CEWP P1 Business and Innovation Programme 2019 track of *Industrial Water Efficiency*

Background paper on water use efficiency in the European Food and Drink sector

January 2019

1. Introduction

1.1 The CEWP PI Process on industrial water efficiency in the food and drink (F&D) sector

The CEWP PI Business and Innovation Program, aka the Access Program, will primarily focus on the business solutions and challenges currently facing Industrial Water Use in the F&D Sector. The focus will be on the water use in food and drink processing, while water use in agriculture will not be dealt with in this CEWP PI Process and not covered by the present Background paper.

Through *Open Innovation Sessions* focusing on how emerging challenges including Digital Transformation, Circular Economy, Climate Change and Regulatory Demands will require new innovative solutions, the program will showcase the capabilities of European Companies to respond to these challenges. The aim is to also stimulate an interest from Chinese side in co-operating with European partners who possess the requested technological capabilities, with the aim of facilitate building of Innovation Partnerships.

The present Background paper will be one of the key documents supporting the open innovation sessions. The Background paper is a “living document”, integrating inputs from CEWP partners and results of the open innovation sessions themselves.

The Open Innovation Sessions and how the present Background document contributes to the process:

4Q, 2018, and 1Q, 2019; Initial dialogue and Screening Process with Qingdao partners and stakeholders; Information and Marketing materials distributed to European Companies about possibilities for participation. All basic Information Materials (Water Tech Market Report, Overview of Funding Opportunities etc. will be available by the beginning of this phase). *It is planned that a first draft of the present background paper on water efficiency in the food sector shall be one of the documents distributed*

Industrial Water Use, Food Sector; Information Event @IE Expo Shanghai April (April 15th-16th) and first event with Key Stakeholders and Challenge Owners in Qingdao (April 11th-13th). *An updated version of the background paper will be one of the documents supporting this meeting*

14th EU-China (EUPIC/EEN) fair and events Qingdao and Chengdu October 28th-November 1st.-*An updated version of the background paper will be one of the documents supporting this meeting*

CEWP Annual Meeting and follow-up visits in Europe, December 2nd – 6th, 2019.

1.2 The European Food and Drink Sector profile

The EU F&D sector is an important sector in terms of value created, employment and not least as a basis for providing food for the EU populations and is depending on access to good quality water and to treatment facilities for the waste water. A profile of the sector operation and outputs is shown below.

The European F&D industries are spread around Europe in industrial areas as well as in rural areas. The industry processes 70% of EU agricultural production. The largest industries (measures as value of production) are the meat, beverage and dairy industries.

While 90% of the F&D sector products are consumed within EU, the EU is also the largest exporter of food and drink products in the world. In 2014, EU exports reached €92 billion. With a record export performance and a growing positive trade balance in recent years, the industry has shown that it is dedicated to delivering safe, high quality, value added innovative food and drinks to consumers worldwide. EU exports doubled over the past decade. Top export markets are the US, Russia, China, Switzerland and Japan. Exports to China, Brazil, South Korea and other emerging markets have significantly grown in recent years.

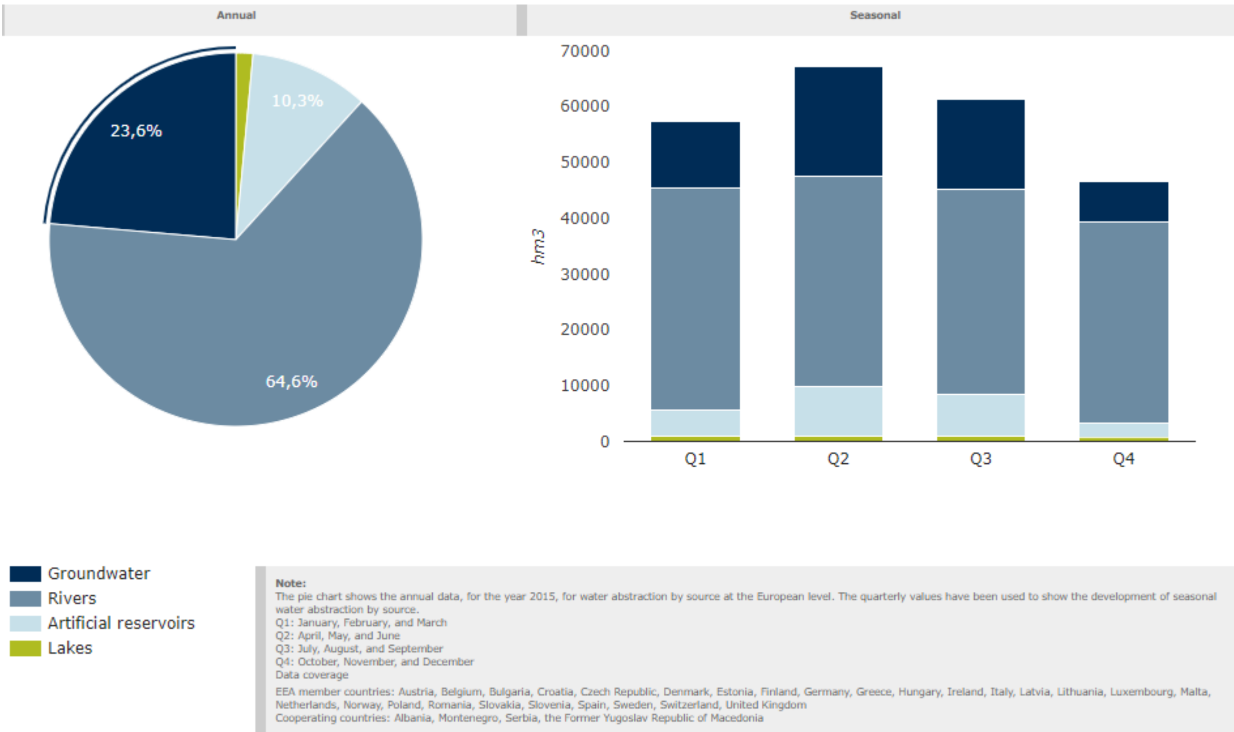
Key products exported include spirits, wine, dairy products, meat products, chocolate and confectionery, and processed fruits and vegetables. EU market shares in traditional markets have declined whereas steady growth is observed in emerging markets (e.g. China).

2. Water resource and water use efficiency in EU

2.1 The water resources situation

Despite the fact that renewable water is abundant in Europe, signals from long-term climate and hydrological assessments, including on population dynamics, indicate that there was 24 % decrease in renewable water resources per capita across Europe between 1960 and 2010, particularly in southern Europe. The densely populated river basins in different parts of Europe, which correspond to 11 % of the total area of Europe, continue to be hotspots for water stress conditions, and, in the summer of 2014, there were 86 million inhabitants in these areas.

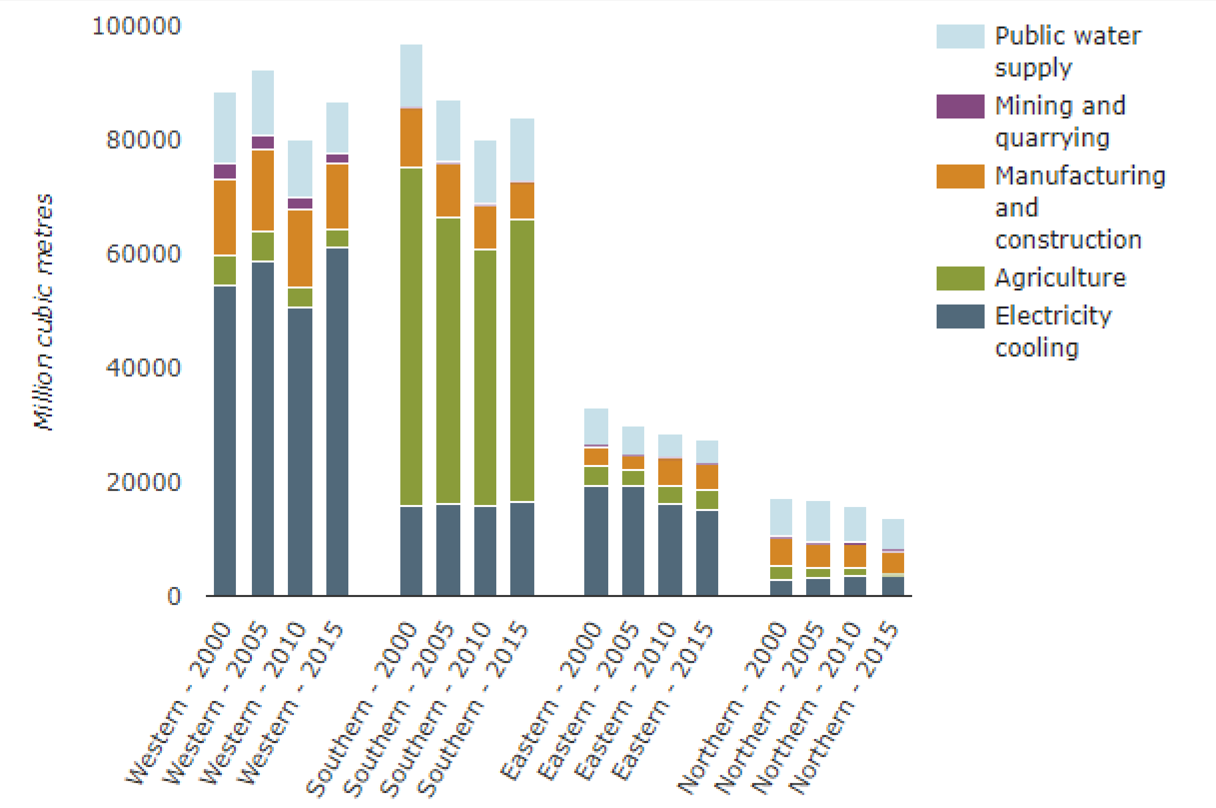
Groundwater resources and rivers continue to be affected by overexploitation in many parts of Europe, especially in the western and eastern European basins.



A positive development is that water abstraction decreased by around 7 % between 2002 and 2014. Agriculture is still the main pressure on renewable water resources. In the spring of 2014, this sector used 66 % of the total water used in Europe. Around 80 % of total water abstraction for agriculture occurred in the Mediterranean region. The total irrigated area in southern Europe increased by 12 % between 2002 and 2014, but the total harvested agricultural production decreased by 36 % in the same period in this region.

On average, water supply for households per capita is around 102 L/person per day in Europe, which means that there is 'no water stress'. However, water scarcity conditions created by population growth and urbanisation, including tourism, have particularly affected small Mediterranean islands and highly populated areas in recent years.

Figure 2. Water abstraction by sector in the EU



Data sources: a. Eurostat. Annual freshwater abstraction by source and sector (env_wat_abs) b. Eurostat. NATIONAL STATISTICAL OFFICES

European Environment Agency

Water scarcity occurs where there are insufficient water resources to satisfy long-term average requirements. It refers to long-term water imbalances, combining low water availability with a level of water demand exceeding the supply capacity of the natural system.

Water scarcity is driven primarily by two factors:

climate, which controls the availability of renewable freshwater resources and seasonality in water supply, and

water demand, which is largely driven by population and related economic activities.

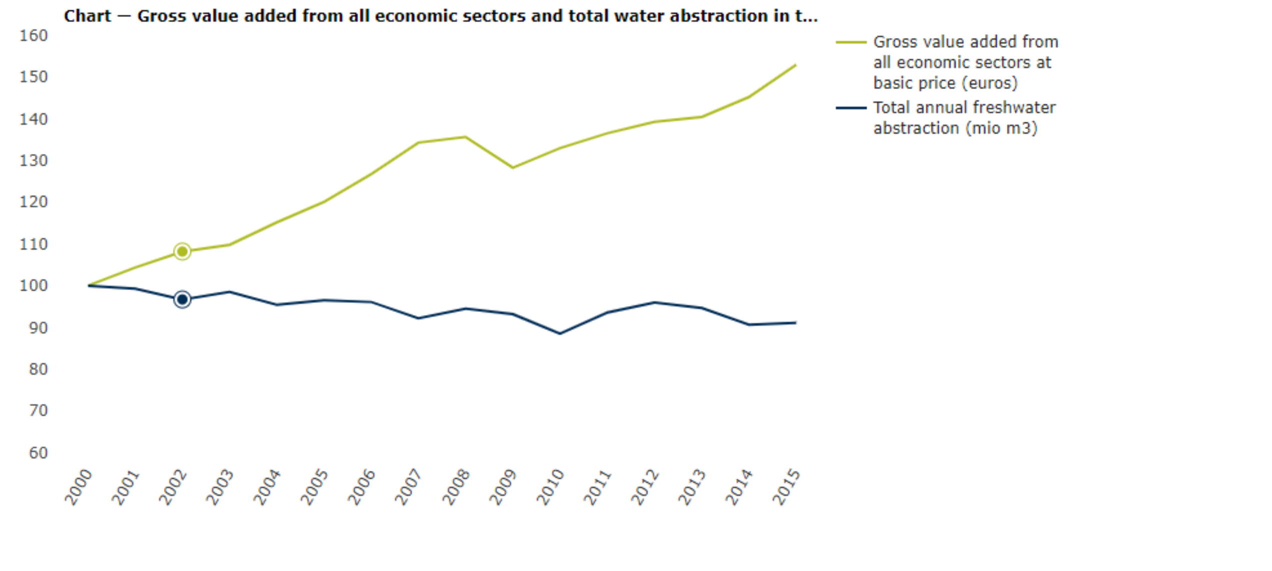
Although water scarcity often happens in areas with low rainfall, human activities add to the problems in particular in areas with high population density, tourist inflow, intensive agriculture and water demanding industries.

Water scarcity prevails in a number of European river basins, with different water stress levels, affecting around 15-25 % of total European territory. Water scarcity is frequently experienced in the southern and western parts of Europe. More than half of southern Europe lives incessantly under water scarcity conditions, of which agriculture and public water supply, including in relation to tourism, are the main drivers. Particularly in spring and summer, water scarcity in southern Europe prevails and the outer boundaries of this scarcity are expanding.

According to the European Environment Agency water exploitation index, water will continue to be exploited by sectors such as agriculture and energy, as well as by consumers at home, to meet demand, which is expected to continue to rise. Climate change will continue to put additional pressure on water resources, and it is expected that there will be an increased risk of droughts in many southern regions. Demographic trends will also play a role. Europe's population increased by 10 % over the last two decades and this trend is expected to continue. At the same time, more people are moving to urban areas, which will also put more stress on urban water supplies.

Certain sectors, mass tourism in particular, will amplify the demand for water in some regions during key periods. Every year, millions of people visit destinations across Europe, accounting for around 9 % of the total annual water use. Most of this use is attributed to accommodation and food service activities. Tourism is expected to put increased pressure on water supplies, especially in small Mediterranean islands, many of which see a massive influx of summer visitors.

From 2000 to 2015, in the EU-28, there was an absolute decoupling of water abstraction (-9 %) and the gross value added generated from all economic sectors (+53 %). This positive development is expected to continue.



Note:
Time series cover the period of 1990-2015. The comparison between water abstraction and gross value added has been made based on gross value added at basic price in euros for the EU-28.

2.2 Water use in the industrial sector and the Food sector

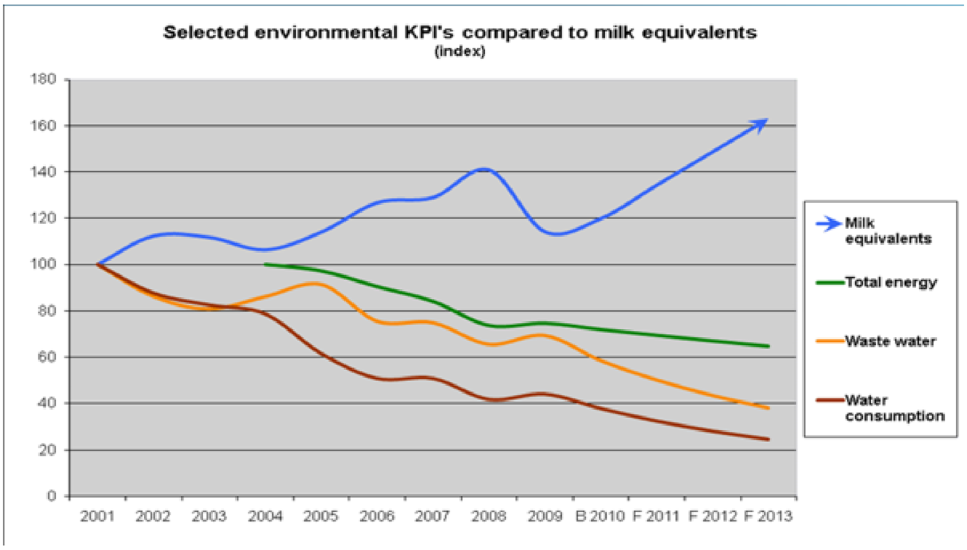
The total water abstaction (2015) was 182 billion m3 in EU of which 12 % is used for industry. F&D use a fair share of this amount with some regional and national variations. Whilst access to reliable sources of potable water varies dramatically around the globe and in EU as well, global trends including food security and global warming increasingly exacerbate water supply shortages to the extent that water security is under threat. Amongst the possible other sources of water available to the F&D industry could be water that is recovered from food or from particular operations in a food processing/handling facility. Such water could be re-used in different ways and for different purposes, but the possible occurrence of microbiological and other hazards needs to be dealt with. Operational best practice for responsible water re-use in key segments of the food industry is increasing. Certainly, when deciding whether a re-use water source can be utilized for a particular food application and whether or not a treatment or other type of reconditioning is required to make this water fit-for-purpose, the key criterion is that the re-use water does not pose a risk to the safety of the consumer that eats the food product.

The European industrial sector as such as well as the F&D sector, has achieved significant efficiency gains over the last decades. This is partly due to shifts to more resource efficient production equipment and production processes. Higher prices for resources like energy and water, stricter regulation and enforcement of regulation of emissions has also had a significant effect in increasing the resource efficiency. The requirement to use BAT (Best Available Technologies) as a basis for establishing resource uses and emission standards in EU member states has contributed to this. BAT is developing over the years and the EU BAT/BREF process helps EU member states and industries in identifying new technologies and new efficiency standards which increased the production efficiency in industries.

The BAT, regulations and technologies differ widely even in the Food sector and solutions recommended for sub-sector in the food sector may cannot easily be used in another industrial sector. There is widespread use of membrane technologies and methods to make water safe for reuse. Circular economy with a strong focus on reducing and utilizing waste and energy streams is spreading in the sector and digitalization measuring resource, energy and water streams has shown its potential to better control and reduce losses.

As other industrial sectors the Food and Drink sector has to cope with new water security challenges in EU as described in section 2.1. The complexity of these challenges in a rapidly changing world means that new, locally-adapted and innovative solutions are often required. Water innovation can apply not only to new sustainable technologies but also to new partnerships extending across public administration, research and industry: new business models and new forms of water governance that are not only innovative themselves but can also stimulate and support technological innovations Furthermore, innovation need not be an entirely new technology or concept; novel combinations and innovative ideas for improvements on current technologies and systems, all have a part to play.

There are best practice examples from the European food and drink sector showing that it is possible to decouple growth (illustrated by the blue line in the figure below) from water and energy use and waste water production.



3. Innovative practices and case stories in F&D processing industry

3.1 Drivers

The development of innovative practices has been driven by both the Food and Drink sector itself but also by public-private partnerships funded by new EU regulation in the water sector supported by EU and by EU member state research and technological development funds.

The Water Framework Directive (WFD), which was adopted in 2000, aimed to address all water challenges faced in the EU, including both water quality and quantity. Its comprehensive coverage extended beyond water distribution and treatment and encouraged integrated water resource management across different spatial scales with the participation of a range of stakeholders including industry.

Achieving the aims and objectives of the WFD and to safeguard Europe's Water Resources require innovation and forward-thinking. To drive this innovation, and to "build an economy that is cleaner, greener and more efficient" the European Innovation. The European Innovation Partnership Water aims to "stimulate creative and innovative solutions that contribute significantly to tackling water challenges at the European and global level, while stimulating sustainable economic growth and job creation. It intends to foster collaboration in the water sector across the public and private sector, non-governmental organizations and the general public.

The drivers of the market for water technology in the F&D sector may be summarized as follows:

1. Emerging market growth: As GDP per capita and urbanization increase, demand for branded processed food and drink also increases.

2. Water scarcity and environmental protection: As global water demand increases, water stress spreads across the globe. The impact of poorly treated wastewater is also becoming apparent to policy makers.

3. Corporate risk: Image is everything, and corporations have begun to assess the operational, environmental, and reputational risks associated with water and wastewater.

4. The value proposition: Increasingly, technology allows good water stewardship to go hand in hand with increased profitability. Value from waste propositions such as energy recovery, water reuse (not within the product) and materials recovery ensure that investment in water technology benefits the bottom line.

5. Effective water pricing can stimulate uptake of new innovations if it reflects true financial, environmental and resource costs. Separate charges for water use and effluent, in particular, can drive industry towards increased efficiency, investment in water treatment innovation and closing of local water cycles, for example treatment and recycling of water on a single industrial site

6. Efficient regulation of water use and emissions

3.2 New and innovative regulations and standards

The EU has stringent waste water standards. Two EU directives- The Urban Waste Water Directive and the Integrated Pollution and Prevention Control Directive (IPPC) are the main EU regulatory frameworks for water use and waste water discharge in EU.

F&D companies are required to comply with local, regional or national regulatory standards when operating a manufacturing site in an EU country. The standards and requirements can vary greatly Overall, the regulatory framework surrounding the water aspect of the food and drink industry addresses:

Water abstraction regulations, which protect water security.

Process water quality standards, which protect human health

Wastewater discharge standards, which protect the environment.

Governments must address water security through issuing *withdrawal permits for industrial users*, which, in turn, drives water efficiency and reuse. These withdrawal permits (or licenses) regulate the volumes of water that F&B companies are given access to. The permits can be revoked or reassessed in times of scarcity or following noncompliance by companies. As competing demands for water continues to rise, water abstraction licenses are expected to get stricter.

Process water quality standards. The two main factors in defining water quality standards are the raw water source and the treatment required to produce process water of acceptable quality. Both of these are critical in ensuring the safety of the product. The quality of any water source that is to be used for process water at F&B plants must be of “at least potable water quality” or of a quality that will not affect the quality of the food and drink product produced. In practice this means that the main source of process water is municipal tap water, well water, borehole water, groundwater and surface water. Increasing numbers of contaminants with the potential to affect human health are being found in raw water sources.

Wastewater discharge standards There is a trend towards more stringent wastewater discharge regulations. This acts as a driver towards more advanced wastewater treatment technologies. Wastewater streams must be effectively treated to prevent damage to the environment, and noncompliance with regulations will likely have cost implications such as fines, penalties or plant closures. In general, wastewater discharge standards are getting stricter worldwide and it is believed that developing nations are developing stricter regulations at a fast pace. The wastewater streams generated from the food and beverage industry are considered to be quite clean when compared to those generated in other industries. This means that there is potential for the biosolids from the F&B wastewater to be disposed of by land application, a practice that is not an option for other industries due to regulations. In some countries the wastewater discharge guidelines or regulations for industrial effluent apply to all industries including F&B. Other countries have developed individual F&B industry wastewater discharge standards on a subsector-by-subsector level. Standards can be set to prescribe minimum values for discharging to treatment plants or discharging directly to water bodies.

Adoption of universal regulations at plant sites Many major international Food and Drink companies are adopting company-wide standards for wastewater treatment across all plant sites, regardless of location. In countries where the local regulations are not as stringent or do not exist, such company-wide standards protect both the environment and the company's image. However, smaller, less global F&B companies may be limited in their capacity to adopt such wide reaching approaches like adopting a company-wide standard for wastewater discharge.

Sector-wide regulation of water use and re-use. The Draft Danish Sector Guide Dairy aims to assist dairies in establishing the necessary documentation and undertake the risk factor analysis. The Draft Sector Guide describes a procedure to establish the documentation, risk factor analysis, and surveillance and verification plan for reuse.

Of special importance for the risk factor analysis is:

Characterization of chemical and microbial water quality

Identification of risk factors which require management control - of particular importance is the direct contact between the water and the product/production process

Assessment of development of risk factors during recovery, treatment and storage of the water

Identification of the most important processes for the management of the risk

The expectation is that the procedures and solutions described in the Draft Sector Guide Dairy will pave the way for a much more flexible dialog between dairy plants and the Food Authorities when it comes to implementation of solutions for improved water efficiency – and that this increased flexibility will significantly increase the reuse of water in dairy processing in Denmark.

3.3 Water technology solutions

Water is used in the F&D industries for:

- food processing, where water is in contact with or added to the product
- equipment and installation cleaning
- washing of raw materials
- water, which does not get in contact with the food e.g. boilers, cooling circuits, heaters, pasteurisation

- cleaning of packaging material
- fire fighting
- sanitary water

Water technology solutions differ widely in the F&D processing industry and the specific process technology applied at a plant side. Evaluating the potential to save water and reduce waste water streams and apply the right technology for this purpose requires a basic understanding of the production process and of the water consumption at the plant. This involves determining the volumes and quality of water that enter and leave the plant and identifying the different processes where the water is used.

The F&D industry use a wide number of technologies to secure the right volume and right quality of water is available for the different production processes. This includes:

- Technologies employed to meet the process water and utility water needs
- Technologies to deal with waste water streams generated
- Technologies that make reuse possible
- Technologies that allow value to be made from wastewater streams

In the following examples of innovative technologies and cases from the application of technologies are presented. The focus will be on technologies that saves water in the F&D processes, that make reuse possible and allow value to be made from wastewater streams. The list is not covering all F&D process technologies. For a more comprehensive overview please consult e.g. Global Water Intelligence Publication on Water for Food and Beverage. Opportunities in water efficiency and gaining value from wastewater.

Water saving technologies

Cases:

Cleaning in place systems improves the water efficiency by reducing the use of water and chemicals. The most efficient systems recover water and chemicals from using membrane systems.

Due to the wide variety of products produced by the Danish dairy, Thise there is a frequent cleaning, 143 CIP per day, of the production facilities. CIP systems use approximately 1/3 of the total water consumption at Thise Dairy plant. Due to limitations in possibilities for discharge of wastewater combined with ambitions to grow the business, Thise Dairy needs to identify and implement improved water efficiency in the production. Thise the water consumption is implementation of counter-current water reuse in the CIP. This implies that water from final rinse is collected and reused later in the next intermediate rinse; and water from intermediate rinse is collected and reused a second time in the next first rinse. For final rinse is in this case applied fresh supply water. Remaining CIP chemicals in the reused rinse water will contribute to overall savings in CIP chemicals.

In the Food & Beverage sector *pumps with water sealing* are frequently applied. This is also the situation at Thise Dairy plant where numerous such pumps are installed. Each pump needs supply with a certain minimum flow of water, where the flow is controlled by a manually adjusted valve. A typical phenomenon is that this set-up will result in excessive water consumption – just to make sure there is sufficient water supply.

During the Water Efficient Dairies project the manually adjusted valves were replaced by constant flow valves designed to deliver a constant pre-defined flow. The replacement was limited to cover pump sealing water delivered one UF-plant at Thise Dairy plant. Water consumption was determined by online-monitoring for a period prior to and after replacement.

In Water Efficient Dairies, (2017), a documentation case is described, where 70 *water meters with wireless communication* to a central data collection unit were introduced at Thise Dairy plant.

The online data collection system replaced a traditional daily 2 hours routine with manual reading of 20-30 water meters. The data were bi-weekly manually registered in a database. The main advantage of the new water consumption monitoring system was a possibility for immediate reaction to unexpected water use - besides the significant savings in man hours for reading and registration of data. Excessive water consumption related to a UF process unit was detected and changed based on the hourly water consumption data as visualized by ebutler.dk. Water consumption in this case reduced from around 700 L/h to 180 L/h. Based on observations and estimates for water savings at Thise Dairy the improved information on water consumption resulted in overall savings around 5%.

Cases:

Membrane filtration can be used to produce water of different qualities using single membranes or combinations of membrane stages), which include one-step processes such as ultrafiltration, reversed osmosis (RO) or Nano Filtration, and combinations ot these

ARLA HOCO at Holstebro processes an input of 750 mio. kg year of milk into a variety of dairy products. The products from ARLA HOCO include mainly: Cream; Casein protein – Food consistency ingredient; Capolac – Calcium enriched food ingredient; Perlac – Animal feed product for pigs; and Whey Powder Concentrate. Figure 5-4 illustrates the main production lines at ARLA HOCO Holstebro.

At ARLA HOCO a centralized concept for water reuse has been developed that includes four water reuse storage tanks – each 300 m^3. Permeate from whey concentration in UF plants and process water from food ingredient lines are treated in RO units and permeate from the RO units is treated in a polisher RO unit and disinfected with UV before being led to the reuse water storage tanks.

Reuse water from the storage tanks is UV treated after storage and before reuse. The stored RO water is reused for various washing and cleaning activities throughout the dairy plant. Selected process streams of the reused RO water are collected and RO treated/polished before being utilized for a secondary reuse in CIP cleaning activities; while other reused water streams are discharged as wastewater after first reuse application.

Once each 48 hour the reuse water tanks are drained and the entire water reuse scheme is undergoing CIP in line with the other dairy food processing lines.

The characteristics of water that is to be used in cleaning of non-sensitive areas are less restrictive and, in these cases, simpler processes can be sufficient to achieve the purpose. ent is reclaimed for reuse as cleaning water of less sensitive purposes, however, the important water quality concern might be safeguarding the working environment for staff applying spray nozzels in manual washing and cleaning, spreading aerosols in the washing area. Obviously, bacteriological control is of paramount importance when the reused water may come into contact with food (cleaning of heat exchangers, etc.).

Condensate is water that is formed when steam condenses. It is found in two places in the F&B industry:

- Steam supply systems and boilers.
- Product condensate, e.g. generated by the dairy industry when using evaporative and drying processes to concentrate milk products or manufacture powdered milk.

Boiler condensate return systems effectively reuse condensate as boiler makeup water. Efficiency savings result from using less water, using fewer chemicals, and not having to reheat the already hot condensate. Combined these savings can reduce operating costs by up to 70%. To maintain boiler efficiency and reduce the need for blowdown, the routine maintenance is essential.

Product condensate recovery When a condensed or dry milk product is being manufactured, water amounting to around 74% of the original milk volume can be recovered as condensate and reused. The recovered condensate can be reused in boilers, as cooling tower feedwater, in CIP systems, for wash water, in dryer wet scrubbers, and for pump seal water. The condensate is also hot, a property that can be made the most of via heat exchangers. To achieve the maximum economic benefit from water reuse and heat exchange, product condensate recovery should be integrated into the process at the design stage.

Case

At the dairy processing plant at FrieslandCampina Aalter in Belgium a condensate reclamation and reuse scenario has been established. The configuration of the reclamation plant is illustrated in Figure 5-5. As mentioned above condensate from evaporators is typically characterized by a high content of organics of which a large portion is (or rapidly during storage turns into) easily degradable organics which might result in bad smell and heavy microbial growth (slime and biofilm) during storage or direct reuse. For this reason, it is necessary to remove the content of organics through biological treatment in one or more steps and combine with membrane filtration through ultrafiltration (UF) and reverse osmosis (RO). Prior to reuse, the reclaimed condensate is treated with UV for disinfection.

Since the condensate contains very little mineral it is well suited for RO treatment and for reuse as boiler feed water, which is also part of the reuse application at FrieslandCampina Aalter. Part of the reclaimed condensate is reused as supplement to the main water supply to the dairy plant – however after addition of chlorine. The capacity of the reclamation plant is 50 m^3/h and the time for return of investment is reported to be 2 years, Case:

Breweries can reuse hot water from wort cooling. Hot water is recovered from the hot wort and stored in insulated tanks. The hot water is used for various processes like in the production. Clearing operations, flushing brew kettles etc.

Waste water treatment

The volume and pollution load from F&D industries is reduced by an appropriate combination of:

- Process integrated techniques by reducing concentrations of certain pollutants, reducing/recycling water streams and raw material streams
- End of pipe technologies i.e. waste water treatment technologies.

While F&D waste water contains pollutants which is broadly speaking similar to domestic waste water the pollutant level may be 10-500 times higher.

Slaughteries, sugar industry and the dairy industry all generate wastewater streams with high BOD loads. Also, certain processes in other subsectors can generate highly loaded wastewater in very small quantities. In the brewery industry, the fermentation and filtration steps generate only 3% of the total wastewater by volume plant, but this wastewater is so highly loaded that it can represent up to 97% of the BOD from the entire plant. The main wastewater challenges stem from the variability of the wastewater from plant to plant. This variety is as a result of the range of the ingredients used, process water qualities, and the processing steps and products. Due to the risk-averseness of F&B companies, pilot trials may need to be conducted on a plant-by-plant basis to ensure that the treatment solutions can handle the wastewater streams.

Another challenge within the Food and Drink industry is the segregation of wastewater streams. It is easier to treat high load/low flow streams separately from low load/high flow streams. Treating such streams separately, rather than combining them, enables better treatment to be achieved at a lower cost. This is particularly true when dealing with one wastewater stream that is highly loaded with fats, oils and greases. For example, the high load streams can be sent to an anaerobic MBR, while the low load streams can be directed to the final stage of treatment in an aerobic unit or RO units for water reuse, depending on how “clean” the wastewater stream is. The challenge is to identify the streams that would benefit from separate treatment, efficiently segregate the flows, and to decide where to combine the flows in order to achieve the most efficient and consistent process possible.

The biological treatment following a physical/chemical treatment of wastewater is designed to remove the dissolved (and remaining particulate) organics and nutrients like ammonia and urea. Biological treatment consists of an aerobic biological process for efficient degradation of organics and nutrients through the addition of oxygen, which is energy consuming. Biological pre-treatment through anaerobic process technology might be attractive for concentrated wastewater with high BOD-values for reduction of soluble organic matter through energy efficient conversion to valuable biogas (methane). The anaerobic/aerobic process combination will have the advantage of a significantly reduced energy consumption – reduced carbon foot-print and lower OPEX – but will have higher investment costs - higher CAPEX.

Anaerobic pre-treatment is typically designed as high rate reactors due to the easily degradable organics and the small foot-print. The advantages of anaerobic pretreatment are: production of a valuable byproduct (methane), that can be recovered and utilized as a fuel, removal of substantial quantities of organics without the input of mechanical energy for aeration and a reduced production of excess sludge as compared to the aerobic process.

When reuse of the treated effluent is relevant, the aerobic treatment process will in general be designed as an extended aeration biological system with anoxic zones for denitrification which will ensure a low level of dissolved degradable organics and a low level of ammonia and nitrate in the effluent. Most reuse purposes will require a stable and very low level of suspended solids in the reuse water, and this will point towards application of membrane filtration (MF or UF) of the treated effluent. This might be either as an MBR system with integrated membranes or as a separate membrane polishing of the clarified effluent from a low loaded biological process step.

Case

ARLA Rødkærsbro produces cheese based on incoming milk of around 700 mio. kg milk per year. Due to increasing production and limited effluent discharge possibilities the dairy wanted to increase the wastewater treatment capacity with a reclamation facility improving the dairy's overall water efficiency through reuse of part of the treated effluent. Based on this ambition a BioBooster MBR

(MembraneBioReactor) RO treatment plant was installed with a capacity for treating 164,250 m^3 per year of RO water from the production.

First step in the reuse of the treated water from the BioBooster reclamation facility was application of the reuse water for cooling of the condenser. Due to the long piping (approx. 1 km) between Grundfos BioBooster RO plant and the dairy - chlorine dioxide is dosed to avoid biofilm growth in this piping. Further, residual chlorine dioxide also helps to supress the biofouling in the condenser. Results from the project have shown that the quality of the reclaimed water complies well with the intended reuse purpose.

The cooling water reuse application amounts to around 1,260 m^3/week or 66,000 m^3/year, and with the 164,250 m^3/year produced there is still a lot of reclaimed water available for other reuse purposes to the extent that water quality demands for intended reuse purposes can be matched with suitable and affordable polishing technologies where needed. The dairy has begun this process by stepping up using treated RO water for washing trucks.

Besides for cooling the condensers and truck wash, the MBR-reclaimed RO water is used for cleaning purposes in the CIP processes. Reclaimed water is used for various CIP rinsing steps including also the final rinse which - water quality wise - is the most demanding rinsing step.

The capital investment in the BioBooster MBR/RO facility was based on a need for increased treatment capacity to allow for an increase in production capacity. The calculated IRR (Internal Rate of Return) is 1525% depending on the degree of water savings introduced through water reuse – corresponding to a time for return of investment of 4-6 years.

Value streams from waste water

Wastewater contains important resources, such as phosphorus and nitrogen, which could, if recovered, be re-used. Integrated and innovative wastewater treatment plants of the future will be able to recover these resources as part of the treatment process, increasing resource efficiency as well as generating clean water (Guest et al., 2009).

One method of capturing and reusing nutrients from wastewater is simply to use the ‘biosolids’, such as the sludge that is removed, for fertiliser. In order to ensure that there are no dangers to human health, biosolids need to be treated before agricultural application by heat-drying. This practice reduces the need for chemical fertilisers, which require significant amounts of energy and resources to produce, and is used across the US and Europe, although use is very low in some EU countries, over concerns that toxic metals can remain in the fertilizer.

Recycled wastewater can be made available for use in diverse areas such as agricultural irrigation, industrial processes, toilet flushing, and replenishing groundwater reserves Wastewater typically contains both nitrogen and phosphorus as well as small amounts of other elements essential to plant growth, such as iron, manganese and zinc, amongst others If these are allowed to remain in the water used for irrigation then the need for fertiliser, as well as expensive further water treatment or nutrient recovery processes, is reduced.

Biogas produced during the anaerobic sludge digestion process can be cleaned and used onsite to generate heat or both heat and electricity.

Several techniques have been tested to polish treated effluents from food industries in general, and dairy industries in particular. Membrane technologies, ranging from microfiltration (MF) over nanofiltration (NF) to reverse osmosis (RO), are among the most promising techniques.,

Due to the paramount importance of the microbiological quality disinfection technology is highly important to include in the palette of relevant polishing technologies prior to reuse of treated effluent. Disinfection will typically take place through UV technology or pasteurization. In many countries disinfection with chlorine or chlorine dioxide is standard in the water supply schemes and therefore also applied at dairy processing industry.

Activated carbon adsorption is a process wherein trace organics present in wastewater are adsorbed physically into the pores of the carbon. Activated carbon adsorption is ideal for removal of refractory organics and color from biological effluent.

Also chemical oxidation technologies – like ozone technology and advanced oxidation technologies are polishing technologies of potential relevance for removal of refractory components. It is here important to take notice of the potential formation of biodegradable organics from the refractory components through formation of intermediate components, which are not oxidized, thus, representing a potential problematic source for biogrowth.

Towards zero liquid discharge technologies and closed loops

In this solution no liquid is discharged from the plant site. All wastewater is retained and reused at the plant site or reduced to solids for disposal off site. Key components of these systems are technologies for water reuse as described above and evaporators and crystalizers.

4. Material used in the preparation of the background paper

BAT Reference Document (BREF), (2005), Food, Drink and Milk Industries

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