TECHNOLOGY
WATCH REPORT

Circular Water

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TECHNOLOGY WATCH REPORT
Circular Water

Autors
Roser Salvat Jofresa, UAB Research Park
Marta Tort Xirau, UAB Office of Patent Valuation.
Hafsa El Briyak Ereddam (UAB PUE - University Business Program)

Edition and design
Communication and Promotion Area
UAB Research Park

UAB Research Park
Av. de Can Domènech s/n - Eureka Building - UAB Campus
08193 Bellaterra (Cerdanyola del Vallès) Barcelona · Spain
www.hubb30.cat

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1
Overview of innovation and tendencies in Circular Water Management

The water crisis

The United Nations forecasts the **demographic increase** in the world's population to reach 8,600 inhabitants by 2030. In this context, **the global water consumption by industry** is expected to increase by up to 50% in territories such as the United States or Europe over this same period. The forecast is, therefore, that the demand for water will double and water reserves will reach their limit.

One of the main consequences of this growing pressure is increased world **water stress**. According to the European Environment Agency, a third of the countries on the continent present low water availability (less than 5,000 m3/year).

These countries include Spain, where the lack and quality of water, droughts and the effects of climate change are problems of the first order. The most arid country of the European Union has one of the largest **water footprints** in the world: 6,700 litres per habitant and day[1]. This shortage is further complicated by high **environmental contamination** by wastewater and emissions into the atmosphere.

There will therefore be less and less fresh water available, especially if no measures are put in place to control and remedy these tendencies. Not surprisingly, the "**World Economic Forum** 13th Global Risks Report 2018" mentions the **water crisis** as one of the greatest social risks to be faced, even before a possible food crisis.

The circular economy as an opportunity

The way in which we usually consume water could be described as linear: the application of costly treatment processes before use, and the later application of costly treatment processes before releasing the water downstream. This system has numerous **inefficiencies, leaks and dysfunctions** that have effects that are prejudicial for people's health as well as the environment. In this context; how can we manage to make water circulate at its maximum value and eliminate the concept of "waste"? The answer is in the **extraction of valuable materials, nutrients and energy** from wastewater before using it for another purpose, or returning to the natural water cycle with guarantees of safety.

Along these lines, experts claim that the current model of a linear economy evolve towards a circular economy, where the value of resources and products is maintained for as long as possible, while at the same time reducing the production of waste and the resulting negative impacts on health and the environment to a minimum.

The truth is that the circular economy has been taking a more and more relevant role in the national and international political agenda over the last few years, as shown by the 2015 **European Union Action Plan for a circular economy**. This vision has slowly been transferred to various states and the Spanish government recently presented the Spanish

[1] ES Agua (2017) El valor de la huella hídrica.

Circular Economy Strategy (Estrategia Española de Economía Circular - EEEC) one of whose priority approaches being water.

In this regard, the EEEC proposes promoting policies for the **sustainable management of water**, encouraging its **exploitation and recycling** with the objective of closing the circle and achieve efficient management of this resource.

It is necessary to **explore the transition** to a more circular water management model for several reasons: the risks of climate change, the degradation of natural systems, the inefficiency of the model for the use of water in agriculture, the high costs of water treatment, and the risks of the offer, especially in urban environments.

Tendencies in urban water management

The **recovery of municipal wastewater** and the **application of treated wastewater** for industrial and agricultural use have become important tendencies in regions with water shortages. The majority of cities with water stress invest in recycling infrastructures, because treated wastewater has direct recycling potential for drinking purposes, while contributing to maintaining water resources and reducing wastage.

Treated wastewater is considered, therefore, a valuable alternative resource to fresh water. At the same time, coastal urban regions are becoming more and more interested in recuperation and recycling rather than **desalination** to mitigate water stress.

There is also an undeniable tendency to apply “smart solutions” to all facets of **wastewater treatment plants (WWTP)**. The majority of new infrastructures, as well as those being extended or updated are focussed on **smart control and management** to further reduce the need for labour, while at the same time contributing to optimising the chemical and energy consumption. Smart meters, smart quality and measurement sensors, and data analytics and predictive maintenance tools are the constant focus of investment among European water utilities.

The report “Outlook of the Global Water and Wastewater Market”[2] mentions these and other **factors** being projected as **key aspects for future** process management in urban water:

- **Rehabilitation and digitalisation of the sewer system:** Cities install highly advanced sensors and software tools to predict, monitor, and maintain sewerage network and treatment assets. Utility managers leverage digital platforms for predictive asset maintenance.
- **Control of disinfectants:** Utility companies tend to invest in digital dosing technologies to optimize the use of chemicals and explore sustainable disinfection systems to replace conventional, chemical-intensive disinfection systems.
- **Sludge recycling:** Sludge treatment technologies, including thermal hydrolysis, and automation enabled by advanced software platforms help leverage wastewater treatment plants as sustainable energy generators. In Europe, the production of sludge as an end result of water treatment, use or final destination, is expected to increase

[2] Frost & Sullivan (2019) Outlook of the Global Water and Wastewater Market- *The Global Adoption of a Circular Economy, Enabled by Digitalization, Boosts Water and Wastewater Market Growth.*

significantly over the next few years as a result of regulations controlling the dumping of this type of sludge from WWTPs.

- **Drones and satellites:** Drones and satellite-based leak detection have erupted on the market.
- **Smart metering systems:** Advanced water utility companies are exploring the transition from Automatic Meter Reading (AMR) towards Advanced Metering Infrastructure (AMI) solutions. These smart metering solutions can provide automated billing, pressure reduction, optimized resource management, and leak management capabilities.

Industries in water-stressed regions are exploring the use of treated domestic wastewater as a dependable source of water: they blend the treated wastewater along with their available resources or directly use the treated wastewater. In this context; they also consider the reduction of water consumption. Cost-effectiveness and environmental sustainability are the key driving factors behind the industrial **water management industry**.

The European industrial water market is set to grow at 5.4%[3], favoured by the tendency and need for industries to invest in advanced technologies to ensure they remain more profitable and sustainable. The chemicals, food and beverage, pharmaceuticals, power generation, and manufacturing industries are progressively rehabilitating their **effluent treatment systems** to adapt to the circular economy and to reduce their water footprint. They also invest in process automation, thus making these activities the main driving force behind the growth of the industrial water and wastewater market in Europe.

Tendencies in industrial water management

Tendencies on the industrial scenario could be:

- **Membrane-based technology:** Industries replace the existing treatment infrastructure with advanced, smart and automated systems to comply with stricter regulations. This will boost the installation of membrane-based technologies, along with smart asset management solutions, which can optimize treatment systems and enable energy efficiency.
- **ZLD technologies:** Industries are exploring options such as captive desalination, the use of reclaimed treated domestic wastewater, and Zero Liquid Discharge (ZLD) to ensure water security and regulatory compliance.
- **IoT:** The cost of Internet of Things (IoT) sensors is gradually declining, thereby spurring adoption across all industrial treatment infrastructures. Global regulatory policies are focused on the acquisition of qualitative compliance data, which boosts demand for IIoT sensors that can wirelessly communicate data, provide valuable insights such as system health, and automatically self-calibrate. Operation 4.0 comprises data analytics tools that use sensor data to enhance process efficiency and provide system transparency.
- **Artificial intelligence:** The key benefits of AI-based software solutions that can optimize membrane-based treatment systems are significant energy and chemical savings.

[3] Frost & Sullivan (2019) Outlook of the Global Water and Wastewater Market- *The Global Adoption of a Circular Economy, Enabled by Digitalization, Boosts Water and Wastewater Market Growth.*

- **APPs:** Leading water companies are developing or acquiring capabilities to capitalize on the data generated from the smart sensors and equipment installed across the treatment and distribution infrastructure. Data analysis and water-as-a-service (WAAS) are bursting into conventional business models and the provision of added value services, such as mobile applications, and becoming basic for growth in North-America, Europe and Asia-Pacific markets.

Industries such as power generation, chemicals, oil and gas, mining, and textiles, which have high pollution rates, are under increasing pressure to showcase sustainability; therefore, they will be key customers of advanced water and energy-efficient treatment systems including IoT, artificial intelligence, APPS and other applications derived from **digitalisation** processes.

Digitalisation of water management

Smart **process automation** has been used by the oil and gas industry over the last ten years, and it is now being applied in water and wastewater treatment and supply infrastructure. This includes various operations such as automated aeration, or dosing across various types of treatment technologies. Furthermore, digitalisation based on **advanced data analysis programmes** is being imposed on systems and control centres. Smart meters in water distribution networks, for example, will enable analysis and prediction of consumption patterns, notably improving billing transparency and efficiency.

Even though the current situation in the water sector is characterized by a low level of maturity with regard to the integration and convergence of ICT solutions and business processes, it seems undeniable that cities throughout the world will adopt digitalisation in all aspects of the water management sector; the implementation of smart **water grids** has become a key priority in all modernisation projects across North-America and Europe.

The **smart water grid** or smart water network is a bidirectional system in real time fitted with sensors and devices for continuous remote follow-up of the water supply system to endure efficient and sustainable management.

Smart supply networks

In the various **stages** of supply, distribution, treatment and irrigation there are derivations for residential, commercial and industrial applications, as well as the recycling of treated wastewater for agricultural purposes and the replenishment of groundwater. Depending on the **type of technology**, this is segmented into smart infrastructures; ICT, software and analytics; control and automation, and design engineering services.

Smart water grid technologies therefore offer opportunities to significantly improve the provision of services and the efficiency of water service suppliers. At the same time, the integration of ICT into the management of the water distribution system allows water service providers to reduce costs and water losses, streamline operation and maintenance, and improve data and asset management. According to the analysis by Frost & Sullivan4, smart water grids have been identified as a "step changing" innovation, because of the technology's ability to reduce water losses, maximize water conservation, provide instantaneous monitoring of the water network, efficient fixing of leaks, accurate billing, and enhanced client engagement. The value of the market is expected to grow to 33.28 billion dollars in 2022.

But apart from added value services related to data analysis and predictive analytics, the critical differentiators of innovation in circular water management are associated with the substantial benefits of advanced water treatment systems, aimed at achieving high levels of **purity in drinking water and industrial processed water**, in a context of increased levels of waste re-use and recycling.

Rapid urban development and ageing of the infrastructures boost the need for advanced treatment systems that require adaptation without space restrictions. The energy efficiency of treatment plants also has a relevant part to play in driving innovation in treatment systems which, in time, have evolved to produce high **quality water and effiuents** with moderate energy consumption.

Advanced water treatment systems

This market is driven by the need for high quality water for municipal and industrial consumption but especially by the legislative increased pressure of government legislation and regulations related to water and wastewater.

The technology of advanced water treatment services includes[5]:

- **Physical treatments:** Advancements in this segment are related to membrane technology, optimised filter performance, application of electricity, and use of sonics, ultrasonics, or photonics in water treatment.
- **Chemical treatments:** Dosing is an important aspect of the chemical treatment process, which requires accurate control and this is where advancements have been focussed; intelligent systems have been designed to inject chemical doses according to the demand for water treatment.
- **Biological treatments:** Bio-technological advancements applied to wastewater treatment lie in the form of enzyme technology (Novozymes) and optimised bio-reactor technologies. Other innovations focus on nutrient removal, such as nitrogen, phosphorous, and ammonia removal from wastewater.
- **Hybrid treatments:** Hybrid technology refers to treatment methods that implement the combined application of two or more independent treatment technologies.

The water industry will begin to **regulate and balance the demand and supply of energy** to arrive at a zero net energy condition. This inevitably requires treatment processes to function at their peak efficiency, the installation of low-emission equipment is also important.

In fact, the tendencies are towards closer and closer coordination between three critical interdependent resources: **water, energy and food**. In an environment of increasing global population, rapid urbanisation, and changing diets, the Water- Energy-Food (WEF) nexus is essential, among other aspects, because **agriculture** is the largest consumer of freshwater resources and also consumes one-fourth of the energy. Agriculture represents 70% of global fresh water usage, but only 40% of this water reaches crops.

[4] Frost & Sullivan (2018) *Technologies Enabling Smart Water Grid ICT- Integrated Smart Water Grid With Remote Monitoring and Water Distribution Management Results in Effective Water Conservation*

[5] Frost & Sullivan (2018) *Growth Opportunities in the Advanced Water Treatment Systems Market, Forecast to 2022 - Actionable Strategies to Accelerate Growth in a Transforming Market*

It is claimed that the management of water resources must be approached with a holistic mentality, imagining closed loop value retention systems. Let's take for example the impact of **the land management of hydrographic basins** on the sources providing water to cities: it is estimated that improving the agricultural practices in only 0.2% of these lands throughout the world would improve the quality of the water for 600 million city dwellers. These actions are often much more economical than the construction of water treatment plants and they also contribute to improving the health and livelihood of rural communities.

Value retention criteria

Regenerative agriculture is another example of systemic thinking applied to water; it is well-known that heavily degraded land increases its filtration rate by up to thirty fold. On the other hand, agriculture that gives priority to increasing the organic content of the land generates various collateral benefits such as a reduced need for irrigation and revitalisation of ecosystems.

The fact is that striving to retain water resources within the system enables them to be used time and time again. Evolving towards a water economy circular consists, precisely, of **recognising and promoting natural water cycles**, synchronising and optimising them.

Nature already circulates water efficiently and has processes that regulate its flow and quality.

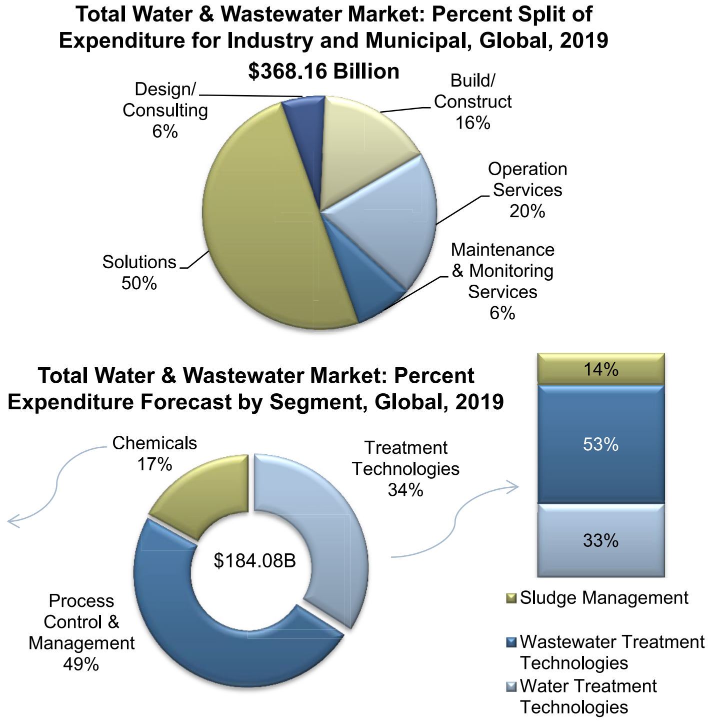
Not only are there weighty reasons, but also sufficient experience to **promote decided access to a circular economy** as way out of the deadlock we find ourselves in:

- **Regulatory pressure:** The objective of UN Sustainable Development Goal number 6 is to "improve water quality and safely increase recycling and re-use". The directives on corporate responsibility related to the use of water are also progressively being adopted by large corporations. In Mediterranean countries, particularly, it seems that an effort is being made to apply regulations and internalise the good practices already existing in advanced European economies.
- **Technological advances:** Revised resource recuperation technologies enable extracting a wider range of useful materials from wastewater, whereas smart sensors; combined with Big Data permit companies and city and territorial managers to administer water more efficiently.
- **New business models:** it is expected that in the future public utility services will not only purify, deliver, collect and treat water, but will also extract and market wastewater resources. WWTPs will tend to become biofactories that accept a wide variety of organic materials, converting them into products or useful by-products, as well as extracting energy.

In conclusion, using nature as a mentor, applying existing knowledge and the principles of a circular economy, will enable avoiding the water crisis predicted by so many. Systemic governance systems and technology are key players to advance towards models that use the same water multiple times, interfering less and less with nature, both in regard to removing the resource from the cycle natural as well as its release after use.

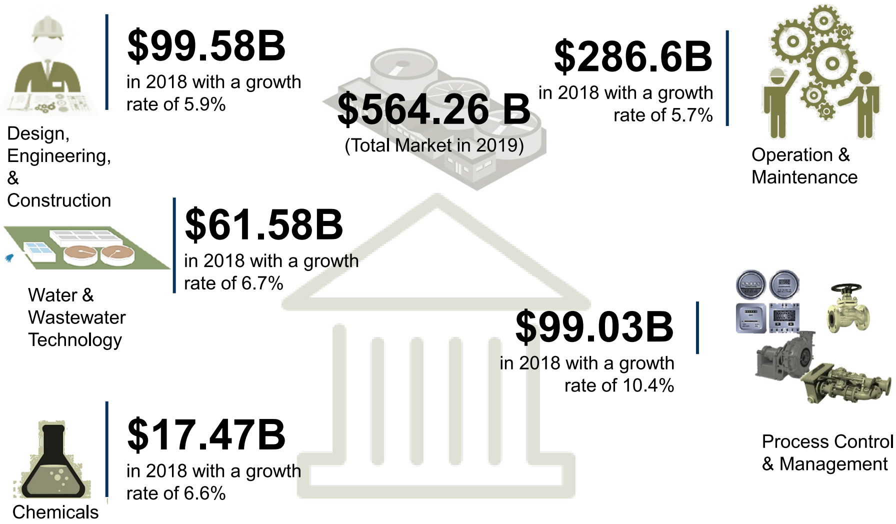
2
Circular Water Management: Key infographics

2.1. Global water and wastewater market, 2019



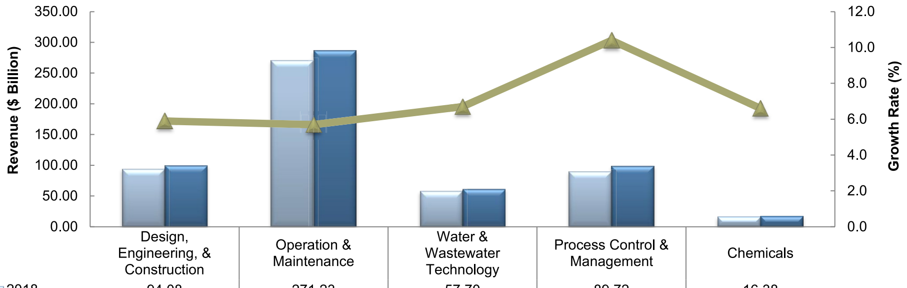
Source: Frost and Sullivan (2019) - Outlook of the Global Water and Wastewater Market

2.2. Urban water and wastewater management: Market segmentation, 2019



Source: Frost and Sullivan (2019) - Outlook of the Global Water and Wastewater Market

2.3. Urban water and wastewater management: Forecast expenditure per segment, 2018-2019

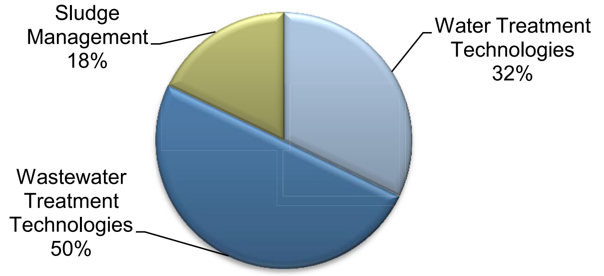


	Design, Engineering, & Construction	Operation & Maintenance	Water & Wastewater Technology	Process Control & Management	Chemicals
2018	94.08	271.23	57.70	89.72	16.38
2019	99.59	286.60	61.58	99.03	17.47
Growth Rate	5.9	5.7	6.7	10.4	6.6

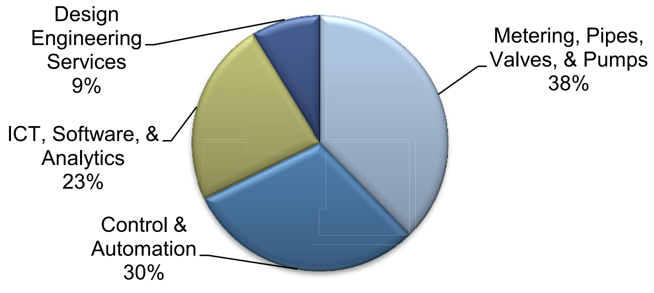
Source: Frost and Sullivan (2019) - Outlook of the Global Water and Wastewater Market

2.4. Urban water and wastewater management: Forecast expenditure per Technology and Solution, 2019

Municipal W & WWT Technology Segment: Percent Expenditure Forecast by Technology, Global, 2019

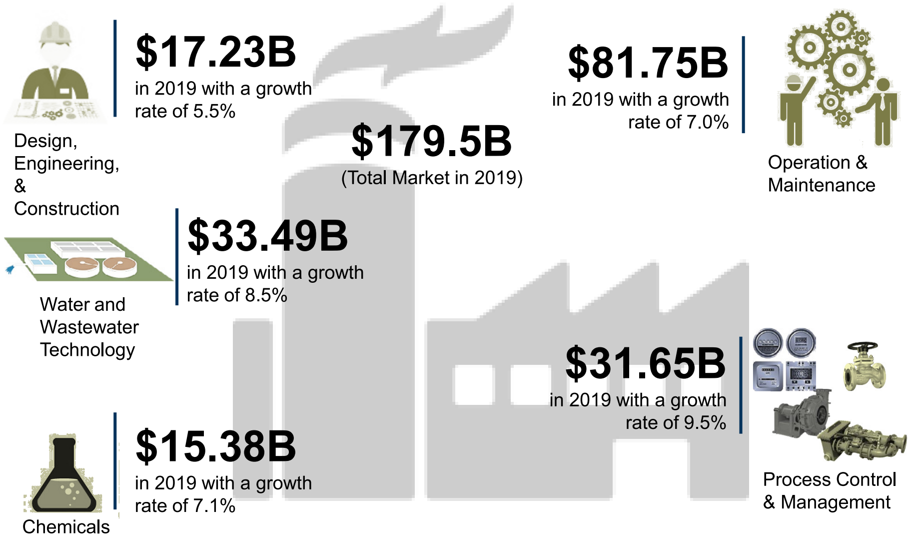


Municipal Smart Water Segment: Percent Expenditure Forecast by Solution, Global, 2019



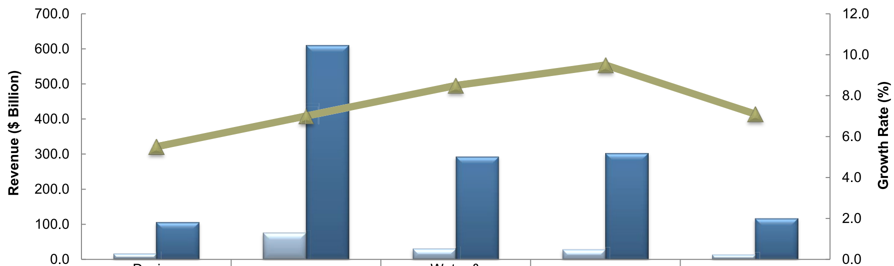
Source: Frost and Sullivan (2019) - Outlook of the Global Water and Wastewater Market

2.5. Industrial water and wastewater management: Market segmentation, 2019



Source: Frost and Sullivan (2019) - Outlook of the Global Water and Wastewater Market

2.6. Industrial water and wastewater management: Forecast expenditure per segment, 2018-2019

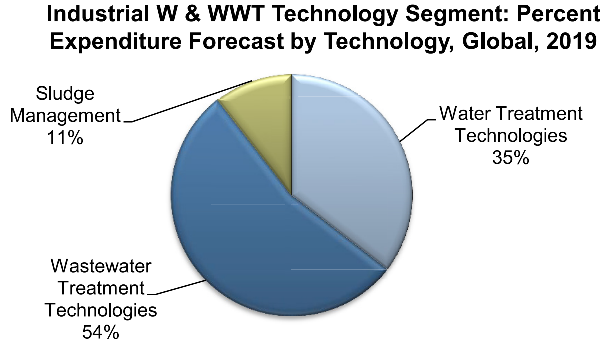


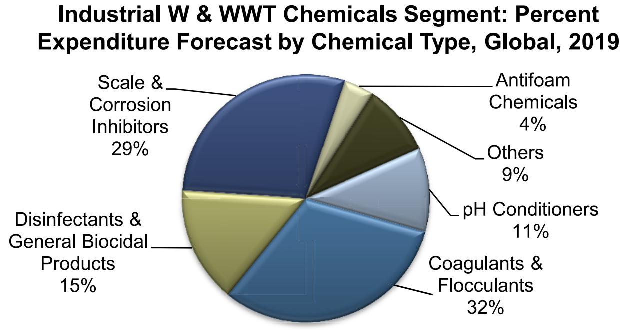
	Design, Engineering, & Construction	Operation & Maintenance	Water & Wastewater Technology	Process Control & Management	Chemicals
2018	16.33	76.38	30.86	28.90	14.37
2019	106.12	611.08	293.20	303.45	116.36
Growth Rate	5.5	7.0	8.5	9.5	7.1

Year

Source: Frost and Sullivan (2019) - Outlook of the Global Water and Wastewater Market

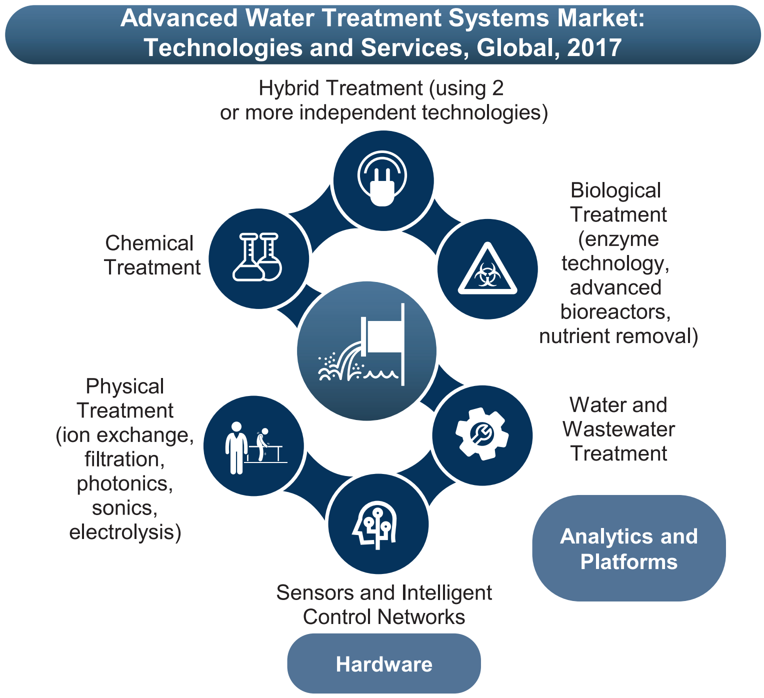
2.7. Industrial water and wastewater management: Forecast expenditure per Technology and Chemical Solution, 2019





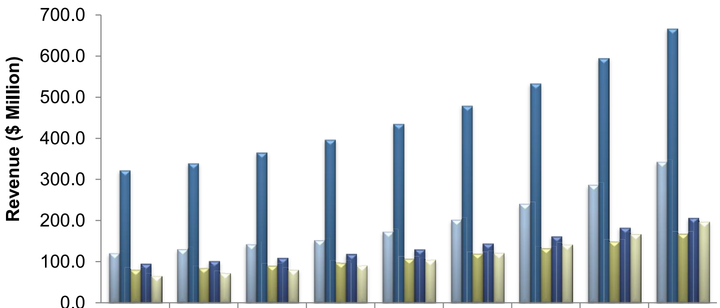
Source: Frost and Sullivan (2019) - Outlook of the Global Water and Wastewater Market

2.8. Advanced water treatment systems



Source: Frost and Sullivan (2018) - Growth Opportunities in the Advanced Water Treatment Systems Market, Forecast to 2022

2.9. Market for advanced water treatment systems: Forecast income 2014-2022



	2014	2015	2016	2017	2018	2019	2020	2021	2022
Advanced Physical Treatment	120.0	129.8	143.0	151.3	173.4	201.5	239.8	286.5	342.4
Advanced Chemical Treatment	322.0	339.4	365.9	397.0	435.1	479.9	533.6	595.0	666.4
Advanced Biological Treatment	80.3	84.4	90.0	97.8	107.4	118.4	132.0	148.6	167.8
Hybrid Technology	95.2	101.4	109.0	118.6	130.3	144.7	162.3	183.2	207.4
Digital Service—Hardware and Analytics	65.4	72.0	80.1	90.7	104.1	120.8	141.5	166.8	197.6

Year

Source: Frost and Sullivan (2018) - Growth Opportunities in the Advanced Water Treatment Systems Market, Forecast to 2022

2.10. Water and wastewater treatment facilities: Forecast income 2019

Water & Wastewater Treatment Equipment Market: Revenue Forecast by Key Technologies, Global, 2019

Key Technology	2019 Revenue ($ Billion)	Market Share (%)
Membrane Bio-Reactor (MBR)	1.38	6.5%
Reverse Osmosis (RO) Membrane	3.44	8.7%
Micro-Filtration (MF) Membrane	1.72	3.0%
Ultra-Filtration (UF) Membrane	2.45	7.0%
Nano-Filtration (NF) Membrane	0.77	1.5%
Ultra Violet (UV)	0.96	4.1%
Ozone	0.32	1.0%
Chlorination	1.83	3.1%
Industrial Demineralization	1.40	3.5%
Clarification	6.33	8.5%
Activated Sludge	6.85	8.8%
WW Pre-Treatment	2.32	4.5%
Sludge Thickening	2.48	4.2%
Sludge Dewatering	3.21	5.0%
Sludge Digestion	1.15	3.5%
Sludge Drying	1.32	2.1%
Other Biological WWT	7.30	8.5%
Other Primary WWT	7.22	7.0%
Other Filtration	10.95	6.5%
Other Treatment Equipment	0.62	3.0%

Source: Frost and Sullivan (2019) - Outlook of the Global Water and Wastewater Market

2.11. Characterisation of wastewater treatment (1): Physical, chemical and biological treatments

	Advanced Physical Treatment	Advanced Chemical Treatment	Advanced Biological Treatment
Advanced Features	• Membrane life prediction and optimisation • Filtration optimisation • Program Logic Controller (PLC)/SCADA-based filtration control • PLC/SCADA-based AOP and photo-catalysis • Flow control into membranes • Heat and temperature control for adsorption • Automatic backflush and washing of membrane systems • Controlled plugging prevention in membranes • LED-UV disinfection • Nano-photocatalysis • Ultrasonic algal control • Biomimetic membrane technology • Forward osmosis	• Odour control • Controlled dosing of chemicals • Over concentration control • Anti-scaling control • Corrosion control • Toxicity and pathogen control • Osmotic pressure-based tablet dosing • Microbiocides for water disinfection	• Enzyme technology • Nano bio-reactors for wastewater treatment • Moving/packed bed biofilm reactors for wastewater treatment • Spiral aerobic biofilm reactors for wastewater treatment • Hybrid activated sludge process • Attached growth technology on filters • Cylic low-energy ammonium removal • Usage of natural retention time (plug-flow reactors) • Simultaneous enery production using hollow-fibre membrane technology • Nutrient removal • Filter-based bioreactors for wastewater treatment
Smart Features	• Wi-Fi-based temperature control in adsorption • Data analysis and optimisation • Forecasting • Software to minimise unforeseen events • Integrated event management	• Odour measurement and diagnostic service • Wi-Fi enabled water treatment monitoring • Data analysis and optimisation	• Bio-stress level indication • Temperature control using the Internet • Aeration control using the Internet • Internet-based compost process control and monitoring • Waste Water Treatment Plant (WWTP) design generation • Integrated event management • Advanced reactor configurations

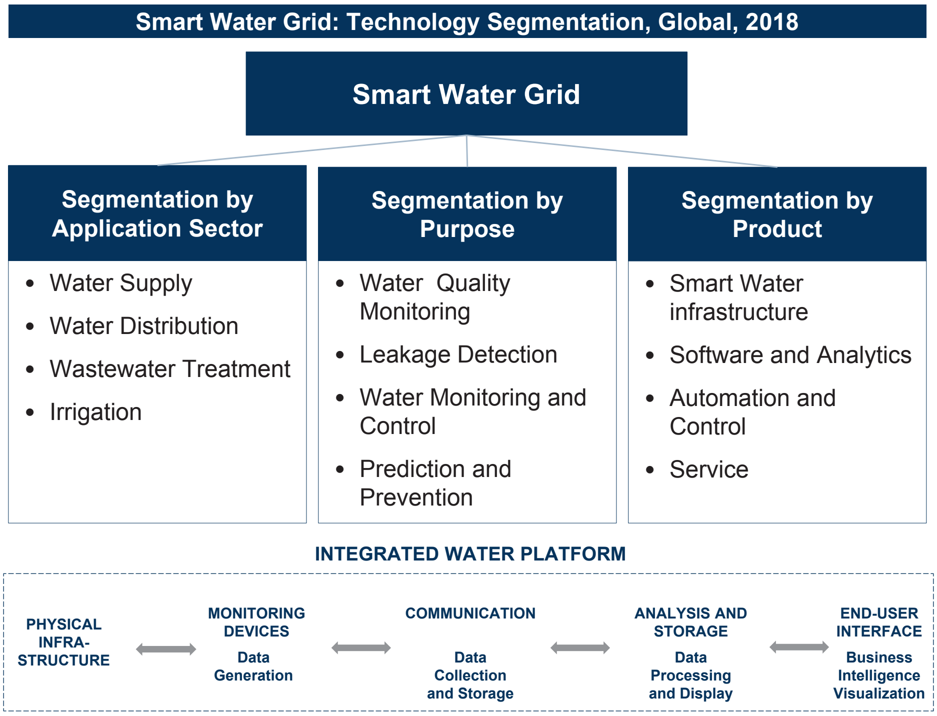
Source: Frost and Sullivan (2018) - Growth Opportunities in the Advanced Water Treatment Systems Market, Forecast to 2022

2.12. Characterisation of wastewater treatment (2): Hybrid treatments and digital services

	Hybrid Treatment	Digital Services
Advanced Features	• Combination of electrolytic water purification and membrane technology • Combination of electrolytic water purification and nutrient removal technology for salt splitting and ammonia splitting • Simultaneous energy generation and water treatment using bioreactors • Aerobic and anaerobic combined biological processes	• Suggested optimal reactor configurations • Online RO monitoring • Wireless process control • Intelligent UF control • Biomass content indication • Wireless aeration control • Wireless compost process control • Data analysis and optimisation • Minimisation of unforeseen events • Plant audits • Event management • Forecasting trends and results • Minimising footprint
Smart Features	• Full automation • Instantaneous on/off, turn up/down features • Intelligent self-cleaning • Smart metering • Smart sensor technology • Intelligent electrode protection • 24x7 Remote Operations Control (ROC) • Proactive monitoring and remote control	• Wi-Fi-enabled services • Mobile applications • Smart sensor technology • Data cloud and analytics services

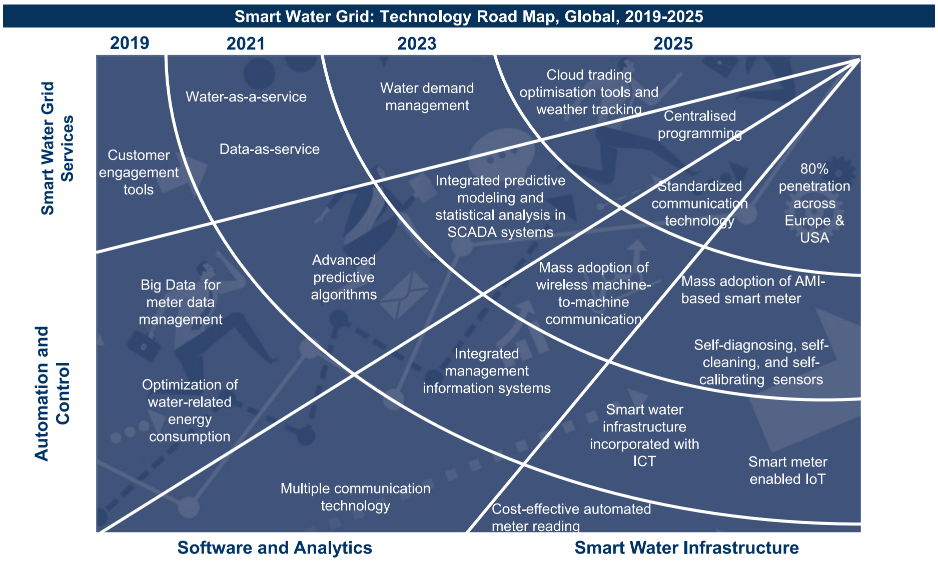
Source: Frost and Sullivan (2018) - Growth Opportunities in the Advanced Water Treatment Systems Market, Forecast to 2022

2.13. Smart water grids: Segmentation per application, intention and product



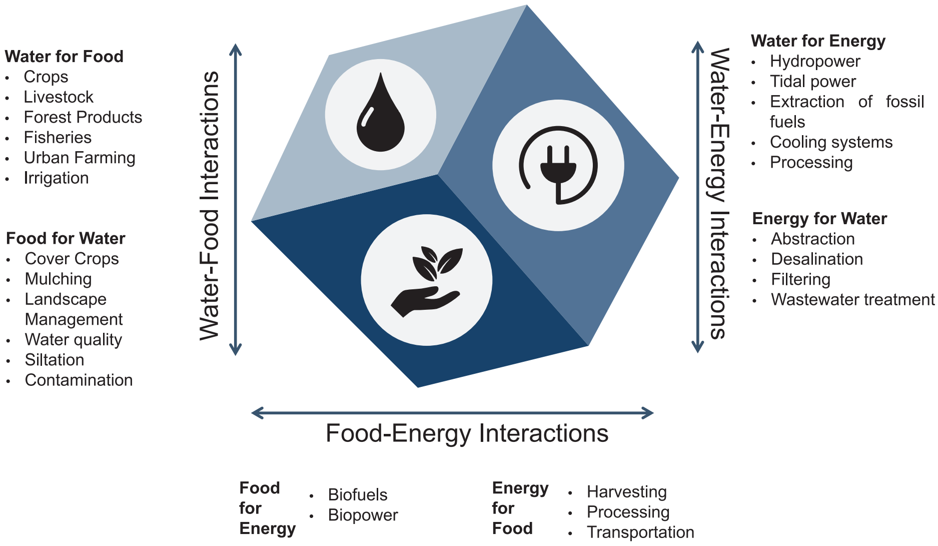
Source: Frost and Sullivan (2018) Technologies Enabling Smart Water Grid

2.14. Smart water grids: Technology road book, 2019-2022



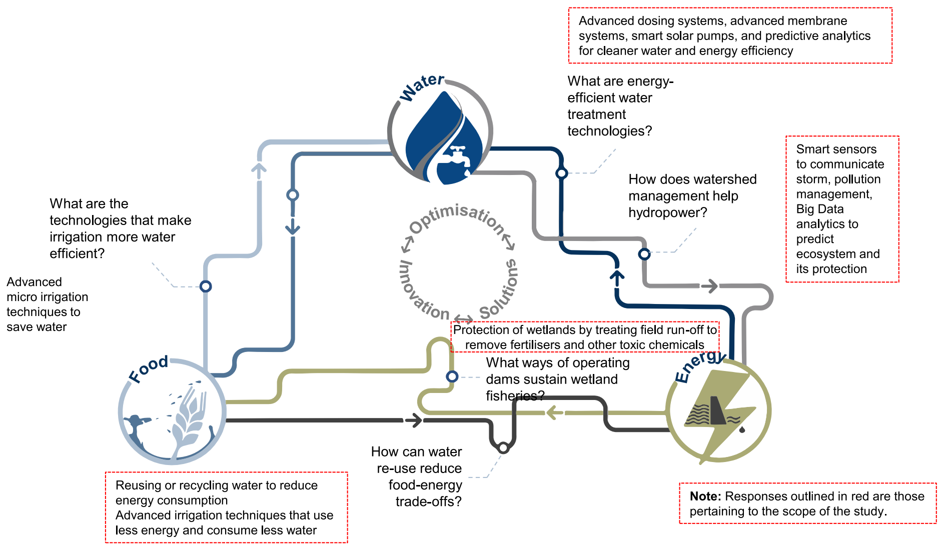
Source: Frost and Sullivan (2018) Technologies Enabling Smart Water Grid

2.15. Water-Energy-Food nexus



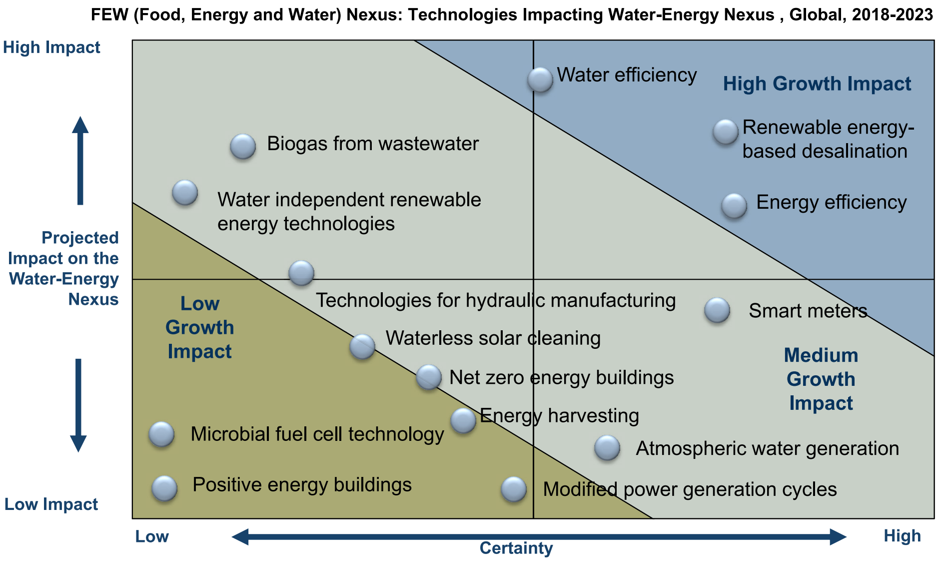
Source: Frost and Sullivan (2018) FEW (Food, Energy and Water) Nexus

2.16. Water-Energy-Food Nexus: Advanced treatment models



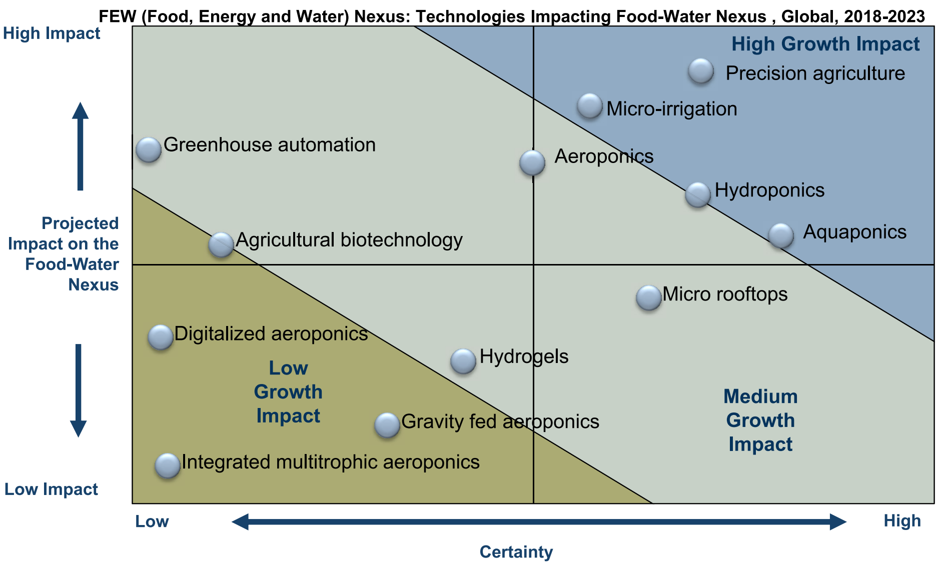
Source: Frost and Sullivan (2018) - Growth Opportunities in the Advanced Water Treatment Systems Market, Forecast to 2022

2.17. Water-Energy nexus: Technologies and impact, 2018-2023



Source: Frost and Sullivan (2018) FEW (Food, Energy and Water) Nexus

2.18. Water--Food Nexus: Technologies and impact, 2018-2023



Source: Frost and Sullivan (2018) FEW (Food, Energy and Water) Nexus

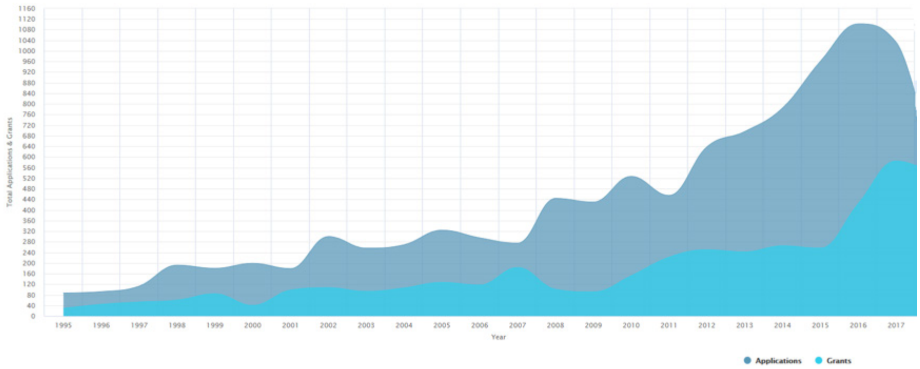
3
Patent analysis

In the field of circular water management, the analysis was defined to include the following related concepts or fields in patents:

- Water treatment plants and water treatment
- Water filtration
- Water pumping facilities

3.1. Evolution of patents applied for and granted

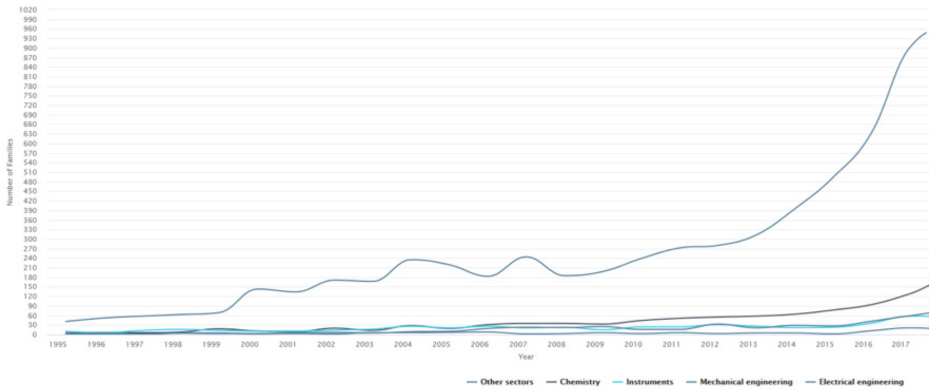
Analysis of patents applied for and granted enables appreciating the growth tendency in this sector over the last 25 years. Furthermore it enables us to determine what percentage of these patent applications are really granted, en this case an average of 44% of patents applied for are granted.



Source: PatBase. July 2019 Query

3.2. Technological sector of the patents applied for

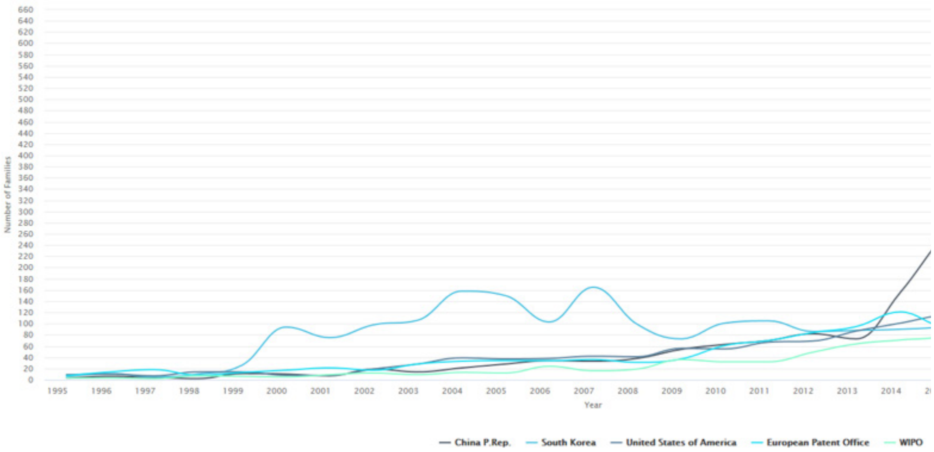
Over the last 25 years, the most active technologies in patents applied for in the field of circular water and all fields included belong to: miscellaneous, chemistry, instruments, mechanical engineering, electrical engineering and other sectors.



Source: PatBase. July 2019 Query

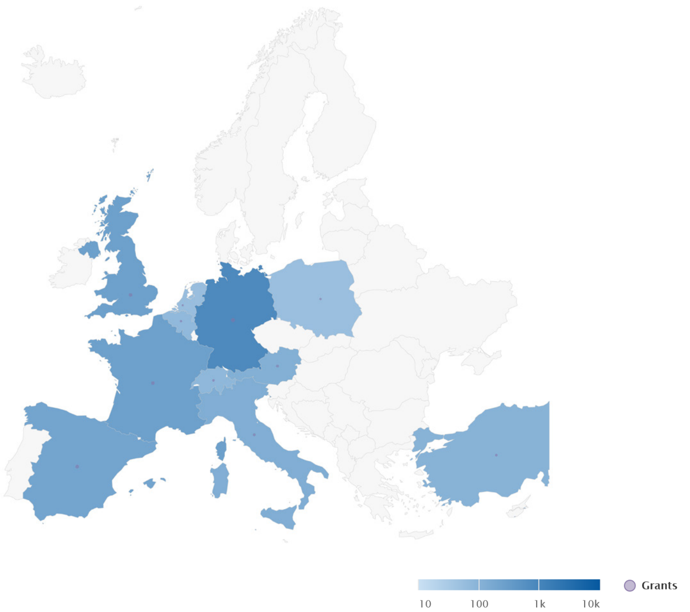
3.3. Location of the application for patents

On a global level, the countries where most patent applications are filed are China, South Korea, the United States and the European Union. China is by far the most active country, especially over the last 5 years.



Source: PatBase. July 2019 Query

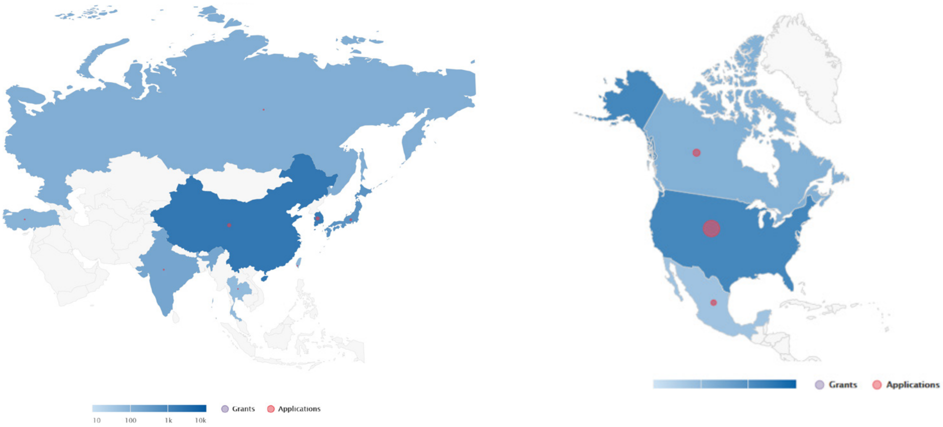
As shown on the map below, within the European Union the countries with most patent applications are, in decreasing order, Germany, France, England and Spain.



Source: PatBase. July 2019 Query

On the other hand, in Asia, the most active countries in patent applications for circular water management are China and North Korea, followed by Japan.

The United States and Canada are quite active in patent applications in this area as shown in the graph below, led by the United States and followed by Canada.

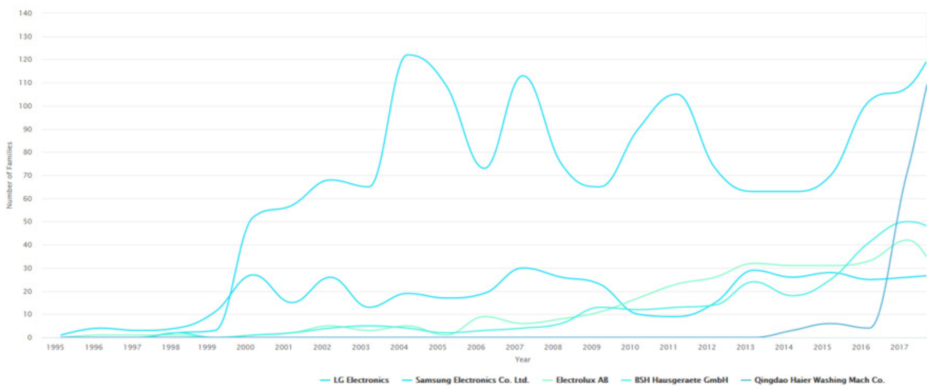


Source: PatBase. July 2019 Query

3.4. Most active patent applicants over the last 25 years

The following graph shows, for the last 25 years, the five most active organisations in patent applications and the time periods where these applications were concentrated.

The most active institutions are, among others, LG Electronics, Samsung Electronics, Electrolux AB BSH Hausgeraete, Qingdao Haier Washing Machine Co., etc.

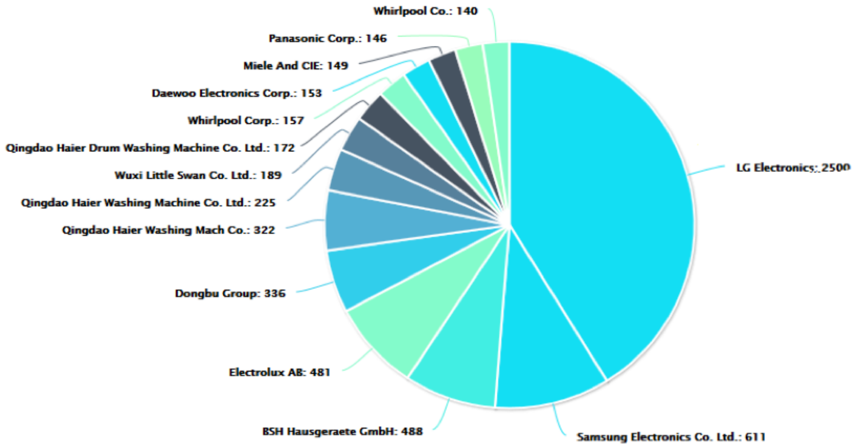


Source: PatBase. July 2019 Query

3.5. Who applies for most patents, the most active applicants

The chart shows the entities (companies, institutions or people) who have applied for most patents in this area together with the number of applications made by each.

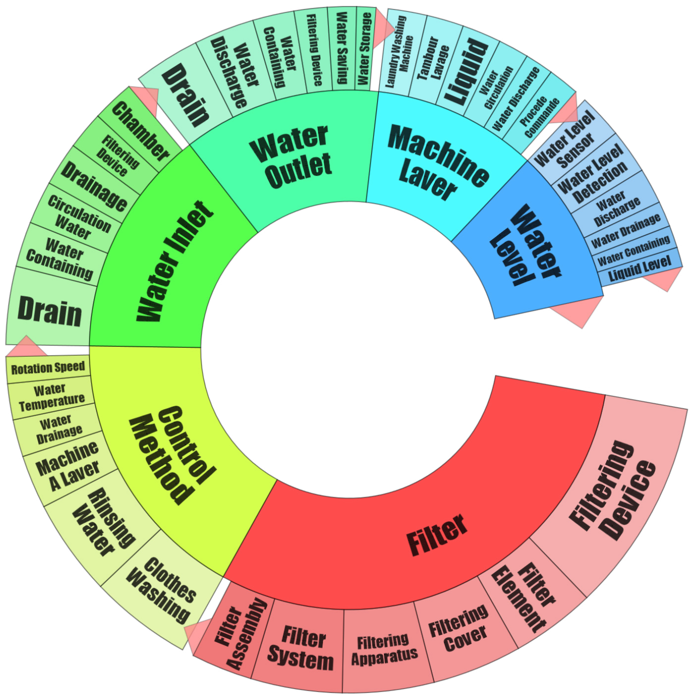
Multinational companies such as LG Electronics, Samsung Electronics, Qingdao Haier and Daewoo Electronics... are the most active applicants in this field; on the other hand there are no public institutions outstanding as being active in this field.



Source: PatBase. July 2019 Query

3.6. Keywords attributed to patents in this field

The terms of filters, water valve, control method, cleaning machine, drain, and water channel are the words most often used in patent applications in this field. Among all these the most active is filters followed by water control methods and water inlet.



Source: PatBase. July 2019 Query

3.7. METHODOLOGICAL APPENDIX

The information provided in the "Patent analysis" section refers to the study performed on a sample of 12,593 patent applications in the area of Circular Water where there have been included: 12,593 patent applications in the following fields:

- Water treatment plants and water treatment
- Water filtration
- Water pumping facilities

5.001	2.808	12.593	16.645
Patent family	Family of patents granted	Applications	Publications
Total number of families in this set of results	Total number of families with publications granted with this set of results	Applications with this result	Publications within this result

Source: PatBase. July 2019 Query

The criterion used for the query of this report was the maximum scope in the field in order not to impose any limit and include all results relative to the field. Specific words were used to define the area.

Patent documents are classified under different classification systems to simply search procedures. The most often used international classification system is the International Patent Classification (IPC) in addition to the Cooperative Patent Classification (CPC) system used for more specific fields.

The sample obtained for drafting the report includes various fields. In accordance with IPC and CPC nomenclature these fields are majority and include other key words included in the definition:

- D06F39/004: Arrangements for measuring or detecting the condition of the washing water, e.g. turbidity
- C02F1/00: Treatment of water, waste water, or sewage
- B08B3/00: Cleaning by methods involving the use or presence of liquid or steam
- F05B2210/00: Working fluid
- F04D13/00: Pumping installations or systems
- C02F2103/002: Grey water, e.g. from clothes washers, showers or dishwashers
- C02F2307/12 Location of water treatment or water treatment device as part of household appliances such as dishwashers, laundry washing machines or vacuum cleaners
- D06F2202/02 Chemical variables; Condition of the washing liquid
- D06F39/083 Liquid discharge or recirculation arrangements
- D06F39/10 Filtering arrangements
- B01D29/00: Other filters with filtering elements stationary during filtration, e.g. pressure or suction filters, or filtering elements therefor.

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