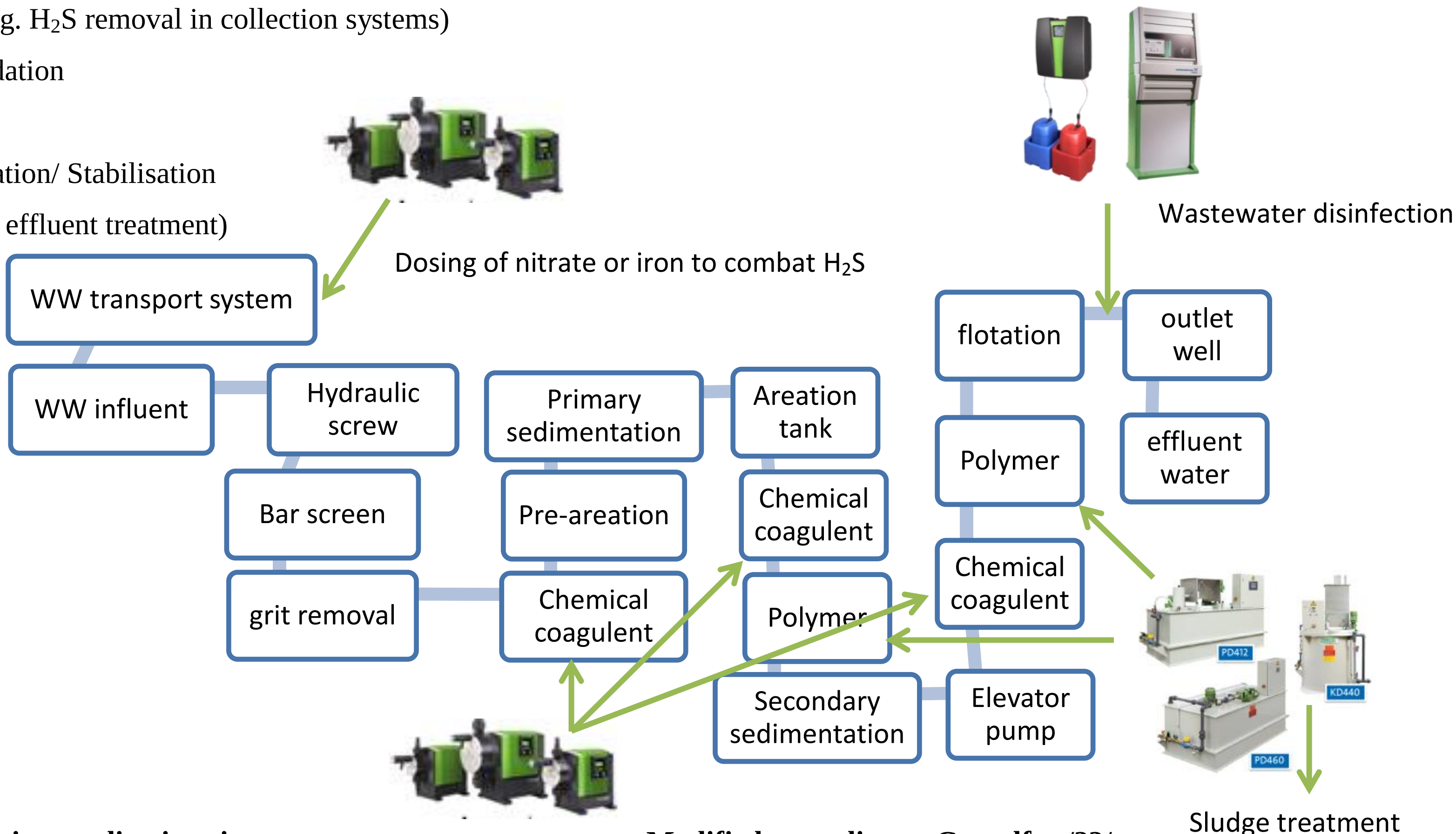

FIGURE 3. Dosing and disinfection applications in wastewater treatment process. Modified according to Grundfos /22/.

PICTURE 4. Dosing units to be renewed in Lynette WWTP, Copenhagen. Photo taken during a customer visit.

In wastewater treatment, chemical unit processes are often combined with physical and biological unit processes, in order to meet specific treatment targets /9/. An estimation of the methods used in the Nordic WWTPs was carried out by Norwegian University of Science and Technology /23/. For WWTPs serving over 50 person equivalent, it predicted that bio-chemical treatment is the most common practice in Finland, Sweden and Denmark that represents 98%, 89% and 47% of all plants respectively, whereas mechanical treatment represents 49% of the small sized Norwegian wastewater treatment. However, for larger sized plants serving over 2000 persons equivalent, chemical treatment is the major method in Norway that represents around 37% of total capacity, followed by bio-chemical treatment in terms of capacity percentage. /23/.

The coagulation of particles, pH adjustment and precipitation of phosphorus are the most common dosing application processes in Nordic wastewater treatment. The most common chemicals for each process are listed in the table below. Some are repeated as they offer more than one purposes.

TABLE 5. Applications of chemical dosing in wastewater treatment. Modified according to /9/.

Processes	Applications	Chemicals for dosing
Coagulation and flocculation	The rapid mixing process destabilises particles in wastewater and coagulants allow floc formation that makes collection easier.	Alum Ferric sulphate Polyaluminum chloride Polyiron chloride Organic polymer
Precipitation	▪ Enhance the removal of total suspended solids and BOD in primary sedimentation facilities ▪ Phosphorus removal ▪ Heavy metal removal ▪ Corrosion control in sewers caused by H_2S	Alum/ Aluminum chloride/ Calcium hydroxide (lime)/ Ferric chloride/ Ferric sulfate/ lime/ Aluminium Calcium/ aluminium/ iron Hydroxide/ sulphide/ carbonate Iron/ Nitrates/ Magnesium
Oxidation	▪ BOD, grease removal ▪ Ammonia removal ▪ Destruction of microorganisms ▪ Odour control in sewers, pumping stations and treatment plants	Hydrogen peroxide/ Chlorine Chlorination Iron/ Nitrates/ Magnesium
Ion exchange	Ammonia, heavy metals and total dissolved solids removal	Zeolites
Neutralisation	pH adjustment	Calcium carbonate/ calcium hydroxide/ calcium oxide/ magnesium hydroxide/ magnesium oxide/ sodium bicarbonate/ sodium carbonate/ sodium hydroxide
Stabilisation	Stabilisation of treated effluents	Sodium hydroxide/ hydrochloric/ methanol/ bentonite
Disinfection	▪ Disinfection with chlorine compounds, bromine and ozone ▪ Control of biofilm in pipelines	Chlorine/ chlorine dioxide/ hypochlorite
Control of scale	▪ Scale control caused by calcium carbonate or related compounds	Carbonic acid/ hydrochloric acid/ sulphuric acid

3 ENVIRONMENTAL AND SUSTAINABILITY PORTFOLIO

Creating a ‘green portfolio’ is an affirmative way to describe how chemical dosing can solve technical challenges. It is known that chemical dosing and disinfection is not gaining a full acceptance from the general public due to their additive nature. Yet, only a few know their values in offering a holistic water treatment solution and sustainable operation. Their role can ultimately ease several environmental challenges the world is facing in the 21st century. For instance, water stress, energy consumption and food production security, etc.

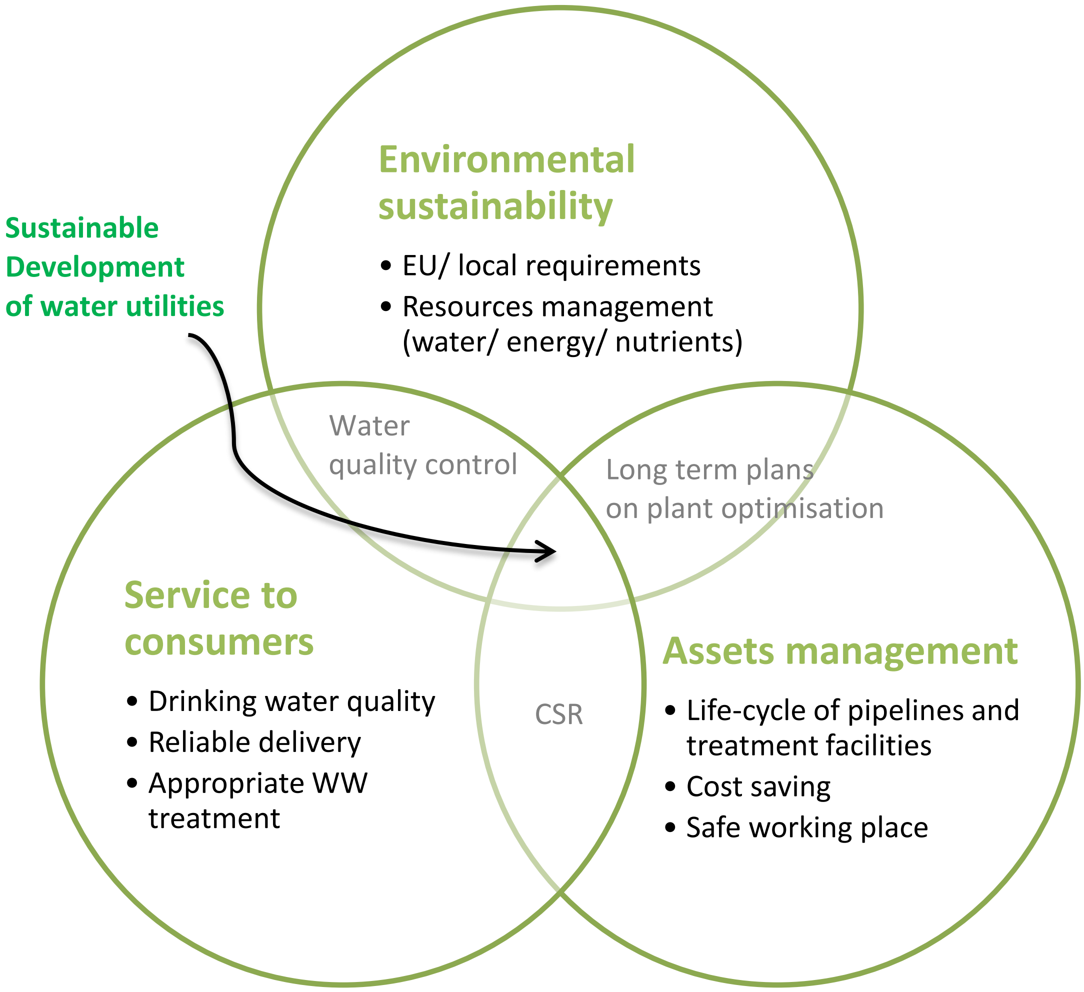

FIGURE 6. Contribution of D&D in water utilities sustainable development. Modified according to /24/.

3.1 Grey water reuse eases water stress

Water stress is one of the main global challenges today as a result of climate change, ever growing population and water scarcity. Hence, water resources need to be managed in a more sustainable manner. By recycling and reusing of treated grey water, excessive groundwater abstraction can be avoided and the environmental consequences of wastewater disposal can be minimised. This in return preserves water quality downstream. /25/. To reuse wastewater, disinfection is essential to comply with reuse requirement and parameters set by national authorityies.

Regulations wise, no national guidelines have been set regarding water reuse in the Nordic region because water reuse issue has never been taken seriously due to the plentiful water resource. In Denmark, preserving groundwater quality and quantity is crucial as it accounted for more or less the entire water supply system. High water costs motivate private sector to recycle process and cooling water. Yet, water reuse in WUs is still rare. In Finland, there is no incentive to reuse water at present due to the high water availability and low needs on irrigation. /25/.

In south-east Sweden, reusing tertiary treated effluents from WWTPs for irrigation is gaining publicity, regardless of the abundant water resources and low water abstraction in the country. The incentives behind are to preserve coastal waters and to protect groundwater for more ethical usages. More than 40 reuse projects have been running, which treat and store effluent up to nine months in reservoirs prior to irrigation. /25/. This allows wastewater to be treated at low cost and efficiently. The situation is similar to the ‘struvite project’ in Aarhus, Denmark, in which nutrients in wastewater are recycled to farmland when farmers are offered with low-priced water. The selling of water is a win-win situation that profits both WUs and farmers. It compensates the building and operating overheads of WWTPs, while simultaneously securing optimal harvest for farmer with lower water cost than private irrigation systems. Ecological wise, needless discharge is lessened and nutrients are recovered by this trade model.

3.2 Resources recovery secure food production

Resources recovery is a big step forward to the sustainable development of wastewater treatment. Phosphorus which is known as a limited resource on earth is critical for sustaining agriculture production. Prevention of nutrient loss means securing global food production. Likewise, resource recovery can maximise renewable energy utilisation in utilities. For example, biogas production can be achieved by utilising sewage sludge. /25/

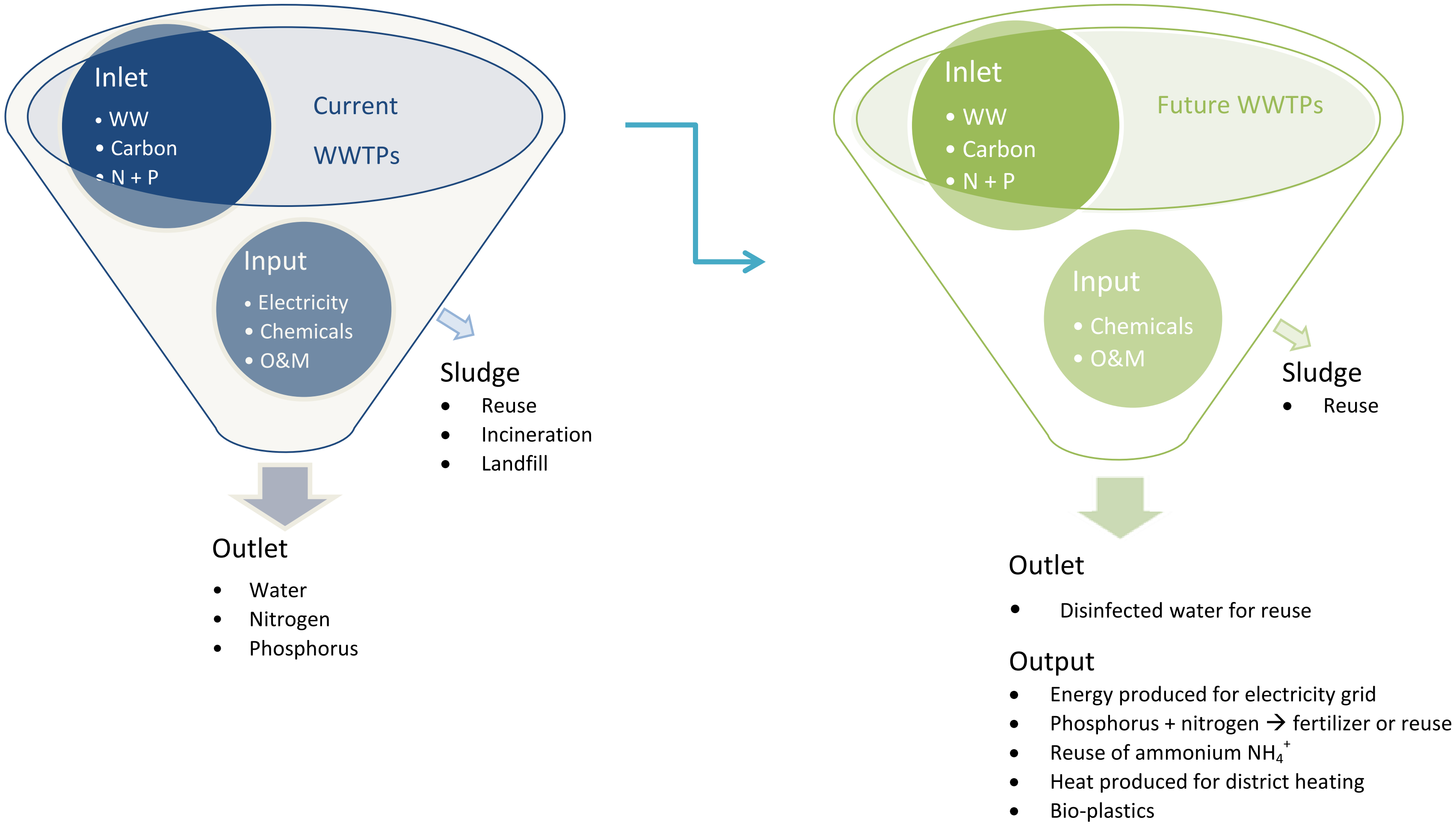

FIGURE 7. Transformation of wastewater treatment plants from energy and resource consuming to utilisation (WW = wastewater, N = nitrogen, P = phosphorus, NH_4 = ammonium, O&M = operation and maintenance). Modified according to Grundfos material /26/

3.3 Marketing success – phosphorous recovery by struvite

One of the success cases of Grundfos D&D application is the ‘Struvite project’ held in a WWTP in Aarhus, Denmark. Its aim is to reduce and recover phosphorous from a digester centrate using struvite. The project demonstrates how chemical dosing can ease one of the global environmental challenges, by recycling finite nutrients. /27/.

Background

A partnership was established between Grundfos, Aarhus Vand and Norconsult to develop a holistic solution that precipitates struvite from wastewater. The Åby Purification plant where the project is held is part of Aarhus Vand, the second largest Danish water utility company. It is an activated sludge plant with a treatment capacity of 50,000 m^3/d serving 70.000 capita. Norconsult, an engineering and design consultancy participated the project as a process specialist, while Grundfos participated as a technology company. /28/.

The original incentive of this project was driven by the clogging issues of struvite. The problem was brought out by the internal overload of P from the reject water of dewatering process to the plant’s inlet. The high concentration of P in the reject water initiates the formation of struvite, which clogged the pipes, heat exchangers and decanters. For that reason, the aim of the ‘struvite project’ is to precipitate struvite in the plant by removal and reuse. /28/.

PICTURE 8. Struvite plant and dosing pumps. Photo taken during a customer visit.

Formation of struvite

Struvite is a white crystalline compound that comprises of magnesium, ammonium and phosphate. It precipitates at neutral pH according to the reaction below /29/:

$$Mg^{2+} + NH_4^{+} + HPO_4^{2-} + 6H_2O \rightarrow MgNH_4PO_4 \cdot 6H_2O\ (s)$$

The full scale plant deals with both digested sludge reject water and return sludge with extended hydrolysis. The final product - struvite pallets, are collected at the bottom via a mechanical valve. This means more than half of the incoming load of phosphorus to the WWTP can be potentially removed and recovered as struvite, which can be utilised as organic fertiliser. /28/.

Results showed a 90-95% removal efficiency of phosphorous in the struvite reactor, using a hydraulic retention time of less than an hour. There is about 400 kg of struvite pallets produced every day, containing around 50 kg of pure phosphorous. /28/. The struvite pallet will be sold as a fertiliser. Its heavy metal content was measured to be very low when comparing with limits set by the Danish sludge application for land use and EU standards for fertiliser. Thus, it can be used as a high quality fertiliser. /28/.

TABLE 9. Heavy metal content measured in struvite pallet and sludge /28/.

		Sludge	Struvite1	Struvite2	Limit	Factor
Cd	mg/kg	0,9	0,05	0,06	0,8	15
Hg	mg/kg	0,5	<0,1	<0,1	0,8	>8
Pb	mg/kg	23	<0,2	<0,2	120	>600
Ni	mg/kg	24,4	0,4	0,5	30	67
Cr	mg/kg	17,1	4,7	4,5	100	22
Zn	mg/kg	580	5	7,4	4000	645
Cu	mg/kg	230	3,7	0,8	1000	444
Cd	mg/kgP	28	0,39	0,47	100	233
Hg	mg/kgP	16	0,79	0,78	200	255
Pb	mg/kgP	714	1,57	1,56	10000	6390
Ni	mg/kgP	758	3,15	3,91	2500	708

Cost benefit wise, the market value of struvite is worth up to DKK 3000 per ton. /30/. Moreover, the solution offers the plant several financial compensations in cost saving. These include savings in chemicals used for precipitation, polymer for sludge dewatering, energy for aerating activated sludge and the handling cost of sludge. The most rewarding thing is the income generated from trading of struvite-P fertilizer for water utilities! /28/. The business model creates a triple-win condition for Åby WWTP, farmers and also Mother Nature.

4 DEFINING MARKET DEMANDS AND SALES DRIVERS

Market demands refer to customer's needs. Sales drivers refer to market incentives. Both are associated with a 'demand and supply' relationship. By identifying market demands and sales driver, proficient marketing and sales strategies can be established. Information obtained also aid in important decision making afterwards.

Both market demands and sales drivers can reflect market attractiveness, which is the potential profit availability of a specific products or service in a given market condition. It is greatly determined by external factors. Whereas, competitive positions are competitiveness levels that are differentiated by the offering that allows one to win share in the market, in other words, where a company is standing. Companies can self-evaluate their positions in the given market by identifying both factors.

Market attractiveness of dosing and disinfection in drinking water and wastewater treatment are influenced by different factors. In drinking water treatment, influential factors include (Personal note, information given by Kristensen P. K.):

- Sources of drinking water – groundwater or surface water
- Restrictions on drinking water treatment method
- Perceptions on chemicals usage

In wastewater treatment, influential factors include:

- The use of reclaimed wastewater
- Bathing water regulation
- Environmental regulation on outlet parameters

4.1 PESTEL model analysis

PESTEL analysis is an auditing tool of external influences of an organisation, with a purpose to escort strategic decision making. The model is recognised as a holistic approach to identify sales drivers in marketing. It stands for political, economical, social, technological, legal and environmental. /31/.

4.1.1 Political and economical

Investors like public authorities are keen to see solid evidence and examples of water investment opportunities, which involve innovative technologies and intelligent solutions that could generate significant returns /32/. Despite the fact that consumer willingness to pay is high in the Nordic countries these investments are rare in parts of the Nordic WU market at present, especially Norway where water treatment level is low. On the other hand, this also indicates a market niche for such solutions.

On economical policy grounds, there is a positive correlation among safe water accessibility and GDP per capita /32/. As a water technology specialist, Grundfos can offer holistic technological solutions for treating water and nutrient recovering, which thrive and improve society, the environment and economy. This way, the Nordic governments will appreciate the synergy of smart chemical utilisation in water treatment. Besides, the ever-increasing price of energy, chemicals and effluent discharge (except Norway) will drive utility companies to recognise the values of more efficient dosing pumps, profitable solutions and water reuse.

4.1.2 Social

Water is often the most common media for spreading waterborne *Campylobacter* diseases, which affect hundreds or thousands of inhabitants through drinking water intake /17/. The reasons for these outbreaks can either be mismanagement or natural occurrences, for instance, inadequate design of pipeline causes municipal drinking water being contaminated by sewage discharge, or infiltration of storm water run-off respectively. Despite the under-reported outbreaks in some countries, the data of studies shows that majority of the reported waterborne outbreaks specially linked to *C. jejuni* occurred in the Nordic countries. *C.jejuni* is a kind of Campylobacter species that is apparently one of the main agents of waterborne outbreaks globally /17/. Also, most *Campylobacter* outbreaks occurred at small scale groundwater works with an absence of sufficient disinfection. Although supply sources and outbreak frequency may indicate the needs for proper disinfection in drinking water works, tertiary water treatment with a disinfection process does not guarantee the prevention of a waterborne outbreak if cross connection in the distribution system or intrusion of contaminated water is the cause. /17/.

4.1.3 Technology

Technology development is a necessity for innovative solutions in environmental issues. It creates new possibilities by all means. /32/. However, technology is not just about solid devices, but also about know-how in problem solving.

In water treatment process, there are procedures that demand innovative technologies to reach full optimisation of the plant. For instance, advanced smart metering requires leakage detection, measurement and control, to prevent needless waste of water; sustainable recovery and reuse of scarce nutrients like phosphorus requires chemical treatments technology; waste energy requires biogas production facilities and etc. All of these require technical know-how and market understanding. Customisation is one of the up-coming trends of technology in the next few years. Automation is reckoned to improve technical performance in the future. For the sake of handiness, worried-free technology and process are what the market is longing for. Nevertheless, economic feasibility should also be taken seriously while meeting requirements for water quality. /34/.

4.1.4 Environmental

Drinking water quality is one of the main factors that define the potential of D&D for its treatment, in which it can be defined by the quality of water source. Obviously, groundwater quality is by far better than surface water on the ground of purity due to the less exposure to pollutants. For that reason, it requires less treatment. The ratio of drinking water sources reflects the potential of disinfection in DW sector. Countries with higher ratio of surface water sources require more complex treatment or disinfection than those with groundwater as drinking water source. Furthermore, the differences in freshwater abstraction within the Nordic countries (Figure 10) is to some extent reflecting the resources available as well as conditions that limit abstraction practices, such as climate, industrial and agricultural structure. /35/.

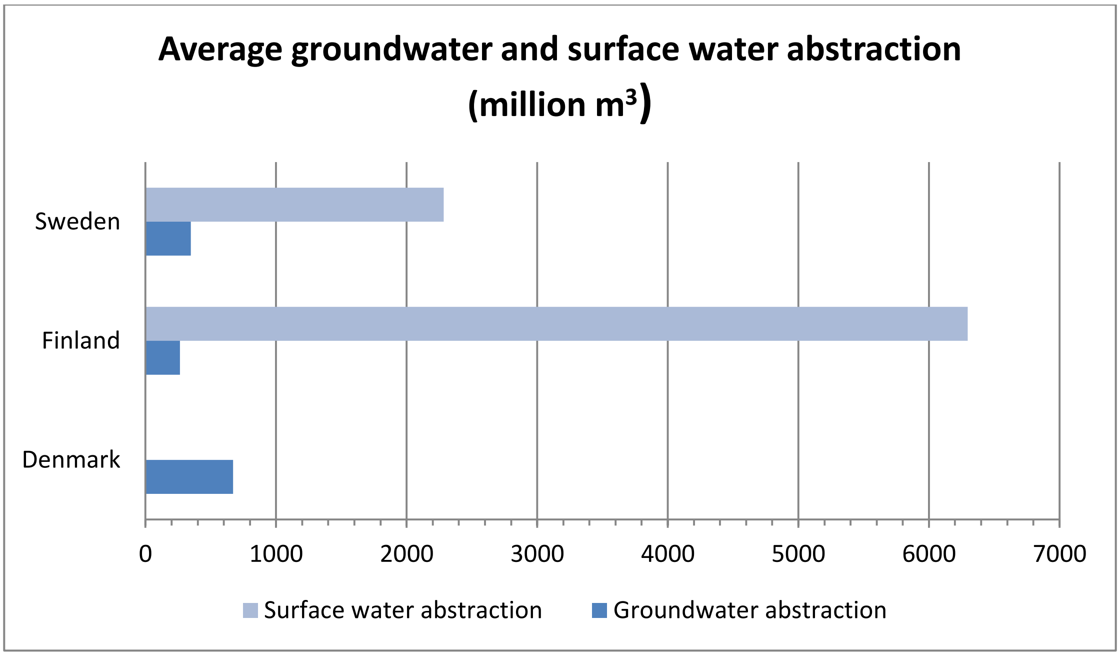

FIGURE 10. Average groundwater and surface water abstraction in 2006.

Modified according to Eurostat data /35/.

Since most water abstraction data is available in 2006 for the Nordic countries, data of this particular year is chosen and illustrated in Figure 10. The breakdown of water abstraction among groundwater and surface water resources is also apparent among the three countries, as shown in table 10. Despite the absence of Norwegian data from Eurostat /35/, surface water from lakes and streams accounted for 90% of the Norwegian drinking water sources according to the data from European Research Media Centre /36/. In Sweden and Finland, surface water accounted for 83% and 96% of the drinking water source correspondingly, while at the other end of the range groundwater accounted for 99% of Danish drinking water source. This indicates a high potential of DW disinfection in the Nordic region, apart from Denmark. Although chlorination is forbidden in Danish DW treatment, an exception for legionella prevention is granted.

Water, energy and nutrient management are the focal points of utility sustainability development. Water quantity and quality may not be a worry in the Nordic. Still, several factors have put pressure on water quality in recent years. These include disasters associated with drinking water quality, improved knowledge on health and hygiene, and the tightening of food quality standard. /33/.

The ever growing world population may lead to a war over nutrients someday. Consequently, nutrients recycling and recovery is practicable and even obligatory in the long run. /33/. The struvite project of recovering phosphorus in Aarhus, Denmark is a good model of transforming sludge into a marketable product of high quality and competitive value /30/.

4.1.5 Legislations and international standards

EU Directive is a legal requirement of the European Union, which requires member states to meet a common goal /38/. ISO management system standards offer organisations models to follow when they intend to set up and operate a management system /39/. The difference between Water Directives and ISO management systems is the scales. EU Directive is implemented on a national scale, whereas ISO systems are on an organisation level that is voluntary in adaptation /39/.

4.1.5.1 EU Water Directives and national legislations

The Water Framework Directives is a EU directive that commits to member states in achieving good qualitative and quantitative status of all water bodies. Its approach is to prescribe steps and guidelines to reach the common goal. /40/. Its covered area is rather broad concerning water issues. Table 11 lists the most relevant directives of drinking water and wastewater.

TABLE 11. EU directives for drinking water and wastewater.

Drinking water	Wastewater
Drinking Water Directive (98/ 8/ EC)	Urban Wastewater Directive (91/271/EEC)
Groundwater Directive (2006/118/EC)	Sewage Sludge Directive (86/271/EEC)
	Integrated Pollution Prevention and Control (IPCC) Directive (96/61/EC) (2008/1/EC)
	Bathing Water Directive (76/160/EEC) (2006/7/EC)
	Nitrates Directive (91/676/EEC)
	Priority Substances Directive (2455/2001/EC)

The Drinking Water Directive 98/83/EC states that drinking water and water intended for human consumption should be free from any microorganisms, parasites and substances in large quantities or concentrations, which may constitute a potential harm to human health /18/. Although Legionella is not mentioned specifically, some EU countries have included this parameter in its national legislations (Table 12).

Two EU Water Directives concerning drinking and bathing water are related to *Legionella* in some EU countries. The difference in the significance and frequency of *legionella* outbreaks and governmental structures have led to different approaches towards combating *legionella* and *legionnaires*' disease by each Nordic country, via legislations, policies and standards. *Legionella* outbreaks are unusual in Finland based on the number of reported cases. The incidence occurred has been low compared to Europe in average. /33/. Yet, more attention is paid on the existence of *Legionella* spp. in work places as several outbreaks have happened in industrial water treatment plants and power plants /41/. Similarly, what drew the attention of and created an urge for Norwegian authority to establish *Legionella* preventive action, was the frequent incidents that took place in industrial facilities and public showers from 2001 to 2006, which involved a large number of victims and caused fatal outcome /42, 43, 44/. In Sweden, it is estimated that around 500 people are affected by Legionnaires disease annually and one out of ten dies from the disease. Most are classified as the vulnerable population, including elderlies, patients and smokers, etc. The lack of correct diagnosis and effective treatment has raised concern. /33/.

As far as legislations and policies are concerned, instead of launching a set of direct legislation on Legionella prevention, the Nordic countries have interpreted a few indirect legislations from Directive 2000/54/EC Biological Agents at work (Table 11). The most common piece of legislation related to legionella in water utilities would be Occupational Health and Safety legislation, which has been adopted by all Nordic countries. /33/.

In Denmark, OHS legislation seems to be the most relevant piece of legionella-related legislation until now /45/. Nevertheless, a report published by the EU was focused on measuring the risk of Legionella in various water systems, including hot water systems, bathing water and drinking water, etc. It underlined that hot water supplies has a high risk, especially when it is operated at too low temperatures condensation may occur. Moreover, other systems considered as high risk in water utilities include cooling towers, pre-mixing tanks for tempered water and the utilisation of high pressure cleaning with water containing Legionella or the flushing of biofilm surfaces. /46/. In terms of limit values of *Legionella* in water systems, Denmark only follows the guideline values provided by EWGLI, the European Working Group for Legionella Infections /33/. This means no specific limit values have been set for *Legionella* in hot water supplies. However, action plans and risk assessments of high risk systems are recommended in both present and new plants in order to prevent *Legionella* /33/.

In Finland and Sweden, the OHS legislation required operators working in biological wastewater treatment plants to wear protective equipment so as to avoid exposure to *legionella* bacteria. Several examinations in the wastewater systems of Finnish and Swedish forestry sector were carried out after a number of reported outbreaks. /33/. Research studies illustrated that it is not uncommon of active sludge basins in WWTPs being heavily contaminated with *Legionella*, the aeration basins in particular /47/. It also pointed out that the use of aerating basins can spread *Legionella* in aerosols in the atmosphere /48/. Furthermore, air samplings in Norway were done in the environs of active sludge basins and it was discovered that viable *Legionella* cells can be spread up to 180-270 metres downwind. This can indicate that any WWTPs installed with an active sludge basin underneath aeration tank can possibly consist of elevated concentrations of *Legionella* bacteria, as well as to produce aerosol with *Legionellae*. /47/. Also, cooling towers used to lower the temperature of wastewater in some WWTPs should be considered as a direct source of *Legionella* infection. Hence, the hygiene of wastewater cooling towers and also the area of sludge basins should be maintained in line with the European *Legionella* guidelines and local legislation. /33/.

Nordic countries are member states of EWGLI, and thus have to follow the guideline delivered by the group /33/. 'Treatment methods for different water systems' was one of the guidelines' chapters. The use of chlorine dioxide was included, along with heat practice and copper/silver ionization disinfection methods, for the preventing *Legionella* in hot water systems. /49/. This shows that the EWGLI guideline is acting as a sales driver for Oxiperm, the chlorine dioxide disinfection system, in WWTPs for *legionella* prevention.

TABLE 12. Legislations, policies and standards combating *legionella* in the Nordic region /33/.

	Legislation	Policies	Standards
Denmark	▪ Occupational health and safety Act ▪ Legislation on swimming pools	▪ EWGLI guideline levels of *legionella* in water systems	
Finland	▪ Occupational Safety and Health Act ▪ Finnish Building Codes	▪ Guidance on *legionella* in ventilation and water system	▪ ISO 11731 Water quality – detection and enumeration of *Legionella*
Norway	▪ Occupational health and safety Act (Arbeidsmiljøloven) ▪ Environmental Health Order, chapter 3 – Prevention of *Legionella* diseases transferred via aerosols (Kapittel 3a. Krav om å hinder spredning av Legionella via aerosol)	▪ Extended guideline on the prevention of Legionella diseases (by the Norwegian Institute of Public Health – Folkehelseinstituttet)	▪ ISO 11731-2:2008 Water quality - detection and enumeration of Legionella, part 2: Direct membrane filtration method for waters with low bacterial counts

	Legislation	Policies	Standards
Sweden	▪ Work Environment Act (1997:1160) ▪ Provisions (AFS 2005:1) on Microbiological Work Environment Risks ▪ Provisions (AFS 2009:2) on Design of the Workplace ▪ Building Regulations ▪ Boverket's Building Regulations Clauses 6:61 and 8:42 – water supply systems requirements ▪ Ordinance on Drinking Water requirement SLV FS 1989:30, H318 ▪ Environmental Code (1998:808) ▪ The Swedish Communicable Diseases Act	▪ EWGLI policies	▪ ISO 11731-2:2008 Water quality 'Vattenundersökningar – Bestämning av Legionella – Del 2: Membranfiltermetod för vatten med lågt antal bakterier (ISO 11731-2:2004)

Bathing Water Directives

Bathing water directive 2006/7/EC concerns the supervision of bathing water quality and has laid down provisions for the monitoring, classifying, managing and publishing regarding its quality. The reinforcement of this directive will drive the disinfection of wastewater discharge nearby coastal area and beaches where recreational activities take place, in order to meet the required parameters. /50/.

Urban Wastewater Treatment Directive

The Directive 91/271/EEC states that member states should have collecting and treatment systems for urban and some industrial waste waters. It gives rules on treated effluent from treatment plants. The overall objective is to protect the environment from human activities. /51/. Municipal wastewater quality refers to the condition of a mixture of waste water coming from domestic and industrial sources and runoff water, collected in populated areas. Biological treatment is required as minimal treatment. On top of that, additional treatment is required when discharging to more sensitive environments, such as coastal areas. /52/.

At present, the EU does not have specific regulations or guidelines dealing with water reuse 532/. Yet, Directive 91/271/EEC indirectly raises the issue in its objective, by stating that treated wastewater shall be reused whenever appropriate in order to minimise the negative impacts on the environment /54/. In the Nordic region, wastewater reuse has never been a serious concern due to the abundant water resources. However, different factors are causing a raising trend particularly in Sweden and Denmark. Groundwater is the major source of Danish water supply. Consequently, a sustainable management of groundwater quality and quantity is essential. In the 90’s, domestic grey water recycling was introduced and financially supported by the environmental authority, but it was nearly abandoned due to its infeasibility. /25/.

Sewage Sludge Directive

Sewage sludge is regulated by EU Directive 86/827/EEC, which encourages its utilization for agricultural purpose while usage is strictly regulated for soil and vegetation pollution prevention, as well as animals and human's health protection. This also means untreated sludge is prohibited on agricultural land. /55/.

The Landfill of Waste Directive

Wastewater sludge signifies a great potential energy source. One of the main drivers for treating sewage sludge is Directive 99/31/EC that requires 65% of organic matter to be diverted from landfill by 2020 /56/. In Sweden, policy stated that 60% as a minimum of the phosphorous in sewage should be recycled to productive land /57/. One of the most significant projects of Grundfos is the 'struvite' project in Aarhus, Denmark, which recovers more than half of the incoming phosphorous from wastewater /28/. The drivers for nutrients recovery means a potential for many more 'struvite' project to be done. Alternatively, Grundfos may consider collaborating with Kemira as they have a sludge conditioning technology named 'KemiCond'. This may diversify sales channel through Business-to-business corporations.

4.1.5.2 ISO management systems and EMAS

International Organisation for Standardisation, in short ISO, is a global developer of voluntary international standards. It offers diverse range of standards for management systems to improve organisation's efficiency, by specifying products, services and solutions. /39/. EMAS, the EU Eco-Management and Audit Scheme, is a management tool established by the European Commission for companies and organisations to evaluate, report and enhance their environmental performance /58/.

ISO 14001 - Environmental management standard

The standard provides organisation specific requirements for an environmental management system, to help them in developing and implementing environmental policies and objectives. The aim is to support environmental protection and prevention of pollution in balance of socio-economic needs. /59/. If applied in WUs, aspects concerning the reduction of effluent cost, energy savings and resources consumptions are to be prudently managed. In the sense of water treatment, Grundfos dosing pumps can assist in lowering plant energy consumption as a whole. Besides, the solutions of nutrients recovery and sludge utilisation minimise effluent discharge, which lessen the adverse impacts to the ecosystem.

ISO 18001 - Occupational health and safety management standard

The standard is based on a British standard, OHSAS 18000, for the sake of occupational safety. It offers organizations a standard and guidelines for establishing an occupational health and safety management system, with the ultimate goal to protect employers as well as employees. /60/. If a WU has implemented this specific standard, plant operators are guaranteed a work place which is free from legionella or that H_2S issues has been tackled to avoid adverse health effects from exposure.

ISO 11731 - Water quality standard: Detection and enumeration of *Legionella*

The standard provides methods for monitoring, isolating and enumerating Legionella in water intended for human use and consumption. The goal of this standard is to protect people from Legionella organisms. /61/. Water utilities show commitment to legionella prevention in its operation if this standard is implemented. This means it can be used by Grundfos to convince these potential water utility customers for installing chlorine dioxide system in the water treatment plant.

ISO 55000 - Asset management standard

The standard provides organisations specification and guidance for an integrated, effective and optimised management system of physical assets. It implicates almost the entire lifecycle of asset systems, from planning, asset selection, development, utilisation, maintenance to disposal or renewal of the asset. /62/. An efficient asset management can maximise value-for-money while satisfying investor’s expectation /37/.

In water utilities, this specific standard aid in managing water infrastructure throughout the whole transport, treatment and distribution system. In the Nordic countries, neglected pipes are the legal liability for municipalities or the water utilities /63/. In wastewater transport and collection system, pipelines can be gradually corroded by H_2S if it is not tackled by preventive or removal solutions. This would result in higher capital expenditure. For that reason, this standard is one of the drivers for combating H_2S in wastewater transport system.

EMAS

EMAS stands for Eco-Management and Audit Scheme. It is available for all kinds of organizations, to increase their environmental performance and thus to get recognition. EMAS demands an environmental management system that takes into account environmental objectives, targets and programmes of an organization. If a WU has adopted this scheme, auditing should be performed regularly by a certified party. /64/. This means energy auditing offered by Grundfos may enable business opportunities.

5 CUSTOMER SURVEY AND INTERVIEWS

Customer survey is a way to collect first-hand data in market research. It is presented as a questionnaire with a mixture of quantitative and qualitative research method. Quantitative method allows numerical data to be collected for statistical analysis in order to solve specific research problems. Whereas, qualitative method allows free answers that maybe consist of opinions, ideas and other unexpected info to be collected via open-ended questions.

To find out the current position of Grundfos's dosing and disinfection range in the Nordic water utility market, a questionnaire was designed with the help of Grundfos management and Senior Lecturer Puttonen from MAMK. It contains 16 key questions (25 questions, including the sub-questions) covering 6 main areas targeting Grundfos's D&D range:

- General perception of Grundfos being a water treatment specialist
- Products and applications
- Grundfos competitors
- Market demands and drivers
- Supply chain
- Environmental portfolio

To position Grundfos internally and externally in the Nordic water utility markets, the questionnaire was designed thoughtfully to answer the following questions: 1) What are the current and future roles of chemical dosing in Nordic water utilities? 2) Which disinfection technique is the most common and preferred alternative? 3) Who are the key players in the dosing and disinfection market? 4) What is the level of customer's satisfaction on Grundfos D&D product range and service performance, plus areas for improvements? 5) Where is Grundfos standing in terms of pricing competitiveness? 6) How parameters are prioritised in WUs' decision making on treatment methods and proposal offered? 7) What are the potential market needs that may enhance the 'green portfolio' of D&D in water utilities? Answers to these questions would aid Grundfos in benchmarking, value-adding and identifying opportunities in the Nordic market.

The customer questionnaire was written in two languages, English and Finnish. It was sent out to more than 400 customers via email contacts obtained from both utility company's websites and sales engineers. 19 Finnish and 3 Norwegian water utilities plus a distributor conducted the questionnaire from mid-March to early June, 2014. However, none were obtained by the Swedish WUs due to language barrier. Also, it was decided that a separate customer survey is to be carried out in Denmark by Grundfos. Yet, answers from this particular survey will be kept partially confidential due to business secret protection. Along with this survey, information collected from customer visits and interviews during the practical training of the author is also taken into consideration.

The questionnaire is shown in Appendix 1, while the schedule and data of the customer survey can be found in Appendix 2.

6 RESULTS

All forms of answers collected have been structurally organised using tables by EXCEL and Word, and data is partially analysed using specific tools from EXCEL. The result is shown in Appendix 3.

In terms of response, a total of 23 answers were collected in which 22 are electronic and 1 is paper form. The map below illustrates the locations where the answers were collected in the Nordic countries.

MAP 13. Locations of the WU(s) who have conducted the questionnaire (N=22)
Green dots: DWTPs Brown dots: WWTPs Orange: Mixed plants.

Majority of the respondents were Finnish water utilities. 55% and 41% of the WUs responders are DWTPs and WWTPs respectively, and 4% are mixed plants. A distributor respondent Christian Berner Oy, is also included in the survey. Among all respondents, Turun Seudun Puhdistamo Oy located in Turku, is the largest among WW plants with capacity of 120000m^3/d. On the contrary, Itä-Savon Vesi Oy is the smallest DW plant with capacity of about 600m^3/d.

Grundfos is well-known as a water treatment specialist

One of the interesting findings is that on top of being a full-line pump manufacturer, Grundfos is known as a water treatment specialist by all interviewed WUs. Grundfos pumps are installed throughout the DW and WW treatment systems of some plants, from water intake to transport wastewater.

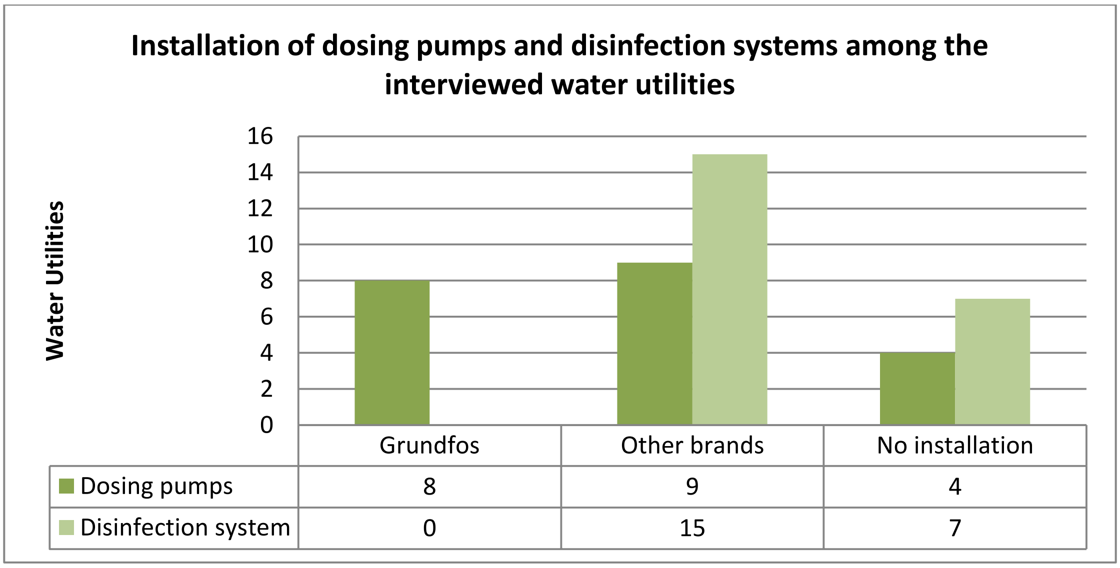

FIGURE 14. Number of dosing pump and disinfection system installation among the interviewed water utilities.

Customer contacts for executing the questionnaire were obtained from different sources, such as Grundfos sales engineers, water utilities' webpages and the thesis supervisor. Those contacted via sales engineers are Grundfos current customers, who obviously have installed Grundfos dosing pumps. However, the rest are either competitor's customers or have no D&D installation in their treatment plants.

It can be seen that Grundfos's chlorination disinfection system has a relatively weak position in the Nordic water utility market. No installation is noted from this specific survey, neither Grundfos current customers nor other water utilities. Possible reasons behind this may include: 1) the lack of technical competence of local sales teams towards chlorination, leading to the 'play-safe' and passive retailing attitude 2) narrow sales channel 3) low marketing profile of Grundfos disinfection systems limits sales opportunities 4) the trend of adopting chemical-free process for health and safety and cost effectiveness reasons. OPEX, operating cost may be lowered when chemicals is not required.

The purposes for chemical dosing varied among DWTPs and WWTPs. However, chemical dosing in WUs is mainly used in the processes of flocculation, coagulation, pH adjustment, precipitation and drinking water disinfection. Distributor included in the figure below is referring to Christian Berner Oy in Finland and their data represents their customer's dosing purposes.

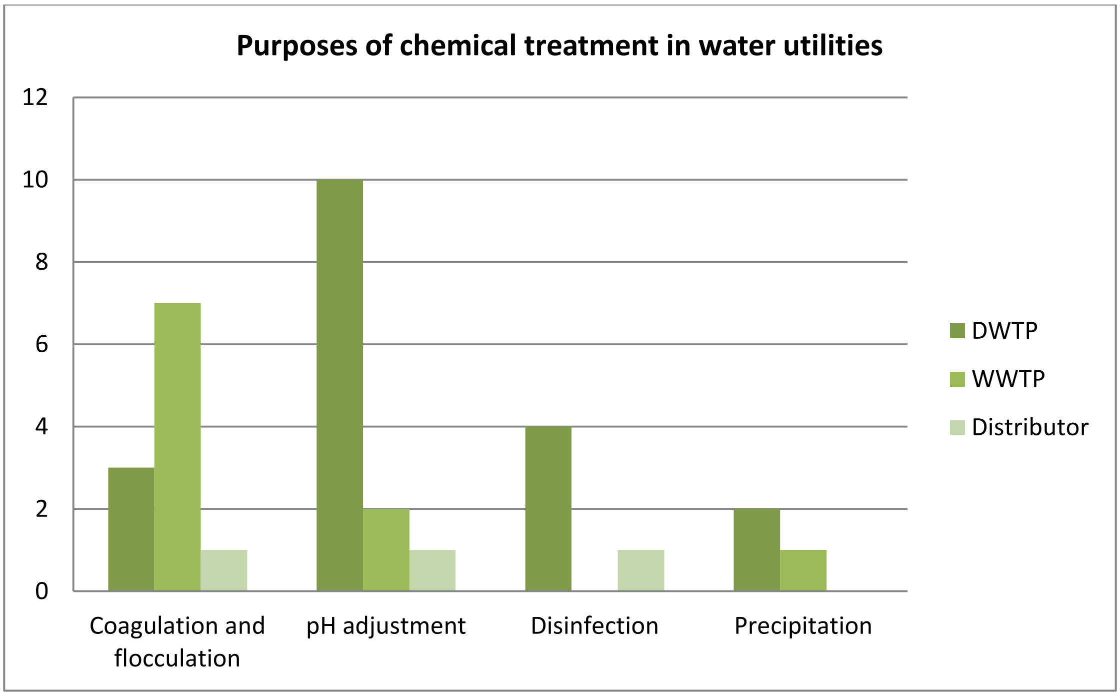

FIGURE 15. Purposes of dosing in Nordic water utilities.

Dosing of sodium hypochlorite for disinfection primarily happens in Finnish DWTPs. The demand for disinfecting wastewater may rise if the Bathing Water Directives is going to tighten wastewater discharge parameters nearby bathing water areas, such as coastal beaches. (Appendix 1).

In terms of disinfection, UV is currently dominated among all interviewed WUs, followed by chlorine dioxide and Ozone. However, chlorine gas and electro-chlorination are not used by any of these plants due to their disinfection ineffectiveness and low depot time compared to chlorine dioxide.

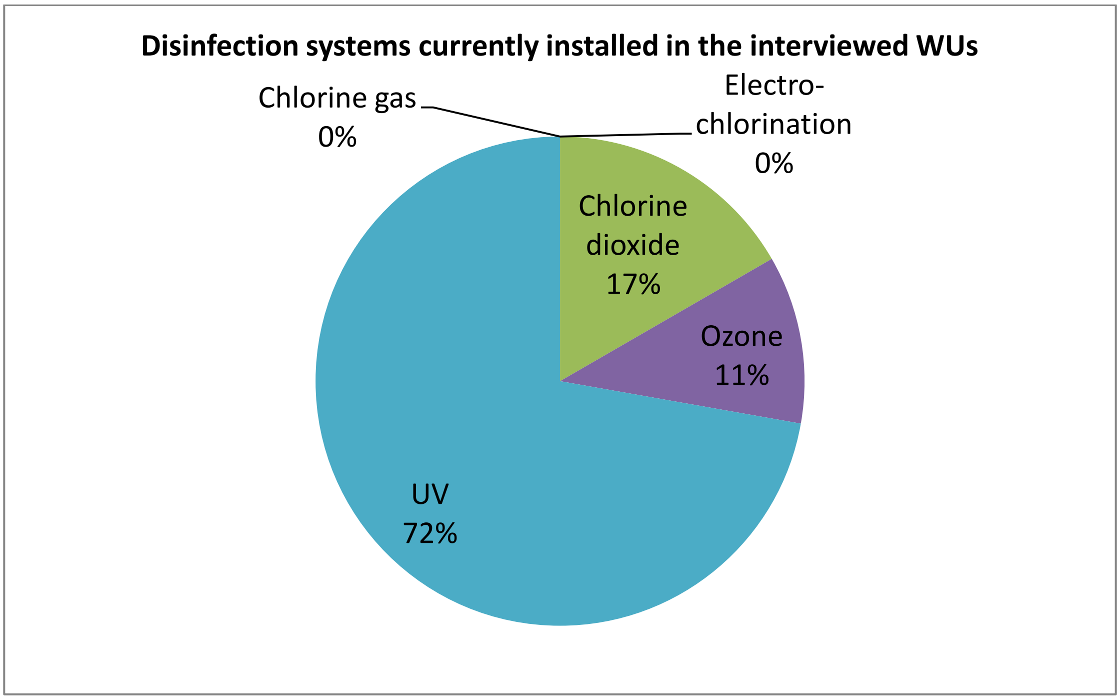

FIGURE 16. Current disinfection systems installed in interviewed water utilities.

Chlorine dioxide is the only chemical disinfectant used in these Finnish WUs. It has a higher disinfection property and its retention effect can last for days, compared to chlorine gas, electro-chlorination and ozone which can only last for hours. Moreover, ozone is the most effective disinfectant among all techniques, despite its high investment cost and its necessity to be removed from drinking water.

No monopoly player is observed in the D&D market. Among all the installed disinfection systems, Wedeco, a Xylem’s brand, is somewhat the most active in the given market, particular their UV disinfection system. Whereas, Prominent and Grundfos are equally dominated in the dosing pump market, which means Prominent is our biggest competitor in dosing installations. (Appendix 1)

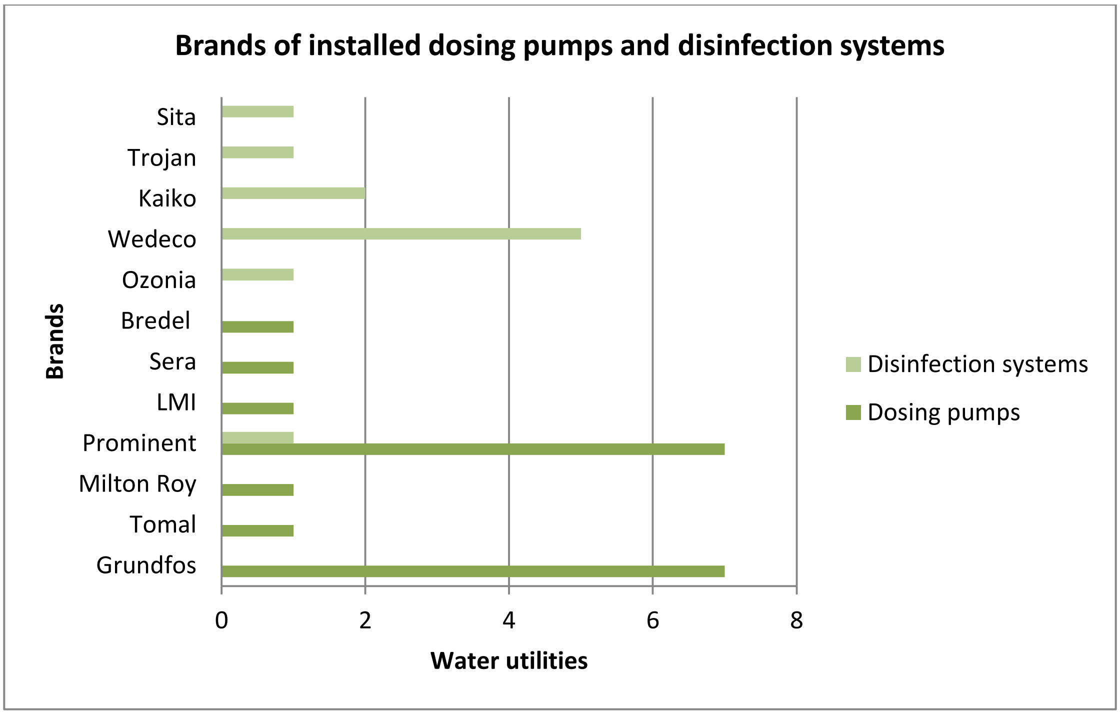

FIGURE 17. Brands' shares of installed dosing pumps and disinfection systems.

Knowing how different factors are valued by WUs in treatment method selection can aid Grundfos in designing value-creation strategy for utility customers. It can be seen that health and safety, efficiency and sustainability are considered as the most important aspects by Nordic WUs, suggesting that it is worthy to work on their arguments, evidence and success cases in sales presentations. Examples would be legionella prevention using chlorine dioxide; overall plant optimisation based on pump efficiency and functionality; resources recovery, etc.

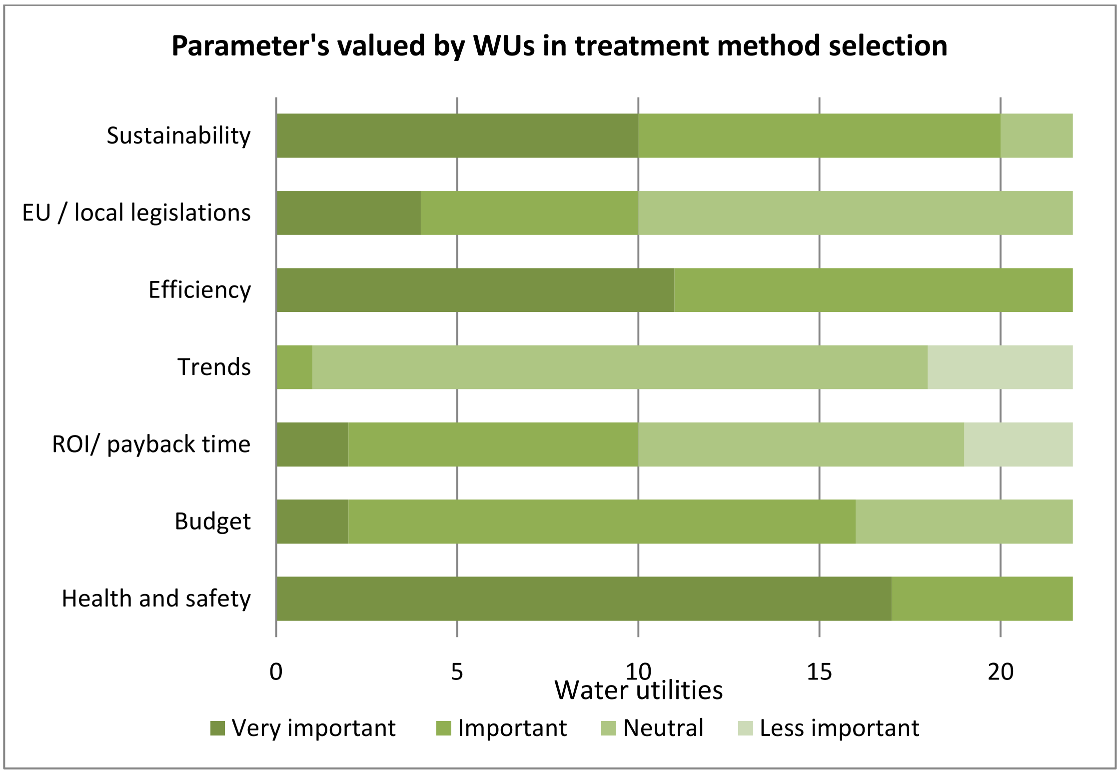

FIGURE 18. Parameters valued by water utilities in treatment method selection.

Other important parameters include the compliance of the EU legislation and financial aspects, such as budgeting, payback time and return of investment. The compliance of EU and local legislation urges the need of auditing which may open up more opportunities. Energy auditing is a good example. Trends are considered as a neutral or less important parameter for most utilities. Still, understanding the general preference may aid developing of product and service varieties in the given market.

Knowing how different factors are valued by water utilities can aid Grundfos in proposing high quality quotations. Sales teams can prioritise focused areas when preparing quotations, which may increase the chance of winning quotations against competitors. Nevertheless, the scale of this survey is fairly narrow given that the data does not represent all Nordic WUs. Thus, the result shown is only a reference. Likewise, every sale is unique in terms of customers need, solution and scale, and a comprehensive evaluation must be executed by sales engineers in advance. As shown in table 19, disinfection effectiveness and product functionality are the common priorities, followed by dosing accuracy by DWTPs, and product quality by WWTPs.

TABLE 19. Factors prioritisation of water utilities in selecting quotation (The highest and lowest numbers are abstracted for a trimmed mean, as outliers can affect the average significantly).

1 = 1st priority, 12 = last priority				
	DWTPs		**WWTPs**	
	Priority average subtract the lowest and highest values	Priority	Priority average subtract the lowest and highest values	Priority
Disinfection effectiveness	1.33	1	1.25	3
Product functionality	1.57	2	1.25	2
Dosing accuracy	2.00	3	3.25	12
Product quality	2.00	4	1.00	1
OPEX	2.17	5	3.00	11
After service and warranty period	2.57	6	2.25	7
CAPEX	3.17	7	2.75	9
Intelligent solutions	3.50	8	2.25	5
Brand reliability	3.57	9	2.00	4
User friendly process	3.67	10	2.50	6
Delivery time	5.29	11	3.00	10
System designing	7.00	12	2.67	8

Disinfection effectiveness is one of the main common priorities for WUs, predominantly for DWTPs. It guarantees health and safety of water supply and delivery to consumers as well as a safe work place for plant operators, by limiting biological outbreaks. Effectiveness also means achieving goals with the least resources and time. Hence, Oxiperm, the chlorine dioxide system might suit the Nordic market the most, based on its long depot time and low investment cost. Above and beyond, product functionality is also a main common priority. It refers to the features and solutions of dosing pumps and systems, which customers can pick up merely by hands-on experience. Showing customers a demo pump may also enrich the appreciation of its sophisticated design.

Dosing accuracy is the 3rd factor that concerns DWTPs the most. Overdosing can potentially increase OPEX spending when chemical consumption needlessly increases. For that reason, it is essential to emphases and explain to the customers that dosing is system based and is adjusted by the process automatically.

Intelligent solution is highly valued by WWTPs. Utilities appreciate convenience from automation and proficiency from environmentally sound solutions, making worry-free processes and sustainable solutions more demanding than ever. By solution selling, more sales of other equipment and accessories may be activated which in return increases market share.

Brand reliability increases customer’s confidence. The special market situation of no competition allows collaboration and knowledge sharing among utility companies. In solution-based projects with first-hand practice, in which ‘The Struvite project – phosphorus recovery’ is a good example. Grundfos nailed it with the ‘word-of-mouth’ effect to increase potential customers’ confidence, by connecting them to the existing customers in meetings. This not just brings a domino effect for growing trustworthiness but also allows continuous improvements to take place.

Delivery time plays a critical role in system operation. Without right equipment the whole system may paralyse and water quality may deteriorate. It is calculated that the ideal delivery time for replacement and new installation to be less than 6 days and 16 days respectively.

TABLE 20. Ideal delivery time for pump replacement and new installation.

	Replacement	New installation
Ideal delivery time (days)	5.8	16.4

However, this may be restricted by Grundfos stocking policy, which stock must be kept low in local storage. Alternative solutions may be offering customer temporary rental service or that local offices renting private storage for stocking, to avoid the loss of customers.

Utility plant operators often have a high degree of technical proficiencies. Yet, the skills may differ amongst system designing, installation and service. Installation skill is shown to be the highest and service skill to be the lowest. In reality, most WUs often rely on consultant for system designing, and original equipment manufacturer (OEM) or chemical manufacturer for servicing.

TABLE 21. Competences of plant operators.

Skills	System designing	Installation	Service
Yes	9	11	9
No	9	7	8
Total plant no.	18	18	17

A service out-sourced example would be the Turku WWTPs - Turun seudun puhdistamo Oy, the 2nd largest Finnish WWTPs, is relying on Kemira for servicing. Inspection and maintenance of the dosing system is performed once every 3 months approximately. Besides, Kemira is also the most preferred chemical provider in the Nordic region.

PICTURE 22. Dosing skid/system in Turku WWTP. (Photo taken during a customer visit).

PICTURE 23. dosing skid system with the chemical tank containing iron sulfate. (Photo taken during a customer visit).

UV disinfection is the most preferred alternative to chlorination by Nordic WUs, followed by ozone. It is an effective disinfectant that is user-friendly, easy to maintain and with reliable dispensing. Compared to chlorination, UV process is also safer in handling and thus no personal protective gear is needed.

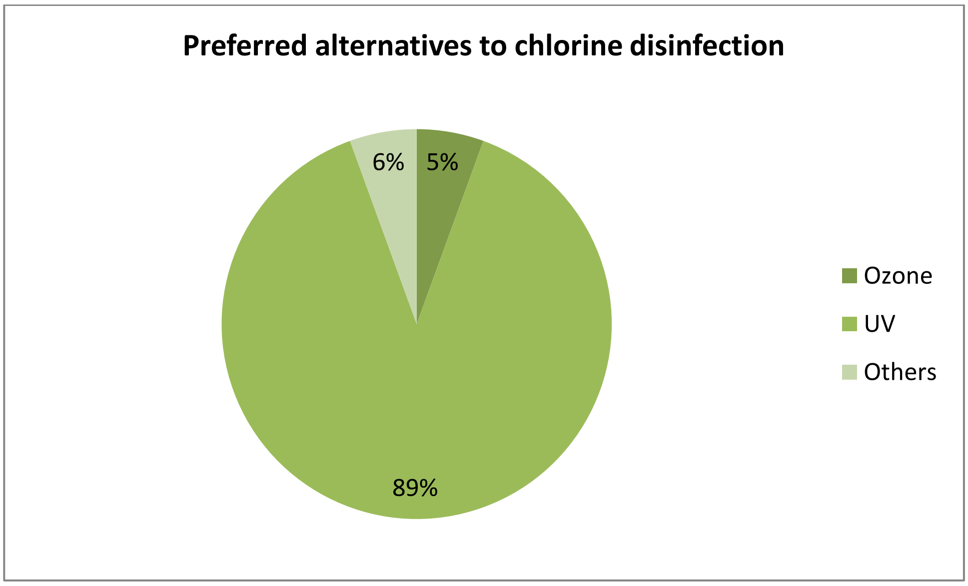

FIGURE 24. Preferred alternatives to chlorination in water utilities. (n=17)

Moreover, chemical-free means no by-products are produced during the deductive disinfection process, therefore the characteristic of drinking water, such as taste and smell is not altered. Drinking water quality is hence lifted at a lower cost. If UV system is included in Grundfos disinfection range, market share in the Nordic will surely be amplified.

Odour problem is often an issue in WWTPs. It is often linked to the formation of hydrogen sulfide in sewage transport system. The unpleasant smell not just reduces work efficiency and also the worker's health. This is why tackling it is crucial.

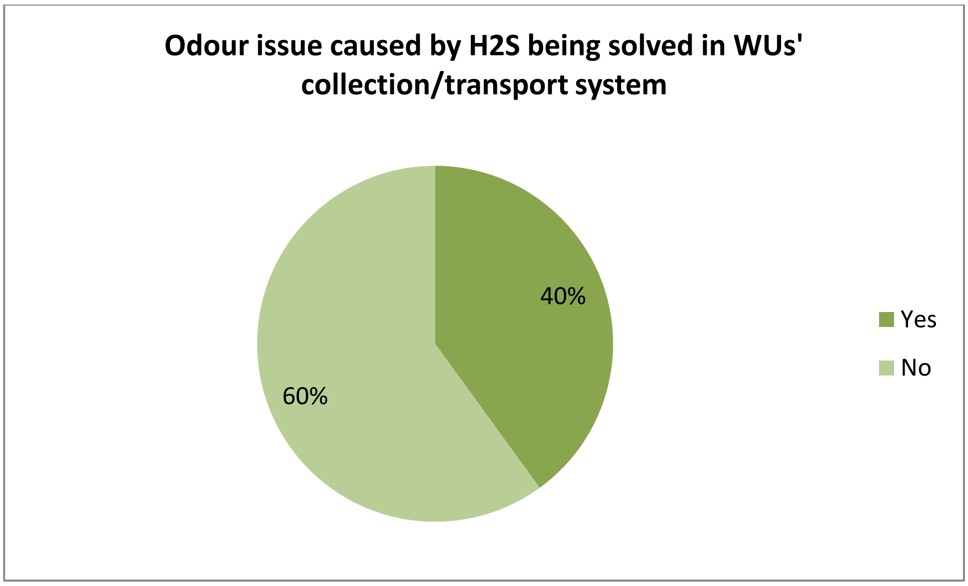

FIGURE 25. Hydrogen sulfide combating installations in water utilities. (n=10)

Hydrogen Sulfide, H_2S is a colourless, flammable and extremely hazardous gas with a rotten egg smell. It is usually produced by bacteria during degradation of organic materials, e.g. in wastewater sewage. /65/. Numerous problems can be initiated by H_2S, for instance, odour, hazardous working environment and pipeline corrosion /66/.

Without control, the obnoxious odours escaped from sewers can deteriorate the surroundings and its economic value. Besides, health risks may pose to collection system operators depending on the level and duration of H_2S exposure. Level exceeds 100 ppm is Immediately Dangerous to Life and Health, IDLH in short /66/. Health effects including the irritation of eye, skin and respiratory system, headache, nausea, damage to central nervous system can occur, or be fatal in the worst case. Moreover, H_2S may deteriorate the structural integrity of sewer infrastructure by corroding the pipelines, concrete, metal and electrical installations, which can cause huge economic damage. Also, corrosion problem remains regardless of H_2S peak levels. /66/.

To regulate the problem, local regulations and some international standards are intended to motivate utilities in combating H_2S problems.

- BS EN 752 Drain and Sewer Systems Outside Buildings
- EN/ ISO 18000 Occupational Health and Safety Management Standard
- EN/ ISO 55000 Asset Management Standard

Figure 25 illustrates that 40% of the interviewed Nordic WUs have combated odour issue caused by H_2S in the collection and transportation systems, by four different methods:

1) Installation of drain-waste-vent system in the buildings affected, along with dosing of oxygen and ozone in transport systems and at pumping stations respectively.
2) Dosing of nitrate
3) Dosing of iron
4) Using active carbon filter

Methods 1) and 2) are adopted by WWTPs and 3) and 4) are adopted by DWTPs.

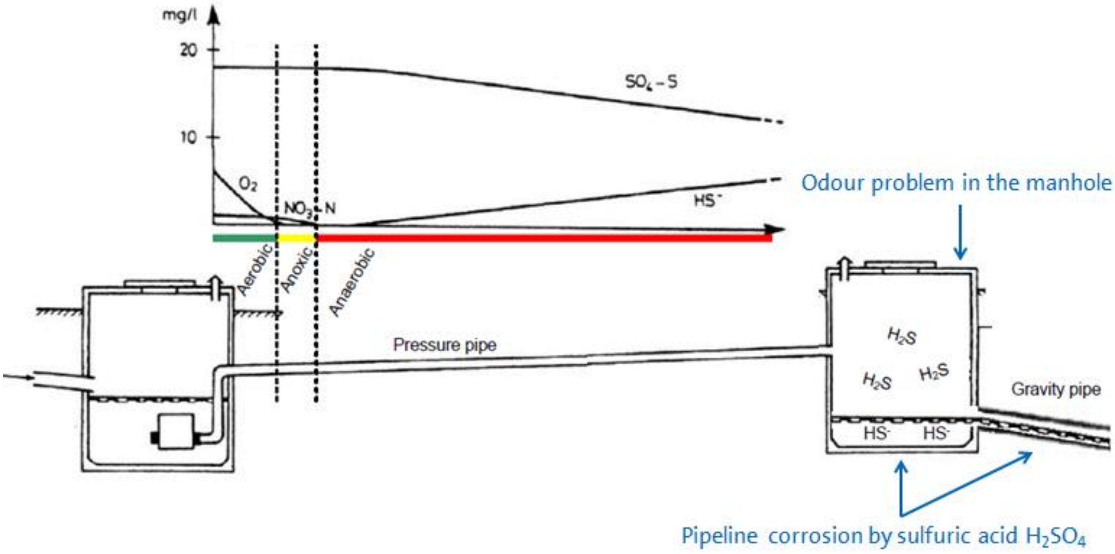

FIGURE 26. Formation stages of H_2S in sewage collection system /67/.

Figure above illustrates the three stages of reaction conditions within the wastewater pipeline. Principally, the shorter the anaerobic process, the less H_2S is being produced. There are two solutions available in terms of dosing, which are prevention and removal. Dosing of nitrate can prevent H_2S formation by shortening the anaerobic process, whereas, dosing of iron or magnesium can remove H_2S formed in the system. /67/.

Aerobic:	$Organic\ matter + O_2 \rightarrow CO_2 + H_2O + cell\ mass$	
	Denitrification:	Solutions:
Anoxic:	$Organic\ matter + NO_3 \rightarrow CO_2 + N_2 + cell\ mass$	= prevention
Anaerobic:	$Organic\ matter + SO_4 \rightarrow CO_2 + H_2S + cell\ mass$	= removal

Dosing of **iron**: $Fe + H_2S \rightarrow FeS$

Dosing of **magnesium**: $Mg + H_2S \rightarrow MgS$ /67/.

Dosing of iron or magnesium gives the same result. H_2S is trapped in the crystal formed sulphide in which odour is eliminated simultaneously. However, cost efficiency might be a concerned factor when dosing magnesium as prices vary in different countries. /67/.

TABLE 27. Customer's perception on plant optimisation possibilities - based on plant numbers.

Plant optimisation possibilities	**Energy production + selling it to electricity grid**		**Heat production + selling it to consumers**		**Recovery of phosphorus and nitrogen as fertilizer**		**Reuse of Ammonium**	
	FI	NO	FI	NO	FI	NO	FI	NO
Very high			1		1		1	
High		1	1	1		1		
Average			1		4		1	
Low	2	1	1	1			1	1
Very low	7		5		4	1	4	1
FI = Finland, NO = Norway								

By aiding in recovery processes, chemical dosing and disinfection play a critical role in plant optimization which is essential for sustainable development. To create a 'green' portfolio for D&D, four prospects have been chosen for evaluation, including energy and heat productions, recovery and reuse of resources.

Results illustrate that the potential of energy and heat production, plus its trading to electricity grid and consumers are moderately low in Finnish WWTPs. However, some say the potential in heat production is somewhat higher. In Norwegian WWTPs, some say there is a potential in energy and heat production, as well as phosphorus and nitrogen recovery. Yet, the level of potential is indistinct.

The table above is based on customer's perception, which can be used as an inspiration for future business opportunities in the Nordic countries. However, it may be limited by different factors such as plant capacity, serve distance and local infrastructure, etc. In my opinion, customer's perception is influenced by current practice and available technology. Therefore, it would be convincing enough to open up a new market if the biggest plants would take the lead.

Life cycle of dosing pumps and disinfection systems

In Grundfos Finland, the recycling of dosing pumps and disinfection system is either handled by local private companies or by service from the premises rental agreement. It is a business for both parties depending on the value of the recycled materials. However, used pumps from distributor's customers are disposed directly to the landfill due to the lack of environmental awareness and economic feasibility.

To improve the pumps' life-cycle and to diverse business areas, it may be worthy to cooperate with chemical manufacturer and local recycling companies. As harshness of chemical dosed determines the life span of a dosing pump, inventing milder chemicals or solutions with chemical manufacturer might be an alternative solution.

7 DISCUSSION AND CONCLUSION OF THE SURVEY

Table 28 shows the estimated market size of disinfection and chemical feed system in Nordic water utilities and industries from 2014 to 2018. Numbers illustrated are the average market size of the next 5 years from now. Disinfection refers to all available technologies such as chlorination, ozone, UV, membrane, etc. Whereas, chemical feed system refers to all dosing applications in the treatment processes.

TABLE 28. Estimated market size of disinfection and chemical feed system in utilities and industries in 2014-2018 /68/.

(€ million)	Disinfection	Chemical feed system
Denmark	14.11	9.41
Norway	8.67	7.09
Sweden	6.83	5.61
Finland	7.8	5.54

According to Grundfos Business Development Manager, Per Krøyer Kristensen, Denmark is passive towards the use of chlorine disinfection, Although Denmark has the highest estimated market size in disinfection, chlorination is forbidden in municipal drinking water treatment. However, with the intention for legionella prevention, chlorine dioxide in the water treatment facilities can be accepted, in order to enable compliance with occupational health and safety legislation. This also means majority of the chlorine disinfection potential lay in the industrial sector or municipal wastewater treatment.

TABLE 29. Chlorine disinfection in municipal drinking water treatment. (Personal note obtained during the internship)

Countries	Dosing of hypochlorite	Chlorine gas	Eletro-chlorination (Sodium Hypochlorite)	Chlorine dioxide
Denmark	✗	✗	✗	✗
Finland	✓	✓	✓	✓
Sweden	✓	✓	✓	✓
Norway	✓	✓	✓	✓
✓ = allowed, ✗ = forbidden				

The results of this customer survey only represent part of the Nordic water utilities, with a major focus on Finnish WUs along with a few Norwegian WUs. Due to the limited time and resources, Swedish WUs are left out and a market survey of Danish WUs is conducted independently by Grundfos but the result is kept confidential. Moreover, the survey was distributed to customers via a moderately narrow channel, including the contacts obtained from sales engineers, a university professor and utilities' websites. The uneven ratio of current and potential customers may accomplish a result that is not objective enough to deliver a rational conclusion. 36% of the respondents are current customers of Grundfos, and 64% are potential customers.

It is shown by the survey that Grundfos is well-known as a water treatment specialist, on top of being a full-line pump supplier in the Nordic utility industry. All interviewees either have heard of or have had business relationship with Grundfos. Products wise, dosing pumps have a stronger position in the Nordic market than the chlorine disinfection systems, in terms of popularity and acceptance. Yet, some prefer to have a higher capacity of the small dosing pumps, such as Smart Digital. The fact that no installation of chlorine disinfection systems among the interviewed WUs may due to the limited survey targets and lack of technical competence of sales team or backup support from Grundfos management. An in-depth study is therefore needed, along with a set of comprehensive training on products and applications for sales engineers. Competition wise, market players such asWedeco and Kaiko are rather active in the market with their UV systems, while Prominent is the biggest competitor for dosing pumps. In terms of disinfection method, UV is the most common and preferred disinfection system among the Nordic WUs. For that reason, UV system should be made available in Grundfos's D&D range to increase competitiveness and hence market share.

In terms of applications, dosing in DWTPs is mainly for pH adjustment and disinfection, whereas in WWTPs it is mainly for coagulation and flocculation. The needs for D&D may increase as the demand for sustainable solutions upsurge when plants need to be optimised. This may bring tremendous opportunities to chemical dosing and disinfection, such as resource recovery.

For a better supply chain management, the ideal delivery time Nordic WUs customers expect it to be no more than 6 and 16 days for pump replacement and new installation respectively.

Internal technical competences wise, designing, installation and service skills need to be boosted in order to compensate the shortcomings of plant operators. It is also possible to corporate with the preferred partners of WUs, such as local consultants, distributors, installer and chemical manufacturer. Kemira is the most preferred chemical manufacturer so far.

Tackling H_2S issues in the wastewater transport and collection systems is one of the hot topics in the WU sector. 60% of the interviewed WWTPs have not yet combated H_2S. The market is massive and is gradually driven by several EU legislations and international standards, for instance, regulations regarding drain and sewer systems outside buildings, occupational health and safety, as well as asset management.

One of the main roles D&D plays in the sustainable development of WUs is by aiding in plant optimization. Possibilities for plan optimisation include electricity and heat production, recovery of phosphorus and nitrogen as fertilizer and reuse of ammonium. Resources recovery is relatively high among all. However, the estimation of potential is neither easy nor reliable if purely relying on customer's feedback, and that numerous factors need to be taken into account, such as plant capacity, local infrastructure for electricity and heat grid. And so, in-depth studies are obligatory to evaluate the economic and social feasibility of these possibilities.

8 RECOMMENDATIONS

A number of recommendations are listed based on the current situation in Nordic WUs and the result obtained from the customer survey. They can be used as an inspiration or a reference for Grundfos to improve its dosing and disinfection position in the given market. Recommendations contain both facts and personal opinions acquired from this comprehensive research. Thus, they are discretionary in one's decision making.

8.1 SWOT analysis of current situation

Two SWOT analyses are conducted to evaluate the current situation of D&D in the Nordic region and Grundfos position. The first one is focused on external aspects, while the second one is focused on internal aspects. Both analyses are by some means coherent to each other. Traditionally, 'strengths and weaknesses' are used for evaluating internal factors of an organisation, whereas 'opportunities and threats' are used for evaluating external factors, in a single SWOT analysis. Yet, two separate SWOTs are conducted in this thesis research for the convenience of excluding some confidential comments. A more comprehensive internal SWOT analysis is left out in this thesis version for the sake of business secrets protection.

The Nordic region has shown a conspicuous progress in sustainable development, by reforming public sectors consistent with a vision and value of environmental and economic sustainability. Although innovation is promoted via legislations and standards to create new markets, it is not just about technology but also about creating new co-operation models amongst the public and private sectors. In the case of water utilities, sophisticated WWTPs have been built via varied cooperation. Along with EU legislation, incentives driving the up-to-date technology in WUs include reducing odour, utilising sludge as energy and optimising plant to be zero-energy consuming or energy productive, in which the last one is fairly ambitious.

There is a ‘not-invented-here’ syndrome in the Nordic, which gives pride to Nordic innovation. This offer Grundfos D&D a decent position of using Nordic countries as a globe test markets. It is down to the small scale operation as well as the long tradition of collaboration between municipalities and private companies, which WUs are not an exception. For instance, cooperation often happened among Danish WUs when new solutions are developed for WWTPs.

TABLE 30. SWOT analysis based on external factors - the relation between the characteristics of Nordic water utilities and D&D potential for water treatment. Modified according to /32/.

Strengths	Weaknesses
• Visions and values in sustainable development • Promoting innovation via legislation • Global test markets • High level of knowledge in chemicals	• Lack of collaboration among utility companies • Public bodies are rewarded for stable operations, not innovation • Many small scaled water utilities
Opportunities	**Threats**
• Up-to-date technologies enables improvements • Pride in Nordic innovations • Differ in treatment levels among countries • Raising in energy price	• High cost • Safety conscious world • Growing trend of chemical-free treatment methods

One of the interesting findings is that Nordic public utilities are often rewarded for stable operations, not innovation. The ‘play it safe’ or ‘zero failure’ culture makes public institutes more focused on operational practice than maybe opposing to innovation. This explains the low incentives and passive attitude of utilities in adopting new technology. /32/. As shown in the comments, operator's satisfaction is depending on the adequacy of dosing pumps and systems. A lack of initiative is shown on demanding new and risky technologies. On the other hand, the 'play safe' culture forces public institutions to choose external partners who are capable in offering stability, which benefits experienced firms like Grundfos. This means product quality, system constancy and technical competences play a vital role.

High safety consciousness and the hype of chemical-free disinfection may not be a total threat to Grundfos D&D. In contrast, it stimulates the needs in new treatment methods and collaboration with high-tech firms such as Kemira.

Evaluation of internal management structure enables identification of pain-points. It allows continuous improvement of market position against competitors. To analyse Grundfos D&D performance in the given market, several aspects have to be taken into account, which include marketing and sales strategies, human resources management and organisation enablers.

TABLE 31. SWOT analysis based on internal factors - Grundfos internal structure and D&D sales performance in Nordic water utilities.

Strengths	**Weaknesses**
• High quality products • Good will • Global organisation with rich human resources and financial backup • Strong backup team - GWTS	• Missing of UV systems and larger capacity Smart Digital dosing pumps
Opportunities	**Threats**
• Easy to give practical support by top management within the Nordic region • Collaboration within Nordic cluster	• Pricing competition

8.2 Recommendations

A holistic set of business strategy is essential for a fruitful business to give its products or services a competitive position in the market. Businesses of D&D in WUs are not an exception. A comprehensive strategy package should take marketing, sales and organisational enablers into account.

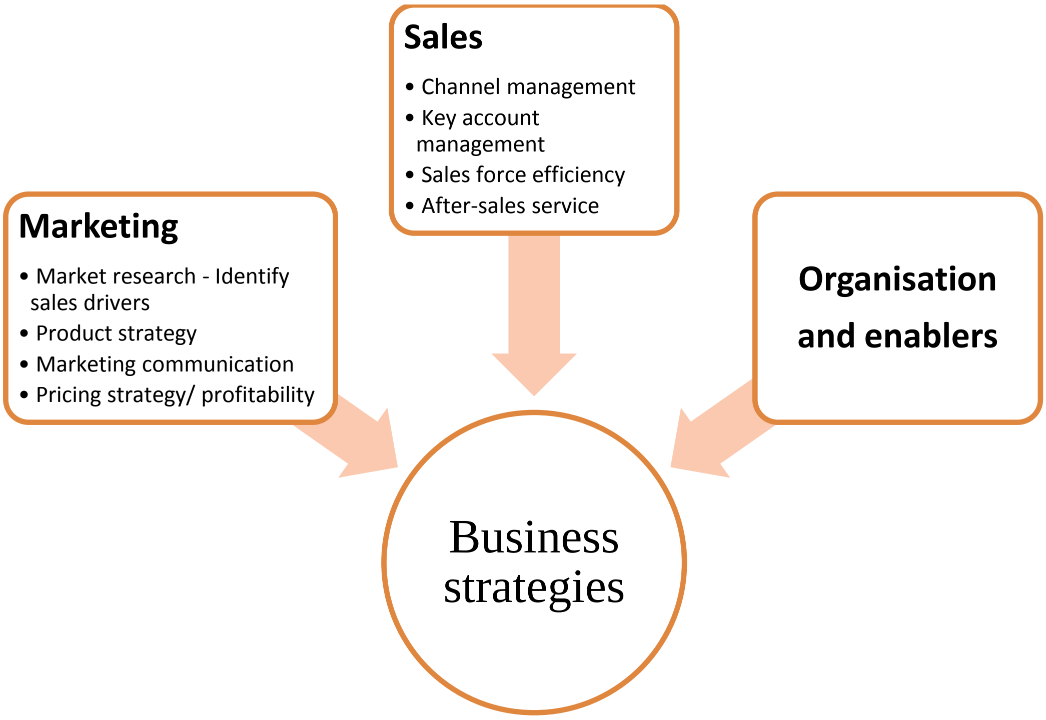

FIGURE 32. A business strategy model that may enhance D&D capabilities. (Personal note obtained during the internship)

Strengthen the internal Nordic network

It is advisable to build up a strong internal Nordic network for D&D, by organizing regular cluster meetings. This not just enhances communication between local sales teams and top management, but also allows sharing of experience and setting of common goals for continuous improvements. To some extent, this helps to build up a stronger backup team which may enhance technical competences overall.

Invest in human resource

By recruiting more D&D dedicated sales, technical and service engineers in the local sales company, D&D business will be more focused by a clearer and structured management. This should be achieved by appointing at least one person for each segment, preferably two (one for dosing, and the other for disinfection) to avoid crossed segment responsibilities that may possibly cause internal competition and conflicts.

Enrich technical competences

Experience is what it takes to be a specialist along with knowledge. 'Trainer to trainer' is a practical and effective approach, which simultaneously offers a platform for knowledge sharing that reinforces the local team. It is predominantly needed in chlorination systems down to its inactivated position in the Nordic market.

Above and beyond, the following training should also be deliberated to enrich technical capabilities of sales engineers:

- Water treatment system
- Product and solutions concepts
- Chemical applications / chlorine disinfection and handling
- System designing and building
- Service

Diversify sales channels

Diversifying sales channels by project sales can increase direct contact with end-users that gives a better understanding of the local market characteristics and perceptions. Similarly, service training allows market extension but also provides inspirations for continuous improvements on both products and solutions.

Strengthened corporation with local consultants, distributors and chemical manufacturer will create a win-win situation for both parties, in enhancing technical competences, increasing brand awareness and gaining market share, etc. For instance, Kemira is one of the biggest chemical suppliers in the Nordic region. In disinfection business, DesinFix is one of their ultimate technologies in wastewater disinfection that leaves no toxic by-products. It is based on a highly effective biocide DEX-135 formed from the accurate mixing of formic acid and hydrogen peroxide. This biocide has performic acid as the active substance, which can create hydroxyl radicals to kill bacteria when decomposing. The whole process only takes a few minutes to complete and no toxic by-products are form, as DEX-135 is broken down into carbon dioxide and water. /69/. The thought-provoking thing is that the mixing unit is a standardised skid that contains dosing pumps which can be provided by Grundfos via collaboration. Besides, this by-product free technology can be an alternative for chlorination or other chemical dosing that may form by-products.

Diversify D&D range

Survey conducted indicates that UV is perceived to be the most popular disinfection alternative against chlorine disinfection. Also, feedback from customers stated that the availability in dosing pumps capacity is somewhat limited. Therefore, extending D&D range by having UV system and larger capacity dosing pumps may attract more utilities, which ultimately enhances Grundfos position in the Nordic market.

Price management

Altering pricing strategies or launching sales campaign may attract buyers' attention on Grundfos D&D range but also can indicate local price sensitivity. Benefits of right pricing strategies include:

- Increasing willingness and confidence in introducing customers of Grundfos D&D range
- Attracting customers' attention when prices are comparable
- Increasing the awareness of Grundfos being a water treatment full-line supplier
- Opening up inactive markets with huge hidden potential

Obtain all approvals needed

Sales will only be permitted when all relevant approvals are obtained. They are mostly referring to the health and safety issues of chlorine disinfection systems. The act of obtaining approvals is rather important and urgent, in order to avoid losing market share.

Evaluate the market on a regular basis

Key Performance Indicator, in short KPI, is a kind of performance measurement that is used to evaluate the success of a specific activity a company is engaged in /70/. Regular evaluation would give an insight and update of the current market plus own performance. This may aid in continuous improvements by identifying new challenges and pointing out weaknesses.

Reference list

A reference list with existing installations should be produced and updated on a frequent basis, for both internal and external purposes. It can be used for inspiration as well as a tool for convincing customers. However, permission maybe needed from relevant customers.

9 CONCLUSION

‘Älä mene merta edemmäs kalaan’

- Don’t go fishing further than the sea. (Finnish quote) /71/.

= Only do what is necessary and focus on the opportunities ahead

Nothing is perfect on Earth. Every available water treatment technology has its ‘pros’ and ‘cons’. Despite the impacts on health, chemical dosing is able to offer plentiful innovative solutions in water treatment, which aid in solving some of the world’s most challenging environmental and social problems today. If utilised appropriately and efficiently, its benefits would certainly outweigh its drawbacks. In the end, what matters most is the know-how.

Grundfos is positioned well in the Nordic water utility market in terms of products. The high quality and sophisticated design of digital dosing pumps gained appreciation and compliments from most users. Yet, like everything else there is always room for continuous improvements. For instance, upgrading is needed by extending the capacity for the Smart Digital models. Another main issue is the lack of internal technical competences and backup support of sales teams, particularly for chlorine disinfection systems. More effort is needed in enhancing their positions in the market. Recommendations have been emphasised to correct those weaknesses.

Focus on solutions, then products! Survey results have shown appreciation for intelligent solutions and worry-free processes from water utility customers. Intelligent solutions help them in achieving efficiency technically and financially. Plant operators are also perceived to be slothful and archaic on technology, they are easily irritated when unexpected incidents occur. Hence, ensuring product quality and technical capability is a must to retain reputation.

Numerous opportunities have been identified throughout this thesis research. Market demands and sales drivers such as the relevant EU Water Directives and International management standards certainly worth noticing, since the parameters listed are strict in compliance. The biggest hidden potential of chemical dosing in Nordic drinking water treatment would be legionella prevention, whereas, for wastewater treatment opportunities mainly lay in plant optimisation and nutrients recovery.

Moreover, other opportunities include cooperation with customers’ most preferred partners such as local chemical manufacturers, consultants and distributors would diversify sales channels. The synergy created via business-to-business may bring plentiful new opportunities while increasing brand awareness. The idea of collaborating with chemical manufacturer, Kemira can also strengthen overall technical capabilities. By adopting their disinfection technology Desinfix in sludge treatment, the drawbacks of chlorination can be hypothetically eliminated. Despite this kind of collaboration can be somewhat complex at a local level while demanding extra human resource, the potential opportunities it brings may secure Grundfos market share in the disinfection market.

In terms of price benchmarking among competitors, limited information has been obtained via the survey. Water utility customers are preserved and thus hesitated in sharing the cost of dosing equipment. In addition, permission might have been obligatory from the suppliers. For that reason, further investigation is needed by Grundfos.

The research has given me opportunity to develop professionally and personally. Now I have got a clearer overview and a deeper understanding on the technical aspects of water treatment which used to be unfamiliar to me. I truly hope that the findings and practical recommendations of this thesis research can contribute to and inspire the future development of Grundfos Dosing and Disinfection in Nordic water utilities.

‘Ju närmare källan, desto klarare vatten’

– The closer to the source, the clearer the water (Swedish quote) /72/.

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APPENDIX 1(1).

Products: dosing pumps and disinfection systems

Table 33. Technical data and applications of different dosing pumps models. /7/

Pump type(s)	Model(s)	Descriptions	Application(s)	Technical data
Diaphragm dosing pumps – Smart digital	DDA DDC DDE	Dosing pumps with powerful variable speed stepper motors	**Areas:** GW/ SW/ DW/ Recycled and reused water **Processes:** • Disinfection • pH adjustment • Coagulation/ flocculation • Precipitation • Chemical dosing • Biocides	Q: 0.0025-30l/h Max. system pressure: 16-4bar 
Digital dosing	DDI		**Processes:** • pH adjustment • Disinfection (disinfectants: • hypochlorite, peracetic acid, peroxide) • Coagulation/ flocculation	Q: 0.022-150 l/h Max. system pressure: 16-4bar 

	DME 60-10 150-4 375-10 940-4		Q: 60-940 l/h Max. system pressure: 10-4bar	
Mechanical diaphragm dosing pumps	DMX 221 226 227	Robust diaphragm-based design	Q: 0.4 – 2 x 4000 l/h Max. system pressure: 10 bar	
Hydraulic piston diaphragm dosing pump	DMH 25x series (6 models) 28x series (7 models)	Extremely strong and robust pumps for pressure and reliability demanding applications	Q: 0.15 – 2 x 1500 l/h Max. system pressure: 200 bar	

Table 34. Technical data and applications of different disinfection units. /7/

System type(s)	Model(s)	Descriptions	Application(s)	Technical data	
Full-vacuum chlorine gas dosing systems	Vaccuperm AGS	High capacity disinfection system that uses innovative sensors and microprocessor electronics for measuring and controlling chlorine concentration and dosing flow	• DW disinfection • Municipal WWTPs		
Electro-chlorination systems	Selcoperm SES	Production of hypochlorite solution from common salt using electricity	• DW disinfection • Industry • Municipal WWTPs	Max. system pressure: 15 bar	

APPENDIX 1(4).

Products: dosing pumps and disinfection systems

Chlorine dioxide preparation and dosing systems	Oxiperm Pro OCD 162	Production of chlorine dioxide using diluted solutions of Sodium chlorite and hydro-chloric acid	• DW disinfection • Wastewater treatment • Cooling water	4 different capacities: 5/ 10/ 30/ 60 g/h of ClO_2 Sufficient to treat up to 150m^3 of DW per hour at the max. admissible concen-tration of 0.4mg/l ClO_2	
	Oxiperm OCC/OCD 164			Q: 0.005-10kg/h Max. system pressure: 9 bar	
	Oxiperm OCG 166	Chlorine gas /sodium chlorite method			

Table 35. Technical data and applications of dosing installations. /7/

System type	Series and model(s)	Descriptions	Application(s)	
Dosing installation	Polydos series 400: Polydos 412 Polydos 412 ECO TD 423 Polydos 460 KD 440	One to three chamber preparation systems of dry or liquid polyelectrolyte. Systems are customized to fit the application	**Processes:** • Coagulation/ Flocculation • Precipitation	

Nordic water utilities customer interviews / questionnaire

Interviewer's name: Interview date:

Interviewee's name:

Country:

Water utilities name:

Type: Private / publicly owned,

Drinking water treatment plant / Wastewater treatment plant

Plant capacity (m^3/d):

Approx. served population:

General questions:

1) Do you know that Grundfos is a water treatment specialist? yes☐ no☐
Comments: ____

____

Products and applications

2) Dosing pump(s) installed in the treatment plant yes☐ no☐

2a) Are the dosing pumps from Grundfos? yes☐ no☐

2b) What is the application purpose?

Flocculation/ coagulation ☐ pH adjustment ☐

Precipitate of _____________ ☐ Disinfection ☐

Others: ____☐

2c) What chemical(s) are being dosed?

Purpose of dosing	**Chemical (s)**	**Dosage (l/d)**

2d) What needs do you see in future chemical dosing?

____
____
____

3) Disinfection(s) installed in the treatment plant yes☐ no☐

   3a) Are the disinfection systems from Grundfos? yes☐ no☐

   3b) What disinfection is it?

Chlorine gas	☐	Electro-chlorination	☐
Chlorine dioxide	☐	Ozone	☐
UV	☐		

4) What is your opinion about Grundfos dosing pumps and disinfection systems?
   *satisfaction / advantages and disadvantages / ideas for improvements

   Dosing pumps:____
   ____
   ____

   Disinfection:____
   ____
   ____

Grundfos competitors:

5) If dosing pumps or disinfection systems are not from Grundfos, what brand are they?

   Brand of **dosing pumps** ___________________________________

   - Cost of the dosing pumps (€) ___________________________________
   - Warranty period ___________________________________

   Brand of **disinfection systems** ___________________________________

   - Cost of the disinfection system (€) _______________________________
   - Warranty period ___________________________________

Market demands / drivers:

6) How important are the following parameters when **deciding the treatment method**?

	Very important	**Important**	**Neutral**	**Less important**
Health and safety	☐	☐	☐	☐
Budget	☐	☐	☐	☐
ROI / payback time	☐	☐	☐	☐
Trends	☐	☐	☐	☐
Efficiency	☐	☐	☐	☐
EU/ local Legislations	☐	☐	☐	☐
Sustainability	☐	☐	☐	☐

7) Prioritise of different factors when **choosing a proposal offered by different companies:**

Scale 1-12 **1 = 1st thing to consider** **12 = last factor to consider**

Why?

Brand reliability ☐ ________________________________

____

____

Cost/ Budget

- CAPEX (investment cost) ☐ ________________________________

____

____

- OPEX (operating cost) ☐ ________________________________

____

____

Delivery time ☐ ________________________________

____

____

System designing *if applicable ☐ ________________________________

____

____

Intelligent solutions ☐ ________________________________

____

____

Product quality ☐ ________________________________

____

____

Product functionality ☐ ________________________________

____

____

Disinfection effectiveness ☐ ______________________________
____
____

Accuracy of dosing ☐ ______________________________
____
____

User-friendly process (monitoring and control system e.g. remote sensing) ☐ ______________________________
____
____

After sales service and warranty period ☐ ______________________________
____
____

Others e.g.___________________ ☐ ______________________________
____
____

8) Do any of the operators in the treatment plant have the ability in the following?

			Who?
○ System designing	yes☐	no☐	____________________
○ Installation	yes☐	no☐	____________________
○ Service	yes☐	no☐	____________________

9) Who are your preferred partners?

		Name(s)
Local consultant	☐	________________________________
Distributor	☐	________________________________
Installer	☐	________________________________

Supply chain:

10) What is an ideal delivery time period of pump(s) or disinfection system(s)?
*delivery time = period between order date to arrival date of the products

- ○ Replacement pump(s) ______________________
- ○ New installation(s) ______________________

11) Preference of chemical provider? **Name(s)**

Chemical manufacturer ☐____________________________________

or

Pump manufacturer ☐____________________________________

Environmental portfolio:

12) What do you think of chemical dosing and chlorine disinfection in drinking water /wastewater treatment plants?

____
____
____
____
____

13) Which of the following is preferred as an alternative for chlorine disinfection?

Ozone ☐

UV ☐

Others ☐ e.g. ____

12a) Why? ____
____
____
____

*Applicable for wastewater treatment plant only

14) Has odour issue caused by H_2S being solved in the wastewater collection/ transport system?

yes☐ no☐

13a) if yes, what method has been applied?

		Dosage (l/d)	**Cost (€/l)**
Dosing of iron	☐	________________	________________
Dosing of magnesium	☐	________________	________________
Dosing of nitrate	☐	________________	________________

Others:____
____
____

15) Possibilities of the following in your wastewater treatment plant:

	Very high	**High**	**Average**	**Low**	**Very low**
Energy production + selling energy to electricity grid	☐	☐	☐	☐	☐
Heat production + selling to consumers	☐	☐	☐	☐	☐
Recovery of Phosphorus + Nitrogen as fertilizer	☐	☐	☐	☐	☐
Reuse of NH_4 (Ammonium)	☐	☐	☐	☐	☐

16) Handling of discarded dosing pumps:

- ☐ Land-filled
- ☐ Recycled by____
- ☐ Others:____

Thank you for your precious time!

APPENDIX 3(1).

Data of customer survey

Table 36. Information of water utilities from the questionnaire survey.

Country	Water utility	Interview date	Interviewee	Plant type (Public/private, DWTPs/WWTPs)	Plant capacity (m^3/d)	Approximate served population
Finland	Jakobstads Vatten	9.4	Jan Snellman	Public, DWTPs	10 000	20 000
	Itä-Savon Vesi Oy	30.4	Reetta-Kaisa Pelkonen		500-600	3500
	Lemin vesilaitos	30.4	Markku Immonen		N.A	N.A
	Paavolan Vesi Oy	30.4	Seppo Rantoharju		1500	5000
	Tuusulan seudun vesilaitos kuntayhtymä	30.4	Unto Tanttu		36100	122 000
	Eurajoen vesihuoltolaitos	6.5	Petri Hautakoski		900	5500
	LRE	9.5	TVe, RMo		15 000 (all plants)	65 000
	Rovaniemen kaupunki Napapiirin Vesi liikelaitos	9.5	Jouni Räisänen		10 000	55 000
	Mynämäen vesihuoltolaitos	12.5	Timo Salminen		1200	7000
	Savonlinnan Vesilaitos	12.5	Timo Hyvönen		21600(max), 4270(use)	24000
	Nastolan Vesilaitos	N.A	Venla Avelin		2500	12 000
	Turun Seudun Puhdistamo Oy	13.3	Esa Malmikare, Jarkko Laanti	Public, WWTPs	120 000	300 000
	Iisalmen vesi	30.4	N.A		8500 (max)	22000
	Hämeenlinnan seudun vesi oy Akaan Jätevedenpuhdistamo	5.5	Juhani Hakala	Private, WWTP	4000	N.A
	Inarin Lapin Vesi Oy	8.5	Mauri Portti	Corporate?,	1000	5000

				WWTP		
	Perhon kunnan vesilaitos	12.5	Pasi Rannila		900	2800
	Alheda	N.A	Jonas Ahlström	Public, WWTPs	8900	32000
	Tervolan Vesi Oy	N.A	Markku Isometsä		N.A	N.A
	Raaseporin Vesi	30.4	N.A	Public, DWTP+WWTP	4800	23000
Norway	Hole Vannverk	21.5	Roar Frydenberg	Public, DWTP	N.A	N.A
	GIVAS	N.A	N.A			
	Årnes RA	1.6	Pål Myruold	Public, WWTPs	14000	N.A

Total no. of interviewed water utilities: **22**

Finland: 19 (DWTPs: 11 / WWTPs: 7 / Mix: 1)

Norway: 3 (DWTPs: 1 / WWTPs: 2)

Table 37. Installation of dosing pumps and disinfection systems (Products and applications).

Water utilities	**Installed dosing pumps**			**Installed disinfection systems**		
	Yes (Grundfos)	**Yes (Other brand)**	**No**	**Yes (Grundfos)**	**Yes (Other brand)**	**No**
Jakobstads Vatten	✓				✓	
Iisalmen vesi	✓				✓	
Itä-Savon Vesi Oy			✓		✓	
Lemin vesilaitos		✓				✓
Paavolan Vesi Oy	✓				✓	
Tuusulan seudun vesilaitos kuntayhtymä			✓		✓	
Eurajoen vesihuoltolaitos		✓			✓	

Data of customer survey

LRE - Lappeenrannan Energia Oy	DWTPs	✓				✓	
Napapiirin Vesi liikelaitos			✓			✓	
Mynämäen vesihuoltolaitos				✓		✓	
Savonlinnan Vesilaitos			✓			✓	
Nastolan Vesilaitos			✓			✓	
Hole Vannvek		✓				✓	
Turun Seudun Puhdistamo Oy	WWTPs	✓					
Perhon kunnan vesilaitos				✓			✓
Tervolan Vesi Oy			✓			✓	
Alheda		✓					
Hämeenlinnan sendun vesi oy Akaan Jätevedenpuhdistamo			✓				✓
GIVAS							
Årnes RA		✓					✓
Raaseporin Vesi	DWTP + WWTP		✓			✓	

APPENDIX 3(4).

Data of customer survey

Table 38. Dosing purposes and chemicals (Products and applications).

Utility names	**Type**	**Application purposes**				**Chemicals** (Dosage: l/d)								
		Coagulation/ Flocculation	pH control	Precipitation/ oxidation	Disinfection	Ferric sulphate	Aluminium sulphate	Hydrogen peroxide	Sodium hydroxide	lime	Sulfric acid	Soda	Hypochlorite	Chloramination
LRE												40-85		
Rovaniemen kaupunki Napapiirin vesi													Statues dependent	
Savonlinnan Vesilaitos						231							32	
Paavolan Vesi Oy									N.A		N.A		N.A	
Nastolan Vesilaitos	DWTPs			phosphorus		N.A			N.A	N.A				
Lemin vesilkitos												N.A		
Jakobstads Vatten						800			200				70	120
Eurajoen vesihuoltoloitos		nickel		nickel		1.5		1.5	N.A					
Mynämäki vesihuoltolaitos										Limestone				
Hole Vannverk			Dosing: Sodi-		Dosing: Neuthox (1700l/d)									

APPENDIX 3(5).

Data of customer survey

			um silicate (25-30 l/d)											
Alheda						340								
Turun Seudun Puhdistamo				phosphorus		5000								
Tervolan Vesi Oy						50								
Iisalmen Vesi	WWTPs					1200			101					
Hämeenlinnan sendun vesi oy Akaan Jäteve-denpuhdistamo						2000								
Inarin Lapin Vesi Oy							200							
GIVAS							KEMIRA ALG: 600							
Årnes RA		Dosing: Ecomix (200-250 l/d)												
Raaseporin Vesi	DWTP + WWTP								70			28		

Data of customer survey

Table 39. Prioritisation and comments on factors in selecting proposal offered by different companies (market demands and drivers).

	Brand reliability	**Cost**		**Delivery time**	**System design *if applicable**	**Intelligent solutions**	**Product quality**	**Product functionality**	**Disinfection effectiveness**	**Dosing accuracy**	**User-friendly process (M&C system)**	**After sales service + warranty period**
		CAPEX	**OPEX**									
Average grade	Scale: 1-11	1= 1st priority	12= last priority									
Water utilities	**DWTP**											
Jakobstads Vatten	7 – Someone to trust	9 - Invest-vest-ment accord-ing to the reliabil-ity and lifetime	8 - low operat-ing costs are im-portant than invest-ment costs	6 - A short deliver time is essential when spare parts or new equipment is needed	12	10 - Intelligent solutions are easy to setup and use	2 - Product quality = reliability i.e. products have to be used 24/7	3 - It has to be easy to use and flexible	1 - The purpose of disinfection is to be effective	4 - When dosing g/m2 thas to be accurate	11 - Easy to use and control	5 - If help is needed then you must have someone to call to get problems solved
Lemin vesilai-tos	5	3	3	5	6	3	1	1	N.A	3	4	2

Tuusulan seudun vesilaitos kuntayhtymä	7	10	2	8 - It can be considered in advanced	9 - It is usually planned in advanced before decision making	3	3	3	6	3	3	8
Itä-Savon Vesi Oy	Maintenance and spare parts availability are key issues	Money is always a consideration	A very important issue in the long term	Little wait is acceptable	If planning is needed it should be well prepared	Other solutions cannot even be taken into account	A consideration for the cost	A very important issue in the long term	Not worth putting an inefficient one	It depends on the target, if it needs to be accurate, then it has to be taken into account	In the long term, a very important thing	In the long term, a very important thing
Eurajoen vesihuoltolaitos	Unreliable gadgets is time consuming			For the replacement parts			Well-known, reliable brand	References	Results depend on current measurements	Relevant to the operation of the process		
Rovaniemen kaupunki Napapiirin Vesi liikelaitos	Question is always about the customer's health	Reliability is the most important	Reliability is the most important	It has to be reliable	Possible	No harm	High-quality and reliable	High-quality and reliable	High-quality and reliable	High-quality and reliable	Important	Important
LRE	10	1	1	6	11	7	8	2	3	9	5	4
Mynämäen vesihuolto-	1	4	4	3	4	4	1	1	1	1	1	1

laitos												
Savonlinnan Vesilaitos	3 - If it's a well-known brand, it's a more reliable purchase	1 - Purchase criterion	2 - Important in life-cycle-thinking	10 - Not so important when designing a new system	11 - Not important if own planning is successful	3 - Important when thinking about the big picture	5 - Important, price might compensate the importance a bit	2 - Important criterion	1 - Important for the process	1 - It is vital to monitor chemical consumption and avoid over dosing	8 - Not so important, if other hardware does not support the system	4 - Important even after the warranty period
Hole Vannverkk	8	3	2	10	1	4	11	5	7	6	8	9
	Brand reliability	**Cost**		**Delivery time**	**System design** ***if Applicable**	**Intelligent solutions**	**Product quality**	**Product functionality**	**Disinfection effectiveness**	**Dosing accuracy**	**User-friendly process (M&C system)**	**After sales service + warranty period**
		CAPEX	**OPEX**									
Water utilities	**WWTP**											
Turun Seudun Puhdistamo Oy	3	3	3	9	6	5	1	2	5	7	4	5
Alheda	4 - Good brands	3 - At official	2 - The same as	5 - Quite significant		4 - It depends on the	2 - Less breakdowns	2 - Easy to use better	2 - The same as CAPEX	9 - It depends on the	5 - It depends on the applications	4 - The same as CAPEX

	that have a good reputation often work well	purchases CAPE X , OPEX and effectiveness are vital	CAPE X	for spare parts. Not so important for new equipment		complicity of the dosing needs	equal better end result in the process	final result in the treatment		application. At our WWTP not so important due to large feeding of chemicals		
Nastolan Vesilaitos	3 - Durability plus usuability	8 - Quality outweight the capital cost	4	5 - Sulfur is vital in delivery. Also, DT is important as no system can run with no pump	5 - Design and product from the same company can be a good solution	3	1	1	1	2	2	2
Tervolan Vesi Oy	1	4	3	1	2	1	1	1	1	3	3	2
Hämeenlinnan sendun vesi oy Akaan Jäteve-	6	10	11	2	3	4	7	1	N.A	5	8	9

denpuhdista-mo												
Årnes RA	7	8	4	3	11	10	1	2	N.A	6	5	9
Distributor												
Christian Berner Oy (Finland)	2	1	1 - Total energy saving in WU due to high cost	3			1	1 or 2		More important for industry due to chemical prices	Buy and sell separately	

Table 40. Abilities or competences of plant operators.

Water utilities	**Plant type**	**System designing**	**Installation**	**Service**
y = yes , n = no				
Jakobstads Vatten		n	n	y – service/ operator personnel
Lemin vesilaitos		n	n	n
Eurajoen vesihuoltolaitos		n	n	n
Rovaniemen kaupunki Napa-piirin Vesi liikelaitos		y	y	?
LRE		n	n	n
Mynämäen vesihuoltolaitos		n	n	n
Savonlinnan Vesilaitos		y	y	y
Nastolan vesilaitos		n	n	n
Itä-Savon Vesi Oy		n	n	n
Hole Vannverk	DWTPs	y	y	y
Tuusulan seudun vesilaitos kuntayhtymä		y	y	y
Turun Seudun Puhdistamo Oy		y	y	y
Alheda		n	y - everyone	y - everyone
Iisalmen vesi		y	y	n
Hämeenlinnan sendun vesi oy Akaan Jätevedenpuhdistamo		y	y	y
Inarin Lapin Vesi Oy		y	y	n
Årnes RA	WWTPs	n	y	y
Raaseporin Vesi	DWTP + WWTP	y	y	y

Table 41. Comments (products and applications).

Water utility	Plant type	Comments on Grundfos being a water treatment specialist	Comments on future needs	Comments on dosing / disinfection system from Grundfos
LRE	DWTPs		Dosing of chemicals will stay the same	
Lemin vesilaitos			No other needs than pH control	
Paavolan vesi oy			No new needs in the horizon	Easy to use and function very well; no experience with Grundfos disinfection system
Rovaniemen kaupunki Napapiirin Vesi liikelaitos		Clean water pumps used by the utility are from Grundfos. About 200 of them are used in pressure rising and water intake facilities.	Reliability of dosing	
Nastolan vesilaitos			Do not know to say	
Tuusulan seudun vesilaitos kuntayhtymä				Do not know to say
Hole Vannverk			Neuthox is not a pilot project together wth Sterner AS	Very satisfied with the dosing pumps during the past 8 years
Turun Seudun Puhdistamo Oy	WWTPs	98% of the pumps at Turku WWTP are Grundfos made. Existing pump maintenance contract with Grundfos.	H_2S removal chemical	Good quality (esp. Smart digital), easy to use, clear menu structure, sensing faults
Alheda			More dosing based	Only have one but

			on actual needs, not only on the basis of flow	it has worked well
Tervolan vesi oy			Do not know to say	
Iisalmen vesi			To extent adjustment parameters	OK
Hämeenlinnan sendun vesi oy Akaan Jätevedenpuhdistamo		Especially in the pumping facilities	Better automation	No experience with Grundfos
Inarin Lapin Vesi Oy				I don’t know
GIVAS			I don’t know	
Årnes RA			Nothing	Dosing pumps are very good
Raasepori Vesi	DWTP + WWTP		No actual needs at the moment	

Table 42. Comments (Environmental portfolio).

Water utility	**Plant type**	**Comments on chemical dosing and chlorine disinfection in water treatment plants**	**Preferred alternative of chlorine disinfection (Ozone/UV/others)**
Eurajoen vesi-huoltolaitos	DWTP	Chlorine worsen the taste of water but garentee safety all the way to the endusers in a normal situation	UV – easy to use and efficient
Itä-Savon Vesi Oy		In ground water intake facility the more natural water you can take the better. Dosing chlorine to distribution system is of course ensuring reliability and preventive treatment of the distribution system, but at the moment we are not dosing chlorine	In principle, there is no alternative to chlorine as other methods do not affect the plant further. Chlorine however also manages the network
Jakobstads Vatten		It's very difficult and expensive to get clean water without chemicals. Chlorine disinfection is needed when surface water is used as raw water	Others: Chlorine disinfection cannot be compared with ozone or UV as they are used for different purposes. Ozone is a very good disinfectant, but lifetime of ozone is short in the water. UV is even shorter! Chlorine disinfection is used for disinfection of water in the water pipelines and distribution system, as well we disinfection at the waterworks. Both ozone and chloramine disinfection are used in the plant
Mynämäen vesihuoltolaitos			UV - Easy to use; environmentally friendly; no need for personal safety gear and cheap
LRE		Requires expertise from users and equipment reliability, in order to avoid discrepancies arising and the risks would be managed. Options for the future focus on alternative, though more expensive, methods	UV – currently in us and it is easy to operate
Lemin			UV

vesilaitos			
Rovaniemen kaupunki Napa-piirin Vesi liikelaitos			UV - It does not change the characteristics of drinking water. It is reliable in dispensing and easy to maintain
Nastolan vesi-laitos		E.g. Ammonium is easy to dose at the water station, but not completely risk free in terms of work safety and usage. Chorination should be avoided, but in some stations it's the only method to quarantee hygienic water quality in the distribution system	UV – easy and safe to use
Tuusulan seudun vesilaitos kuntayhtymä		If water quality allows, chlorine is usually avoided. Also, TSV does not use any chemicals	UV – It does not affect taste nor smell
Savonlinnan vesilaitos			UV – It is powerful and cheap to use and good efficiency. In addition no poisonous chemicals are needed.
Hole Vannverk		Prefer to use chlorine	Ozone and UV
Turun Seudun Puhdistamo Oy	WWTPs	It would be better if no chemical was needed	UV – WWTP has rooms reserved for UV treatment
Alheda		Not so familiar with the subject	
Tervolan vesi oy		Chlorine is not suitable for any automation	UV - safe
Perhon kunnan vesilaitos			UV
Iisalmen vesi		Important and necessary	UV
Inarin Lapin Vesi Oy			UV
Årnes RA		Effective in cleaning	UV - effective
Raasepori Vesi	DWTP + WWTP		UV - safe

Table 43. Ways of handling discarded dosing pumps.

Countries	**Plant type**	**Water utilities**	**Landfilled**	**Recycled by…**	**Others**
Finland	DWTPs	Eurajoen vesihuoltolaitos	✓		
		Nastolan Vesilaitos	✓	✓	
		Raaseporin Vesi		✓	
		Napapiirin Vesi liikelaitos			Only metal is recycled
	WWTPs	Inarin Lapin Vesi Oy	✓		
		Hämeenlinnan sendun vesi oy Akaan Jätevedenpuhdistamo	✓		
		Perhon kunnan vesilaitos		Millespakka	
		Turun Seudun Puhdistamo Oy		Everything is recycled	
		Alheda		Ekorosk Oy	
		Iisalmen Vesi			Romun keräykseen
Norway	WWTP	Årnes RA	✓		