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CIRCULAR ECONOMY IN ITALY

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CIRCULAR ECONOMY IN ITALY.

Market analysis and business opportunities
for dutch innovative companies:
clean & safe water and water resource recovery

December 2020

COLOPHON

The study is a market analysis owned by the Embassy of the Kingdom of the Netherlands, Consulate General of the Netherlands in Italy and the Netherlands Enterprise Agency.

Kingdom of the Netherlands

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EXECUTIVE SUMMARY

The world population growth and the consequent impacts on human and the environment health demand a fast-moving transition towards a low-emission and zero-waste economy.
Clean and sustainable use of water is one of the leading priorities for a sustainable society called upon to counteract water depletion, pressures on the ecosystem due to urbanisation processes and new emerging pollutants. Therefore, new business and consumption models based on a circular approach to optimising resources stimulate increasing investments in green technologies to face climate change challenges. In this context, the market study on the *Circular Economy in Italy* provides a complete framework of the Italian water supply landscape with a focus on clean and safe technology as well as water resource recovery. The ultimate scope of this study is to provide a concrete insight in how innovative Dutch companies operate in these sectors in terms of business opportunities, favourable legislative conditions, relevant stakeholders and leading players to further improve the Dutch presence in the market and Dutch-Italian collaborations.

The ***Introduction*** provides an overall picture of the water consumption for civil, industrial and agriculture services and the water supply in Italy, key actors and policy authorities of the integrated management system.

- The total water consumption in 2015 was approximately 21.6 billion m^3, including for civil and industrial use. Agricultural practices dominate the water demand covering 59% of the total volume of withdrawals, followed by water for households accounting 22% - placing Italy first in Europe for freshwater consumption.
- Request for drinking water is growing over decades to extent that from 1999 to 2015 it increased by 6.9%, and according to more recent data, withdrawals in 2019 were of 9.2 billion m^3 equal to 419 litres per day per inhabitant.
- Water losses are one of the significant problems in the Italian water system, which means that 37.3% is not received by the end-users, with greater severity (45%) in the South and islands.

The governance of water resources in Italy is characterised by a very complex multi-level model with substantial differences between regions. It takes on diversified forms, with a predominant role of the regions and the local authorities responsible for awardingthe service and handlingthef water basin model.

- In Italy, there are 91 regional authorities responsible for water supply and sanitation services in Italy (AATOs, from its Italian initials or "Autorità di Ambito Territoriale Ottimale"), in charge of rmanaging economic and environmental resources at the local level under the governance of the municipalities for the reference area.
- The AATOs entrust the integrated water service to public or private operators through an agreement, based on various contract schemes. The most widespread form is the *in-house* model which reconciles in a new Incorporating Company entrepreneurial entities and municipalities.

The ***first part of the study*** provides a general understanding of the Italian Legislative framework for managing, monitoring and promoting a sustainable use of water. It aims to investigate the pillars of the decision-making mechanism in establishing water uses, microbiological parameters and restrictions on drinking, industrial and agricultural use.

- In Italy, the EU Water Framework Directive - WFD (2000/60/CE)[1] is the reference legislation for managing water and drinking water; its regulations are transposed in the Environmental Law (Italian Legislative Decree 152/2006)[2].
- Italian legislation for wastewater treatment and reuse is based on the Technical Regulations on wastewater treatment and reuse (Ministerial Decree of 2 May, 2006)[3], establishing discharge limits forwastewater, measures for water pollution prevention and the technical rules for urban and industrial wastewater reuse.
- The Drinking Water Directive represents a further crucial European directive related to water management (98/83/EC)[4]; its regulations are transposed in Italian legislation with the National Decree on drinking water (Italian Legislative Decree 31/2001)[5] and its subsequent additions and amendments (Italian Legislative Decree 27/2002)[6]. These two decrees establish a set of 62 microbiological, chemical, and physical parameters that must be monitored and tested regularly.

The ***second part of the study describes*** the leading **technologies** for water purification and sludge treatments in Italy, in accordance with the service offer of top players.

- The regions with the largest share of water subjected to purification treatments are Basilicata (80%) and Sardinia (79%), followed by Emilia-Romagna (59.3%), Puglia (58.8%) and Tuscany (56,5%).

- In Italy, only 4% of the volume of purified wastewater is destined for reuse. However, an increasing trend in sustainable wastewater reuse is becoming a reality along the water supply chain.
- Innovative membrane bioreactor processes are an emerging technology, that is becoming increasingly common for tertiary or advanced wastewater treatment, due to their efficiency and cost-effectiveness [7].
- In 2018, there were 339 plants in Italy for the biological treatment of sewage sludge and municipal waste, treating a volume of approximately 10.3 million tonnes of organic waste.

The ***third part*** part of the study researches the *industrial water competitive landscape* by selecting 475 operators covering the integrated water supply system from collection to wastewater treatment.

- Water distributors dominate the sector. Large companies responsible for the overall water management system cover 43% oof the total service providers, followed by urban wastewater treatment (16%) and companies involved in the design, construction, and maintenance of aqueducts, sewerage networks, and wastewater treatment plants (13%).
- The median growth rate of the best companies in the sector (75th percentile) in 2019 records an improvement of almost 5% per year. The water industry's top players can be broken down into mono-utility and, for the majority, multi-utility operators also active in energy and gas services.
- The North-West regions host over a third of the companies in the sample. Companies who are operating in this area show a growth rate in the median value of 23.74% compared to 2018, covering distribution and urban wastewater treatment services for medium-large agglomerates and high-intensity populated areas.

The ***fourth part*** of the study provides an overview of the opportunities for cooperation between Italian and Dutch companies, including collaborative scenarios based on research and innovation trends and progress. As a result of a growing political commitment, some Italian regions have launched a series of incentive and financial measures for sustainable management of water resources. Favourable conditions for water purification and reuse technologies are more encouraged in areas with a high intensity of agricultural production and urbanisation or with limited availability of water resources. The primary areas of interest are:

- WATER-SAVING SOLUTIONS and WASTEWATER REUSE. Water scarcity stimulates the reuse of treated wastewater, as well as raising public awareness to prevent desertification and encourage water savings. The South is the area most affected by these phenomena where regions provide incentives and investments to counteract surface water depletion. Italian regions (i.e. Lombardy, Sardinia, Emilia-Romagna) with a high agricultural intensity in recent years have launched programmes to encourage the dissemination of solutions for the recovery of purified water for irrigation purposes.
- DEMAND FOR DECENTRALISED WATER RECYCLING SYSTEMS. In Italy, despite this high potential, the number of companies involved in the sale and installation of domestic wastewater treatment plants from homes is minimal. The demand for water recovery solutions is growing as well as that for systems for capturing, filtering and reusing rainwater for non-human consumption through a double network.
- TECHNOLOGY FOR SEWAGE SLUDGE REUSE. With 3.1 million tonnes produced in 2018[8], sludge is one of the leading products derived from wastewater treatment, and further growth is expected in the coming years as a result of an increasing number of households connected to the sewer network.

INFOGRAPHIC SUMMARIZING KEY DATA

2015
21.6 billion m³
TOTAL WATER CONSUMPTION

AGRICULTURE 59% HOUSEHOLD SECTOR 22%

FROM 1999 TO 2015
+6,9%
REQUEST DRINKING WATER

9.2 billion m³ — 419 Liters/day
DRINKING WATER WITHDRAWAL IN 2019

37,3%
WATER LOSSES

IN SOUTH AND ISLANDS

91
AATOs
IN ITALY
RESPONSIBLE FOR THE MANAGEMENT OF ECONOMIC AND ENVIRONMENTAL RESOURCES

ITALIAN LEGISLATIVE FRAMEWORK

EU WATER FRAMEWORK DIRECTIVE - WFD
Environmental Law (D.lgs. 152/2006)

TECHNICAL REGULATIONS ON TREATED WASTEWATER RE-USE
Defining emission limits of the wastewater

DRINKING WATER DIRECTIVE
National Decree on potable water

LEADING TECHNOLOGIES

TOP 5
REGIONS SUBJECTED TO WATER PURIFICATION TREATMENTS

4%
VOLUME OF PURIFIED WASTEWATER DESTINED FOR RE-USE

MEMBRANE BIOREACTORS 2018

339
PLANTS FOR THE BIOLOGICAL TREATMENT OF SEWAGE SLUDGE

INDUSTRIAL WATER COMPETITIVE LANDSCAPE

475
OPERATORS

43% WATER DISTIBUTION
16% Urban wastewater treatment
13% Process water treatment and maintenance

2019
+5%
GROWTH RATE OF THE BEST COMPANIES PER YEAR

+23,74%
GROWTH RATE OF THE COMPANIES OPERATING IN NORTH-WEST REGIONS COMPARED TO 2018

OPPORTUNITIES FOR COOPERATION

WATER-SAVING SOLUTIONS AND WASTEWATER RE-USE

DEMAND FOR DECENTRALISED WATER RECYCLING SYSTEMS

TECHNOLOGY FOR SEWAGE SLUDGE RE-USE

INTRODUCTION

INTRODUCTION

Italy is one of Southern Europe's three great peninsulas located in the centre of the Mediterranean Sea. Its overall coastal length is around 7,600 km, divided between the articulated coasts of the peninsula, the major islands including Sicily (25,426 km^2) and Sardinia (23,813 km^2) and minor islands and archipelagos.
According to the geographical areas, smaller basins are part of the Mediterranean Sea.
The Adriatic Sea separates Italy from the Balkan Peninsula, with a depth that increases towards the South, up to over 1,000 meters off the coast of Bari, it communicates with the Ionian Sea; the second eastern basin located between western Sicily and Greece. The western coasts are bathed by the Tyrrhenian Sea (the largest of the Mediterranean basins that reaches high depths, up to - 3,800 metres), and the Ligurian Sea in the north-west of Italy. Finally, the two major islands host the two respective basins of the Sea of Sicily and Sardinia.

Italy is located at an intermediate latitude with a temperate climate, alpine in the North, continental in the Po valley and adjacent areas, as well as the more internal Apennine and the Mediterranean along the coastal strip, and subtropical in the South. Temperature variations are almost modest everywhere, even though water scarcity prevails in the South with a consequent drought of its water basins.
The peninsula extends from the region of the Po River southward for around 960 km and a maximum width of 240 km. Regarding freshwater basins, related to its characteristic elongated shape and the position of mountain reliefs, Italy's rivers are mostly short, lacking in water and characterised by periods of dryness. Major watercourses flow in the North of the country receiving water from glaciers in between Alps and Apennine mountains range. The Alps boasts breathtaking scenic views which overlook the Alpine lakes and glacier-carved valleys stretching down to the Po River; the longest river in Italy, which crosses the Po Valley with numerous tributaries and flows into the Adriatic Sea after 652 Km. It also has the most extensive annual average flow rate at its mouth of approximately 1,540 m3 per second.
The pre-Alpine belt hosts the most extensive lake basins -Garda (370 Km^2), Maggiore (170 Km^2 within the Italian part, in total 212 Km^2) and Como (146 Km^2) - followed by Trasimeno (128 Km^2), and the Lake of Bolsena (114 Km^2), the largest in Europe of volcanic origin.

The Italian peninsula is Southern Europe richest country in terms of water resources. It has high a concentration of water bodies, comprising 69 natural lakes with a surface equal to or greater than 0.5 km^2, 183 artificial basins with over one km^2 surface area, 234 creeks and rivers representing a valuable natural heritage. Furthermore, there are almost 500 surface and underground water bodies destined for purification, as well as 400 are lakes with a minimum extension of 0.2 km^2, thus consolidating an abundance of water resources already physiologically present in the country, both naturally and artificially. The distribution of freshwater in Italy is heterogeneous, the majority of which is located in the North hosting over six-tenths of lake resources and the large Alpine and pre-Alpine basins, which alone amount to 124 billion m3, equal to 62% of the national total.
More than half of freshwater (75 billion m3) is found in the Lombardy region, which also responsible for its significconsumes a significant amount of it, followed by the lakes of the central Apennines (25 billion m3), while only 3% is found in the South and Islands.
While most of the national water basins are located in the North covering about 100,000 km^2, there are smaller basins in the South - in particular in Sicily and Sardinia -, reinforcing the water disadvantage of these regions[9].
Metals and other micropollutants represent one of the major issues affecting groundwater, led by arsenic, which is strongly detected in Lazio, Lombardy, Piedmont, Umbria, Trentino-Alto Adige, and Tuscany. Chlorites, vanadium, boron and other micropollutants represent a significant hurdle in some regions such as Sicily and Sardinia stimulating a considerable demand for safe water technologies.

WATER CONSUMPTION, DEMAND FROM PRODUCTION SECTORS AND WATER QUALITY

According to the Italian National Institute of Statistics (ISTAT), **the total water consumption in Italy** in 2015, including households, industrial, agricultural, and zootechnical use was approximately **21.6 billion m^3**. Facts on the Italian use of water in the sectors of production - agriculture, industry, and zootechnic - are significantly limited, especially regarding sources and water reuses, causing a high degree of uncertainty in its measurement.

Agricultural practices dominate the water demand in 2016 - last estimates available - covering **59%** of the total volume, mostly used for irrigation. In 2015-2016, irrigation areas were estimated around 2,553 thousand hectares with a medium volume of 5,000 m^3 used for the irrigation of 1 hectare, for a total of over 12.7 billion m^3 of water.
Greenhouse crops represent a production sector of considerable economic importance for the national agricultural system: greenhouse crops reach a turnover of more than 3 billion euro between structures, equipment, phytosanitary and plant production[10]. Greenhouse extensions in Italy exceed **42,000 hectares**, of which 5,000 are dedicated to vegetable crops and over 37,000 hectares to flowers. There are 31,256 farms involved in greenhouse plant production out of a total of 107,118; about **60%** of the entire Italian greenhouse area is located in the

South, especially in coastal areas. Regarding water consumption, a greenhouse with an extension of **1 hectare** uses about **200 m³ of water per day for irrigation**, this is without taking into account water for cooling systems, which means 8,4 million m³ of water per day for the total area covered by greenhouses[11].

Drinking water supplied to final users for **household consumption** was 4,78 billion m³, accounting for **22%** of total water consumption in 2015, positioning Italy at that time as the first European country for freshwater consumption. Among the sectors with the highest water demand is the **manufacturing industry** - comprising a variety of industrial sectors, such as pulp and paper, textile, chemicals, food - and **zootechnical sectors** were the third and fourth sector in terms of highest water demand with an estimate of 3,79 billion m³ (**17.6%**) and 317,5 million m³ (**1.5%**) respectively. Data does not consider the actual amount of water withdrawn from natural water sources.
Lombardy had the highest water consumption volume, covering 15.7% of the national drinking water withdrawal value. Moreover, 20% of the national irrigated area and 28% of water uses for livestock purposes are located in Lombardy. Regional information on industrial water use is not available[12].

According to ISTAT estimates, in 2019 **withdrawals of drinking water consumption** for the domestic sector in Italy were of 9.2 billion m3 equal to 419 litres day per inhabitant, without taking into account the amount of water used for other sectors (agriculture, industrial, etc.). However, only 5.77 million m3 of water was supplied to end users as 37.3% is not receivedby end users generating severe economic and environmental impacts due to water leakage losses along with the distribution network.
Losses are consistent in the South and the islands where the highest figure is attested (45%), while the lowest are in the North (29%). Even though a progressive decrease from 2015 in water consumption (9.5 billion m³ of total water withdrawn for domestic use which means 428 litres day per inhabitant), and water losses (47.9%, the highest value in Europe)[13], leakages remain a relevant problem for Italy.

Regarding water sources, national withdrawals of drinking water for the civil sector mainly derives from **groundwater** (**84.3%** of which 48.0% is from wells and 36.3% from springs) - placing Italy in the seventh place in Europe for the use of groundwater sources[1] -, **15.6%** from **surface waters** (9.9% from artificial reservoirs, 4.8% from surface watercourses and 0.9% from natural lakes) and the remaining 0.1% from marine or brackish waters. It is essential to note that this data refers only to the civil sector, while data for production sectors (agriculture, industry, zootechnical) is not available.

North-West and Southern regions are the primary sources supplying over half of drinking water withdrawals. More specifically, the use of surface water is remarkable in Basilicata, Puglia, Sardinia, Liguria, and Emilia-Romagna. Lombardy is the region with the largest volume of water withdrawn for drinking purposes (15.4% of the national total), followed by Lazio (12.5%) and Campania (10.1%).
The variability throughout Italy is substantial, due not only to different water needs but also to the location of water bodies, the various water transport infrastructures and the performance of the supply service[12].

Water quality depends on the properties of the waterbody it comes from, affecting the water treatment before being distributed to end users. Ordinary operations require a disinfection and chlorination process, but a much more articulated disinfection process purifies one-third of water consumed, removing pollutants from the water.
Groundwater, coming from rocks, is generally of a good quality and does not require a purification treatment, unless anthropic or natural water contamination events are observed. On the contrary, surface water must be purified in almost all cases. Purification processes are mostly applied in Basilicata (80% of water) and Sardinia (79%) due to water withdrawals from the surface and artificial reservoirs. A high value is also recorded in Emilia-Romagna (59.3%), Puglia (58.8%) and Tuscany (56.5%)[12].

From studies deriving from literature[14], Italy ranks fifth in Europe for **tap water quality**, demonstrating the daily commitment of the various managers in terms of control and analysis of the resource. To ensure the quality of water supplied and that is restored to the environment, all stages of the integrated water cycle are subject to complex control activities carried out both at the facilities and through laboratory analysis. In particular, the integrated management of the water service in Italy allows for water to be available both for household and industrial use and consumption during all stages of the cycle: from collection to potability up to its distribution to users, from sewerage system management to purification up to the return of water to the environment.

[1] Withdrawal sources depend on the properties of the water bodies used for the drinking water supply and are mainly divided between groundwater and surface water. Groundwater is the most abundant and most exploited resource for drinking purposes, placing Italy in seventh place in Europe. Austria leads the European ranking, followed by Malta, Denmark, Lithuania, Slovenia and Croatia.

WATER SUPPLY MANAGEMENT IN ITALY

The Ministry of Environment as a pivotal national authority establishes the country's water policy guidelines for the proper functioning of the water sector. It sets the general quality objectives of the integrated water service in Italy through the collaboration of regions and consumer associations. It determines the quality standards of the resource, based on European directives, costs and regulation in water system management.

The Italian Law 36/1994 so-called «Galli Law»[15] is one of the main pillars of the Italian water regulation which results in a dramatic optimisation of the integrated water system and decrease of the fragmentation in decision-making mechanisms. It remedied several system inefficiencies since more than 45% of the population suffered interruptions in the water supply and absence of a sewer system. It also set rules for service management, reducing the over 9,000 different operators involved in water distribution introducing regional public bodies responsible for policies and strategies design, the **AATO** (from its Italian initials or "Autorità di Ambito Territoriale Ottimale" which are Local Authority Water Boards).
Finally, the Galli Law defined the first integrated model for managing aqueduct, sewerage and purification services by merging the management government at the supra-municipal level. It adopts an industrial approach to exploit economies of scale, ensuring the regulation of tariffs able to cover management and investment for regulatory compliance.

In Italy, there are **91 AATOs** responsible for managing economic and environmental resources at the local level. In water management, the AATOs supervise the water basins under the governance by an assembly of mayors (or their delegates) of all the municipalities in the reference area called **ATO** (from its Italian initials or "Ambito Territoriale Ottimale" - or Local Authority Water Board), which usually correspond to a province. An AATO has the task of organising the Integrated Water System (IWS), assigning the service to an operator, establishing tariffs, programming and control of the integrated water system. The ATOs draw up an ATO plan (Local area plan); an instrument that defines objectives for improving the water service to achieve quality standards in compliance with minimum service levels; the investments necessary to achieve them; the optimisation of the tariff system, with cost coverage and methodologies rewarding the efficiency and quality of the service; management policies relating to savings, reuse and the allocation of the most valuable resources for drinking purposes.

Italian Environmental Law of 2006, established eight River Basin Districts, managed by its own River Basin Authority, which establishes and periodically updates the water balance to ensure a balance between the availability of resources available for the various uses. The Basin Authorities promote the adoption of measures for planning the water economy based on the water services and program agreements between regions. A summary table[2] of the River Basins Districts, their geographical extension and the regions they belong to is reported in ***Figure 1***.
At the regional level, the managing authorities (Regions) govern the area in terms of water services and adopt measures aimed at rationalising consumption and eliminating types of waste. Regions hold the supply and distribution networks to reduce losses, the promotion of information and the dissemination of water-saving methods both in the domestic sector and in the industrial and agricultural sectors. The regional authorities establishthe local authority water boards (ATOs). Moreover, they can amend the limits of the ATO based on the following principles: 1) river basin unit, 2) management unit and overcoming the vertical fragmentation of the management, 3) adequacy of management dimensions.

River Basin Districts	Geographical extension in km²	Regions belonging to the River Basin districts
Eastern Alps	37,600	Trentino Aldo-Adige, Veneto, Friuli-Venezia Giulia, Lombardy
Po	86,859	Piedmont, Valle d'Aosta, Liguria, Marche, Lombardy, Veneto, Emilia-Romagna, Tuscany, and Autonomus Province of Trento
Northern Apennines	24,300	Tuscany, Liguria, Umbria
Central Appenines	42,506	Abruzzo, Lazio, Marche, Emilia-Romagna, Tuscany, Molise, Umbria
Southern Appenines	68,200	Basilicata, Campania, Calabria, Puglia, Lazio, Abruzzo, Molise
Sardinia	24,000	Sardinia
Sicily	26,000	Sicily
Serchio	1,600	Tuscany

Figure 1 - River Basins Authorities

[2] Source: Ministry of Environment: https://www.minambiente.it/direttive/distretti-idrografici

The Local Health Authority is responsible for protecting public health, exercising official control and supervision over water for human consumption. Finally, the Regional Environmental Protection Agency (ARPA, from its Italian initials) monitors natural water resources present in the base area for developing any resource remediation policies, and verifies compliance by the Operator with the provisions agreed in the Local Area Plan. The protection of water and its sustainable consumption are essential priorities for numerous stakeholders and policymakers in Italy who are active in encouraging synergistic and integrated actions at industrial, consumption, research and innovation levels.

Hundreds of operators are responsible for managing integrated water services in Italy, and their considerable variability hurdles an accurate census. In its annual Blue Book, Fondazione Utilitatis (an organisation that promotes culture and best practices in the management of local public services), records **72 awarding contracts** divided into **five typologies** based on which water service companies operate. It is important to note that one contract can serve more than one ATO and that, in some ATOs, the service is not awarded but managed directly by local authorities. This explains the lower number of contracts when compared to the numbers of ATOs:

- «In house» model (34).The local authority manages the service on its own, without access to the external market but by setting up a fully publicly controlled company.
- Contracts entered into with listed companies (13).
- Contracts entered into with public-private capital (12).
- Multi-management model (7), various operators serve the same ATO.
- Contracts entered into with third-party private operators (6)[16].

Figure 2 shows the map of ATOs and their currently active[3] awarding contracts.

According to a recent study by UTILITALIA on the integrated water services in 2019, the majority of the population (97%) is served by public service provider composed by totally public, or majority/public controlled companies (85%) and municipalities (12%) that directly manage the water supply (so-called "management in the economy"). Mixed companies serve only 1% with a private majority, and 2% is served by wholly private companies[17]. Almost, all municipalities (97.6%), are served by a single company, and only 200 are served by several companies locally operating in different areas. This multiple-management approach is common in the provinces of Bolzano and Catania[12].

APPENDIX 1 provides an analytical list of ATOs divided by region, geographical area. The number of municipalities and population served is reported for each ATO.

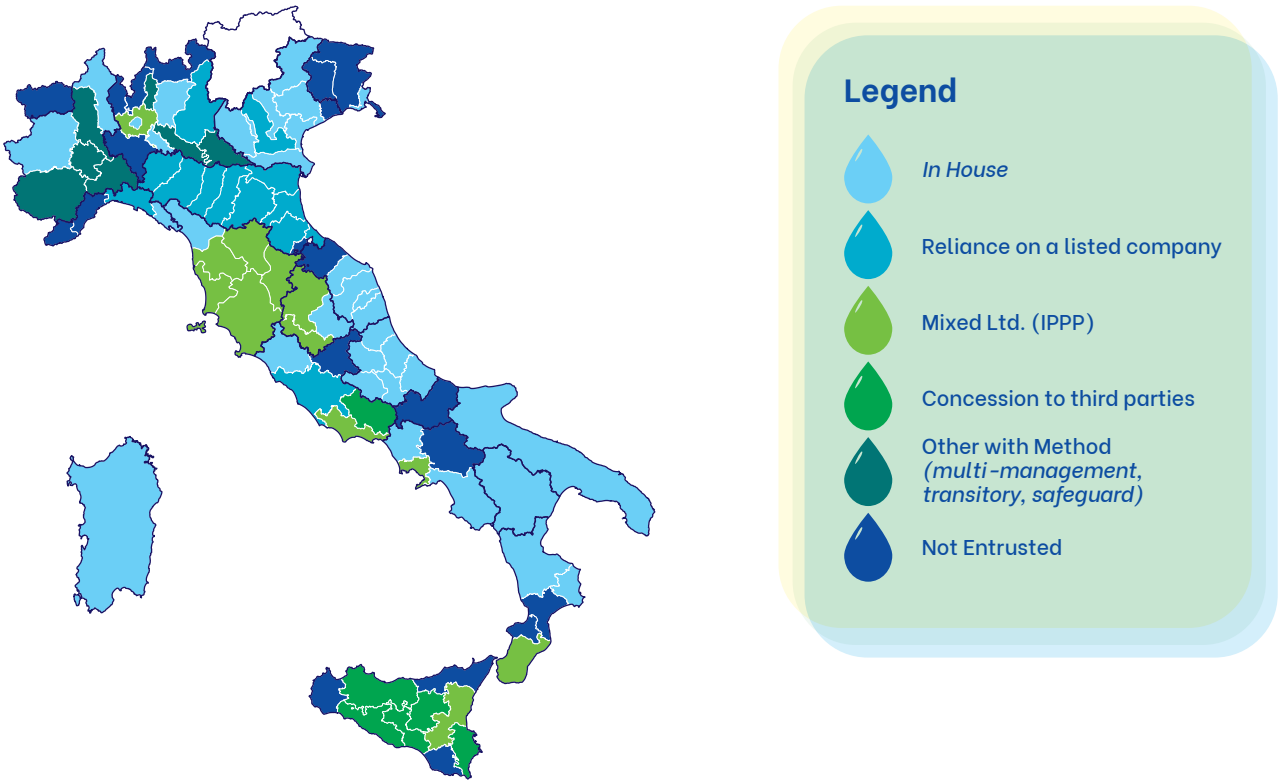

Figure 2 - Map of the 91 ATOs and awarding contracts divided into five typologies

[3] Source: Mangano A. (Acea s.p.a.) Water service in Italy. 2009.https://eau3e.hypotheses.org/files/2009/11/ATHENS_Andrea_Mangano.pdf - Data processed by Consorzio Italbiotec.

COMPOSITION OF THE INTEGRATED WATER SYSTEM

The integrated water system is defined as the range of services related to the administrative management of water, consisting of a series of integrated processes that allow water to be withdrawn from the natural reservoir and to be distributed, following purification, to houselds. This system is divided into 7 stages:

1. **Collection**: the process of withdrawing water from natural sources. In the case of surface water, water is captured only employing lifting systems, pipelines using suction pumps or crosspieces that obstruct the current and raise it to a higher level. In the case of natural springs, water is channelled into large storage tanks and then conveyed into the water network. In the second case (underground aquifers), it is necessary to build wells connected to pumps or pipes. This stage of the water cycle is the least subject to technological changes.
2. **Potabilisation**: the use of physical or chemical processes to treat water and remove pollutants. Water purification aims at making water comply with the requirements for drinking by improving its organoleptic proprieties (colour, odour, taste), chemical and microbiological aspects (e.g. by removing iron and manganese and pathogenic microorganisms, such as Escherichia coli). It is possible to make a primary classification by dividing the system into processes, such as (i) physical processes (filtration and flotation), (ii) physical-chemical (flocculation), (iii) chemical (disinfection with ozonisation and chlorination), carried out through the introduction of chemical substances that facilitate the elimination or reduction of pollutants or unwanted bacterial agents.
3. **Supply**: the passage of drinking water from the withdrawal points to containers before being released into the water supply network. Once water has been made potable, it is pumped into the distribution network through a system of structures able to guarantee the necessary flow rates and pressures in the various areas, as well as preserving waterquality properties.
4. **Distribution**: this involves the use of aqueduct networks from which the connections branch off to connect them to the end customers' internal networks. Water distribution is possible by using compensation tanks and lifting plants, which allow the water to reach the end customers by flowing up to the taps. Along with the distribution networks, which generally follow road routes, there are so-called "in-line" systems, designed to guarantee a regulation of the operating pressures and/or cover disinfection.
5. **Sewerage**: the collection of wastewater, following use, in the sewer network which directs it to the treatment plant.
6. **Wastewater treatment**: mechanical, chemical, and biological processes to eliminate pollutants from wastewater. After careful quality controls, treated wastewater can be discharged into the environment. This stage includes the disposal of sewage sludge where there is a concentration of organic and inorganic pollutants removed from wastewater.
7. **Reuse**: treated wastewater and rainwater can be reused both in the domestic and industrial water supply[18].

CHALLENGES OF THE WATER SUPPLY: WATER LOSSES

Regarding water supply, 90% of the Italian families are satisfied with the provided service.
However, there are many differences in the **performance of the water service** between regions due to different management structures, geographical and morphological differences in the territory, and susceptibility to water scarcity phenomena. In the North of Italy, people are more satisfied with the water supply service. At the same time, in the South and on the islands, where the infrastructures are mostly outdated, a great percentage of families complain about irregularities in the water supply service. The North of Italy reveals a higher level of efficiency in the water supply service of the national average, except for the Friuli-Venezia Giulia region. The lowest values are observed in Basilicata (43,7%), Sardinia (44,4%), Lazio (47,1%) and Sicily (50,0%)[19]. Moreover, Sardinia (42,8%), Calabria (40,1%), Sicily (38,8%), and Umbria (32,7%) are dissatisfied not only about the service but also about the organoleptic characteristics of their tap water and do not trust it sufficiently to drink it[13].
In addition to organisational problems, the Italian integrated water system also suffers from an infrastructural deficit.

Water losses represent the major hurdle in managing the water supply as **37.3% does not reach the end users thus** generating severe economic and environmental impacts.
Losses are consistent in the South and on the islands where the highest figure is attested (45%), while the lowest is in the North (29%). Despite a progressive decrease from 2015 in water consumption (428 litres day per inhabitant), and losses (47.9%, the highest value in Europe) 13, leakages remain a relevant problem for Italy.
Inefficient water supply management is due to several causes: beyond the physiological losses due to the extension of the water supply network, the loss of water is also due to the breakdown in the pipelines, an obsolete infrastructure, unauthorised water consumption, illegal water withdrawals and measurement errors19 of water meters.
In 2019, ISTAT calculated the total amount of water withdrawn from natural sources, the amount of water consumed and the amount of water regarding the domestic sector. Unfortunately, this data is not available for the production sectors, for which the total amount of water withdrawn is unknown.

PART I
LEGISLATION AND DECISION-MAKING POLICIES IN WATER MANAGEMENT

PART I – LEGISLATION AND DECISION-MAKING POLICIES IN WATER MANAGEMENT

CLEAN AND SAFE WATERTECHNOLOGY: ENVIRONMENT AND WATER DIRECTIVES

The main goal of EU and national water policy is to ensure access to good quality water in sufficient quantity to all citizens and to ensure the good status of water bodies across Italy. Pollutants and contaminants in water endanger not only natural ecosystems but also public health, while water scarcity and drought have severe consequences for the economy.

In Italy, the **EU WATER FRAMEWORK DIRECTIVE - WFD** (2000/60/EC)[1] is the reference legislation for managing water and drinking water. This ambitious EU directive provides a solid legislative framework for long-term integrated water management in Europe, aiming to prevent water deterioration, to improve water status, and to promote a sustainable use of water. A crucial step in the WFD is the adoption of the River Basin Management Plans; management tools for managing water resources in an established area unit.
The **ENVIRONMENTAL LAW (Environmental Consolidated Act (ECA), Legislative Decree no.152/2006)**[2], which comprises a set of regulations for environmental management in Italy, a Directive which has been transposed into Italian legislation. It establishes **8 River Basins districts** and the **relevant Management Plans** aiming to reach an efficient, cost-effective and sustainable water management. The River Basins Authorities, chosen by the regions, oversee the water management in each district.
In 2015, the six-year period of water monitoring, required by WFD, ended. However, the "good status" was not fully achieved not only by Italy but also by the other EU countries. In 2016, River Basin Authorities carried out a revising and updating process of the 2000-2015 management plans, according to the River Basin Authority Decree (Ministerial Decree no. 294 of 25 October, 2016)[20].
New management plans lasting up to 2021, provide an updated, integrated and organic water framework taking into account the geography of each river basin, the impact of human activities on the state of surface and groundwater, and the economic analysis on the use of water resources. Moreover, they identified new measures to achieve the water quality goals, also considering those required by the former management plans and not yet reached. The programme is the key element of the river basin management plans, it includes and harmonises in a single political action the application of directives related to water management (agriculture, soil protection, protected areas) also through a process of public participation. Furthermore, it provides for the evaluation of measures in terms of economic and technical sustainability, cost-benefit, and cost-effectiveness analyses. The update of the plans is expected in 2021, and they will remain in force until 2027.

At the **local level**, each region has adopted a **WATER PROTECTION PLAN** (Piano di Tutela delle Acque or PTA), an implemental tool based on the management plan of River Basins to which the regions belong. It must be updated following the approval of amendments to the River Basin Management Plans. It includes a series of measures to achieve the qualitative and quantitative goals required by the Environmental Law and Water Framework Directive, such as water-saving technologies and planning of water use and to protect vulnerable areas. The purposes mentioned above are also achieved through the improvement and implementation of sewerage and wastewater collection and treatment plants[21].

The **URBAN WASTEWATER TREATMENT DIRECTIVE** (91/271/EEC)[22] defines urban wastewater as "domestic water or the mixture of domestic wastewater with industrial wastewater and/or run-off rainwater". This Directive, concerning urban wastewater collection, treatment, and discharge to protect the water environment from the adverse effects of discharges of wastewater and from certain industrial discharges, is the reference legislation in Italy for wastewater treatment. It demands European countries reuse treated wastewater whenever appropriate to reduce the withdrawal of surface and groundwater from natural resources.

The reuse of wastewater is a crucial issue in EU water policy[23] as an alternative water source in regions with obvious water scarcity issues. As stated by the European Union in 2015, "the reuse of treated wastewater under safe and cost-effective conditions is a valuable but underused means of increasing water supply and relieving pressure on over-exploited resources".

The regulation adopted by the European Parliament and the Council on 13 May 2020[24] introduced minimum requirements for the reuse of water for irrigation purposes in agriculture. Entering into force from June 2023, it contributed to removing major obstacles in widespread reuse, ensuring the safety of treated water as well as a high level of protection of the environment and human and animal health. In this context, the reuse of wastewater has been acknowledged as one of the priority solutions with lower environmental impact than alternative water supply measures, such as water transfers or desalination. These guidelines are also part of the **European New Green Deal** which aims to reduce pollution from excess nutrients through a strategy called "from producer to consumer". Water re-use and nutrient management are among the actions promoted by the new Circular Economy Plan[25].

CIRCULAR ECONOMY IN ITALY

The **Environmental Law**[2], which transposes the Urban Waste Water Treatment Directive into Italian legislation, requires regions to adopt regulations and incentives designed to promote water recycling and the reuse of treated wastewater. The incentive measures in this sector fall, therefore, within the competence of Regional Authority.

Italian legislation for treatment and reuse of wastewater is also based on the **TECHNICAL REGULATIONS ON TREATED WASTEWATER REUSE** (Ministerial Decree of 2 May, 2006)[3] (which substitutes the similar Ministerial Decree no. 185/2003[26] issued according to the previous Legislative decree no. 155/99). Together these two regulations establish wastewater **emission limits**, including a set of rules for their management and the prevention of water pollution and the technical rules for the reuse of urban and industrial wastewater. According to these decrees, treated wastewater must be used safely for the environment and public health, avoiding alteration of ecosystems, crops, and soil as well as hygiene risks for the population.

In particular, the following intended uses are admissible:

- **Irrigation use** of crops for food and feed production and non-food purposes (recreational or irrigation of green areas for sports). As agriculture is the sector with the highest water demand, the re-use of treated wastewater represents an opportunity to improve the sector's efficiency, which would mean savings of precious water resourcess.
- **Domestic use** to wash streets in urban centres and to power cooling and heating systems. Treated wastewater can also be used in dual water supply networks installed in residential complexes. As the name implies, dual distribution systems involve two separate distribution networks, one supplying drinking water and the other supplying treated wastewater for toilet flushing. However, except for toilet drains, the direct use of this water in buildings for household consumption is not permitted.
- **Industrial use**, such as water for firefighting, processes and washing water, and for thermal cycles of industrial processes, with the exclusion of services that involve contact between treated wastewater and food, pharmaceutical or cosmetics products.

The use of treated wastewater as drinking water is not permissible.
Therefore, Italian legislation is favourable to the reuse of treated water, as it makes it possible to limit the withdrawal of water from natural sources, improving the quality of water bodies. However, it requires the monitoring of a considerable number of chemical parameters and stringent microbiological limits for the reuse of treated wastewater.
According to national legislation, emission limits do not differ based on their the final use. Regions govern the matter in various aspects, prescribing parameters and limit values to be monitored based on regionall characteristics, as well as adopting both support policies aimed at promoting the reuse of water and infrastructural measures aimed at the adaptation/refining of purification treatments.

The **DRINKING WATER DIRECTIVE**(98/83/EC)is a further crucial European directive related to water management[4], which concerns the quality of water intended for human consumption. Its goal is to protect human health from adverse effects of any contamination of water intended for human consumption by ensuring that it is wholesome and clean. The Directive was transposed into Italian legislation with the **National Decree on drinking water** (Legislative Decree no. 31/2001)[5] and its additions and amendments (Legislative Decree no. 27/2002)[6].
These two decrees establish a set of **62** (14 extra parameters than the ones required by the EU directive) **microbiological, chemical, and physical parameters** to be monitored and tested regularly.
The tests are performed both by internal monitoring (the water supply service provider) as well as external (Local Health Authorities - ASL - and the Regional Agency for the Environment Protection (ARPA, from its Italian initials)). The Local Health Authorities are responsible for the verdict of the suitability of water intended for human consumption. The legislation provides for the possibility of parameters in derogation from the values set within the maximum permissible values established by the Ministry of Health in agreement with the Ministry of Environment. However, these exceptions must be maintained only for the necessary time to allow the competent bodies to take measures to reduce the water values under the parameters required by the national law. In any case, they must not exceed three years from the request made to the Ministry of Health. National legislation also provides for a final derogation period of a maximum of three years to be submitted directly to the EU Commission.

In 2003 limits of contaminants in drinking water were increased for the first time in derogation from the national legislation. Exemptions for additional substances[4] were requested by thirteen regions (Campania, Emilia-Romagna, Lazio, Lombardy, Marche, Piedmont, Puglia, Sardinia, Sicily, Tuscany, Trentino-Alto Adige, Umbria, Veneto) from 2003 to 2009. After six years, some regions (Campania, Lazio, Lombardy, Tuscany, Trentino-Alto Adige, Umbria) requested the third exemption for arsenic, boron and fluorides. The European Commission only partially accepted these requests; more specifically, for arsenic higher than 20 µg/L (a limit stated by the WHO as not dangerous if consumed for limited periods) were refused.

4 Boron, chlorites, chlorides, fluorine, magnesium, nickel, nitrates, selenium, sulphate, trihalomethanes, trichloroethylene, vanadium

The unexpected refusal affected 128 municipalities and a population of around one million people[27]. Regions and parameters requesting exemption are included in ***Figure 3*** below[5].
As reported by the Ministry of Health, in 2018, no exceptions were granted to Regions concerning the quality of drinking water[28].

Regions	Parameters
Campania	Fluorine
Emilia-Romagna	Chlorites
Lazio	Arsenic, vanadium, trihalomethanes, fluorine, selenium
Lombardy	Arsenic
Marche	Chlorites
Piedmont	Arsenic, nichel
Puglia	Chlorites, trihalomethanes
Sardinia	Chlorites, trihalomethanes, vanadium
Sicily	Chlorites, boron, vanadium, sodium, chlorides
Tuscany	Arsenic, boron, chlorites, trihalomethanes
Trentino Alto Adige	Arsenic
Umbria	Arsenic
Veneto	Trichloroethylene

Figure 3 - Parameters for exemption requested by regions

Finally, it is essential to mention the **Nitrates Directive** (91/676/EEC)[29], which forms an integral part of the Water Framework Directive. It is considered one of the critical elements for the protection of waters against nitrates, a vital nutrient for plants and crops but dangerous for people and the environment if present in high concentrations. The European Directive aims to protect water quality across Europe by preventing nitrates from agricultural sources polluting ground and surface water and by promoting the use of good farming practices.
The maximum value set by the European Directive above which water is considered polluted by nitrates is 50 mg/L. The Environmental Law2 with article no. 92, transposes the Directive into Italian legislation. European legislation also establishes the identification of nitrate vulnerable zones (NVZs), corresponding to areas characterised by waters polluted by nitrates or affected by nitrification or which could become polluted unless actions are taken to prevent it. The Nitrates Action Programmes (NAP), a series of measures to be adopted by farmers to improve the quality of water, must be established in these zones. Ministerial Decree no.5046 of 25 February, 2016[30] is the reference for adopting the NAPs: it represents the National NAP to which all regions refer for adopting regional NAPs.

REGIONAL WATER PROTECTION PLANS

The Water Protection Plan is a regional tool aimed at achieving environmental quality goals in inland and coastal waters of the Region, and at guaranteeing a sustainable water supply in the long term. According to the **Environmental Law**, Italian regions are obliged to produce and update the plan under the water basin management plans.
The fundamental purpose of the Water Protection Plan is to constitute a fact-finding, programmatic and dynamic tool through actions of monitoring, planning, identification of interventions, measures, constraints, aimed at the integrated protection of the quantitative and qualitative aspects of water resources. The idea behind these regional plans is that only integrated interventions that act not only on the qualitative but also on the quantitative elements can guarantee sustainable use of water resources.

In particular, regional plans pursue the following goals:

1. to achieve and/or maintain environmental purposes set out in the 2000/60/EC water framework directive
2. to recover and protect surface and groundwater in the regional area, also pursuing a view of sustainable community development

[5] Source: Legambiente.
Water limits in derogation from national legislation - acque in deroga. https://www.legambiente.it/sites/default/files/docs/dossier_derogheacquepotabili_2012.pdf (2012)

3. to strengthenthe resilience of aquatic environments and related ecosystems and to address the effects of on-going climate change
4. to guaranteethe balance between water needs and availability, ensuring sustainable use of water resources, also through the promotion of measures aimed at the conservation, savings, reuse and recycling of water resources

The Water protection plan contains local-specific environmental goals,the list of water bodies with a specific use and areas requiring pollution prevention and remediation measures, qualitative and quantitative protection measures integrated and coordinated by river basin, and lastly, the programme of implementation and verification of the effectiveness of planned interventions[31].

Information on the regional plans, restrictions and other regional legislation in derogation from the national legislation on water purification, storage, and supply sectors is provided in the following subparagraphs. More details for each section are available in **APPENDIX 2**.

Northern Italy

In Northern Italy, wastewater treatment legislation mostly follows national legislation. Water Protection Plans and relevant regional legislation for each region govern the limits and the most appropriate type of treatment for wastewater from conglomerations with less than 2,000 PE (Population Equivalent) depending on the source and final destination (surface water, sewer, soil, sea).
The Veneto region has stricter emission limits as well as a requested treatment in accordance with the potential of the plant and the degree of protection of the region expecting the evaluation of 51 physical, microbiological and chemical parameters[32]. Wastewater treatment and discharge into the Venice Lagoon and its basin, due to its delicate nature, are governed by a specific ministerial decree (30 July, 1999 "Limits to industrial and civil discharges that deliver into the Venice Lagoon and its basin")[33]. The **Piedmont** region also requires stricter emission limits, which entered in force due to the deliberation 7/2004[34] to achieving a 75% decrease of a load of nutrients entering wastewater treatment plants from agglomeration with more than 2,000 PE. Specific measures of intervention to adapt wastewater treatment plants are needed; in particular, the region identified 60 plants in sensitive areas for which new emission limits have been requested[35].
It is also necessary to mention the province of Trento where emission limits follow those established in national legislation. However, with the provincial consolidated text on the protection of the environment against pollution[36] (DGP n 1-41/Legisl 26-01-1987) this province requires more frequent monitoring on a weekly basis for the organic content and physical parameters present in incoming sewage and on water treated during the final stage for all treatment plants, regardless of the potential and periodically, correlated to the possibility of the individual plant, for heavy metals and organic solvents.
Treated wastewater is mostly discharged into public sewers or surface water. Still, Northern regions are trying to reuse this water for agricultural, industrial, and domestic consumption in the interest of saving water and to protect water resources from pollution. In particular, the Emilia-Romagna region established the goal of reusing treated wastewater for irrigation purposes, for at least 50% of the potential of regional plants[37].
Water savings are promoted by the **Environmental Law** (Art 26)[2], which requires a series of measures aimed at reducing water consumption and eliminating useless waste. Water protection plans of the majority of the Northern regions include a detailed programme of actions to reach these goals. For example, some areas limit water withdrawals quantitatively.
Lombardy prohibits water withdrawalsfrom glaciers and limits this process from natural lakes where withdrawals are solely allowed in the event of water scarcity or unavailability of other adequate resources[38]. In the Autonomous Province of Bolzano, regulations are stricter: water withdrawals from natural sources cannot exceed 300 L per day per inhabitant or 140 L per day per livestock unit for drinking water consumption and 0.5 L/s*ha in the agricultural sector highly recommending the use of water-saving technologies[39].
Other regions, like **Liguria** and **Friuli Venezia Giulia**, promote the use of domestic water-saving technologies such as valves, gate valves, and flanges and support the installation of tanks on buildings to collect and reuse rainwater[40,41]. Measures adopted in **Piedmont** are quite attractive. The Through European funds, the region support plans to invest 88 million euro on improving drinking water quality, reducing water losses by replacing damaged sections of water networks as well as to make the system more cost-efficient. Around 60 interventions have been planned and these will affect 150 municipalities[42].

Central Italy

Due to **water scarcity** and the presence in the area of a higher number of reservoirs with insufficient quality[19], central regions are more inclined to reuse treated wastewater than Northern regions. **Abruzzo**, **Lazio**, and **Tuscany** considered wastewater as a promising source of water for the agricultural sector and domestic sector (eg. Irrigation of green areas.
The region of Tuscany provides several examples of reuse of treated wastewater, such as the city of Prato aqueduct, which reuses 3 million m^2 of water per year[43]. Efforts in reducing water losses are a crucial priority in Lazio, where the region reserves an investment of at least 10% of its annual resources to upgrading the network[44].

Moreover, central regions foster citizens' awareness about water saving needs and support the installation of **water-saving technologies**. For example, the regions of Molise, Marche, Lazio and Umbria offer a series of economic contributions or a decrease in water tariffs for the installation of domestic water-saving technologies such as reduction valves, systems for collecting and reusing of rainwater, individual meters. These measures are mandatory when a new building is constructed[44-47]. The region of Marche even offers a certification of environmental sustainability for buildings that adopt these technologies[47]. Water treatment, discharge, and reuse are processes governed by the Environmental Law and by regional-specific legislations. Emission limits in Molise, Tuscany, Lazio, and Umbria follow those established in the national legislation, while Marche and Abruzzo require stricter limits for E. Coli[6] and Lazio requests BOD purification efficiency based on the technical standard of all wastewater treatment plants serving agglomerations above 2,000 PE[44].

Southern Italy

Water scarcity, the **dependence mainly on surface water** and its progressive depletion as well as inadequate quality make the use of water-saving measures essential in southern Italy.
The most widely used practice is the reuse of treated wastewater which is governed by regional legislation mostly following the Environmental Law. This practice is part of the programme of measures requested by the local water protection plan in **Calabria, Campania, Puglia,** and **Sardinia**.
The latter is one of the advanced regions in this sector and promotes the reuse of treated wastewater as a strategy to deal with a water deficit in an area where the water supply occurs mainly from surface water. Regional regulations establish general rules that imply the prohibition of opening new wastewater discharges into the sea, of direct releases on the ground and within 2 km from the coast and the obligation to reuse wastewater produced by coastal conglomerations[7].
In the region of **Sardinian**, the direct reuse of treated wastewater (introduction of treated wastewater from the plant directly into the distribution system) is allowed. The Region promotes economic incentives to stimulate water savings to deliver treated wastewater from the owner of the recovery plant to the distribution networks without any charges. Moreover, energy costs for the release of pressurised water used for irrigation are covered by the region, as treated wastewater is considered to bea non-conventional water supply strategy source[48]. The reuse of treated wastewater is also highly recommended in **Calabria**; a region that faces several periods of drought every year. A study conducted by Sorical, the company entrusted with the management of the water service in the area, has evaluated a significant decrease in the water flow of some aqueducts that will affect 385 municipalities during autumn this year[49]. Water scarcity stimulates the region to adopt additional measures - over the reuse of treated wastewater -, to reduce water consumption, such as the decrease of losses in water supply and distribution networks, the elimination of unauthorised withdrawals, and the rationalisation of tariffs for non-drinking water consumption[50].
Sicily is the region that suffers the most from severe delays in the wastewater treatment sector due to incomplete, never implemented, undersized, or technologically outdated plants. A wastewater treatment plant serves only about 61% of the approximately 5 million inhabitants of Sicily. Therefore, innovations in the wastewater treatment sector are urgently needed[51].

BIOECONOMY AND RESOURCE RECOVERY: THE SEWAGE SLUDGE DIRECTIVE

Sludge is one of the leading products derived from wastewater treatment and the progressive practical implementation of the Urban Wastewater directive as well as of the number of households connected to sewers is increasing the quantity of sewage sludge requiring disposal. The National Regulation on landfill waste (Legislative Decree no. 36/2003)[52], establishes precise and restrictive limits for the landfilling of waste with a high content of organic matter, such as sludge from wastewater treatment, implying different options for its disposal or reuse.

The **Sewage Sludge Directive (86/278/EEC)**[53] seeks to encourage the use of sewage sludge in agriculture and to govern its use in such a way as to prevent harmful effects on soil, vegetation, animals and man. According to this Directive, "sludge" is defined as "residual sludge from sewage plants treating domestic or urban wastewaters and from other sewage plants treating wastewaters of a composition similar to domestic and urban wastewater; residual sludge from septic tanks and other similar installations for the treatment of sewage; residual sludge from sewage plants other than those referred above". The field of application of this Directive is, therefore, vast.
The Directive prohibits the use of untreated sludge on agricultural land, regardless of its source, unless it is injected or incorporated into the soil. It also establishes the limit values for concentrations of heavy metals and microbial parameters (Salmonella spp. and Escherichia Coli) in sewage sludge intended for agricultural use. However, no triggers exist for organic contaminants which might be present in the sludge. The Sewage Sludge Directive is currently under revision to incorporate limit values also for "classical" and anthropogenic pollutants.

6 In Abruzzo, the limit is established at 3000 CFU/100 mL[49]. In Marche, parameters are restrictive only during the period from March to September 3000 CFU/100 ml for discharges that take place directly into the sea or bathing lakes or within 10 km from the coast or 1500 CFU/ml for discharges that take place into the sea in areas not accessible for swimming or within 10 km from the coast[48].

7 (DGR n 69/25 10-12-2008[166] and DGR n 75/15 30-12-2008)[167]

At the national level, the sewage sludge treatment and management are governed by Legislative Decree no. 99/1992, integrated and partially substituted in 2006 with the inclusive Environmental Law[2] and in 2018 with **GENOA DECREE**(Legislative Decree no.109 of 28 September, 2018)[54]. The scope of application of these two decrees involves sludge produced from treated domestic wastewater, defined in the Environmental Law as "wastewater from urban settlements and service industries originating mainly from human metabolism and domestic activities.

Moreover, they establish the limit values for concentrations of heavy metals in accordance with the Directive and accept a higher value for the presence of Salmonella in sludge (***Figure 4*** and ***5***)[8]. The adjustment implies an increased risk of soil contamination with human and animal pathogens, since establishing a limit of 1000 mg of hydrocarbons for 1 kg of sludge, no differences between the hydrocarbons category are considered. They indeed comprise both safe and carcinogenic, persistent, bioaccumulative and toxic substances.

	Cd	Cr	Cu	Hg	Ni	Pb	Zn
D. 86/278/EEC	1-3	100	50 - 140	1 - 1.5	30 - 75	50 - 300	150 - 300
Italy	1.5	\	100	1	75	100	300

Figure 4 - Limit values for concentrations of heavy metals in soil (mg/kg of dry matter in a representative sample of soil with a pH of 6 to 7)

	Cd	Cr	Cu	Hg	Ni	Pb	Zn
D. 86/278/EEC	20 - 40	\	1000 - 1750	16 - 25	300 - 400	750 - 1200	2500 - 4000
Italy	20	\	1000	10	300	750	2500

Figure 5 - Limit values for concentrations of heavy metals in sludge for use in agriculture (mg/kg of dry matter)

In addition to its use in agriculture, sewage sludge can also be used as biomass to produce biogas through anaerobic digestion. The term "biogas" was introduced into national legislation with the **National Law on energy from renewable sources**(Legislative Decree no. 28/2011)[55] which transposed the European Directive 2009/28/EC[56] on the promotion of energy from renewable sources aimed at decreasing greenhouse gas emissions. Italian legislation defines "biogas" as a "gas obtained from renewable sources equivalent to methane from fossil resources". This technology, therefore, follows the EU targets in the climate and energy framework to move towards a climate-neutral economy. This latter strategy, in particular, sets new challenges for sustainable mobility by providing for at least a 32% share for renewable energy by 2030[57].

According to the National Law on energy from renewable sources, the authorisation for the construction and operation of biomethane production plants and any changes to them is issued by the municipalities, for plants with a production of maximum 500 standard mc/h or adaptation works on pre-existing plants, and by the regions, in all other cases. The Ministerial Decree issued on 2 March, 2018 (also called the **Biomethane Decree**)[58] implements the provisions in the National Law on energy from renewable sources and established new requirements aimed at encouraging the use of biomethane and other biofuels in the transport sector. The Decree supports advanced biomethane and biofuels produced by biomass defined in turn as progressive matrices. This term refers to raw materials listed in Annex 3 of ministerial decree of 10 October, 2014[59] and includes, among other, municipal waste, organic waste, animal manure and sewage sludge.
However, in Italy, regulations on wastewater treatment and reuse of treated wastewater and sludge are mostly entrusted to regions.
Therefore, a more detailed analysis of regional legislation on sludge treatment and reuse is includedin **APPENDIX 3**.

8 Source: Environmental Decree and Genoa Decree. Data processed by Consorzio Italbiotec.

PART II
WATER TREATMENT TECHNOLOGY LANDSCAPE

PART II – WATER TREATMENT TECHNOLOGY LANDSCAPE

The wastewater treatment cycle encompasses a series of purification operations in accordance with the variety of pollutants detected of various origins (industrial, urban or agricultural) which require specific processes. Usually, the treatment cycle includes a solid-liquid separation stage, divided into two fundamental treatment sections[60]:

- **Waterline**: for the removal of pollutants in the liquid stage with the production of sediments with a high moisture content, consisting of the component already present in a sedimentary form in the drain, or sedimented following chemical-physical, chemical, or biological transformations.
- **Sludge line**: for the treatment of sediments produced in the water line aimed at ensuring that the residue is compatible with the final disposal (as waste or reused in agriculture).

The products of a purification plant are:

- Clarified water discharged into the receptor body closest to the plant.
- Sludge, which, according to its organoleptic properties, can be sent to a composting plant, special landfills, or used in agriculture.
- Waste products, such as sand, strainers, foliage, debris, toxic and non-toxic waste that are separated from the top products and disposed of at the appropriate sites.

Wastewater purification technologies embrace several processes, based on the following methods: chemical (oxidation-reduction or redox, neutralisation, etc.), physical (solid/liquid aggregation and separation), and biological (biodegradation by selected organisms). Together, they contribute to increasing the efficiency of the entire process, as well as effluents disposal under hygienic and environmental safety conditions and in compliance with the regulations[61].

In 2015, a third of the volume of water withdrawn for drinking use in Italy was subjected to purifying treatments that allowed the removal of contaminants from the water following procedures that generally require more complex operations than those of disinfection or chlorination. Surface waters require a higher level of assessment of potability than groundwater, being generally of better quality, except for cases of anthropogenic or natural pollution phenomena.
Regions with the largest share of water subjected to **purification treatments** are **Basilicata** (80%) and **Sardinia** (79%), followed by **Emilia-Romagna** (59.3%), **Puglia** (58.8%) and **Tuscany** (56.5%).
In 2017, the **water sector** with references to equipment for primary domestic consumption recorded a **growth of 3.1%** and an increase in investments of 9.4%, mainly focusing on technologies for the reuse of water resources. The forecasts for the next few years confirm a positive general trend in this sector[62].
According to the last census, there are **17,897 wastewater treatment plants** responsible for the treatment of wastewater derived from both domestic and industrial facilities. These plants are absent in 342 municipalities with 1.4 million residents[12].

Wastewater treatment plants are essential for preventing surface and groundwater contamination due to the release of untreated wastewater, protecting the environment and public health. Wastewater treatment plants can be classified based on the efficiency of the chemical-physical process in reducing the pollutant load. They can be grouped under the following categories, from the simplest to the most effective: Imhoff tank, primary, secondary (includes all biological treatments), and advanced (includes nitrification, denitrification, and filtration) treatments.

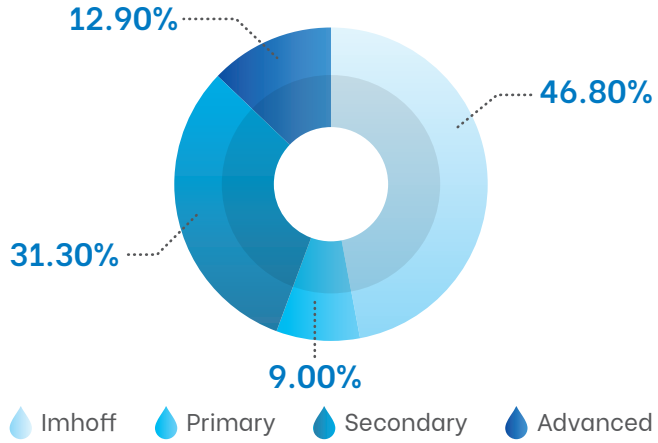

Figure 6 - Wastewater treatment facilities by type

Imhoff tanks are the most widely used technology, accounting for **46.8%** of the total, followed by secondary (31.3%), advanced (12.9%) and primary treatments (9.0%) - ***Figure 6*** [9].

Piedmont is the region with the highest number of wastewater treatment plants (11.4%), followed by Emilia-Romagna (11.4%) and Lombardy (8.4%).

Regions with mountain areas, such as Valle d'Aosta, Liguria, Piedmont, and Abruzzo, mainly use Imhoff tanks or primary treatments, which are more suitable for the geography of their region.

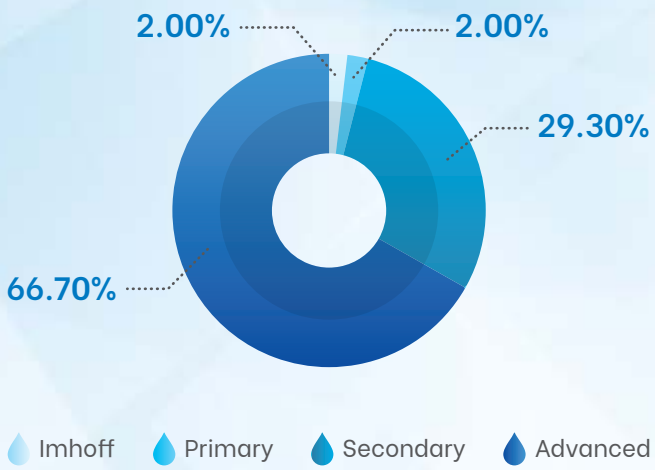

Figure 7 - Amount of wastewater treated by facilities type

Although **advanced treatments** account for just 12.9% of the total plants, they are used to treat more than **66.7%** of wastewater produced in Italy. Secondary and advanced plants treat 96% of the wastewater produced - ***Figure 7***[9].

Lombardy (373) and Piedmont (259) host the highest number of advanced plants. Large infrastructures are mostly based in Lombardy (48) with a pollutant load higher than **50 thousand population equivalents (PE)**, followed by Puglia (24) and Lazio (22). Overall, these regions account for 264 plants (1.5% of total wastewater treatment plants), covering 61.4% of wastewater treatments in Italy[12].

CLEAN AND SAFE WATER TECHNOLOGY FOR DOMESTIC CONSUMPTION AND AGRICULTURE

Technological innovation is driven by economic progress and many other factors, which have led states and major players in the sector to face continuous challenges, such as global warming, water scarcity and numerous problems regarding environmental quality.

Recently, innovation and technological development have led to a paradigm shift in wastewater management as part of a circular economy. **Membrane technologies** - reverse osmosis, microfiltration, ultrafiltration - are becoming increasingly common for tertiary or advanced treatments, due to their efficiency and cost-effectiveness. Among unconventional and innovative processes developed over the years, Membrane Biological Reactors - MBRs are an emerging technology, resulting from the advanced use of membrane separators in conjunction with activated sludge. Membranes are selective barriers composed of a porous semipermeable material, which allow water molecules and dissolved substances to pass through the pores, intercepting suspended solids, bacteria and viruses. MBR systems combine activated sludge and microfiltration processes, in which the organic matter removal of wastewater is carried out by biological nutrient removal (BNR) and nitrification, followed by the separated liquid fraction from biomass[63].

Recent studies demonstrate that the number of plants with MBR technology is increasing and they represent an up-and-coming method supporting sustainable wastewater reuse[7].
Despite this innovation potential, in Italy, to date, almost all wastewater from urban and industrial treatment plants is discharged into water basins without exploiting the potential for reuse. Wider use of treated wastewater could meet the needs in agriculture and those of industrial and urban supply services.

Agriculture is the production sector that requires more water resources and in some areas, uses more than 80% of the available water, often resulting in significant water wastage[64].
Irrigation is the primary use of wastewater in agricultural practices ("food" and "non-food" crops), followed by zootechnics, aquaculture (including algae production). The water purification process for irrigation uses requires more stringent procedures and quality requirements than regular treatments. It usually is guaranteed by wastewater plants upgrading through the so-called "**refinement plants**"[61]. According to the ARERA annual report, overall, agricultural reuse in 2019 remained the most common application of water reuse in Italy even if only **4%** of the volume of purified wastewater is destined for reuse. However, the 20% potential available for reuse - intended as treated wastewater whose chemical-physical values fall within limits set by law - mainly for irrigation purposes is located almost exclusively in the northern regions and is absent in the South of the country except for a few cases.

The high costs deemed necessary to make reuse possible and the low costs of conventional water resources for irrigation in combination with the absence of definite financial incentives to support the reuse are one of the causes of the **limited practice** of water reuse in Italy. Data of 105 water supply service management companies covering 61.5% of the Italian population in 2018-2019 indicates that the reuse of water for irrigation purposes is broken down as follows: 80% (of the total amount of reused treated wastewater) in the North-East, 77% in the North-West, 70% in Central Italy and 34% in the South and Islands[65,66].

[9] Source: ISTAT - Italian National Institute of Statistics. Use and quality of water in Italy. https://www.istat.it/it/archivio/234904 (2019).

Negative factors are also the complexity in transferring water resources from the wastewater treatment plant to distribution networks, a lack of precise management and infrastructures maintenance rules and difficulty in removing all the pathogens and micropollutants present in wastewater[66,67]

Domestic use or household consumption is the second top use of treated wastewater, such as street cleaning, irrigation of green areas, sanitary flushing, etc. Almost **50%** of potable water is used for the above applications for which ahigh chemical and microbiological quality of potable water is not necessary as it is not intended for human consumption. Therefore, the use of treated wastewater could significantly reduce the consumption of high-quality water[68].

Saving water is a priority for many Italian regions which encourage the installation of **dual water supply networks in residential complexes**. It involves the use of water supplies from two different sources in two separate distribution networks. The two systems work independently of each other within the same service area.

Dual distribution systems are designed as two separate pipe networks usually used to supply potable water through one distribution network and non-potable water through the other. This system is, therefore, used to increase public water supplies by maximising the use of treated wastewater[68]. The additional advantage is to reduce the pollution of receiving water sources. However, the adoption of this practice requires huge investments for the construction of the non-drinking water supply networks. Wastewater used in dual supply networks always needs to be treated based on the chemical and microbiological composition of the wastewater. Tertiary refining treatments (phosphating, nitrification-denitrification, filtration, disinfection treatments) and refinement treatments using phytoremediation for the removal of excess nutrients load could be necessary[69].

INDUSTRIAL BEST PRACTICES IN WATER REUSE AND WATER SAVINGS

With a growing demand for freshwater and progressive depletion of water resources, the adoption of circular models for the reuse of treated water represents an indispensable opportunity for economic and environmental sustainability.
The role played by incentives and legislative measures is crucial to encourage this practice, which places Spain among the EU countries with the highest potential (over 1,200 m^3/year), followed by Italy (497 m^3/year) and Germany (144 m^3/year)[70].

Regional fragmentation of the water distribution management system makes it difficult to apply solutions on national scale to encourage water-savings, often delegated to the big players in the sector or independent initiatives. Water reuse for agricultural practices is mostly used in regions characterised by intense urbanisation and agricultural production (Lombardy and Emilia-Romagna) or in dry, coastal or low water supply areas (such as Sardinia, Puglia and Tuscany)[66].

A selection of industry best practices in water re-use for productive purposes, mainly agriculture and domestic supply services as well as water-savings are provided below.

- **Irritec SpA** (Rocca di Caprileone, Sicily www.irritec.it) is a Sicilian company founded more than 40 years ago as a pioneer in smart irrigation systems for agriculture and currently, one of the major players in the sector at a global level.
  Sicily which has always been characterised by water scarcity has become for Irritec the place where to experiment and develop **drip irrigation systems**, which allow to save water and energy, protecting the environment and the economy of farms. In fact, Irritec drip irrigation systems, due to the use of Commander controls, allow to centralise the control of irrigation and fertilisation in a single point enabling a better management of the entire irrigation system, organising irrigation cycles, backwashing of automatic filters and management of quality and operation sensors[71].
- **The Circle** Società Agricola (Roma, Lazio www.thecircle.global) is an excellent example of innovation in the zero impact sector. It is an agricultural and energy company with a high technological content that has developed a sustainable and competitive model that enhances waste through an **aquaponics system**. Acquaponics is a farming technology that provides the coupling of aquaculture and industrial hydroponic crops, ensuring higher yield and faster growth of cultivated plants. In the aquaponics system, water circulates from the fish tanks reaching and fertilising the plants and then returning clean to the fish again. It allows to recover all water not absorbed by the plants, reducing by 90% the water consumption per kg of product compared to traditional agriculture[72].
- **Gruppo CAP**(Milan, Lombardy www.gruppocap.it)manages the integrated water supply service in the Metropolitan City of Milan and various municipalities in the provinces of Monza and Brianza, Pavia, Varese, Como according to the in house supply model.
  Among the advance example of the application of **Membrane Biological Reactors - MBRs**, Gruppo CAP the has recently developed a project with the city of Pieve Emanuele (Milan, Lombardy) for the distribution of purified water from its plant in Rozzano for the irrigation of nearby areas. The water, treated in accordance with the law (Ministerial Decree no. 185/2003) with membrane technology system, allows to obtain water of an excellent quality without using disinfectant agents, in a sustainable logic[73].

- **Gruppo HERA** (Bologna, Emilia-Romagna www.gruppohera.it) is one of the largest national multi-utilities providing waste management, water (aqueduct, sewerage and purification) and energy (distribution and sale of electricity, gas and energy) services.
  Gruppo HERA, in collaboration with Energy Way, has launched in Modena (Emilia-Romagna) the "Modena 4.0" project. It improves the purification of urban wastewater through the creation of an **intelligent sensors system** capable of controlling the oxidation process, predicting the oxygen requirements necessary for cleaning, and the optimal bacteria growth conditions that feed on organic substances present in water. The outgoing water from the treatment plant, about 30 million cubic metres a year, enters the channels and supports the irrigation needs of the peri-urban area of Modena.
  Additionally, in partnership with Enea, HERA has recently tested a 4.0 purification system at the purification plant in Granarolo dell'Emilia (Bologna, Emilia-Romagna). The prototype built and patented (Constance), has reached TRL 7, and it is a system based on machine learning technologies, which can decrease energy and water purification costs by more than 30%.
  The innovation of the project lies in the fact that sensors and control algorithms are used that can estimate the percentage of incoming pollutants in real-time, allowing to break down nitrogen and organic matter[74].
- **MM SpA** (Milan, Lombardy www.mmspa.it) is one of the most important Italian engineering companies providing custom-made solutions in the design and requalification of urban ecosystems. MM Spa for the city of Milan guarantees access to the city's public water, also managing the wastewater disposal and purification system.
  With regard to regards innovations for the aqueduct network, it is engaged in a series of investments in technological innovation to renew water and sewerage service networks to improve standards up to a performance of maximum excellence. These interventions for **upgrading the pipelines** are classified as "no-dig". They allow to upgrade the existing networks minimising the excavation and demolition of the road surface and with clear economic, environmental and social advantages for the city of Milan (Lombardy)[75].

REGIONAL INITIATIVES FOR WATER SAVINGS AND WASTEWATER REUSE

Regions characterised by intense urbanisation and intensive agriculture, such as Lombardy, Emilia-Romagna, or in dry, coastal, or low water areas, such as Sardinia, Puglia, and Tuscany boast the **Italian best practices in wastewater reuse**.

- **The region of Puglia**, for instance, has focused its attention on the reuse of water for agricultural uses, through the construction of a pilot purification plant for wastewater treatment and reuse in Capitanata, at the farm Fiordelisi Srl.
  The process consists of a conventional activated sludge process followed by a refinement, which in turn includes pressure filtration on granular media and ultrafiltration through polymeric membranes. Purified water is stored in a reservoir, from which it is withdrawn and used for irrigation. Water is subjected to a UV disinfection treatment to avoid possible bacterial growth during storage in the tank. The results of the pilot demonstration proved the technologies suitability inwater re-use for irrigation purposes. Contributions of nutrients supplied to crops and the consequent savings in terms of chemical fertilisers were also assessed[76].

  In addition, the **Puglia Region** has recently allocated an investment of 10 million euro for the construction of a wastewater treatment plant in the **city of Trani**, to minimise the discharge of purified wastewater into the sea and the management costs of the resource.
  The project encompasses several uses of treated wastewater, such as irrigation of crops intended both for the production of food for human and animal consumption and for non-food uses, irrigation of areas designated as green areas or for sports activities, cleaning of streets in urban centres, supply of heating or cooling systems, supply of dual supply networks, separated from drinking water.
  The investment foresees the extension of the current purification plant by adding a disc filter and a debacterisation station to the current system of mixed bed filters of anthracite and sand made up of several layers of granular material. The proposed solution is based on the use of multiple discs, each consisting of a series of filter panels, which determine an increase in the filtration area with a simultaneous decrease of the occupied surface area. The Filters - operating mechanism provides for water flowing by gravity inside the central drum, and then through the panels towards the outside of the discs[77].
- **The region of Emilia-Romagna**, through the ReQpro project, has developed a model for the recovery and reuse of wastewater to irrigate high-quality vegetable crops.
  The wastewater treatment included the implementation of a tertiary finishing treatment system at the city of Mancasale urban wastewater plant, aims to optimise its operation, recovering effluents with high-quality standards to be used for irrigation.
  The results achieved by the project have demonstrated that about **65% of the treated wastewater was reused for irrigation**, confirming the potential of reuse to provide an alternative source of water in environments characterised by water scarcity. In addition, the tertiary treatment, which includes a sand filtration system, together with UV/H2O2, allowed to break down suspended solids and microbiological loads (e.g. Salmonella, total coliforms, Escherichia Coli) and also the most critical chemical pollutants (e.g. surfactants and mineral oils), therefore achieving excellent technical and economic results[78].
- **The region of Sardinia** reused **1.2 million m³** of water for both agriculture (Alghero) and public greenery (Stintino) in 2019. The Municipality of Alghero, in partnership with Abbanoa and the Consortium of Nurra lead a project for the reuse of treated wastewater to

satisfy the irrigation needs of areas covered by the Nurra Remediation Consortium. Severe refinement treatments to ensure compliance with the required quality requirements are applied to wastewaters treated in the San Marco facility[79]. In addition, Abbanoa is carrying on the project to provide the public green areas of Cagliari with the water treated by the Is Arenas purifier, the largest in Sardinia, which already guarantees the water balance of the Molentargius park ecosystem.

BIOECONOMY AND WATER RESOURCE RECOVERY

In Italy the bioeconomy generated about 345 billion euro of revenue and employed more than 2 million people, representing 10.2% and 8.1% of national total production and jobs in 2018. It is indeed a booming sector which grew over 7 billion (+ 2.2%) compared to 2017. According to the last report of Assobiotec Bioeconomy in Europe, the need for sustainable production, new circular solutions, and environmentally-friendly products has driven the innovation in this sector resulting in 941 start-ups, broadly considered as new companies established in the last 5 years active in various sectors of bioeconomy - e.g. agriculture, forestry, agrofood, water resources, biobased industries - with over 50% of operating entities in R&D and consulting.

The bioeconomy encompasses several activities addressing the exploitation of renewable biological resources, including the collection, treatment, and reuse of the organic fraction of municipal solid waste and sewage sludge produced from wastewater treatment. With a considerable added-value for agricultural practices, biowastes can be transformed into fertilisers due to their high organic content with agricultural and environmental advantages. They can also serve as feedstock for additional bio-based products and bioenergy, such as feed and biogas following an adequate biological or chemical treatment, replacing the use of non-renewable fossil sources.

In Italy, the total organic matter recovered and reused following a biological treatment has grown between 2009 and 2018 at an average rate of 8.8% per year, with the total volume increasing from 4.4 to 7.8 million tonnes[80]. These processes are elements of the circular economy, at the heart of the European strategy for sustainable growth.

Sewage sludge is the main product obtained from wastewater treatment. The disposal of sludges represents a relevant part of the operating cost of a wastewater treatment plant, contributing up to 50% of the total cost. Therefore, a process of dehydration is usually applied, increasing dry content typically to a percentage between 20-25 % and reducing the amount of sludge release.

In 2018, the urban sludge production (comprising domestic or a mix between industrial and domestic wastewater) in Italy was around 3.1 million tonnes, with Lombardy accounting for the largest part of sludge production (14.2%). The treatment of wastewater coming from the industrial sector produced about 775,000 of sludge, 8% of which defined as dangerous due to its chemical contents related to the industry that generated it[8].

Figure 8 below shows the urban sludge production in each region per year[10].

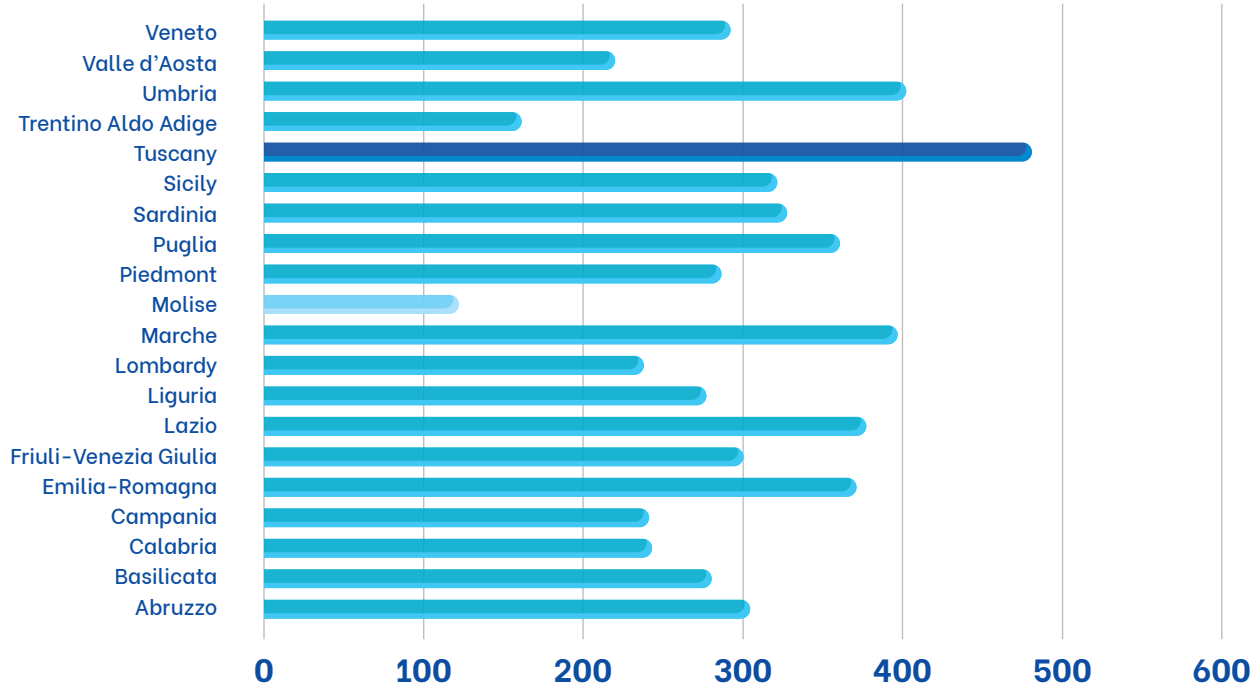

Figure 8 - Urban sludge production by region (t/year)[97]

[10] Source: AITA-ISWA ITALIA. Tavolo tecnico "Fanghi di depurazione" - 2019. http://www.atiaiswa.it/wp-content/uploads/2019/07/Tavolo-tecnico-fanghi-ATIA_ISWA_finale.pdf

The reuse of sewage sludge is a crucial element of sustainable management of the integrated water system. It is an essential resource in terms of the circular economy for the production of electricity from biogas or as biological raw material for the production of biomethane, eco-fertilisers, phosphorus and nitrogen, to be reused in the most advanced industrial sectors and agriculture.

In 2018 there were **339** active plants for biological treatment of sewage sludge and municipal waste were with a volume of about 10.3 million tonnes of organic waste. Among these, 281 plants were dedicated to aerobic treatments only (composting), followed by integrated aerobic/anaerobic treatments (35) and anaerobic digestion (23). The total volume of sewage sludge treated in these plants was of 877,499 tonnes; a prominent part used composting treatment (425,770 tons), followed by anaerobic digestion (374,850 tonnes) and mixed treatment (76,879 tonnes)[80].

Sewage sludge obtained from a biological process that meets strict qualitative requirements, also called **biosolids**, can be used in agriculture as an organic fertiliser due to its high content in macro and micronutrients which are essential for the growth of crops.

In Europe, the word "biosolids" is more often used to indicate treated sludge that meets quality standards for safe land application. The significant component of biosolids is organic matter, which forms an average of 50% to 60% of the dry solids content. This organic matter is generated from suspended solids that are contained in the effluent discharged into wastewater treatment plants, and from the excess microorganisms produced by the biological part of the treatment process.
Moreover, biosolids contain nutrients deemed essential in crop nutrition (25.5% such as nitrogen, phosphorus, and potassium, but also small quantities of copper, magnesium, and zinc. However, they can also contain potentially toxic elements such as metals and pathogens, but these contaminants must be reduced under limit values established by Europe and the Member States to ensure the safety of biosolids applications[81].

Quality, physical and fertilising properties of biosolids depend on the type of treatment to which they are subjected. There are three basic types of treatments:

- Treatments to reduce humidity: which consist of drying and dehydration processes to increase the percentage of dry content, improve its physical characteristics, simplify storage, transport, and distribution operations.
- Treatments to stabilise and sanitise organic matter: these treatments (anaerobic digestion, composting, and liming) make it possible to reduce putrescence and increase the stability of Biosolids, thus limiting the production of odours but also guaranteeing the sanitation of the product from pathogens.
- Sanitation treatments: these treatments, which typically consist of liming and conditioning, serve to eliminate pathogens and stabilise Biosolids. The sanitation and stabilisation process of sludge is often carried out simultaneously through conditioning with calcium oxide.[81]

REGIONAL INITIATIVES FOR DERIVING BENEFITS FROM SEWAGE SLUDGE

The reuse in agriculture (direct or through composting) of treated sludge is the most practised option (64%), the only suitable solution for **biosolids** with the most favourable outlet for the environment. Other outlets for biosolids are landfills (26%), the most comfortable option for disposing of biosolids but also the one with the most negative impact on the environment, and incineration (9%), the most expensive option which reduces the volume of biosolids but produces ashes that need to be disposed in landfills[81,82].

- According to data provided by ARPA in 2017, **Lombardy** produced about 800.000 tonnes of sewage sludge, of which 500,00 derived from urban wastewater. Therefore, it is necessary to search for long-term strategies for the treatment, recovery and reuse of this waste, through a sustainable management approach, aimed at protecting both the land and the people that live in it[83].

  The Lombard supply chain represents an exemplary case in the sector of production and reuse of biosolids, qualifying Lombardy operators as pioneers in the circular economy sector. Operators have invested in qualified human resources (agronomists, biologists, chemists) and in new technologies to optimise their industrial process.
  They have studied innovations in the quality of the product recovered on agricultural land and in monitoring the correct intake of organic substances and nutrients based on the crops.

  Among the relevant examples of biosolids use, is that of the **Pavia** area, where the sector employs more than 140 direct employees, to which must be added over 100 units related to the relevant industries (distributors, transporters, research centres). There are about **350** farms using this service, which attest to how the recovery of material, unlike other possible choices such as incineration or landfilling, is a choice capable of generating development and favouring employment[84].

Moreover, a relevant example of innovative technology is **bio-drying**, used to significantly and sustainably reduce volumes of sewage sludge. Adopted by **Gruppo CAP**(Milan, Lombardy www.gruppocap.it) it aims to improve the efficiency in the recovery of energy and materials, as well as to reduce 87% of the sludge volume by 2033. The substantial difference of this solution compared to a traditional dryer is that it does not use external heat sources except in the initial start-up and final drying stage but uses the natural heating process triggered by the bacterial biomass present in the sludge. Heat produced by bacteria fermentation determines boil-off of the water contained in the sludge, decreasing the volume by up to 70%[85].

- The region of **Sardinia** holds the national record for the reuse in agriculture of sludge produced during the sewage treatment process, with **96.8%** against a national average of 15%[86].
  In fact, out of a total of 340 sewage treatment facilities managed by **Abbanoa** (Nuoro, Sardinia www.abbanoa.it), the Sardinian multiutility[79], 327 plants have produced in recent years sludge with chemical, physical and biological characteristics deemed continuously suitable for spreading in agriculture.
  Due to this circular recovery process, farms have been able to count on a production of 54 thousand tonnes of quality sludge.
- The region of **Veneto** hosts the Ca' Nordio wastewater treatment plant, a **high-tech sludge treatment greenhouse** - the only one of its type in Italy - to significantly reduce sludge volume and costs of the wastewater treatment process.
  The innovative plant serves aims at improving the possibility of reusing the sludge (used as an agricultural soil improver), and further reducing the costs of the service.
  As a result of the introduction of the high-tech greenhouse, following a dewatering stage, sludge is stretched, and a sophisticated ventilation system manages the convective drying movements so that water still contained in the sludge evaporates as quickly as possible. Moreover, during the dewatering process, a robotic rover runs through the greenhouse turning the sludge so that surface sludge, already dried, is mixed with the more humid sludge underneath[87].

BIOENERGY PRODUCTION FROM SEWAGE SLUDGE RECOVERY

In recent years, anaerobic digestion has assumed an increasingly important role in the treatment of organic waste, due to the possibility of producing biogas and biomethane, consisting mainly of methane (CH4) and carbon dioxide (CO2) and considered as one of the most promising renewable energy sources in the world[88].

Italy counts **2,000 biogas facilities**[89] which position Italy as the second-largest producer of biogas in Europe and the fourth worldwide. Emilia-Romagna is the first region for several facilities. This sector is therefore quite promising, and it is estimated that Italian biogas production will reach 10 billion m^3 by 2030[90], supporting the fight against climate change. However, in Italy, the use of biogas production from sewage sludge is still relatively small in contrast to Switzerland and Sweden, where sewage sludge is the most used biomass to obtain biogas. A major limitation in using sewage sludge is the high costs associated with the use of this raw material which can double, or triple compared to the use of agricultural waste.

The production of **biogas** to recover thermal or electrical energy is an additional option to recover sewage sludge. The practice has a huge potential as it represents an opportunity to convert waste into a valuable product while contributing to the production of sustainable energy. More specifically, the production of biogas to recover thermal or electrical energy is achieved through the process of anaerobic digestion of biodegradable organic substances.
These substances may be present in waste from a separate collection, agricultural residues, zootechnical waste, or to a much lesser extent in sludge produced by the wastewater purification process. Anaerobic digestion represents the most widespread solution for biogas plants, due to the stability of the process and the low operating cost. Primary sludge consists of fresh organic matter. Therefore it is anaerobically degraded more quickly and produces more biogas than biological sludge[60].

Regarding the sustainable reuse of treated water, at the Bresso-Niguarda Gruppo **CAP** (Milan, Lombardy www.gruppocap.it) built the first methane distributor from sewage sludge, related to a domestic wastewater treatment plant serving agglomeration of 220,000 PE in the municipalities of Cormano, Bresso, Paderno Dugnano, Cusano Milanino and Cinisello Balsamo. The purity index of methane at the process outlet is close to 99% and once compressed, it is ready to be used directly by cars. The Bresso-Niguarda plant produces 340,000 kg of biomethane per year, which is the fuel needed to drive 416 vehicles for 20,000 km each[89].

PART III
WATER MANAGEMENT SYSTEM: COMPETITIVE LANDSCAPE

PART III – WATER MANAGEMENT SYSTEM: COMPETITIVE LANDSCAPE

FACTORS DRIVING THE DEVELOPMENT OF AN INTEGRATED WATER SYSTEM

The PESTLE analysis, developed to support decision-making processes, contributes to measuring environmental macro-factors that describe a sector or a business model. PESTLE is an acronym that stands for Political, Economic, Social, Technological, Legal and Environmental factors[91]. In this study, it helps to make the best recommendations to innovative Dutch companies to better position theiroffering in the Italian market by considering the key elements of the water sector and its development scenarios.

• POLITICAL KEY FACTORS

Regulatory framework. In Italy, water for human consumption and the reuse of treated wastewater for agriculture, domestic and industrial sectors follow a strict regulatory framework, which mainly consists in the control of a series of chemical-physical parameters that ensure the quality of water and the well-being of people and the land. Strict limits are also required for the reuse of sewage sludge in the agricultural sector. While the limits for drinking water are uniform between regions and exceptions are made only for a limited annual period, regarding the concentration of micropollutants, some areas require stricter emission limits as well as a requested treatment according to the area's level of protection: this is the case of Veneto, Piedmont and Sardinia, just to cite a few examples. Similarly, some regions, such as Lombardy and Puglia, require stricter limits for the reuse of sewage sludge, making this practice critical.

Fiscal and economic incentive measures. At the national level, there are no specific and defined incentive systems for the reuse of treated wastewater. However, some regions have provided incentives, funding and other measures to support the reuse of purified water, especially in regions characterised by intense urbanisation and agricultural production or in dry and low water supply areas. Sardinia, for example, is the most advanced region in the reuse of treated wastewater. The region makes use of some fiscal incentives combined with a strict regulation that prohibits the discharge of treated wastewater, therefore promoting its reuse. In other areas, there is an obligation for new construction works, as well as renovations, to install devices for limiting water consumption, such as flow reducers, valves and toilets with two push buttons for flushing, or dual systems.

A recent regulatory provision is Law 221/2015[92], encouraging the transition towards a more significant simplification and centralisation of management as well as the promotion of green economy measures. The law has initiated a process of unification of the responsibilities of the water system management to ensure better economic performance, a more uniform system of tariffs and boost new investments through a guarantee fund for upgrading the water infrastructure.

• KEY ECONOMIC FACTORS

Uneven GDP regional distribution. GDP has historically been heterogeneously distributed, especially between the northern and southern regions. GDP per capita in the north-west is almost double that of the south, and this is reflected in a greater industrial dynamism, employment and competitiveness.
Lombardy, which has the highest GDP value, is also the region with the largest number of registered companies operating in various production sectors. It is therefore not surprising that Lombardy is also home to the largest number of companies in the water sector.

Economies of Scale. The presence in Italy of multi-utility companies managing all stages of the integrated water system, from the collection to the treatment and reuse of wastewater reduces the number of companies operating in the water sector located in the region. This is the case of Hera Group, Abbanoa and Acquedotto Pugliese which respectively serve Emilia-Romagna, Sardinia and Puglia, whose business model generates economies of scale and allows to optimise supply costs.

ARERA's tariff system. The new tariff method approved by ARERA for the 2020-2023 period provides a bonus for private citizens and companies that apply water-saving technologies. The most supported solutions are reduction valves, systems for the collection and reuse of rainwater, or individual meters and measures such as a decrease in energy consumption to supply water and a decrease in the use of plastic. These measures, which aim to promote environmental sustainability, also include the reuse of treated wastewater, especially in the agricultural sector. However, the above incentive mechanism which should result in a decrease in the price of water, is not entirely clear, sometimes representing a limit to reuse. These incentives are currently entrusted to the voluntary initiatives of the local government bodies or operators of the Integrated Water Service (IWS) and not regulated nationally.

• KEY SOCIOCULTURAL FACTORS

Water conservation campaigns. Many regions promote water-conservation campaigns to cope with the progressive depletion of natural water resources. Conscious consumption of drinking water is essential to help protect the quality and quantity of water. Included inP this

promotional system, is the initiative for the distribution of water supply vendors sch as the "case dell'acqua" (or water kiosks), which ensure an average supply from each plant of about 2,500 litres per day, which means annual savings of about 1,700 plastic bottles of one and a half litres and 20 tonnes of PET. There are over 500 water vendors in Italy, and their distribution is constantly growing.

Decentralised wastewater treatment. The development of the sector of decentralised purification plants is limited by national legislation, which allows their installation for agglomerations that cannot be connected to the sewer network and by the lack of knowledge of the advantages associated with this solution.
However, in recent years, some regions have expressed their interest in these innovative technologies, acknowledging their value in meeting the growing demand for freshwater while safeguarding natural water resources. Among the nationally significant examples, is that of the region of Puglia, which in order to tackle water scarcity, is investing in the renovation and installation of wastewater treatment plants including wastewater treatment solutions from agglomerations that are not connected to the sewage system.

Social acceptability of wastewater. Social predisposition towards the acceptance of wastewater reuse, especially in agriculture, represents an essential qualitative aspect that can have an impact on the use of this promising resource. It is an aspect that affects both end and direct users of water resources (farmers), and those who purchase agricultural products (consumers) resulting from irrigation with reclaimed water. Among the aspects that affect the predisposition to accept the new irrigation practice, we highlight the knowledge of innovation and the information available on its impact on the environment and society, the lack of trust in regulations, certification and monitoring; user concerns about environmental risks and health impacts[93].

- **KEY TECHNOLOGICAL FACTORS**

Innovative and emerging technologies. Many companies have invested in the study, validation and development of innovative technologies that operate in various stages of the integrated water cycle. These technologies are not only an operational challenge and a cost element, but represent an opportunity in terms of growth for the company and the water sector. Included among the emerging technologies under diffusion, are membranes for wastewater treatment and intelligent and remote control systems for improving the quality of treated water and reducing the operating cost of plants.
Innovative maintenance technologies to repair distribution networks and reduce the major issue of water losses as well as sewage sludge treatment and reuse are among the pillars of Italian R&D activities in the water sector.

Investment in water supply networks. Outdated infrastructures are the leading cause of water losses; the major hurdle in managing the water supply. Due to pipes being in a poor state of repair, breakages and leaks along with the water distribution network, the amount of water lost reached almost 40% last year, representing both an economic and environmental issue. The presence of outdated infrastructures also implies a poor water supply service.
In some regions, primarily in Southern Italy and the islands, a high percentage of families complain of irregularities in the water supply service. In Sicily, this value reaches 50% and the sewer system serves only 60% of the population. In the investment landscape, the most frequent concern is the implementation of purification plants or their size, which are often insufficient to meet the demand; and in the case of the sewage, the extension of the network which in some regions does not serve the total population.

- **KEY LEGAL FACTORS**

Water management supply. The Italian framework for managing the integrated water cycle is characterised by a significant fragmentation of responsibilities among the authorities which often determines large geographical differences between the North and South of the country. Concerning the recovery and reuse of treated water, although Italy applies stringent parameters positioning it among the countries with the best quality, the complexity of its management hinders the introduction of widespread innovations.

- **KEY ENVIRONMENTAL FACTORS**

Water scarcity in Italy. According to research conducted by the Worlds Resource Institute in 2019 on water scarcity, Italy was included under the "high baseline water stress" category and ranked 44th in the national water stress ranking, only one position below Egypt. Although historically endowed with an abundance of natural water resources, Italy has to counteract a constant increase in water withdrawals.
The water demand for industrial and agricultural purposes adds to a decrease in rainfall and exceptionally high temperatures caused by climate change. The quality and quantity of water resources are therefore in great danger with worsening forecasts. According to WRI and the National Research Centre studies, a "business as usual" policy put almost 21% of the Italy at risk of desertification (41% in the South)[94].

Safe and clean water. In some regions, the natural geography and the composition of the soil are responsible for the presence of contaminants and micropollutants in drinking water for human consumption. Over the last twenty years, more than half of the Italian regions have found a concentration above the legal limits of certain pollutants. To adapt to the values established by the law, more complex purification

treatments are therefore necessary. Lazio, Sicily, Tuscany, Lombardy, Umbria and Trentino are among the regions where this issue is more pronounced, especially with regard to arsenic.

Heterogenous distribution of water resources. Natural water resources and the leading national basins of over 1,000 km2 are found mainly in northern Italy, while in the south and especially in the islands there are rivers of lesser importance. The heterogeneous distribution of water resources contributes to the additionaldisadvantage of Southern Italy, which is forced to use surface waters, characterised by low flow rates and which require long and complicated purification treatments.

INDUSTRIAL LANDSCAPE

The industrial landscape of clean and safe water technologies and wastewater resource recovery is composed of **475 leading operators** covering the entire integrate water supply.
According to data aggregation methodology, companies are classified based on their primary business activities under **NACE codes** 36.00 "Water collection, treatment, and supply" and 37.00 "Sewerage".

Companies covering the integrated water management system from collection to wastewater are divided into eight leading categories as follows:

1. **Consulting and technologies supply (47)**. Private service providers of water quality analysis and waterworks management and sewage networks. This category also includes companies that sell devices and technologies to third parties in the water sector.
2. **Distribution (204)**. Operators covering collection, distribution and wastewater services to end-users responsible for managing the whole integrated water service.
3. **Potable water treatment (34)**. Private service providers of physical or chemical processes to treat water and remove contaminants.
4. **Decentralised wastewater treatment (6)**. Operators promoting approaches for collection, treatment and discharge/reuse of wastewater and rainwater for individual dwellings and/or isolated communities.
5. **Industrial wastewater treatment (25)**. Operators responsible for wastewater treatment of industrial origin only.
6. **Urban wastewater treatment (76)**. Treatment of mixed-origin wastewater (domestic and/or industrial).
7. **Process water treatment and maintenance (63)**. Suppliers involved in the design, construction, and maintenance of aqueducts, sewerage networks, and wastewater treatment plants.
8. **Sewage sludge (20)**. Treatment and reuse of sewage sludge. Companies responsible for wastewater treatments, in addition to sewage sludge treatments, have been included under "Urban/industrial wastewater treatment".

The breakdown of companies into the eight service categories is shown in ***Figure 9***.

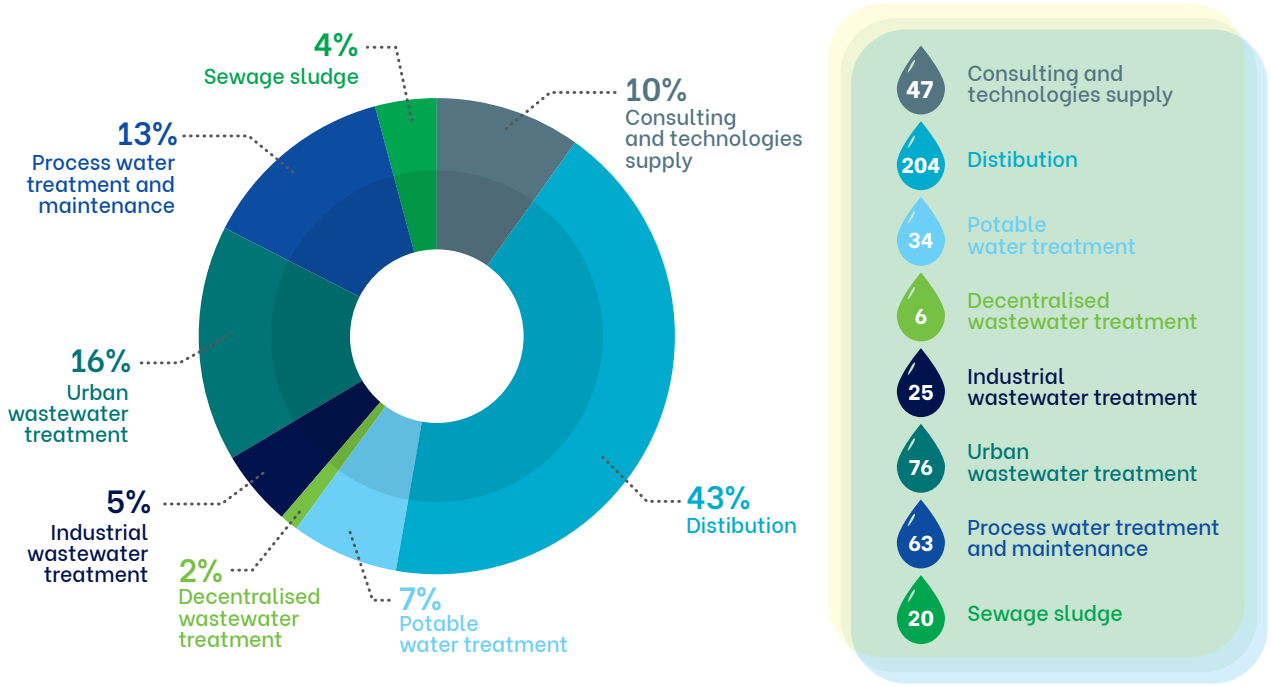

Figure 9 - Integrated water management system. Operators by sector

The aforementioned information has been useful to establish the Italian water treatment, supply and reuse sector and to identify its key players, decision-makers as well as its supply chain.

The parameters used for classifying samples refer to:

A. **Geographical area**, in accordance with the registered office where the company operates, mainly subdivided into five areas based on the Italian region's distribution:
   - North-East (Friuli-Venezia Giulia, Trentino Alto-Adige/Sudtirol, Veneto, Emilia-Romagna)
   - North-West (Liguria, Piedmont, Lombardy)
   - Central Italy (Marche, Tuscany, Umbria, Lazio)
   - South (Abruzzo, Molise, Campania, Puglia, Basilicata, Calabria)
   - Islands (Sicily, Sardinia)

B. **Company size**, according to the turnover achieved during in the last year, is subdivided into five types:
   - **MICRO**. Companies achieving less than 2 million euro
   - **SMALL**. Companies achieving between 2 and 10 million euro
   - **MEDIUM**. Companies achieving between 10 and 50 million euro
   - **MEDIUM-LARGE**. Companies achieving between 50 and 100 million euro
   - **LARGE**. Companies achieving over 100 million euro

C. **Number of employees**, based on the macro-class distinguishing SMEs from large companies:
   - From 0 to 9 employees
   - From 10 to 50 employees
   - From 51 to 250 employees
   - Over 250 employees

D. **Leading sector of activities**, based on eight application areas from the collection of water to sludge treatment:
   1. **Consulting and supply of technologies**
   2. **Distribution**
   3. **Potable water treatment**
   4. **Decentralised wastewater treatment**
   5. **Industrial wastewater treatment**
   6. **Urban wastewater treatment**
   7. **Process water treatment and maintenance**
   8. **Sewage sludge**

GEOGRAPHICAL DIVISION BY SECTOR

The greater concentration of companies operating in water is based in **North** Italy, covering **49.47%** of the total[11], followed by the central regions[12] and then the South and Islands[13], respectively 32% and 18.53%.
Lombardy is a prominent area throughout Northern Italy, where **99** companies operate equal to 21% of the national total, one-third of them are active in water **distribution** (35). Among the prominent top players are CAP Holding Spa (Milan, Lombardy, www.gruppocap.it),

[11] Lombardy (99), Piedmont (41), Emilia-Romagna (28), Veneto (27), Liguria (20), Friuli-Venezia Giulia (11), Trentino-Alto Adige /Sudtirol (9)

[12] Lazio (45), Campania (39), Tuscany (33), Marche (18), Abruzzo (13), Umbria (4)

[13] Sicily (44), Calabria (16), Sardinia (13), Puglia (8), Basilicata (5), Molise (2)

MM Spa (Milan, Lombardy, www.mmspa.it), A2A Ciclo Idrico Spa (Brescia, Lombardy, www.a2acicloidrico.eu), Amiacque Srl (Milan, Lombardy, www.gruppocap.it/ilgruppo/societa-trasparente/amiacque).

Lazio comes second in terms of the total number of companies (45) mostly involved in the **water treatment process**. Furthermore, it encounters the recurring problem linked to the presence of arsenic concentrations in water intended for drinking above the legal limits, as well as vanadium, trihalomethanes, fluorine, selenium. Therefore, it is the third region in Italy in terms of the number of companies employed in water purification (6, which is 13% of the companies in Lazio).
With **44** companies, **Sicily** comesthird with regard tothe number operators in the water sector. These are mostly active in the distribution category, which dominates the regional industrial landscape (25, more than 50% of the companies total). Furthermore, several companies (7.16%) deal with water purification. After Lombardy, it has the highest number of companies classified in this sector linked to the high number of contaminants in collected water (Chlorites, boron, vanadium, sodium, chlorides) and several potabilisation treatments are needed before supplying it to end users.

The companies' regional geographical division by sector is shown in *Figures 10* and *11*.

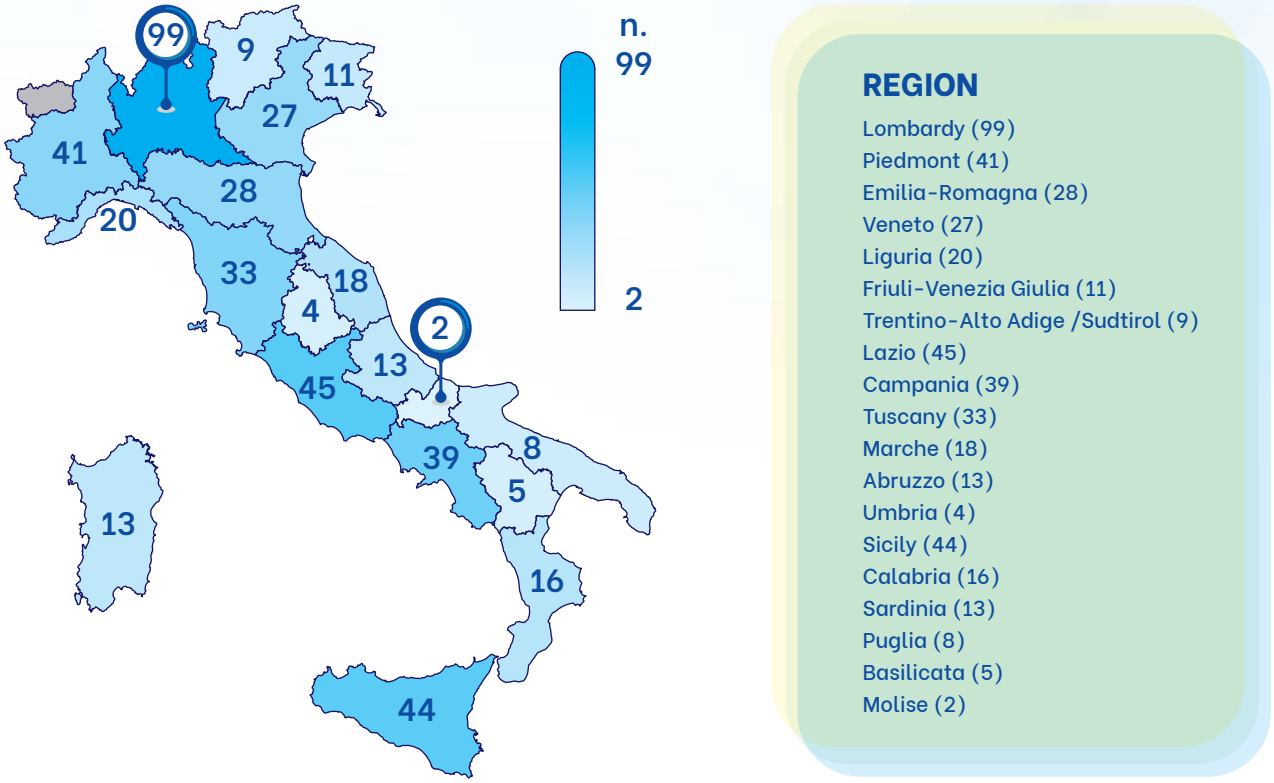

Figure 10 - Water supply: competitive landscape geographical distribution

On the contrary, Sicily lags behind in the water treatment sector counting only four companies that deal with urban wastewater treatment, and no companiesunder the categories of industrial wastewater treatment, decentralised wastewater treatment and sewage sludge. The lack of sewerage services confirms this absence; in fact, 39% of the region's population is not connected to the sewer system[51].
Unlike Sicily where there is a large number of small companies, in **Emilia-Romagna**, a large multi-utility such as Hera SpA (Bologna, Emilia-Romagna, www.gruppohera.it) manages all stages of the water cycle in most municipalities in the region thus halving the number of companies present in the region (28). This phenomenon is recorded in two other Italian regions, **Puglia** (8) and **Sardinia** (13) where Acquedotto Pugliese SpA (Bari, Puglia, www.aqp.it) and Abbona SpA (Nuoro, Sardinia, www.abbanoa.it) are respectively present and serve the entire area. In particular, in Sardinia, Abbanoa is mainly supported in its wastewater and sludge treatment activities by five companies (38.5% of Sardinian companies) divided into industrial (1), urban (2) and sewage sludge (2). It is due to the regional policy of incentivising the treatment and reuse of wastewater in a circular economy perspective to tackle the region's drought problem.

The geographical distribution of companies by regions based on the leading service is provided in **APPENDIX 4**.
Key company data (operational headquarters, email address, web address) of the top 10 operators of each service category is provided in **APPENDIX 7**.

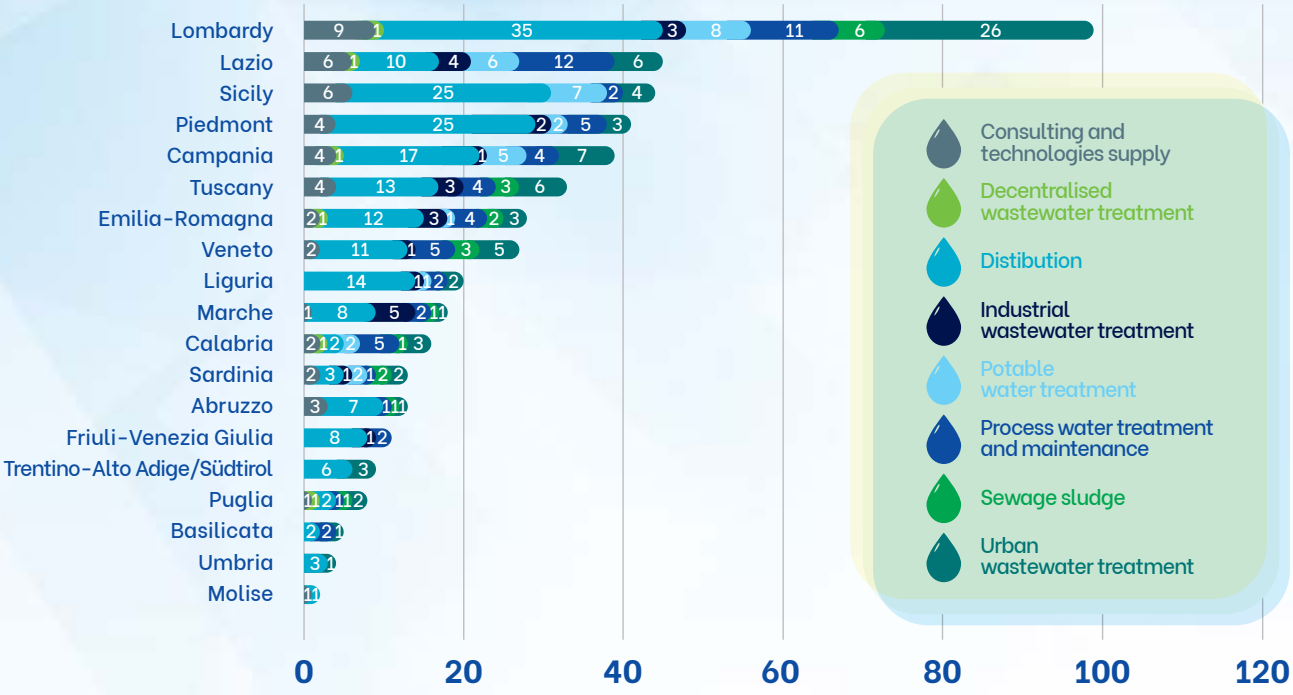

Figure 11 - Operator breakdown by region and by sector

INDUSTRIAL OPERATORS: BREAKDOWN BY SECTOR

With **204** companies, **distribution** is the most represented Italian industrial sector, according to the mapping in this Report. Falling under this category are all the top companies in the water sector, managing the entire integrated water services from collection to water treatment. After being withdrawn from the environment and eventually treated to ensure the quality standards required by Italian law, water is distributed to end users through a system of networks and plants capable of guaranteeing the flow rates and pressures deemed necessary in the various areas as well as preserving the qualitative characteristics of water.

Most of the aqueduct network is managed remotely with a system adjusting the distributed flow according to the client's requests and identifying network leaks in real-time to promptly plan maintenance and upgrading interventions[95].

The aqueduct network is made up of metal pipes of a variable diameter and generally placed under the road surface, to protect water from thermal changes. Water is brought from the aqueduct pipes to the entrance of each building, where a separation valve and a meter measure water consumption. In each building, wateris distributed by the internal condominium network to each apartment [96].

The majority of the companies classified under the distribution category are also responsible for the purification of potable water, a step-by-step process that use of chemicals, filtration and pumping procedures to eliminate potentially hazardous substances such as bacteria, viruses and hydrocarbons that settle in aquifers. In addition to these companies, there are 34 additional companies classified under the "potable water treatment category" which must be included. Among the many processes used for water purification, the use of filters, clariflocculation and reverse osmosis must be highlighted.

Water treatment includes **107** Italian companies, divided into three categories based on the type of wastewater ("urban wastewater treatment" (76) - "industrial wastewater treatment" (25), and "decentralised wastewater treatment" (6).

Most of these companies (**76**) treat **urban wastewater**, which means "domestic water or the mixture of domestic wastewater with industrial wastewater and/or run-off rainwater" as defined by the Urban Wastewater Treatment Directive (91/271/EEC).

The type of wastewater treatment depends on the pollutant load and the type of pollutants. One of the most used methods is the activated sludge biological process; an aerobic treatment conducted through aeration of wastewater inside a biological reactor in the presence of a microbial population (biomass). It aims to reproduce, in an artificial environment, the same biological processes that occur in nature for the purification of water polluted by biodegradable organic substances.

Depending on the size, plants can include tertiary and sewage sludge treatment [97].

In this Report, **industrial wastewater treatment** is represented by companies (**25**) purely devoted to this treatment, that often requires more advanced methods for the decreasing pollutant loads and removing dangerous micropollutants , such as heavy metals, radioactive or natural radioactive compounds (TENORM)[98]. Lastly, companies operating in the "**decentralised wastewater treatment**" sector (**6**) work

in the sale and installation of plants for the purification of domestic wastewater, facilities and isolated settlements not connected to sewer networks. The central systems used are Imhoff tanks of smaller sizes than those used for the treatment of wastewater from more extensive areas. These are tanks with a circular or rectangular plan, to be installed in the ground, divided into two compartments: an upper one for sedimentation and a lower one for accumulation and anaerobic digestion of the sedimented sludge. An alternative method of wastewater treatment for small agglomerates is phytodepuration which is based on the action of plants which, in specific aquatic environments, develop physical, chemical and biological processes suitable for purifying wastewater[99]. Decentralised water solutions are also used for the treatment of rainwater: unique systems with tanks and filters convey rainwater, treating any bacteria and making it reusable for agriculture or domestic use[100].

The companies in the categories mentioned above often treat, dispose and/or reuse **sewage sludge**, in addition to treating wastewater. In addition to these, there are **20** companies operating in the sewage sludge treatment sector. Dehydration is the treatment mainly applied to sludge to reduce the amount of water and thus make transport and disposal operations more accessible and cheaper. In some cases, treated sludge is not only disposed of but is reused in agriculture. An emblematic case is that of the Sardinian company Shift SpA which as a result of this type of sludge, 2,000 / 2,500 hectares of agricultural land are fertilised annually. The spreading of sludge on farms is carried out using specific sludge-spreading trolleys. Backfilling is carried out by scalar disc cultivators and clod breakers pulled by suitable agricultural tractors. Different sludges are mixed with other organic matrices through wheeled mechanical shovels and sludge spreading trolleys and subsequently scattered and buried at the authorised farms[101].

Among the service providers, there are **47** companies classified in this Report under **Consulting and supply of technologies**, providing water quality analysis and aqueduct or sewage networks management. Consultancy conventionally includes resolving the client's needs regarding wastewater treatment plants or potabilisation plants, also dealing with all regulatory requirements, laboratory analysis on wastewater or drinking water to establish compliance with the legislation and eventually support their client in adapting to them. This category also includes companies that sell devices and technologies to third parties in the water sector, such as companies selling water treatment devices for domestic uses.

Lastly, the **Process water technology and Maintenance** category includes **63** companies mainly operating in the design and constructions of distribution and sewerage networks as well as treatment plants or their maintenance. Most of these deal with the distribution care and sewerage networks, using consolidated or innovative technologies, such as the so-called "relining".
This is a continuous pipeline that replaces areas with breakages and missing sections of the old pipeline, thus eliminating infiltrations or product losses. Cracks, roots, structural damage or loss of bushings, infiltration of foreign water, low pipeline laying and diameter changes, are quickly and effectively repaired for pipelines regardless of the diameter and the material of the existing pipe. Relining technologies are a non-destructive intervention that guarantees the complete functional recovery of the current lines, with zero or minimal excavation and surface disruption[102].

ECONOMIC PERFORMANCE OF INDUSTRIAL OPERATORS

The analysis considers the financial statements for 2019, 2018, 2017 financial statements of 475 companies active in the integrated water system, primarily selected based on their leading activity as declared in the Italian Business Register[14]. Due to a further analysis based on literature and secondary source, it is possible to assert that the sample, include the most representative players in the sector.

Economic performance is described in accordance with the Study's parameters, such as geographical distribution, company size, employment and business model. The data come from the databases of the Italian Chamber of Commerce and CERVED's datasets (Primary sources), ISTAT processes and market studies (Secondary sources).

The evolution of turnover in median value records a negative result of **-4.94%** in **2019**, confirming the downward trend of **-4.07%** in **2018**. While the 25th percentile continues to record a drastic reduction in turnover of -18.97%, companies with the best performance conversely, (75th percentile) grow by almost 5% per year (4.97% in 2019) - ***Figure 12***.

[14] The methodological approach used for the competitive landscape analysis is based on a selection of the leading activity according to the following NACE codes:
- 36.00 "Water collection, treatment, and supply" which encompasses several industrial fields, such as the integrated water service, withdrawal, potabilization, water distribution for civil uses, waste-water treatment, desalination
- 37.00 "Sewerage" which encompasses the management of the sewage systems, collection and purification of wastewater.

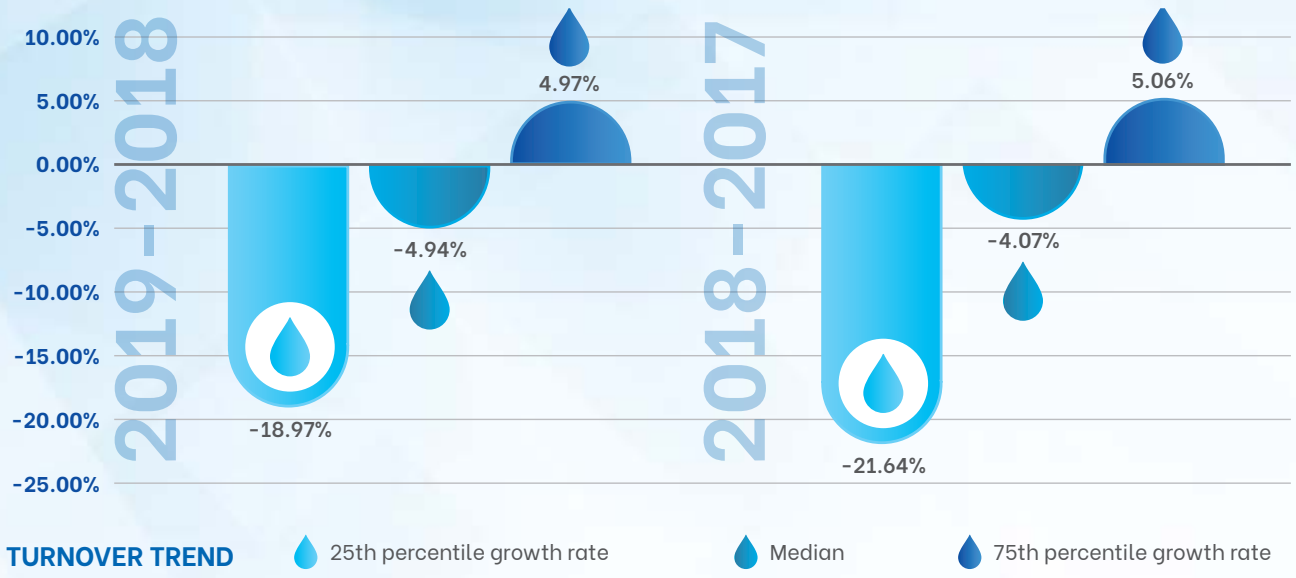

Figure 12 - Turnover trends in 2019-2018 and 2018-2017 (median value)

The dynamic analysis of the turnover trend of the last three years indicates that **SMALL**, **MEDIUM** and **LARGE** companies achieve the best results, with a median growth in 2019 of 6.03%, 8.40% and 2.51%. The top players in the water service, mainly **multi-utility**, belong to these three categories. Despite the median negative growth trend of 2019, the analysis of the performance of the 75th percentile represented by these companies, reveals a positive trend in turnover connected to a business model that includes the supply of energy services and wastewater treatment. Better performances are also due to infrastructure investments, research and development and upgrading of networks.
Concerning the geographical distribution, the **North-West regions** host over a third of the companies in the sample, in which the multi-utilities of water distribution prevail, such as Ireti SpA (Genoa, Liguria, www.ireti.it), SMAT SpA (Turin, Piedmont, www.smatorino.it), CAP Holding SpA (Milan, Lombardy, www.gruppocap.it), MM SpA (Milan, Lombardy, www.mmspa.it), Amiacque Srl (Milan, Lombardy, www.gruppocap.it/il-gruppo/societa-trasparente/amiacque), Iren SpA (Genoa, Liguaria, www.gruppoiren.it) and A2A Ciclo Idrico SpA (Brescia, Lombardy, www.a2acicloidrico.eu), with a turnover in 2019 of between 100 and 450 million euros - *Figure 14*.

Companies operating in this area showed a growth rate in the median value of **23.74%** compared to 2018 and mostly have a multi-product business model, covering distribution and urban wastewater treatment services for medium-large agglomerates and high-intensity populated areas. The **Islands** are in the second position for the best turnover results in 2019, with growth in the median value of **13.77%**. Two of the leading distribution players Abbanoa SpA (Nuovo, Sardinia, www.abbanoa.it) and Amap SpA(Palermo, Siciliy, www.amapspa.it) operate here with a turnover of between 100 and 270 million euro.

MEDIUM-LARGE companies (50 and 100 million euro) recorded a stable median growth rate of 0.55% in 2019. The sector is led by multi-utility joint-stock companies responsible for the entire integrated water system of provincial and regional capitals (over 400 thousand inhabitants) and large metropolitan cities (e.g. city of Naples with over 3 million inhabitants) - *Figure 13*.

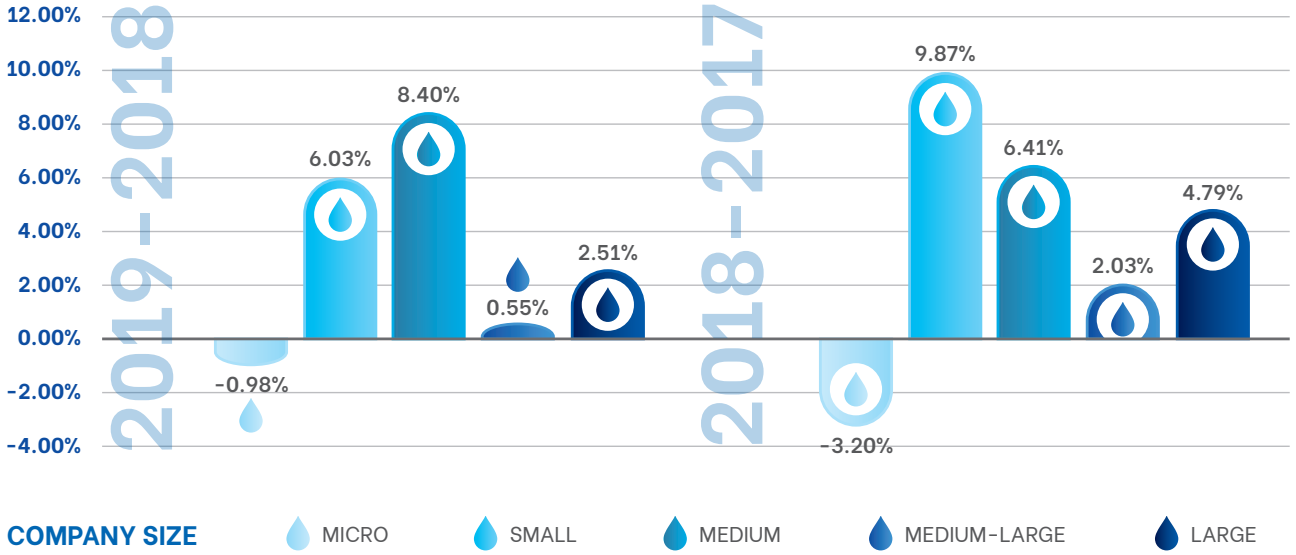

Figure 13 - Percentage change in turnover 2019-2018 and 2018-2017 by company size (median value)

A substantial decrease of MICRO companies (turnover less than 2 million euro) continues, which in 2019 recorded a further decrease in the median growth rate of - 0.98%. Consortia, cooperatives and limited liability companies, **MICRO** companies have a single-product business model mainly concentrated in the provision of water **distribution** to small urban agglomerations and network **maintenance** services.

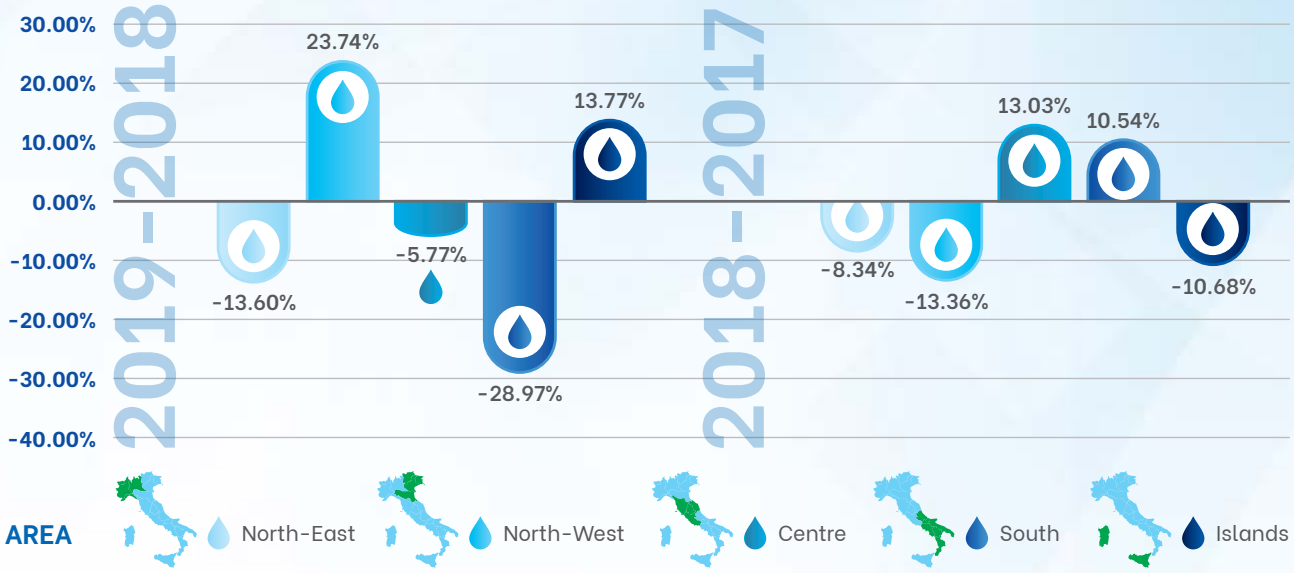

Figure 14 - Percentage change in turnover 2019-2018 and 2018-2017 by area (median values)

ECONOMIC PERFORMANCE OF INDUSTRIAL OPERATORS

With regard to the profitability index by sector, there is a steady and transversal trend in EBITDA in over the three years and across the entire sample analysed.
EBITDA stood at **10.36%** of turnover at the median rate in 2019, and in the best companies in the sample analysed (75th percentile) exceeds 8%. The ratio between EBITDA to turnover in the last three years is shown in ***Figure 15***.

Considering the performance by geographical area, the profitability index expressed in median value, revealed a drastic disparity in the southern regions than in the rest of Italy.
Central Italy and the **Islands** come first and second in terms of profitability in 2019, mainly due to the presence of six large multi-utilities companies half of them among the top 10 national players. The EBITDA in the median values of these areas is of **13.88%** and **12.78%** respectively in 2019. Although the business models of these large companies are focused on multi-products, water supply prevails and also receives the largest share of investments.

Notable cases include Acea (Rome, Lazio, www.gruppo.acea.it) water services provider in Rome and Frosinone invested 1.9 billion euro for the installation of smart water meters, decrease of network leaks, rationalisation and automation of water treatment plants, division of networks into districts and improved technical quality.

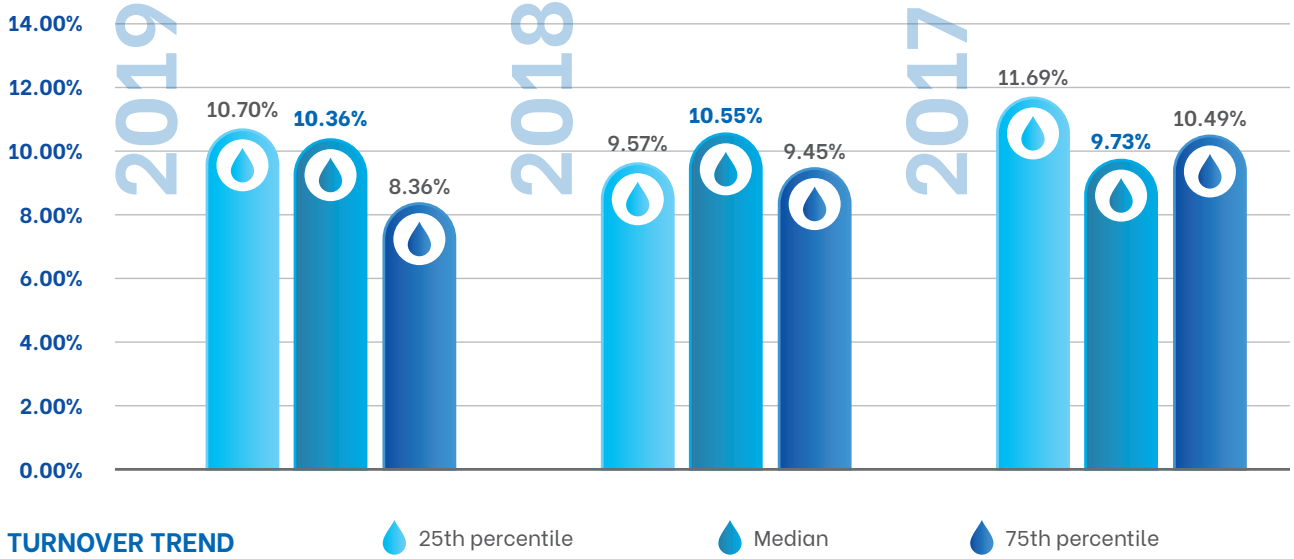

Figure 15 - Ratio of EBITDA to turnover (median values)

The **South** achieved the lowest results with an **EBITDA** of **4.55%** of turnover (in median value) in 2019, confirming the weakness of the supply system. Small businesses characterised by less dynamism than the northern regions, were also affected by less favourable geographic conditions, such as high drought and the progressive depletion of water resources - ***Figure 16***.

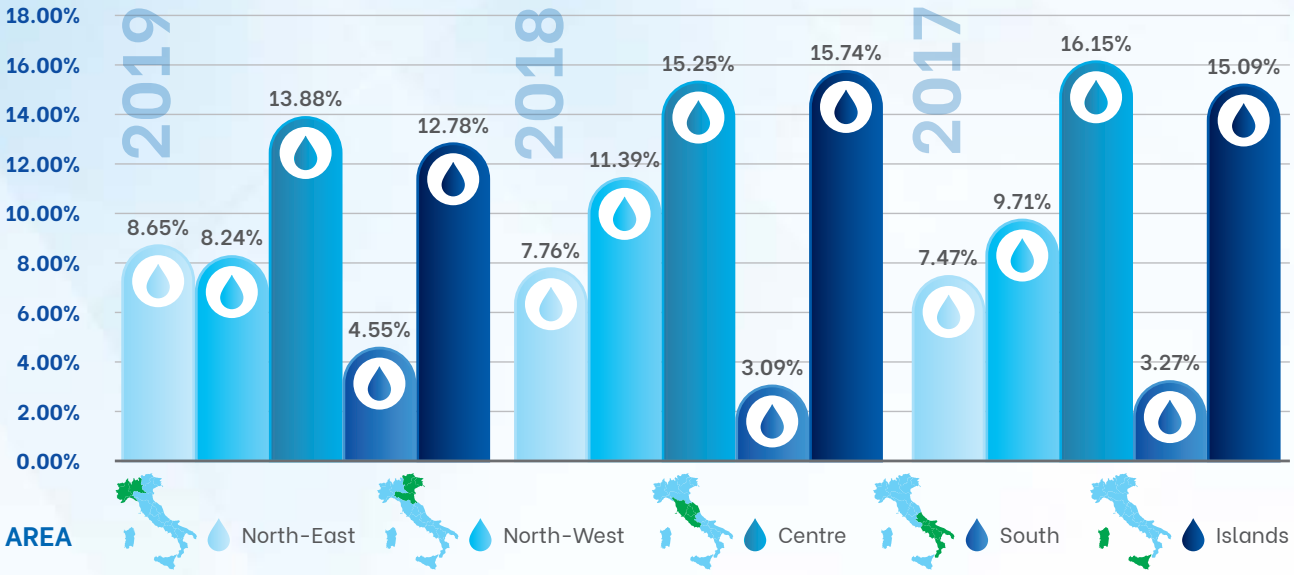

Figure 16 - Ratio of EBITDA to turnover by area (median values)

The integrated water management sector generated jobs for **39,540 people** in 2019.

More than a third of the total number of companies (193) employ 0 to 9 employees, followed by small (125) with less than 50 employees, and medium-sized (90) up to 250, while less than 10% engages over 250 employees, confirming the central role of SMEs in generating employment and added value.
The **distribution** sector produces more than **80% of the total maximum employment** made up of micro-enterprises (less nine employees), entrusted with the management of water services for small-medium urban agglomerations distributed heterogeneously throughout Italy.

The breakdown of companies, according to the four sizes in terms of the number ofemployeesand by sector, is shown in ***Figure 17***.

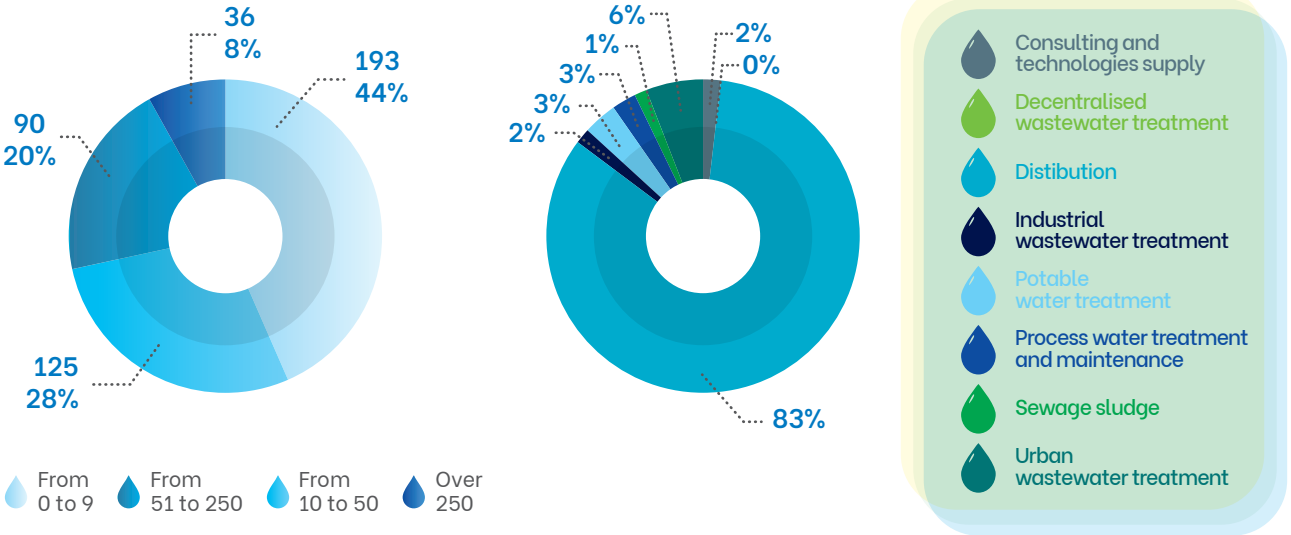

Figure 17 - Number of employees by macro-category and by sector

KEY PLAYERS IN THE INTEGRATED WATER MANAGEMENT SYSTEM

Two main business models drive the integrated water system in Italy: the **mono-utility** focused on the water and sewage service, and the **multi-utility**, which includes additional offers, such as energy and gas distribution, up to public lighting and cleaning of streets.
In recent years, the number of multi-utilities has grown due to the progressive consolidation of operators into a single large industry characterised by a vast and complex offer.

The **first 20 national operators** represent the dominant offering in the Italian market over the last three years (2017-2019), whose overall profitability performance (EBITDA) shows a steady positive trend over 26% of turnover at the median rate. Regarding economic performance, mono-utilities and multi-utilities gained a turnover of almost **250 million euro** (median value) in 2019, with a **growth rate** of **3.56%** compared to the previous year, confirming generally positive results in the positioning in the water supply market.

Figure 18 shows the breakdown between Multi and Mono-utility according to the business model of the first 20 national Italian operators[15].

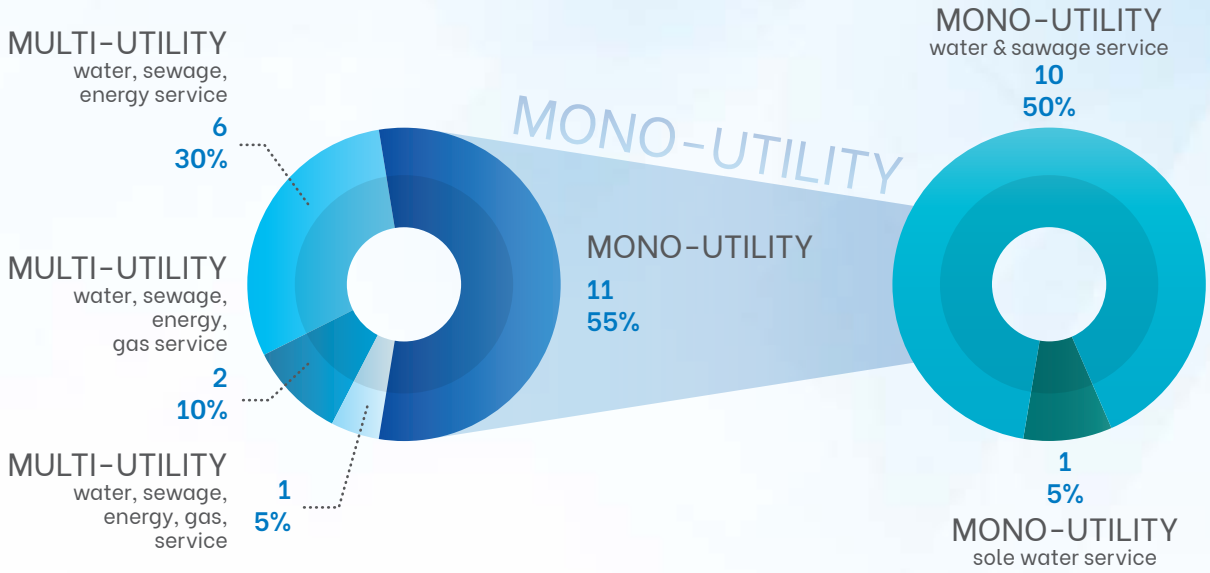

Figure 18 - Business model types in water supply management (mono and multi-utility)

The **mono-utility** model represents more than half of the sector (**55%**), characterised by companies that cover the entire integrated water service, from the collection, purification, supply, and distribution to the management of sewerage.
Mainly active in central Italy (Lazio, Tuscany, Marche, Umbria), mono-utilities supply **55 municipalities** and **773,400 inhabitants** (median value). The dominant corporate structure has a strong public composition, in which local authorities (municipalities) hold the majority of shareholding or exert a direct role in managing water services.

Company name	Geographical area and Region	Company size	Number of employees	Municipalities served (n)	Inhabitants (n)
ACEA ATO 2 SPA	CENTRAL, Lazio	LARGE	Over 250 (1,469)	96	9 million
CAP HOLDING SPA	NORTH-WEST, Lombardy	LARGE	Over 250 (398)	194	2.4 million
ACQUE SPA	CENTRAL, Tuscany	LARGE	Over 250 (413)	55	773.429
ABBANOA SPA	ISLANDS, Sardinia	LARGE	Over 250 (1,331)	345	1.6 million
GORI SPA	SOUTH, Campania	LARGE	Over 250 (918)	76	1.4 million
ACQUEDOTTO DEL FIORA SPA- ADF	CENTRAL, Tuscany	LARGE	Over 250 (403)	55	400,000
MM SPA	NORTH-WEST, Lombardy	LARGE	Over 250 (1,273)	1	50,000
ACQUALATINA SPA	CENTRAL, Lazio	LARGE	Over 250 (334)	38	250,000
ACQUA CAMPANIA SPA	SOUTH, Campania	MEDIUM-LARGE	From 51 to 250 (72)	42	3.8 million
VIVA SERVIZI SPA	CENTRAL, Marche	MEDIUM-LARGE	Over 250 (351)	44	220,000
UMBRA ACQUE SPA	CENTRAL, Umbria	MEDIUM-LARGE	Over 250 (372)	38	500,186

Figure 19 - Selection of mono-utility companies among the top 20 in the water supply sector

Mainly active in Northern Italy, multi-utilities cover the remaining 45% of the sample identified, consisting of large companies which, in addition to an integrated water supply (including sewerage), offer energy production and supply up to public lighting and cleaning of streets. One-third of the sample also provides gas supply services (Ireti SpA, Acegas Aps Amga SpA and A2A SpA). Multi-utilities diversify the profits generated by the sale of water by combining the supply of energy, gas and related utilities to high-intensity agglomerations of more than 2 million people.

[15] Source: ARERA operators datahub provides information about the type of services supplied (water, sewage, energy and gas). Data processed by Consorzio Italbiotec

They serve **179 municipalities** and **1.3 million inhabitants** (median value).
The composition of the share capital has a strong private participation and a structure based on private-public partnerships.

In terms of employment, mono-utilities involve 650 employees (median values), compared to 854 for multi-utilities, a difference a difference associated with the more numerous business assets of multi-utilities (energy, gas and other public utility services).
Figures 19 and ***20***[16] show an overview of the main companies divided, respectively, into mono-utilities and multi-utilities, while ***Figure 21*** shows their geographical distribution in Italy.

Company name	Geographical area and Region	Company size	Number of employees	Municipalities served (n)	Inhabitants (n)
IRETI SPA	NORTH-WEST, Liguria	LARGE	Over 250 (1,354)	265	2.8 million
SMAT SPA	NORTH-WEST, Piedmont	LARGE	Over 250 (946)	289	2.2 million
PUBLIACQUA SPA	CENTRAL, Tuscany	LARGE	Over 250 (608)	45	1.3 million
HERA SPA	NORTH-EAST, Emilia-Romagna	LARGE	Over 250 (2,992)	330	4.3 million
ACQUEDOTTO PUGLIESE SPA	SOUTH, Puglia	LARGE	Over 250 (2,014)	254	4 million
ACEGASAPSAMGA SPA (HERA group)	NORTH-EAST, Friuli- Venezia Giulia	LARGE	Over 250 (1,196)	179	252,951
A2A SPA	NORTH-WEST, Lombardy	LARGE	From 51 to 250 (198)	74	595,000
VERITAS SPA	NORTH-EAST, Veneto	LARGE	Over 250 (2,842)	36	800,000
AMAP SPA	ISLANDS, Sicily	LARGE	Over 250 (789)	35	1.2 million

Figure 20 - Selection of multi-utility companies among the top 20 in the water supply sector

A summary table of the services offered by the top 20 companies in the water sector is contained in **APPENDIX 5**.

Figure 21 - Top players by geographical distribution

APPENDIX 6 contains the company profiles of the top ten players.

[16] Source of Figures 19 and 20: Company websites (number of municipalities and inhabitants served) and ARERA operators datahub for the type of services supplied (water, sewage, energy and gas). Data processed by Consorzio Italbiotec

INVESTMENT TREND IN WATER QUALITY AND SUPPLY EFFICIENCY

Over the last four years, investments for improvingthe integrated water system recorded a growing trend gaining a total volume of **11,9 billion euros**. Expenditures went from 2.2 billion in 2016 to 3.4 in 2019, contributing to reaching a significant improvement in the technical quality of the water supply.

According to the ARERA Annual Report, the average annual investment per capita was of **178 euro/inhabitant** calculated on a sample of 148 operators that provided the service to 50,626,331 inhabitants between 2016 and 2019. The value is higher in Central Italy (225 euro/inhabitant), followed by the North-West (171 euro/inhabitant), while it drops significantly in the South and Islands (142 euro/inhabitant).

The measurement of the efficiency of water services is established by ARERA, through a series of indicators referring to the minimum conditions and the adequacy of the quality standards that operators must guarantee.
More specifically, indicators aimed at improving:

- The containment of water losses in networks and plant aqueducts
- The preservation of the continuity of the supply service
- The adequacy of the quality of the drinking water supply
- The adequacy of the sewer network
- The efficient disposal of sludge deriving from the purification of wastewater
- The minimisation of the associated environmental impact of the disposal of wastewater coming out of purification treatments

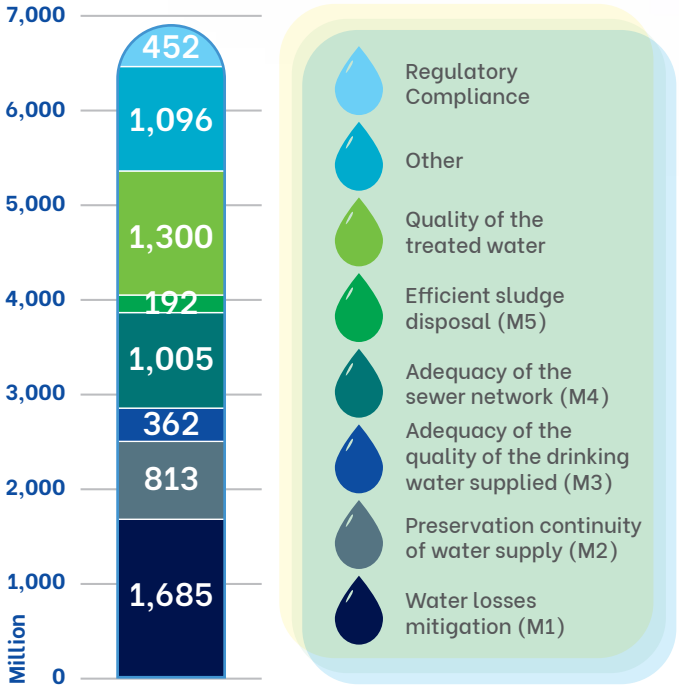

Figure 22 - Expected investments in 2016-2019 by quality indicators

Looking at the investment priorities (**Figure 22**)[17], the forecasts for the 2016-2019 period focused mainly on reducing water losses (1.6 billion euro), followed by improving the quality of purified water (1.3 billion euro) and the sewage system (1 billion euro).

According to the latest ARERA survey of the state of performance of the water system, despite significant improvements, there are still some areas that require more interventions, such as:

- Obsolescence and age of the distribution networks and systems responsible for the majority of water losses along the distribution chain
- Absence of sewage networks in some areas and of adequate purification treatments compliant with community provisions
- Inadequacy of purification treatments (plant obsolescence of networks, non-compliance of discharges or insufficiency of automation, control and monitoring services) and insufficient treatment potential of plants

Huge investments in renewing the infrastructures for water purification, the management of sewage and distribution networks represent one of the main pillars of the business plan of many companies in the water supply sector.
Among the most considerable, **IRETI SpA** (Genova, Liguria, www.ireti.it) will invest more than 3.3 billion euro over the next five years and **Acea Group SpA** (Rome, Lazio, www.gruppo.acea.it) 1.9 billion between 2019 and 2022. Investments by mono-utilities are minor but still sustained, such as **AQP SpA**(Bari, Puglia, www.aqp.it) which invested around 160 million euro in 2019 for improving wastewater treatment plants, **CAP Holding SpA** (Milan, Lombardy, www.gruppocap.it) expects 500 million euro by 2024 and **SMAT SpA** (Turin, Piedmont, www.smatorino.it) 1.2 billion euro in the 2020-2030 period.

[17] Source: ARERA, Annual report 2019 p. 358

AQP SpA (Bari, Puglia, www.aqp.it) and **SMAT SpA** (Turin, Piedmont, www.smatorino.it) must also be mentioned for their outstanding engagement in training activities by creating synergies between companies and universities through the creation of dedicated training bodies, namely the **AQP Water Academy** for Acquedotto Pugliese and the International School of Water for Development and SMAT Research Centre for SMAT group. Considerable investments were also made in the study, validation and development of innovative technologies that operate in various stages of the integrated water cycle. For example, **CAP Holding SpA** (Milan, Lombardy, www.gruppocap.it) developed a new membrane technology system for the purification of drinking water that allows to obtain water of excellent quality. **Hera group SpA** (Bologna, Emilia-Romagna, www.gruppohera.it) is currently studying an intelligent control system for wastewater treatment plants to control the oxidation process, and **MM SpA** (Milan, Lombardy, www.mmspa.it) is a pioneer in the use of "no-dig" technologies for the maintenance of pipes minimizing excavation and demolition.

All top players are committed to environmental issues and circular economy, promoting the reuse of treated wastewater and sludge in agriculture and other sectors. In particular, **AcegasApsAmga SpA** (Trieste, Friuli-Venezia Giulia, www.acegasapsamga.it) and **VERITAS SpA**(Venice, Veneto,www.gruppoveritas.it) acknowledge in their business model the importance of environmental protection and the commitment to environmental sustainability through the adoption of innovative solutions and technologies. Veritas also, as it deals with the management of the integrated water service in a delicate area such as that of Venice, places extreme importance on safeguarding the historical, artistic, cultural, landscape and natural value of Venice and the Adriatic coast. Concerning sustainability, it is also necessary to mention **Acea Group SpA** (Rome, Lazio. www.gruppo.acea.it) and **Publiacqua SpA**(Florence, Tuscany. www.publiacqua.it) which manage various hydroelectric plants, using water as a green source for the generation of electricity.

Small and medium-sized enterprises representing over 90% of the Italian production sector, and 80% of the water sector, are increasingly engaged in research and development. The technological innovation is mainly focused on improving water purification and safety, attested by interesting examples of excellence, even among the youngest companies such as start-ups[18].

Among these, of specific interest is the innovative start-up **H20 Srl** (Sant'Antonio Abate, Campania. https://h2osrl5.wixsite.com/h20srl) dealing with the design and construction of innovative and cutting-edge purification plants by integrating chemical-physical and biological processes of wastewater purification.

With investments of 3.46 million euro over the last four years, **Aqua Mantova Srl** (Castiglione delle Stiviere, Lombardy, http://www.aqa-mantova.it/irj/portal/aqa) is adopting high-precision electromagnetic systems to measure the speed of water in full pipes without interrupting the water supply.

The company **Sensor for Water Srl** (San Giuliano Terme, Tuscany, https://sensorforwater.it/) is one of the many companies developing smart sensors for monitoring and detecting water leaksand sewer networks.

WATER PRICINGAND CONSUMPTION DYNAMICS BY REGIONS

Companies offering water supply services are also generally responsible for **water pricing**. The national tariff system comprises five elements: a fixed fee, three variable shares based on water consumption for the aqueduct, sewerage, and wastewater treatment, and a VAT tax (10%). A survey conducted by Federconsumatori, Anea and Isscon in 2016 estimated an expense of **€283 per year** for average consumption of **150 m³**, broken down into a fixed tax (9%), variable share for the aqueduct (41%), variable share for sewerage(12%), variable share for wastewater treatment (28%) and VAT(10%). The average water cost was, therefore, 1,88€/m³ [103].

A second survey conducted in 2019 by Osservatorio prezzi e tariffe di Cittadinanzattiva (Cittadinanzattiva tariffs and observatory of prices) observed a significant increase in this value: 319 euro per year for an average consumption of 150 m³. The average cost of water is **2,125 €/m³.** This price is expected to further increase significantly in order to provide for the necessary infrastructure investments.

The **Italian central regions** are characterised on average by the highest tariffs, with an average expenditure of 428 € per year. **Molise** is the region with the **lowest water price** (121 euro per year).

In contrast, with an average expenditure of 477 euro per year, **Tuscany** is the region with the **highest water price**.

Water pricing methodology is, therefore, characterised by a substantial heterogeneity throughout Italy: Isernia is the city with the lowest water price (97€ per year, which means 0.64 €/m³), while the water price in Enna grows up to 558€ per year (3.72 €/m³)[104].

[18] The definition of start-up in accordance with Article 25 of the Decree no. 179 of 18 October 2012, is an independent organisation, active for less than five years, with a turnover of less than 5 million euro, of which at least 15% of its activities dedicated to research and development. A start-up is also aimed at creating, improving and expanding a scalable, innovative, technology-enabled product with high and rapid growth[168].

With resolution 664/2015/R/idr[105], ARERA established the rules for calculating the costs allowed for the tariff recognition, and the identification of macroeconomic benchmarks as well as risk-sharing parameters in water sector regulation. The cost of the service and the approval of the tariff method are established according to the following segments:

- fixed asset costs understood as the sum of financial charges, tax charges and depreciation and return of the investment
- operating costs understood as the sum of operating management costs and upgradable operating costs
- any advances for the financing of new investments
- environmental and resource costs
- adjustments deemed necessary for the recovery of costs approved and relating to previous years.

The above factors are responsible for the changes in water prices across Italy.

The subdivision of regional water costs[19] are shownin ***Figures 23***, ***24*** and ***25***.

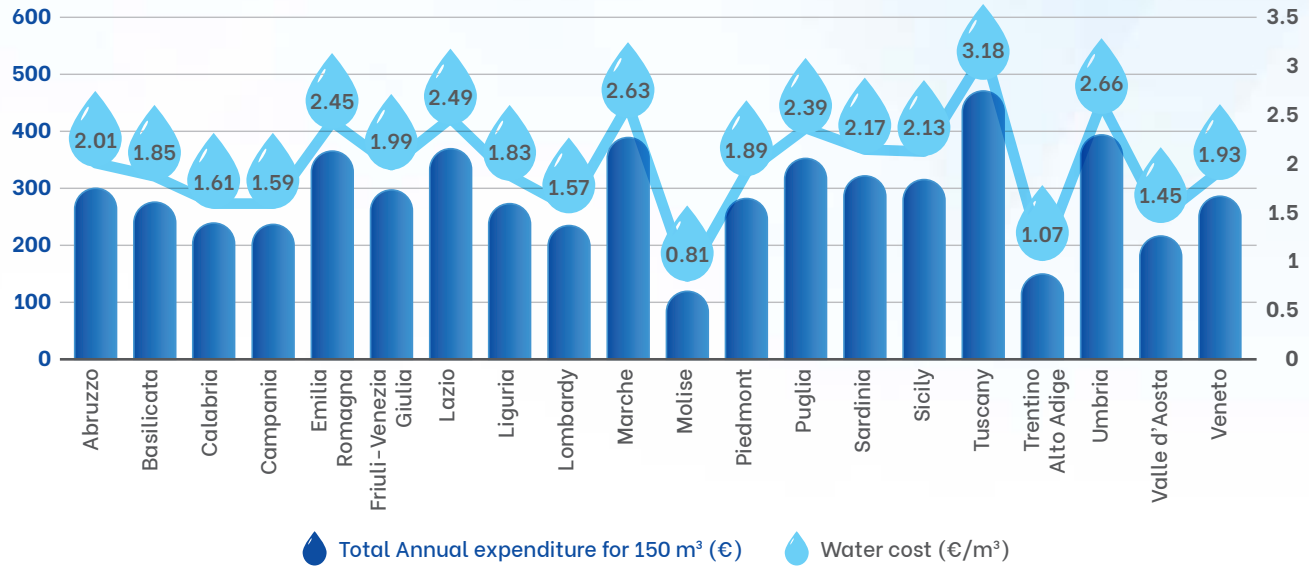

Figure 23 - Total annual expenditure for 150 m3 of water per region (in euro)

Region	Total annual expenditure for 150 m3 (€)	Water cost (€/m3)	Region	Total annual expenditure for 150 m3 (€)	Water cost (€/m3)
Abruzzo	302	2.01	Molise	121	0.81
Basilicata	278	1.85	Piedmont	284	1.89
Calabria	241	1.61	Puglia	358	2.39
Campania	239	1.59	Sardinia	325	2.17
Emilia-Romagna	368	2.45	Sicily	319	2.13
Friuli-Venezia Giulia	298	1.99	Tuscany	477	3.18
Lazio	374	2.49	Trentino Aldo Adige	160	1.07
Liguria	275	1.83	Umbria	399	2.66
Lombardia	236	1.57	Valle d'Aosta	218	1.45
Marche	394	2.63	Veneto	290	1.93

Figure 24 - Total annual expenditure and water cost for m³

[19] Source: Osservatorio prezzi e tariffe di Cittadinanzattiva. Water supply service - annual investigation on costs, quality and legal protection. https://www.ambienteambienti.com/wp-content/uploads/2020/06/Report-Servizio-Idrico-2020.pdf (2020). Data processed by Consorzio Italbiotec

Province	Total annual expenditure for 150 m^3 (€)	Province	Total annual expenditure for 150 m^3 (€)	Province	Total annual expenditure for 150 m^3 (€)
Isernia	97	Monza	171	Pisa	544
Milan	115	Catanzaro	181	Arezzo	506
Trento	128	Bolzano	192	Livorno	496
Imperia	143	Enna	558	Firenze	475
Campobasso	145	Frosinone	553	Pistoia	475
Cosenza	146	Grosseto	548	Prato	475
Catania	164	Siena	548		

Figure 25 - Top 10 provinces with the lowest water price and the highest water price

Water pricing in industrial uses for water derived from the aqueduct varies based on the operator, but not diverging from that applied for domestic consumption. Industries can withdraw water from the natural sources autonomously but under strict public (national and regional) regulation, as groundwater and surface waters are part of the public domain and cannot be exploited indefinitely and without authorisation.

Public and private entities intending to withdraw water from their own land or lands owned by others must apply for the concession; the fee will depend on the type of water uses as listed below[106].

a) human consumption for the drinking water supply

b) irrigation for land and crops inside greenhouses

c) hydroelectric for electricity or motive power production

d) industrial encompasses watering of urban green and sports areas and fish farming

e) hygienic and similar use for toilets, also inside sports facilities, industries and various structures.

For all uses, except for hydroelectric production, the fee depends on the constant or average annual nominal flow rate of the concession measured at the single unit of a flow rate of 100 litres per second.
Fee for electricity generation is calculated based on the average annual rated power expressed in kW. Finally, fees for irrigation use also depend on the extent of irrigated land expressed in hectares.

PART IV
BUSINESS OPPORTUNITIES FOR INNOVATIVE DUTCH COMPANIES

PART IV – BUSINESS OPPORTUNITIES FOR INNOVATIVE DUTCH COMPANIES

The Dutch water sector is globally known for its excellent and extensive water expertise, innovative technologies and capacity to address global water challenges[107]. The Netherlands is a small country in geographical terms, but it is a densely populated deltaic region and shows a high internal diversity[108]. The Dutch have a close connection with water. The total size of the Netherlands is of 41,500 km2, of which 7,700 km2 is water[109]. The three main rivers - the Rhine, the Meuse and the Scheldt - enter the Netherlands and branch out until they eventually reach the North Sea, resulting in a quarter of the country being under sea level. Over time, the Dutch mastered flooding and developed water supply and treatment methods counting about 1,450 companies with an annual turnover of 12 billion dollars (2% of GDP). Public companies, water companies and water purification companies contribute 32% to sales, followed by1,387 companies and private institutions (61%) and engineering and consulting companies (7%). Of the latter group, 222 companies (16%) are producers of water purification technologies[110].

The scarcity of clean water is a major problem in today's world of 7.7 billion people. Tensions on the global water system will increase by 2050 when the world population reaches between 9.4 and 10.2 billion, an increase from 22 to 34%[111]. It is assumed that in the future, 2 out of 10 people will have no access to a safe water supply, and 5 out of 10 will have inadequate sanitation. It means that more than 1.1 billion people worldwide do not have access to drinking water, and around 2.4 billion people do not have adequate sanitation[112].The Netherlands is ranked among the top three best countries in the European Union that fully complies with the treatment of urban wastewater. In total, the Dutch water authorities manage around 360 wastewater purification plants with a capacity of 23m pollution units and each year, about 2 billion m^3 of wastewater from households and businesses are purified[113]. Following the European Urban Waste Water Treatment Directive, the purification output stands at 93% for oxygen absorbents, 85% for nitrogen and 84% for phosphate. In fact, in the Netherlands, many wastewater treatment plants apply stricter standards and techniques for effluents as they discharge their effluents into environmentally friendly surface waters. These treatment plants have an additional third treatment step to remove phosphates and nitrogen.

As the Dutch have a reputation for being leaders in the post-use water treatment industry, they are at the forefront in terms of identification and development of new treatment technologies, that go beyond the traditional focus on removing contaminants such as COD, BOD, nutrients and suspended solids. New technologies continue to be developed to address these contaminants more efficiently and in a broader range of circumstances. Furthermore, academic institutions and private companies invest substantial sums of money in water-related research and development. This has led to many innovations in fields such as filtration. Still, within water management, the sludge sector represents one of the most critical areas for innovation on water use where Dutch researchers and companies are among the prominent leaders. More specifically, Dutch suppliers of water technology are known for anaerobic post-use treatments related, in most cases, to the generation of renewable energy such as biogas[114]. Under the concept of a new circular bioeconomy, the reuse of wastewater must not be limited to water reuse only but also include the possibility of recovering nutrients (such as phosphorus and nitrogen) as well as other resources from meeting current environmental needs.

Another key issue for the Dutch Government is the provision of measures to ensure the availability of drinking water. Collectively, this sector produced 1,150 million m^3 of drinking water while production increased by 13.9 million m^3 (+1.2 %) compared to 2015. The Dutch drinking water sector is served in total by only ten drinking water companies that produce and distribute drinking water. The production of drinking water mainly derives from the following sources: groundwater 58%, surface water 35%, riverbank filtration water 6% and natural dune water 1%.In some European countries, such as the Netherlands, water is supplied without added chlorine, as long as measures for protection of sources, suitable purification and good maintenance of the distribution system are assured. Multiple steps and treatments take place concerning water purification such as sand filtration, ozone treatment, carbon treatment, filtration through special membranes and treatment with ultraviolet light.
Considering, therefore, the pioneering activities developed for the water management sector, the Netherlands could play a key role in collaborating with other countries such as Italy which currently needs support in the treatment of wastewater and sludge[115].

CLEAN AND SAFE WATER TECHNOLOGY

INCENTIVES FOR WATER-SAVING SOLUTIONS. Water scarcity in Italy is a growing problem due to climate change impacts and massive withdrawal for agricultural, industrial and domestic consumption. The South is the area most affected by these phenomena where waterwithdrawalsoccur mainly from surface waters with their increasing depletion. Water scarcity stimulates the reuse of treated wastewater, as well as raising public awareness to prevent desertification and encourage water savings. The consolidated expertise of Dutch companies in the sustainable

use of water and its purification could find an exciting business opportunity especially in Italian regions that are more intensely promoting tax incentives for the purification of surface water. Intelligent treatment systems could guarantee 100% microbiologically safe water, such as applying activated carbon filters, membrane filtration (UF) and UV units to make rainwater safe and usable for domestic and industrial purposes.
Consumers play a major role in supporting more sustainable resource uses. In this context, incentives have a crucial role, and this purpose, the new tariff method approved by ARERA for the 2020-2023 period is a remarkable example. It aims to promote environmental sustainability through a series of incentives such as limiting the consumption of electricity to supply water, decreasing the use of plastic in drinking water consumption as well as stimulating energy and material recovery[116].
Moreover, economic contributions and a reduction in water tariffs for the installation of domestic water-saving technologies are encouraged by numerous regions such as Marche, Molise, Umbria, Friuli-Venezia Giulia, Veneto, to name but a few. These include reduction valves, systems for the collection and reuse of rainwater or individual meters. Additionally, in other regions such as Basilicata, Marche, Umbria and Liguria, construction and restructuring obligations are imposed on the supply network and installation of devices for limiting water consumption, such as flow reducers, valves and dual flush button toilet systems.
Industry ad agricultural sectors are among the leading causes of pressure on water resources and many players are including sustainability in their agendas. The reuse of purified water is, therefore, a pillar in the application of circular economy criteria, allowing to reduce pressure on water withdrawals of surface and underground resources, guaranteeing a continuous supply and helping to mitigate the impacts on the qualitative status of water bodies and soils. Through the tariff system approved by ARERA, local government bodies and operators of the Integrated Water Service (IWS) are increasing incentives, funding and other measures for the reuse of purified water[66]. Among the most notable examples is that of the region of Puglia, which has allocated about 120 million euro between 2014/2020, for reinforcing the domestic and industrial wastewater purification system. The initiative aims to encourage the reuse of treated wastewater for agricultural, domestic and industrial uses, mitigating the scarcity of water resources and their progressive depletion[117]. Several innovative projects in the wastewater reuse sector confirm the prominent role played by this region.

INVESTMENTS FOR WASTEWATER REUSE IN AGRICULTURE PRACTICES. The Italian regions with high agricultural intensity are those that in recent years have launched programmes to encourage the dissemination of solutions for recovering purified water for irrigation purposes.
Dutch water purification technologies, as well as the creation of irrigation networks that make the use of surface water more sustainable, could find excellent business opportunities.

Among the regions that promote incentives and economic support for the dissemination of water use efficiency (WUE) solutions, is Sardinia, one of the most advanced in this sector.
The contrast of the water deficit is a priority of regional legislation, which provides a series of economic and fiscal incentives for the owners of water purification plants connected to the distribution networks. Furthermore, energy costs for the release of pressurised water used for irrigation are borne by the region; a strategy that encourages the practice on farms.
Abbanoa SpA attests to this positive practice, which in 2019 favoured the use of over 1.2 million m^3 of purified water for irrigation, industrial and domestic purposes. The regional directive has identified 34 strategic plants for wastewater reuse, among which there are already existing plants (8), in the process of being launched (8) and planned for development (18) in respect of which the region intends to make a considerable investment. The city of Alghero has one of the primary purification plants in the area, which with an annual capacity of 7,500,000 m^3 represents a precious resource for agricultural practices. Purified water serves the 2,600 hectares of the Consorzio di Bonifica della Nura, which during the 2018-2019 period used 40,000,000 m^3 of water, equal to 15% of the total consumed[48].

Incentives for the diffusion of solutions for the reuse of purified water in agriculture are also relevant in the region of Emilia-Romagna. The region promotes the use of techniques that retain water in the soil and distribute it more efficiently, such as breaking up compact grounds, tilling them deeper, creating small barriers at the edges to prevent slipping and the widespread use of mulch.
Emilia-Romagna aims to reuse wastewater for irrigation purposes for at least 50% of the potential through economic incentives for projects and initiatives that aim to recover and reuse treated wastewater. In 2018, a three-year collaboration programme was launched between the region and a series of integrated water system managers (Hera, Consorzio Bonifica Renana, Atersir and Arpae) aimed at ensuring the maintenance of the flow rate of the Navile and Savena channels through the water from the purifier from Bologna.The initiative aims to protect the water bodies present in the area, collecting 2,160 m^3/h, equal to about 40% of the flow treated during the summer period. From August 2018 to present day, the flow of treated water recovered is equivalent to over 500,000 m^3. Other similar projects underway concern the municipalities of Sassuolo, Savignano and Modena. Hera also participates in a Por-Fers project for the application of intelligent systems for monitoring the quality of water destined for reuse[118].

DEMAND FOR DECENTRALISED WATER RECYCLING SYSTEMS. Decentralised water reuse technologies help meet the growing demand for freshwater while safeguarding natural water resources. Italian regions characterised by high water stress and progressive depletion of resources are the primary recipients. Despite this high potential, the number of companies involved in the sale and installation of domestic wastewater treatment plants from homes is minimal.
Innovative Dutch companies producing award-winning, first-of-its-kind decentralised water recycling solutions in the world could find a profitable market.

Imhoff tanks and small phytoremediation plants to produce purified water of suitable quality for discharge into water basins are the leading technologies used. The demand for water recovery solutions is growing as well as that for systems for withdrawing, filtering and reusing rainwater for non-human consumption through a double network. Many Italian regions favour the installation of dual systems for non-potable domestic uses, for the supply of drinking water and the recycling of rainwater collected and purified on-site. The regions of Basilicata, Marche, Umbria and Liguria require the installation of these devices for new constructions and renovation works. Innovative decentralised solutions for rainwater treatment have a favourable market in areas characterised by numerous small agglomerations which, due to their geographical position, are not connected to the sewer network.

The region of Sicily region represents an emblematic case where approximately 17% of the 463 urban purification plants are inactiveand only 17.5% of the current 388 active plants, operate with valid discharge authorisations. The integrated water supply system requires consistent upgrade works, and only about 61% of the approximately 5 million inhabitants of Sicily are served by a purification plant[51]. This means that nearly 2 million people are not connected to sewage networks and therefore need innovative technologies such as decentralised solutions for wastewater treatment. Sicily is, therefore, one of the central target regions of Dutch decentralisation companies. The smart and innovative Dutch water recycling system, for residences and private buildings, is an excellent alternative for off-grid situations or in arid areas where there is an unstable or insufficient water supply.

BIOECONOMY AND WATER RESOURCE RECOVERY

TECHNOLOGY FOR SEWAGE SLUDGE REUSE. With 3.1 million tonnes produced in 2018[8], sludge is one of the leading products derived from wastewater treatment, and further growth is estimated in the next few years as a result of an increasing number of households connected to the sewerage system. The main application for the reuse of treated sewage sludge is in the agricultural sector as a fertiliser.
Dutch companies offering innovative technologies for reducing the concentration of contaminants and micropollutants in sewage sludge find numerous business opportunities in the Italian market.
The recovery of added-value materials from sewage sludge represents an opportunity both to solve the issue related to its disposal and to transform sewage sludge into high added-value products for various applications based on the circular economy model.

Italian legislation establishes precise and restrictive limits for the landfilling of waste with a high content of organic matter as sludge from wastewater treatment which requires specific disposal measures. Therefore, it is necessary to search for long-term strategies for the treatment, recovery, and reuse of this waste, through a sustainable management approach. To protect the well-being of humans and land, however, this practice is strictly governed by national legislation. In addition, regions accept more restrictive rules in derogation from the national legislation, making sludge re-use essential.

For example, the region of Puglia imposes stricter limitations and the prohibition of spreading treated sewage sludge in all selected protection areas, and only 15% of the regional surface is suitable for spreading sludge on the ground, the majority located in the area of the city of Foggia[119]. However, to improve the sludge treatment capacity in order to meet the strict quality requirements, the Acquedotto Pugliese invested 30 million euro in improving the existing treatment plants and will install 60 more sludge treatment plants by the end of 2020[120].
Lombardy imposes restrictions for the use of treated sewage sludge in agricultural practices, depending on annual nitrogen concentration in manure (170 kg N/ha for sensitive and 340 kg N/ha for non-sensitive areas)[121]. With this directive, the region of Lombardy identifies 186 municipalities distributed among the provinces of Bergamo (30), Brescia (62) and Cremona (40), where the use of sewage sludge for agronomic use is prohibited. Moreover, at the beginning of 2020, the region extended the number of winter days when effluent spreading is forbidden to 58 (from 28 in the previous legislation) taking into account the quality of soil and air to implement reduction measures for fine dust in high-risk areas[122].
Finally, the use of phages is encouraged in Sardinia based on compliance with specific parameters related to the characteristics of the soil, the types of crops and the composition of the sludge. Sardinia reuses 96.8% of the sludge produced during the purification process, compared to a national average of 15%.

INCENTIVES FOR BIOGAS & BIOMETHANE. One of the most efficient incentive measures in the bioeconomy and resource recovery sector is related to biogas production; an up-and-coming industry in Italy, the second-largest producer of biogas in Europe. The Decree issued on 2 March, 2018 (also called the **Biomethane Decree**)[58] introduced in Italy new provisions aimed at encouraging the use of biomethane and other advanced biofuels in the transport sector. The Biomethane Decree focuses on advanced biofuels produced from biomass defined in turn as progressive matrices. This term refers to raw materials listed in Annex 3 of Ministerial Decree of 10 October, 2014[123] and includes, among other, municipal waste, organic waste, animal manure and sewage sludge. It envisages the issue of Certificates of Supply for Consumption (CICs, from its Italian nitials or "Certificati di Immissione in Consumo) providing 20 years of subsidies for those who inject biofuel into the consumer market, diversifying biomethane based on the matrices from which it is generated. A single CIC unit certifies the supply for consumption of 1,230 M3 of biomethane. The GSE- Energy Service Manager is responsible for withdrawing the CICs accrued through the production of advanced biomethane at a fixed price of 375 euro per certificate; a value that is undoubtedly interesting compared to those on the market. Furthermore, biomethane produced will be withdrawn from the GSE at the average monthly market price, with a 5% discount[124].
The above measures boosted the biomethane sector in Italy, reaching over 2000 plants located throughout the country. It could therefore represent an excellent opportunity for both Italian and Dutch companies committed to energy saving and the reuse of waste materials.

RESEARCH AND INNOVATION PERSPECTIVES FOR ITALO-DUTCH COMPANIES

International cooperation is one of the most powerful tools to stimulate the growth of the water sector, attested by the growing number of European research projects dedicated to the various stages of the water cycle, from collection to deriving a benefit from the use of sewage sludge and wastewater treatment. Good practices exchange on sustainable use of water can be placed at the centre of a cooperation agenda between Italian and Dutch companies.
One model of Dutch excellence is the Water Chain Groningen/Noord-Drenthe partnership[20]. The water chain is an initiative of the Association of Municipalities of Groningen (VGG) and the Association of Municipalities of Drenthe (VDG), as a northern initiative that derives from the national administrative agreement on water. The aim of the partnership is primarily to decrease costs for drinking water, sewerage and wastewater treatment, as well as toexchange knowledge and experience in the water chain. International cooperation on these issues could contribute to an increase in the quality of water organisations, their products and services and to a decrease in the vulnerability of participating organisations. Moreover, the academic and industrial excellence present in both countries derives from complementary collaborative fields, sharing a strong commitment to environmental issues and the circular economy in order to achieve a high level of sustainability of the water system.

NEW MODELS FOR CLEAN WATER AND MAPPING OF EMERGING POLLUTANTS. The CE4WE - Circular Economy for Water and Energy[21] project funded by the Lombardy Region aims to develop good practices and processes capable of improving, especially from the energy point of view, waste from water treatment. The project includes the development of new analysis procedures and models for mapping emerging pollutants and forecasting changes in the water cycle in response to various climate scenarios[125]. Measuring water quality combined by saving energy, maintenance and chemical costs qualify Dutch companies among the water purification leaders worldwide. A growing number of solutions include remote control, real-time monitoring, and utility-wide scan of water treatment processes or a river basin, such as those of the Dutch companies Aqua Color sensors, Benten Water Solutions. The detection of pollutants is crucial for maintaining good quality and safety, such as the Biotrack[22].

SENSOR AND SMART TECHNOLOGIES FOR REDUCING WATER LOSSES. Water losses exacerbate the water scarcity as 37.3% does not reach the end users mostly due to the country's obsolete water supply infrastructures. To address this problem, several companies have invested in innovative technologies to quickly and efficiently repair pipelines.
For example, MM SpA, the company responsible for managing water services in Milan, has launched a "no-dig" or "trenchless" programme to upgradethe water network. The initiative encompasses a wide range of construction technologies and methods that allow for the installation, restoration or replacement of underground utility systems, without or with minimal excavation and surface disruption. Avoiding or minimising the use of holes allows to significantly reduce the impacts on traffic, which isessential, especially in big cities, as well as on the environment and the consumption of resources. Social and environmental costs are reduced by 80% through the use of these technologies[75].
Sensors and the ICT sector represent one of the most relevant skills of Dutch companies operating in water supply and management. An example of excellence is that of the Dutch company Acquaint BV, leader in using inspection methods and techniques for improving management performance and maintaining the water network more effectively[23].

[20] Water Chain Groningen/Noord-Drenthe partnership https://www.waterketengroningendrenthe.nl/

[21] CE4WE - Circular Economy for Water and Energy https://www.openinnovation.regione.lombardia.it/it/b/18339/circular-economy-for-water-and-energy

[22] Aqua Color Sensors https://www.aquacolorsensors.nl/en | Benten Water Solutions https://benten-water.com/en/ | Biotrack https://www.biotrack.nl/

[23] Acquaint BV and Acquarius's sensors https://www.acquaint.eu/en/solutions/acquarius/

SMART TECHNOLOGIES FOR WASTEWATER RECOVERY AND REUSE. Among the examples of alternative and sustainable reuse of sludge, the collaboration between the Italian CAP Group and the Dutch company CirTec BV is relevant. An agreement for the installation of a demonstration-scale plant for the recovery of cellulose from purification sludge will allow the approval an innovative process for deriving a benefit from the use of sludge for multiple applications. The technology called Cellavation® is a process that can be used instead of or in combination with the primary treatment of a wastewater treatment plant. Toilet paper contained in sewage sludge is recovered and then recycled into a cellulose product[126].
Moreover, wastewater reuse for irrigation represents a shared, relevant priority to guarantee sustainable production. Among recent Italian experiences, it is necessary to mention the start-up Smart Cloud Farming conceived by CAP Group, designer of a remote system for monitoring the-nutrient content of agricultural soil. The technology consists in using a drone that adopts intelligent sensors and IoT-Internet of Things devices. This innovative technology allows to analyse large surfaces of land in a short time, accelerating the monitoring times of the soil components by reducing them from a few weeks, necessary for classic laboratory analyses, to a few hours. The advantage of the technology developed by Smart Cloud Farming is to rationalise the use of fertilisers and chemical fertilisers, protecting not only the quality of the soil and crops but also the aquifers from contamination of harmful substances. In the same sector, the start-up is also carrying out one of the most exciting researches in Europe, H2020 Digital Water City, which was created to continuously monitor the parameters of purified water intended for irrigation use[127].

ENERGY AND RESOURCE RECOVERY FROM SEWAGE SLUDGE. The reuse of sludge produced by water treatment in agricultural and energy applications is a growing trend. In Lombardy A2A Ambiente SpA, together with some leading companies in the water treatment and scientific research sector (Brianzacque Srl, Mario Negri IRCCS Pharmacological Research Institute, Lariana Depur SpA, MM SpA and TCR Tecora Srl) launched the FANGHI - Advanced management of Sewage Sludge project to test new treatment technologies for sewage sludge.
The project involves the testing of advanced technologies of sludge mono and co-incineration for the waste-to-energy process, and the construction of a sludge incineration plant, one for the extraction of nutrients (phosphorus and potassium) from the ashes and finally a bio-drying of the sludge (bioDryer)[83].
A further research project on deriving benefits from the use of sludge is BIOMASS HUB - Biomethane for a sustainable society[24] funded by the Lombardy Region and lead by the company Agromatrici Srl. It aims to build an integrated and multifunctional HUB combining the needs for innovation in the waste management chain through the synergy between renewable energies and green chemistry.
The BIOMASS HUB involves the construction of a biorefinery for the integrated production of biofuels, biomethane, energy, fertilisers and biomaterials from organic waste, as well as policy tools to contribute to the energy transition towards advanced renewable sources[128].

IMPROVE SUSTAINABILITY IN DRINKING WATER CONSUMPTION. Promoted by a growing number of cities, water supply vendors or "case dell'acqua" stimulate virtuous consumption behaviours and reduce the consumption of plastic bottles. With an average annual consumption of 300,000 litres of water, they save 60,000 kg of PET and 1,380 kg of CO_2[129]. Water kiosks provide citizens with treated, chilled and sparkling drinking water for free or, in some cases, at a negligible cost (only 36% of the plants require 5 euro cents per litre for chilled and/or sparkling water) and represent a service for citizens with a lower logistic impacts and costs. In Italy, water supply vendors (Case dell'acqua) recorded a substantial increase from 213 installations in 2010 to 2016 in 2017 species in Lombardy (574), Lazio (271), Piedmont (233), Emilia-Romagna (181) and Tuscany (150). This phenomenon, which began in Lombardy, is also slowly affecting the central-southern regions which in recent years have seen strong participation, especially in Abruzzo (90), Marche (79) and Umbria (67).

KEY STAKEHOLDERS AND POLICYMAKERS OF THE WATER SECTOR

KEY INDUSTRY STAKEHOLDERS

- Valore Acqua Community | www.ambrosetti.eu/community-valoreacqua/

  The European House - Gruppo Ambrosetti established a high-level multi-stakeholder community in 2019 to deal with the management of the world's water resources as a driver of competitiveness and industrial development, to draw up proposals for the government and national economy.

- Water Alliance | www.wateralliance.it/

  The first network of water companies in Lombardy made up of thirteen operators of the integrated water service serving about eight and a half million inhabitants. Water Alliance is committed to building working groups dedicated to establishing a dialogue with stakeholders in the water sector. As a result of the drafting of specific position papers, companies in the network have explored various topics of common interest.

[24] Agromatri ci Srl https://www.agromatrici.com/progetto-biomass-hub

- Utility Alliance | www.utilityalliance.it

  Established in July 2016, Utility Alliance is a network of companies operating in Piedmont in the water, energy and environmental services sectors that represent three specific operating branches, respectively called Water Alliance, Energy Alliance and Environment Alliance.14 companies join the Utility Alliance Network of Piedmont with the aim of reducing management costs and increasing the quality level of user services.

- Aqua Italia | www.anima.it/associazioni/elenco/aqua-italia/

  The Aqua Italia association represents the manufacturers of plants, accessories, components and chemical products for the treatment of primary (non-waste) water for domestic, industrial and swimming pool use. It promotes product culture, creates opportunities for meetings and discussions with operators in the sector, the supply chain and endconsumers. It also takes part in the drafting of technical-practical guidelines in collaboration with the Higher Institute of Health, the Ministry of Health and associations in the supply chain, as an authoritative reference point for the market. Aqua Italia is part of ANIMA and actively works within numerous technical committees of the CEN (European Committee for Standardization) and of the UNI (Italian National Unification Body). It is a member of AQUA EUROPA (European Water Industry Business Association), of which it is a founding member[130].

- Associazione Italiana Acqua di Qualità | www.acquadiqualita.it

  It was established in 2013 from the collaboration between some of the leading companies operating in the drinking water treatment sector in public and domestic catering. It promotes the culture of water treatment among operators in the HORECA, public and domestic sectors[131].

- Associazione Manutentori Impianti Trattamento Acqua Potabile | www.amitap.it/

  The Association brings together the maintainance operators of drinking water treatment plants. It promotes the training and professional upskilling of the associated companies to favour the best solutions in terms of design, installation and assistance[132].

- UTILITALIA | www.utilitalia.it/

  Utilitalia is the Federation that brings together companies operating in the public services of Water, Environment, Electricity and Gas, representing them at national and European institutions. It offers assistance, upskilling and training services, as well as consultancy activities on contractual, regulatory, management, tax and legal aspects[133].

- Efar Italia | https://efaritalia.it/

  The European Federation for Agricultural Recycling (EFAR) brings together leading Italian companies in the agricultural recycling sector and in the production of biological sludge from water purification. Efar Italia is a national association linked to the European association EFAR[134].

CONSUMER PROTECTION ORGANISATIONS

- Italian Regulatory Authority for Energy, Networks and Environment - ARERA | www.arera.it/it/index.htm

  ARERA is an independent body created to protect consumers' interests and promote competition, efficiency and distribution of services with adequate levels of quality, through regulatory and monitoring water services. ARERA draws up and updates the tariff method for establishing the fees for both the integrated water service and the integrated waste service and approves the tariffs designed by the competent bodies[135]. Moreover, ARERA deals with the regulation of the entire integrated supply, presenting strategic actions[25] that guarantee transparency in terms of customers' information on the integrated water service quality[26] assessed through more than 40 specific standards and the Water Service Charter. It governs transparency in water supply and implying the operators' undertaken about the service quality standards compliant.

MULTI STAKEHOLDERS NGOS

- Associazione Idrotecnica Italiana | www.idrotecnicaitaliana.it/

  Established in 1923, the Association fosters the development and dissemination of the culture of water in the various aspects relating to the management of water resources, the protection of water bodies and environment. The Association brings together the leading public-private operators in the water supply, and it is structured into 12 regional sections[136].

[25] With resolution 242/2019/A[169] and according the "Strategic Framework 2019-2021"[74]

[26] According to the resolution 547/2019/R/idr[170] ARERA has ordered the publication of contractual quality data of the integrated water service disclosed by the managers of the IWS for the first two years (years 2017 and 2018), applying the provisions of the resolution of Annex of 655/2015/R/idr[171]. Data disclosed by IWS operators relate to 28 specific standards and 14 general standards, relating to the following aspects, which allow consumers to become more aware of the characteristics of the services offered by the various operators.

NATIONAL RESEARCH AND INNOVATION CLUSTERS

- Italian Cluster of Green Chemistry - SPRING | www.clusterspring.it/home/

  SPRING creates synergies among active, innovative entities aiming to develop the entire green chemistry sector to foster a new economy (bioeconomy). The goal is to help make the conditions for the growth of an attractive, dynamic, innovative and competitive continuously growing industrial and academic context[137].

- Cluster Blue Italian Growth - BIG | www.clusterbig.it/

  BIG includes the participation of Universities, Public Research Bodies, SMEs and regional associations that in various ways deal with the sea as well as the sustainable use of water resources. Strategic priorities are the marine environment and coastal strip, Blue biotechnology, Renewable energies from the sea, Marine abiotic resources, Marine biotic resources in addition to Shipbuilding and marine robotics[138].

- Consorzio Italbiotec |www.italbiotec.it

  Italbiotec is the leading Italian nonprofit organisation on the industrial biotechnology ecosystem. Established in 1998, Italbiotec brings together 70 innovators operating in the Life Science, Bioeconomy and Agrofood sectors by combining the expertise of 14 leading Italian universities, the National Research Council and more than 50 SMEs and firms active in industrial biotechnology for green chemistry, agro-food and pharmaceutical applications.

KEY PLATFORMS FOR BUSINESS TO BUSINESS OPPORTUNITIES

Water management, technological innovation and sustainability are key sectors for the development of the Italian market and are the focus of numerous fairs and exhibitions. Opportunities for meetings and B2B matchmaking, these events mobilise thousands of national and international operators every year. Areas and priorities of trades as well as leading exhibitions are listed below.

BIOECONOMY, GREEN and RENEWABLE ENERGY

- SMART BUILDING LEVANTE, Bari 19-20 February 2021 | www.smartbuildingitalia.it/levante

  This is the plant innovation fair conceived by industry experts and aimed at operators in the intelligent building supply chain that offers digital products, systems and services with specific attention on product categories of great potential capable of leading the consumer market and business.

- ECOMONDO, Rimini November 2021 | https://www.ecomondo.com/

  The international fair combines all sectors of the circular economy in a single platform: from material and energy recovery to sustainable development. Global Water Expo is its section dedicated to all stages of the integrated water cycle chain, from collection to its return to the environment.

SUSTAINABLE AGRICULTURE

- MYPLANT & GARDEN, Milan 15-17 February 2021 | https://myplantgarden.com/

  Maintenance technicians, gardeners, distributors, architects, planners, landscape architects and designers can stay up to date with the latest news on machinery for irrigation, soil processing, green maintenance, harvesting to irrigation systems, water treatment, handling, air conditioning up to equipment for analysis.

WATER SUPPLY AND TECHNOLOGY

- ACCADUEO, Bologna 5-7 May 2021 | www.accadueo.com/home/1606.html

  This is the largest dedicated national event on technologies, treatments, distribution and sustainability of the water supply chain. It provides value B2B opportunities for domestic operators, producers and suppliers of technologies for water, energy and gas.

- MCE Mostra Convegno Expocomfort, Milan 8-11 March 2022 | www.mcexpocomfort.it/it-it.html

  The event on the intelligent use of water presents the "value of water" technological solutions designed for the bathroom environment and the optimal use of water resources. More specifically, two main themes, comfort and water, will be presented within various aspects relating to design, materials, sustainability, safety and savings.

CIRCULAR ECONOMY IN ITALY

- WATER FESTIVAL, Venice and Bressanone 2022 | http://festivalacqua.org/

  Every two years, the Festival brings together hundreds of national and international speakers, representatives of institutions, leading figures in the economy, science, culture, publishing, entertainment and any other category that deals with water resources.

- WATEC ITALY, 2022 | https://watecitaly.com/?lang=it

  A conference exhibition on water technologies created to promote cooperation between Italian and international companies, as well as encourage interaction between the private and public sectors. To reach this goal, the event organisers also offer a matchmaking platform to allow attendees to establish new contacts and set up meetings with other companies in the industry

SALES CHANNELS FOR WATER SERVICES AND PRODUCTS

In Italy, water supply services are subject to the management of the public authorities, therefore the offer is awarded to a company, following a specific tender and relevant award, which may use companies for the provision of the service or provide for internal management. ARERA established the minimum standards that must be guaranteed in water supply services and provides guidelines on the tariff system.

On the other hand, a more direct relationship between end users and producers is found in the sector of sale and supply of products for domestic use, such as domestic or rainwater purification systems, systems for improving water quality. taps and water technologies. savings (breakwaters, valves, ...). The user can in fact contact and purchase these directly from the technology provider or purchase the product from a third party reseller.

In the case of more innovative and avant-garde technologies, the first method is preferred, while for more standard and consolidated technologies, the purchase is often made by retailers, intended both as retail outlets but also small companies that deal with the installation. and product maintenance especially in the case of domestic purification plants.

To conclude, large industrial plants in most cases rely directly on the manufacturer of the technology for for replacing damaged portions and the supply of the products of interest. However, an emerging trend is the entrusting of the management and maintenance of the plants to consultancy companies that therefore also interface with the supplier of the technology and the product as necessary for the operation of the plant, acting as an intermediary.

CONCLUSIONS

Investments in technological innovations and international cooperation are essential acceleration tools in the transition towards more sustainable consumption paradigms.

In the water sector, synergistic actions are essential to encourage the adoption of solutions based on the circular economy for purification and reuse, as well as for upgrading water supply infrastructures. Together they contribute to reducing the pressure on water bodies and surface waters and in general to improving the environmental impact of anthropogenic activities.

Italy, one of the largest consumers of fresh water in Europe, is called upon to counter the progressive depletion of water resources by increasing the large-scale diffusion of affordable water treatment technologies that support the reuse of treated water for domestic and agricultural uses.

Water losses are among the challenges of the water sector, mainly due to a deficit in infrastructure renovation, which in turn lead to discontinuity of supply, fairness in the application of tariffs and quality assurance. Through recent regulatory provisions, the Italian market has significantly increased investments in research and development to reduce and prevent losses, upgrade its obsolete networks and introduce green technologies. During the 2016-2019 period, investments amounted to approximately 10 billion euro, of which the service and 2.2 covered 7.8 by public funding [65]. The value of investments per capita expenditure is 178 euros (44.5 euros/inhabitant/year).

However, incremental efforts are needed to reduce the differences between the North and South of the country, to ensure the adoption of scalable solutions and technologies for monitoring and to improve the efficiency of distribution systems.

In the landscape of investments and the challenges that the Italian water management sector must face, there are numerous opportunities for cooperation and business that innovative Dutch companies can seize. The Dutch water sector, acknowledged as a world leader, is populated by multiple top players who meet all the needs of the integrated water cycle from collection to treatment and reuse, guaranteeing the satisfaction of greater urbanisation, population growth and climate change. Cooperation with Dutch companies can help deploy new smart solutions on the Italian market to support a redesign of modern water governance practices.

The multi-utility driven integrated water cycle sector is growing, displaying dominant trends in centralised purification systems, development of new emerging pollutant detection techniques and sensors applied to networks. The most urgent investments concern the construction of purification plants or their sizing, often insufficient to satisfy demand; and in the case of the sewerage network, the extension of the system which in some regions does not serve the total population.

Purification plants are essential infrastructures for ensuring quality, safety and sustainability of water use. In the fragmented regional landscape of tax incentives and investments for the development of water services, more business opportunities are being seized where the regions have embarked on a path towards encouraging circular economy models.

Among the relevant examples, Sardinia is one of the most advanced areas in the sector of reused treated wastewater, promoting this practice as a strategy to address the water deficit and the decreased use of surface water. A series of economic and fiscal incentives for companies that implement this practice favour the reuse of water in this region.

The second example of circular use of resources comes from the region of Puglia, investing over 120 million euro in the 2014/2020 period, to upgrade the domestic and industrial wastewater purification system. Moreover, it is one of the first regions to express an interest in decentralised wastewater treatments to improve the efficiency of wastewater treatments.

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LIST OF ABBREVIATIONS

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AATO	"Autorità di Ambito Territoriale Ottimale" or regional authority responsible for water supply and sanitation services in Italy
AQP	Acquedotto Pugliese
ARERA	Italian Regulatory Authority for Energy, Networks and Environment
ARPA	Regional Environmental Protection Agency
ASL	"Azienda Sanitaria Locale" or Local Health Authority
ATECO	(Italian equivalent to the NACE classification)
ATO	"Ambito Territoriale Ottimale" or Optimal Regional Area
BM	Biomethane Decree - Ministerial Decree issued on 2 March, 2018
BOD	Biochemical Oxygen Demand
CIC	"Certificato di immissione in consumo" or Certificate of Supply for Consumption (CIC)
COD	Chemical Oxygen Demand
DWD	Drinking Water Directive (98/83/EC)
EBITDA	Earnings before interest, taxes, and amortization
EFAR	European Federation for Agricultural Recycling
EL	Environmental Law (Legislative Decree No.152/2006)
EU	European Union
GD	Genoa Decree - Legislative Decree 109 of 28 September, 2018
GDP	Gross Domestic Product
GSE	"Gestore Servizi Energetici" or Energy Service Manager
ISPRA	Italian National Institute for Environmental Protection and Research
ISTAT	Italian National Institute of Statistics
IWS	Integrated water system
MBR	Membrane Bioreactors
MCE	Mostra Convegno Expocomfort (an Italian trade fair in the energy efficiency and renewable sources sectors)
MM	Metropolitana Milanese
NACE	Statistical Classification of Economic Activities
PE	Population Equivalent
SMAT	Società Metropolitana Acque Torino
SMC	Standard Cubic Metrers
SME	Small and Medium-sized Enterprises
SSD	Sewage Sludge Directive (86/278/EEC)
TENORM	Technologically Enhanced Naturally Occurring Radioactive Material
UV	UltraViolet
UWTD	Urban Wastewater Treatment Directive (91/271/EEC)
VAT	Value Added Tax
WFD	EU Water Framework Directive (2000/60/EC)
WPP	Water protection plan
WTP	Wastewater treatment plants

GLOSSARY

GLOSSARY

Biomethane Decree	Ministerial Decree issued on 2 March, 2018 - Promotion of the use of biomethane and other advanced biofuels in the transport sector ("Promozione dell'uso del biometano e degli altri biocarburanti avanzati nel settore dei trasporti").
Consulting and supply of technologies	Supply providers of water quality analysis, waterworks management and sewage networks, devices and technologies to third parties operating in the water sector. Industry category used to classify companies in the "water management system competitive landscape" chapter.
Decentralised wastewater treatment	Operators promoting approaches for collection, treatment and discharge/reuse of wastewater and rainwater for individual dwellings and/or isolated communities. Industry category used to classify companies in the "water management system competitive landscape" chapter.
Distribution	Operators covering collection, distribution and wastewater services to end-users responsible for managing the entire integrated water supply service. Industry category used to classify companies in the "water management system competitive landscape" chapter.
Drinking-Water Directive	Council Directive 98/83/EC of 3 November, 1998, on the quality of water intended for human consumption. Its objective is to protect human health from adverse effects of any contamination of water intended for human consumption by ensuring that it is wholesome and clean.
Dual water supply networks	Two separate pipe networks usually used to supply potable water through one distribution network and non-potable water through the other.
EBITA	EBITA is a measure of company profitability used by investors.
Environmental law	Legislative Decree no. 152/2006 - Environmental law ("Norme in materia ambientale")
Galli Law	Italian Law no. 36/1994 - Regulations on water resources ("Disposizioni in materia di risorse idriche").
Genova Decree	Legislative Decree no. 109 of 28 September, 2018 - Urgent provisions for the city of Genoa, the safety of the national infrastructure and transport network, the seismic events of 2016 and 2017, employment and other emergencies ("Disposizioni urgenti per la citta' di Genova, la sicurezza della rete nazionale delle infrastrutture e dei trasporti, gli eventi sismici del 2016 e 2017, il lavoro e le altre emergenze").
Groundwater	Water that exists underground in saturated zones beneath the land surface.
Industrial wastewater treatment	Operators responsible for wastewater treatment of industrial origin only. Industry category used to classify companies in the "water management system competitive landscape" chapter.
Integrated water system	Range of services related to the administrative management of water, consisting of a series of integrated processes that allow water to be withdrawn from the natural reservoir and to be distributed, following purification, to households.

Multi-utility

Company that promotes a multi-product offer, such as the supply of water, energy, gas, public lighting and cleaning of streets.

National Decree on potable water

Legislative Decree no. 31/2001 - Implementation of Directive 98/83 / EC relating to the quality of water intended for human consumption ("Attuazione della direttiva 98/83/CE relativa alla qualità delle acque destinate al consumo umano").

National Law on energy from renewable sources

Legislative Decree no. 28, 3 March, 2011 - Implementation of Directive 2009/28 / EC on the promotion of the use of energy from renewable sources, amending and subsequently repealing Directives 2001/77 / EC and 2003/30 / EC ("Attuazione della direttiva 2009/28/CE sulla promozione dell'uso dell'energia da fonti rinnovabili, recante modifica e successiva abrogazione delle direttive 2001/77/CE e 2003/30/CE").

National Regulation on waste landfills

Legislative Decree no. 36/2003 - Implementation of Directive 1999/31 / EC on waste landfills ("Attuazione della direttiva 1999/31/CE relativa alle discariche di rifiuti").

Nitrates Directive

Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources.

Population equivalent

In wastewater monitoring and treatment, this term expresses the ratio of the sum of the pollution load produced during 24 hours by industrial facilities and services to the individual pollution load in household sewage produced by one person during the same period of time. More specifically, it is the number expressing oxygen-demanding substances whose oxygen consumption during biodegradation equals the average oxygen demand of the wastewater produced by one person. For practical calculations, it is assumed that one unit equals 54 grams of BOD per 24 hours[139].

Potable water treatment

Service providers of physical or chemical processes to treat water and remove contaminants. Industry category used to classify companies in the "water management system competitive landscape" chapter.

Process water treatment and maintenance

Service providers of design, construction, and maintenance of aqueducts, sewerage networks and wastewater treatment plants. Industry category used to classify companies in the "water management system competitive landscape" chapter.

River Basin Authority Decree

Ministerial Decree no. 294 of 25 October, 2016 - Governing the assignment and transfer to the district basin authorities of personnel and instrumental resources, including the offices, as well as financial resources of the basin authorities, as per law no. 183 of 18 May 1989("Disciplina dell'attribuzione e del trasferimento alle Autorita' di bacino distrettuali del personale e delle risorse strumentali, ivi comprese le sedi, e finanziarie delle Autorita' di bacino, di cui alla legge 18 maggio 1989, n. 183").

River Basin Management Plans

This is the regulatory and technical-operational tool through which actions and rules of use for the conservation, defense and enhancement of the soil and the correct use of water are planned and programmed. The Basin Plan can also be drawn up and approved for sub-basins or extracts relating to functional sectors. Specific contents and objectives of the Basin Plan are established by Art. 65 of Legislative Decree no. 152 of 2006.

Sewage sludge

Operators in the treatment and reuse of sewage sludge responsible for wastewater treatment, in addition to sewage sludge treatment, have been included under the "Urban/industrial wastewater treatment". Industry category used to classify companies in the "water management system competitive landscape" chapter.

Sewage Sludge Directive	Council Directive 86/278/EEC of 12 June, 1986, on the protection of the environment, and specifically the soil, when sewage sludge is used in agriculture.
Surface water	Surface water is any body of water above ground, including streams, rivers, lakes, wetlands, reservoirs, and creeks. Even though the ocean is saltwater, it is considered surface water.
Urban wastewater	"Domestic water or the mixture of domestic wastewater with industrial wastewater and/or run-off rainwater" as established by the Urban Wastewater Treatment Directive.
Urban wastewater treatment	Operators in the treatment of wastewater of mixed origin (domestic and/or industrial). Industry category used to classify companies in the "water management system competitive landscape" chapter.
Urban Wastewater Treatment Directive	Council Directive 91/271/EEC of 21 May, 1991, concerning urban wastewater treatment.
Water framework directive	Directive 2000/60/EC of the European Parliament and the Council establishing a framework for Community action in the field of water policy.
Water Protection plan	The regional tool aimed at achieving the environmental quality objective and ensuring a long-term sustainable water supply. Each regional water protection plan contains: (1) the identification water basin and its status within the regional territory; (2) the protection measures to reach these objectives; (3) the programme of implementation and verification of the effectiveness of planned interventions.
Water withdrawal	Freshwater taken from ground or surface water sources, either permanently or temporarily, and conveyed to a place of use[140].

RESEARCH METHODOLOGY

RESEARCH METHODOLOGY

The *Circular Economy in Italy* market report encompasses an extensive usage of both primary and secondary data sources, national and regional legislation. Moreover, the research process involved the study of various factors affecting the targeted industry, including market environment, present and upcoming technologies, present trends in the market, and competitive landscape. Together, these insights contributed to the definition of the Italian industrial landscape in clean and safe water technology and wastewater resource recovery sectors.

Figure 26 shows an illustrative representation of the overall process used for this study, based on a data triangulation approach.

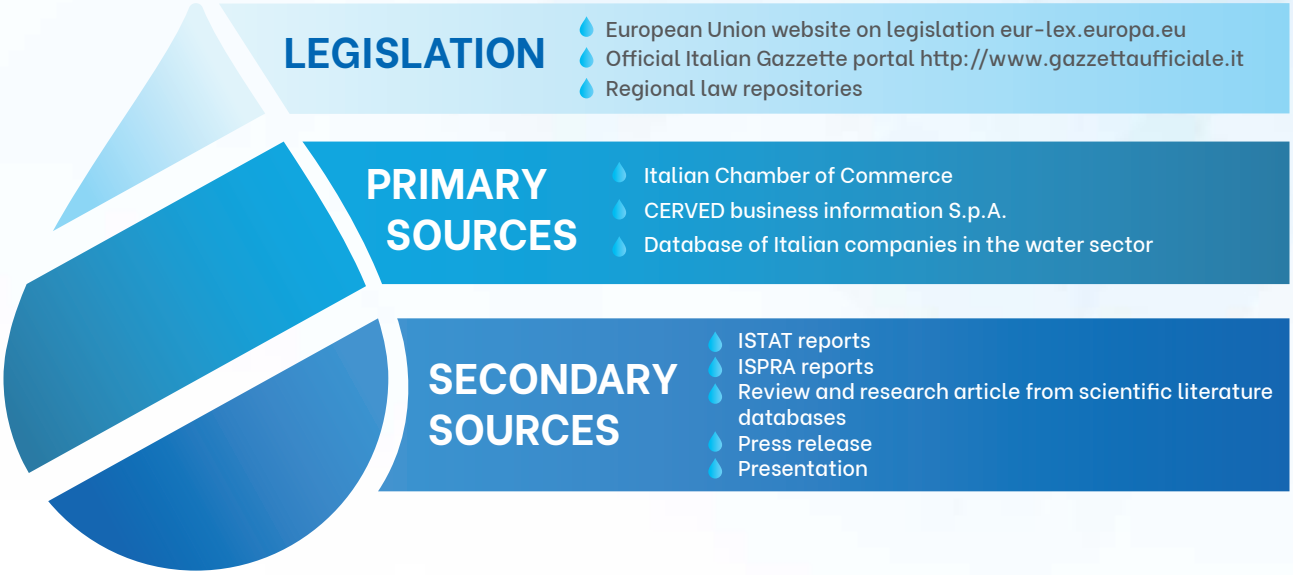

Figure 26 - Data triangulation approach for sources identification

The market analysis is based on primary sources, crucial for the description of the Italian industrial landscape based on the market segment, specifically focusing on top players. They provide data on turnover, EBDTA, revenues, trends in growth rates for the 2017-2019 period.
Secondary sources support data collection on water consumption, the water supply management system, water treatment technologies, offers and tariffs. The legislative and industrial factors that influence the markets are classified as primary sources and analysed to obtain the final quantitative and qualitative data.

PRIMARY SOURCES

The research methodology comprises data aggregation of numerical and non-numerical information mostly from the Business Register of the Italian Chamber of Commerce.
Primary sources also encompass multiple company information repositories, datasets coming from reliable and public sources such as the CERVED companies' titles websites and social networks. CERVED collects and integrates legal, financial and fiscal data filed with the Chamber of Commerce by each Italian company, such as name, address, legal entity, tax code / Companies Register no., share capital, ATECO and NACE codes.
The ATECO code (version 2007) represents the economic activity of a specific company: the letters identify the economic macro-sector, while the numbers represent the specific sub-categories of the sector itself.
The NACE Code is the "statistical classification of economic activities in the European Community" and is the subject of legislation at the European Union level, which imposes the use of the classification uniformly within all the Member States. NACE provides the framework for collecting and presenting an extensive range of statistical data based on economic activity in the fields of economic statistics (e.g. production, employment, national accounts) and other statistical domains[141].

The methodological approach used for the competitive landscape analysis is based on selecting the leading activity based on the following NACE codes:

- **36.00 Water collection, treatment, and supply** which encompasses several industrial fields, such as the integrated water service, withdrawal, potabilisation, water distribution for domestic consumption, wastewater treatment, desalination
- **37.00 Sewerage** which encompasses the management of the sewage systems, collection and purification of wastewaters.

An additional step in the research methodology based on primary sources consists of further calibration of this framework to distinguish between critical and non-critical contributions for better results.

Key Data Information from Primary sources is provided in ***Figure 27***.

Parameters	Key data	Sources
Market positioning of Top Players	Technologies, service, market segments	Company websites, press releases
Qualitative analysis	Company data, NACE code, annual revenues, growth rate, employees	Dara repository, CERVED, Italian Chamber of Commerce

Figure 27 - Key data information from primary sources

SECONDARY SOURCES

The research methodology comprises desk research on available on-line secondary sources, including press releases, journal articles, reports of non-profit organisations, industry associations, governmental agencies, used as a baseline for **bibliographic research** on Italian sectors related to clean and safe water technologies and resource recovery from wastewater.

The research includes a widespread usage of European and Italian databases, annual reports and statistics, mainly produced by the following authorities:

- **ISTAT**: the Italian National Institute of Statistics, a public research organisation and the leading producer of official statistics in the service of citizens and policy-makers[142].
- **ISPRA**: the Italian Institute for Environmental Protection and Research[143].
- **Italian Ministry of Environment**: the national authority promotes environmental research and conservation through the publications of reports and presentations.
- **Scientific review articles** are also extensively used to understand the technology framework.

An additional step in the research methodology based on secondary sources consists of further calibration of this framework to distinguish between critical and non-critical contributions for better results.

Key Data Information from Secondary sources is provided in ***Figure 28***.

Parameters	Key data	Sources
Market size	Water consumption, industrial water demand, water quality	ISTAT, ISPRA, Eurostat, Journals, websites
Market offer	Water Technology, trends and forecast	Company websites, reports, scientific literature
Market positioning of Top Players	Business/Segment, offers, geographical penetration	Company websites, press releases

Figure 28 - Key data information from Secondary sources

LEGISLATION

The policy framework related to water sectors includes analysis of incentives and constraints to enter the markets. It is based on the verification of European, national, and regional law repository. Main sources follow:

- the European Union website on legislation (eur-lex.europa.eu) for establishing the European policy framework
- the Official Italian Gazzette portal (http://www.gazzettaufficiale.it) to identify Italian policies, incentives and constraints in the Italian market
- Regional law repositories to search for specific legislation and restriction in derogation from the national legislation, considering the fragmentation of the sector at the regional level.

LIMITS OF THE STUDY

The competitive landscape of clean and safe water technologies in Italy is based on primary sources selected according to a data aggregation methodology. This approach considers public and private operators of the integrated water system management following their primary activity classification in the Business Register of the Chamber of Commerce (NACE code).
It is possible to assert that this approach allows to identify the majority of market operators grouped under two principal NACE codes (36.00 Water collection, treatment, and supply and 37.00 Sewerage). However, the study's approach excludes companies which, despite operating in the field of water purification technology development and wastewater reuse, consider it a secondary commercial activity and therefore are registered in the business register with different NACE codes. A one-by-one operators verification mitigates the research methodology limit, and a cross-check with other secondary sources that guarantee the highest level of reliability of the analysis.

APPENDICES

APPENDICES

APPENDIX 1 - ATOs' regional distribution, number of municipalities and population served

Source: Mangano A. (Acea s.p.a.) Water service in Italy. 2009. https://eau3e.hypotheses.org/files/2009/11/ATHENS_Andrea_Mangano.pdf
Data processed by Consorzio Italbiotec.

	Region	Province/Area	ATO acronym	N. of municipalities	Population
North-West	Liguria	Genoa	LI-2	67	854,099
	Liguria	Savona	LI-3	69	280,707
	Liguria	La Spezia	LI-1	67	221,003
	Liguria	Imperia	LI-4	66	215,244
	Lombardy	Milan	LO-11	135	2,312,557
	Lombardy	Brescia	LO-2	205	1,264,000
	Lombardy	City of Milan	LO-12	1	1,135,000
	Lombardy	Bergamo	LO-1	244	1,108,000
	Lombardy	Varese	LO-10	141	890,090
	Lombardy	Como	LO-5	103	599,654
	Lombardy	Pavia	LO-8	190	574,962
	Lombardy	Mantua	LO-7	70	412,868
	Lombardy	Cremona	LO-4	113	360,444
	Lombardy	Lecco	LO-3	80	339,254
	Lombardy	Lodi	LO-6	62	229,413
	Lombardy	Sondrio	LO-9	78	181,712
	Piedmont	Turin	PI-3	309	2,286,000
	Piedmont	Cuneo	PI-4	260	666,638
	Piedmont	Verbano - Cusio - Ossola - Pian Novarese	PI-1	165	527,342
	Piedmont	Biella - Vercelli - Casale	PI-2	165	440,477
	Piedmont	Alessandria	PI-6	147	388,792
	Piedmont	Astigiano - Monferrato	PI-5	156	236,486
	Val d'Aosta	Single ATO covering the entire Region's area	VA-1	74	125,666
North-East	Emilia-Romagna	Bologna	ER-5	62	1,006,000
	Emilia-Romagna	Modena	ER-4	47	701,642
	Emilia-Romagna	Reggio Emilia	ER-3	42	523,872
	Emilia-Romagna	Parma	ER-2	44	447,779
	Emilia-Romagna	Forlì-Cesena	ER-7	30	398,322
	Emilia-Romagna	Ravenna	ER-6	18	391,525
	Emilia-Romagna	Rimini	ER-8	25	335,463
	Emilia-Romagna	Piacenza	ER-1	46	286,997
	Friuli-Venezia Giulia	Udine	FV-2	135	533,282
	Friuli-Venezia Giulia	Pordenone	FV-1	50	312,794
	Friuli-Venezia Giulia	Trieste	FV-4	6	234,874
	Friuli-Venezia Giulia	Gorizia	FV-3	25	140,268
	Veneto	Bacchiglione	VE-2	140	1,110,561
	Veneto	Veronese	VE-6	97	917,909
	Veneto	Veneto Orientale	VE-8	93	844,951
	Veneto	Venice Lagoon	VE-4	36	800,309
	Veneto	Brenta	VE-3	73	593,769
	Veneto	Polesine	VE-5	52	262,447
	Veneto	Alto Veneto	VE-1	66	203,253
	Veneto	Valle del Chiampo	VE-7	13	106,137

	Region	Province/Area	ATO acronym	N. of municipalities	Population
Central Italy	Lazio	Rome	LA-2	121	4,340,000
	Lazio	Latina	LA-4	33	574,226
	Lazio	Frosinone	LA-5	91	495,026
	Lazio	Viterbo	LA-1	60	350,279
	Lazio	Rieti	LA-3	73	158,467
	Marche	Ancona	MA-2	45	381,982
	Marche	Macerata	MA-3	46	326,991
	Marche	Pesaro - Urbino	MA-1	67	300,803
	Marche	Ascoli Piceno	MA-5	33	210,066
	Marche	Alto Piceno	MA-4	27	113,351
	Tuscany	Medio Valdarno	TO-3	50	1,205,188
	Tuscany	Basso Valdarno	TO-2	64	766,268
	Tuscany	Toscana Nord	TO-1	52	513,412
	Tuscany	Toscana Costa	TO-5	33	355,617
	Tuscany	Ombrone	TO-6	51	352,199
	Toscana	Alto Valdarno	TO-4	37	298,224
	Umbria	Ambito 1	UM-1	36	452,577
	Umbria	Ambito 2	UM-2	32	221,327
	Umbria	Ambito 3	UM-3	22	152,008
South	Abruzzo	Pescara	AB-4	46	321,973
	Abruzzo	Chieti	AB-6	62	270,634
	Abruzzo	Teramo	AB-5	41	236,476
	Abruzzo	Aquila	AB-1	71	173,239
	Abruzzo	Marsica	AB-2	37	130,000
	Abruzzo	Peligno Alto Sangro	AB-3	37	75,167
	Basilicata	Single ATO covering the entire Region's area	BA-1	131	562,869
	Calabria	Cosenza	CL-1	155	714,400
	Calabria	Reggio Calabria	CL-5	97	555,836
	Calabria	Catanzaro	CL-2	80	363,057
	Calabria	Crotone	CL-3	27	174,712
	Calabria	Vibo Valentia	CL-4	50	162,516
	Campania	Napoli Volturno	CA-2	136	2,821,340
	Campania	Sele	CA-4	76	1,454,825
	Campania	Sarnese Vesuviano	CA-3	144	755,927
	Campania	Calore Irpino	CA-1	195	712,313
	Molise	Single ATO covering the entire Region's area	MO-1	136	305,617
	Puglia	Single ATO covering the entire Region's area	PU-1	257	4,029,000
Islands	Sardinia	Single ATO covering the entire Region's area	SA-1	377	1,640,000
	Sicily	Palermo	SI-1	82	1,271,000
	Sicily	Catania	SI-2	58	1,116,000
	Sicily	Messina	SI-3	50	640,675
	Sicily	Agrigento	SI-9	43	445,129
	Sicily	Trapani	SI-7	24	435,765
	Sicily	Siracusa	SI-8	21	403,985
	Sicily	Ragusa	SI-4	12	320,226
	Sicily	Caltanissetta	SI-6	22	271,758
	Sicily	Enna	SI-5	20	169,782

APPENDIX 2 - Regional Water Protection Plans: essentials

A summary table features the highlights of the regional water protection plan, with specific references to the limits and derogations applied under the national legislation, as well as water saving incentive measures.

Data from regional legislation processed by Consorzio Italbiotec.

Region	River Basin	Regional legislation	Plan Status	Wastewater discharge	Measures encouraging water-savings and wastewater reuse
Abruzzo	Central Apennines / Southern Apennines	- DGR 614 (9.8.2010) - DGR 1013 (7.12.2015) - DGR 55 (13.2.2017)	Approved - under review for 2015 updates	Limits for wastewater discharges from conglomerations with more than 2,000 EI except for E. Coli (3,000 CFU/100 mL).	• Water supply and distribution networks optimisation measures • Creation of the dual supply network
Basilicata	Southern Apennines	- DGR 1888 (21.11.2008)	Adopted	• Stricter limits for the emission of organic and chemical substances (Bod5, Cos, total suspended solids, total phosphorus, ammonia and surfactant) tighten national regulations • Lower limits for total phosphorus and ammonia for wastewater discharged	• Installation of individual meters • Systems for conveying and separating rainwater for the irrigation of green areas
Calabria	Southern Apennines	- DGR 394 (30.6.2009)	Adopted	Control of wastewater treatment plants is carried out unevenly in the various provinces, due to a regulatory gap in the attribution of responsibilities.	• Water losses reduction measures • Reuse of treated wastewater • Rationalisation of tariffs for non-drinking water consumption
Campania	Southern Apennines	- DGR 1220 (6.7.2007) - DGR 433 (3.8.2020)		Guidelines to harmonise the discharge of wastewater into the soil, subsoil and/or surface water are expected by August 2021.	• Groundwater withdrawals are granted based on compatibility with the water balance of the reservoir concerned. • Encourage the reuse of treated wastewater for irrigation, monitoring and remote control
Emilia-Romagna	Po/Central Apennines	- DGR 40 (21.12.2005)	Approved ante 2015	Treatment applied to wastewater discharge based on source	• Encourage the reuse of treated wastewater for irrigation
Friuli-Venezia Giulia	Eastern Alps	- DGR 2000 (15.11.2012) - DPReg 013 (19.1.2015)	Approved	Regional regulation national legislation-compliant	• Limits in the average daily volume that can be drawn from a single tank • Water-saving technologies such as flow control valves, gate valves and flanges.

Region	River Basin	Regional legislation	Plan Status	Wastewater discharge	Measures encouraging water-savings and wastewater reuse
Lazio	Central Apennines/ Southern Appennines	- DCR 42 (27.9.2007) - DCR 18 (23.11.2018)	Approved	Wastewater treatment plants serving agglomeration above 2,000 EI must achieve the BOD's purification efficiency.	• Water losses reduction measures (at least 10% of the annual resource has allocated to upgrade the network) • Integrating/replacing water resources with purified wastewater for irrigation purposes • Tariff system and promoting campaigns on the correct use of water resources
Liguria	Northern Apennines/ Po	- DCR 11 (29.3.2016)	Approved	Different treatments and limits for a lesser conglomeration based on source and destination	• Devices installation and accumulation tanks • Irrigation methods promotion • Differentiated tariff policy
Lombardy	Eastern Apls/Po	- LR 26/2003 - DGR 6990 (31.7.2017)	Approved	• Obligation to connect domestic and similar wastewater drains to the sewer system. • No discharge from heat pumps, cooling water and groundwater used for groundwater drainage	• Withdrawal of water from glaciers is prohibited, from natural lakes is strictly regulated • Irrigation methods and promotion of water-saving measures
Marche	Po/Central Appennines	- DACR 145 (26.1.2010)	Approved before 2015	Stricter limits for microbiological parameters (in particular, E. Coli) than the national legislation	• Flow reducers, valves and dual flush-button toilet systems • Systems for capturing, filtering and reusing rainwater • Reuse of treated wastewater for irrigation and non-potable other services
Molise	Central Apennines/ Southern Appennines	- DGR 599 (19.12.2016) - DCR 25 (6.2.2018)	Approved	Regional regulation national legislation-compliant	• Economic contributions for domestic water-savings • Systems for the collection and reuse of rainwater • Measures for reducing water losses
Piedmont	Po	- DCR 1788/XII (8.2.2006) - DGR 64-8118 (14.12.2018)	Approved-under review for 2015 updates	Strong commitment to achieving a 75% decrease of a load of nutrients entering wastewater treatment plants from agglomeration with more than 2,000 EI.	• An investment of approximately 88 million euro between 2020 and 2025 is prepared to improve the quality of drinking water • Measures for reducing water losses
Prov. Bolzano	Eastern Alps	- DGP 704 (26.4.2010)	Other planning	The municipalities regulate the sewerage and purification service by establishing the technical characteristics and limits of use and the conditions for discharging wastewater.	Water withdrawals for drinking purposes must not exceed 300 L per day per inhabitant or 140 L per day for livestock unit, while for agricultural 0.5 L / s must not be exceeded

Region	River Basin	Regional legislation	Plan Status	Wastewater discharge	Measures encouraging water-savings and wastewater reuse
Prov. Trento	Eastern Apls/Po	- DGR 233 (16.2.2015)	Approved	• Weekly monitoring of the organic content on incoming sewage and water treated under the final step • Periodically, heavy metals and organic solvents • Phosphorus monitoring (required by Legislative Decree 152/2006 for plants over 10,000 EI) is extended to plants with less than 10,000 EI and 2,000 EI.	No detailed information is available
Puglia	Southern Appennines	- DCR 230 (20.10.2009) - DGR 133 (16.7.2019)	Adopted	The water protection plan establishes emission limits and the procedure for obtaining authorisation for the discharge of wastewater.	• Reuse of treated wastewater for irrigation and non-potable other services • Regional water protection plan analyses all wastewater treatment plants to distinguish those suitable for the reuse of wastewater.
Sardinia	Sardegna	- DGR 14/16 (4.4.2006)	Approved before 2015	• Prohibitions opening new wastewater discharges into the sea, direct discharges to land and within 2 km from the coast • Obligation to reuse wastewater produced by coastal conglomerates • Possibility of introducing wastewater treated by the plant directly into the distribution system	• Reuse of treated wastewater for irrigation and non-potable other services • Obligation to deliver treated wastewater to the owner of the distribution networks without any charges for the latter • Energy costs for the release of pressurised water used for irrigation
Sicily	Sicily	- OC n 333 (24.12.2008)	Approved before 2015	• Severe delays in the wastewater treatment sector due to incomplete, never activated, undersized or technologically outdated plant • A wastewater treatment plant serves only about 61% of the approximately 5 million inhabitants of Sicily.	No detailed information available
Tuscany	Northern Apennines/ Po	- DCR n 6 (25.1.2005) - DGR 11 (10.1.2017)	Approved under review for 2015 updates	Regional regulation national legislation-compliant.	• Re-use of treated wastewater for irrigation and non-potable other services (Prato aqueduct reuses 3 million m2 of water per year) • Reuse of treated wastewater for irrigation (floriculture)

Region	River Basin	Regional legislation	Plan Status	Wastewater discharge	Measures encouraging water-savings and wastewater reuse
Umbria	Northern Apennines/ Central Apennines	- DCR 356 (1.12.2009) - DGR 1646 (28.12.2016)	Approved under review for 2015 updates	Regional regulation national legislation-compliant	• Water supply utilities are obliged to draw up an annual report on water consumption • Citizens are encouraged to install water-saving technologies through discounts in water tariffs • New buildings must be equipped with dual systems to allow the use of non-drinking water and tanks to collect and reuse rainwater
Valle d'Aosta	Po	- DCR 117-10731 (13.3.2007)	Approved under review for 2015 updates	Regional regulation national legislation-compliant	• Pricing policy incentivises users to use water resources efficiently. • Technological solutions to vary the water flow
Veneto	Eastern Alps/Po	- DGR 842 (15.5.2012) - DGR 360 (22.3.2017) - DGR1023 (17.7.2018)	Approved	The Regional Plan establishes the obligation to connect the wastewater discharges to the sewer network, while for conglomerates with less than 50 IE.	• Water supply and distribution networks optimisation measures • Installation of devices.

APPENDIX 3 - Leading regional specifications on sludge treatment and reuse

Source: Data from regional legislation processed by Consorzio Italbiotec.

Region	Sludge legislation
Lombardy	• The treatment and reuse of sludge for agriculture is governed by DGR X / 2031 of 1 July, 2014, establishing the characterisation and admissibility protocols for managing sludge treatment plants, the parameters to be analysed for spreading it, making a distinction between "high-quality sludge" and "adequate sludge", technical and administrative obligations for operators in treatment plants • DGR X / 5269 of 6 June, 2016, includes additional requirements for the use of sludge in the agricultural sector • DGR n X / 7076 of 11 September, 2017, includes additional parameters and limit values to be considered for the reuse of sludge • DDUO 6665 of 14 May, 2019, updates the limits characterising the sewage sludge suitable for use in agriculture following the Genoa decree (hydrocarbons <1000 mg/kg and Salmonella injection in the sludge) • DD 18334 of 13 December, 2019, establishes limits on the use of sludge treated in agriculture, allowed only in cases where the concentration of nitrogen in manure exceeds the limit set by the Nitrates Directive and by regional legislation (170 kg N / ha/year for sensitive areas; 340 kg N / ha/year for non-sensitive areas With this directive, the Lombardy Region identifies 186 municipalities, such as Bergamo (30), Brescia (62), Cremona (40), where sewage sludge is used for agronomic use. • DGR XI / 2893 of 2 February, 2020, approves the "Regional action programme for the protection of waters from pollution by nitrates from agricultural sources in sensitive areas" introducing some changes to the spreading of sludge and effluents. More specifically, the programme extends the number of winter days in which the spreading of effluents is prohibited to 58 (from 28 of the previous legislation) managed by the region taking int account the quality of the soil and air to integrate measures to reduce fine particles in high risk areas.
Piedmont	The regional plan for managing urban waste and sewage sludge "(DCR 140-1416 of 19 April, 2016) states that over 96% of sewage sludge must be reused in agriculture directly or through composting. However, there is a high incidence of conferment (60%) in extra-regional plants, especially in Lombardy. Through the DGR 13-669 (17 July, 2020) a "Guidance Act" promotes new regional planning in the field of sewage and sludge treatment.
Puglia	The DGR19 (23.01.2007) and DGR 2460 (16.12.2008) adopted some additional limitations for the reuse of sewage sludge while RR15 (18.07.2008) introduced the prohibition of spreading treated sewage sludge in all special protection areas. Therefore, only 15% of the regional surface is suitable for spreading sludge on the ground. The majority of these areas are located in the province of Foggia. To improve the sludge treatment capacity, Acquedotto Pugliese invested 30 million euro enhancing to upgrade the existing treatment plants and will install 60 more sludge treatment plants by the end of 2020.
Sardinia	The DGR 32/71 of 15 September, 2019, introduces limits and conditions for the use of sludge in agriculture based on the type of soil and crops. Regional legislation prohibits the use of sludge in cultivated land, except for tree, horticultural and fruit crops (within ten months prior to harvesting or during harvesting itself). It is forbidden to use sludge on land intended for grazing (in the previous five weeks) and on land within 100 m from urban settlements or 10 m from the coast.
Tuscany	The region lacks sludge treatment facilities. Regional ordinances (the last of 3 August 2018) provide for the transfer of more than 50% of the sludge produced in Northern Italy.
A.P. Bolzano	The "2000 Waste Management Plan" established the guidelines for managing waste, including sewage sludge. Emission limits follow national legislation.

Region	Sludge legislation
Valle d'Aosta	The regional law LR 88 of 27 December, 1991 identified two plants with technical characteristics as deemed suitable for the treatment of sludge (Arnard, owned by the Unité des Communes Valdotaines Evançon, and Brissogne, owned by the Sub-ATO Monte Emilius). The two purification plants can only accept sewage sludge produced within areas of its remit. As an exception to this legislation, the Brissignone plant can dispose of organic sewage with a content of suspended solids higher than 9% by weight from the whole region.
Basilicata	The law 12 LR of 2 March 2, 1994, governs the treatment and reuse of sludge. Through the LR of 13 March, 2019 "Further urgent legislation in various sectors of intervention in Basilicata", the region has restrictions in derogation of the national legislation. The limit of 1000 mg/kg for hydrocarbons required by the Genoa Decree is lowered to 500 mg/kg as in the previous national legislation DLgs 99/1992).
Emilia-Romagna	• DGR 2773 (30.12.2004) introduces limits on some micropollutants (C, P, N) not included in the national legislation • DGR 1801 (7.11.2005), DGR 297 (13.3.2009) governs the use of sludge in agriculture • RR 3 of 15 December, 2017, updating regional legislation on the use of sludge, purified wastewater and livestock effluents in agriculture • DGR 326 (4.3.2019): "Urgent regulations on the agronomic use of sewage sludge" (in response to the Genoa Decree) for operators and control authorities to protect soil quality in Italy. The new text adopts limits related to arsenic (20 mg/kg instead of the 10 set initially by Dgr 2773/2004) and transforms the old limit value into a "warning threshold" value which, if exceeded, entails a temporary ban (two years) of further use of the sludge in the affected land.
Veneto	LR 130 (24.12.2018) integrates the limits for the use of treated sludge in agriculture with some parameters not evaluated by national legislation, such as heavy hydrocarbons (C10-C40), PAH, PCB, PCDD / DF (dioxins), toluene, selenium, beryllium, arsenic, total chromium and chromium VI.

APPENDIX 4 - Geographical breakdown of companies by sector

Source: Data from regional legislation processed by Consorzio Italbiotec.

REGION	SECTOR								TOTAL
	Consulting & supply of Technology	Decentralised wastewater treatment	Distribution	Industrial wastewater treatment	Potable water treatment	Process water treatment and maintenance	Sewage sludge	Urban wastewater treatment	
Abruzzo	3	0	7	0	0	1	1	1	**13**
Basilicata	0	0	2	0	0	2	0	1	**5**
Calabria	2	1	2	0	2	5	1	3	**16**
Campania	4	1	17	1	5	4	0	7	**39**
Emilia-Romagna	2	1	12	3	1	4	2	3	**28**
Friuli-Venezia Giulia	0	0	8	1	0	2	0	0	**11**
Lazio	6	1	10	4	6	12	0	6	**45**
Liguria	0	0	14	1	1	2	0	2	**20**
Lombardy	9	1	35	3	8	11	6	26	**99**
Marche	1	0	8	5	0	2	1	1	**18**
Molise	1	0	1	0	0	0	0	0	**2**
Piedmont	4	0	25	2	2	5	0	3	**41**
Puglia	1	1	2	0	0	1	1	2	**8**
Sardinia	2	0	3	1	2	1	2	2	**13**
Sicily	6	0	25		7	2	0	4	**44**
Tuscany	4	0	13	3	0	4	3	6	**33**
Trentino- Alto Adige/Südtirol	0	0	6	0	0	0	0	3	**9**
Umbria	0	0	3	0	0	0	0	1	**4**
Veneto	2	0	11	1	0	5	3	5	**27**
Total per category	**47**	**6**	**204**	**25**	**34**	**67**	**20**	**76**	**475**

APPENDIX 5 - Top 20 companies in the water supply sector divided by business model

Source: ARERA. Data processed by Consorzio Italbiotec.

WATER	SEWERAGE	ENERGY	GAS	Other
• Collection • Potabilisation • Supply • Purificationn • Distribution to users	• Collection • Wastewater treatment	• Production • Distribution	• Distribution	1. Other water activities (charging) 2. Street cleaning 3. Public lighting

COMPANY NAME	BUSINESS MODEL	WATER	SEWERAGE	ENERGY	GAS	OTHER
ACEA ATO 2 SPA	MONO-UTILITY	Collection, Potabilisation, Supply, Depuration	•			1
IRETI SPA	MULTI-UTILITY	•	•	•	•	3
SOCIETA' METROPOLITANA ACQUE TORINO SPA	MULTI-UTILITY	•	•	Production		
PUBLIACQUA SPA	MULTI-UTILITY	•	•	Production		1
HERA SPA	MULTI-UTILITY	•	•	•		1-2
ACQUEDOTTO PUGLIESE SPA	MULTI-UTILITY	•	•	Production		1
CAP HOLDING SPA	MONO-UTILITY	•	•			1
ACQUE SPA	MONO-UTILITY	•	•			
ACEGASAPSAMGA SPA (HERA Group)	MULTI-UTILITY	•	•	•	•	2-3
ABBANOA SPA	MONO-UTILITY	•	•			1
GORI SPA	MONO-UTILITY	•	•			
ACQUEDOTTO DEL FIORA SPA	MONO-UTILITY	•	•			1
A2A SPA	MULTI-UTILITY	•		•	•	3
V.E.R.I.T.A.S. SPA	MULTI-UTILITY	•	•	Production		2
MM SPA	MONO-UTILITY	•	•			1
ACQUALATINA SPA	MONO-UTILITY	•	•			
ACQUA CAMPANIA SPA	MONO-UTILITY	Collection, Potabilisation, Supply				
VIVA SERVIZI SPA	MONO-UTILITY	•	•			3
AMAP SPA	MULTI-UTILITY	•	•	Production		1
UMBRA ACQUE SPA	MONO-UTILITY	•	•			

APPENDIX 6 - Appendix 6 – Top players: company profiles

HERA GROUP

Category classification: Distribution

Business overview

- Headquarters: Bologna (BO), Emilia-Romagna
- Turnover: 1.,401,413.,000 €
- Number of employees: 2.,992
- Water costumers: over 1,160,000
- Water supply network: 26.500 km
- Distributed water: 257 million m3
- Sewerage network: 13,552 km
- Wastewater treatment plants: 859

Brief company description

Hera Group operates catiously and sustainably in the field of public utilities and plays a primary role among national leaders in the industry. The company is mainly involved in providing environmental services (from waste collection to disposal, including a full range of treatments), water cycle services (from collection to treatment plants) and energy services (distribution and sale of natural gas and electricity, district heating). Hera Group currently operates in 330 municipalities in Emilia-Romagna, Friuli-Venezia Giulia, Marche, Tuscany and Veneto. Founded in 2002 from the merger of 11 Emilian municipal companies, Hera was privatised in 2003 and 44.5% of the capital placed on the stock exchange.

Business model

Hera Group is based on a business model that combines local roots, competitive development and skills, in addition toa business portfolio balanced between low-risk regulated activities and deregulated services that offer growth prospects. The Group pursues its growth strategy by ensuring the full corporate and organisational merger of companies operating in neighbouring areas with similar multi-business portfolios, benefiting from economies of scale, synergies and added value. A distinctive feature of the Italian utility scenario is the presence in Hera of a diversified group of shareholders made up of 180 local authorities with an absolute majority and almost 22,000 private shareholders.

Water business areas

Hera Group is the largest integrated water cycle management company in Italy, covering over 220 municipalities in the regions of Emilia-Romagna, Tuscany and Marche. The service includes the withdrawal, supply and distribution of water for domestic and industrial use, the collection of wastewater through the sewerage system and its treatment before its release into the environment. It supplies over 1 million customers, with 257 million cubic metres of water sold. Around 48% of the water is withdrawn from groundwater, 46% from surface water and the remaining 6% from minor sources. Due to the significant investments made in infrastructure - 411 euro per 1,000 cubic metres of water sold - and the implementation of technological solutions that provide automation and remote control, Hera guarantees the continuity of supply, an excellent water quality and a network that boasts the lowest percentage of leaks per kilometre in the country. A considerable amount of investment is also allocated to managing a sewerage network of over 3,500 km and purification services as well as the networks dedicated to rainwater collection. Great attention is paid by Hera to the quality of the drinking water delivered, ensuring full compliance with legal requirements by performing checks throughout the process from collection to distribution. The analysis and monitoring work is managed by Hera Group's Laboratories System, which has three main sites in Bologna, Forlì and Ravenna, in addition to several logistical sampling[144].

ACEA ACQUA

Category classification: Distribution

Business overview

- Headquarters: Rome (RM) and Frosinone (FR), Lazio
- Turnover: 666,298,000 €
- Number of employees: 1,469
- Water users: over 9 million
- Water supply network: 58.,000 km
- Distributed water: 538 million m3
- Sewerage network: 1,522 km (just for the province of Frosinone)
- Wastewater treatment plants: 132 (just for the province of Frosinone)

Brief company description

Acea is one of the leaders in managing the integrated water service and considered among the top operators in the sector of electricity distribution, energy (sale of electricity and gas, public lighting, energy management and generation of electricity) and the environment (sludge management, treatment, recovery, benefits derived from it and its anddisposal of waste). Created in 1909 as a company to serve Rome, Acea has developed over the years to become one of the benchmark multi-utility operators on the Italian scene. Acea's corporate world is composed of both investee companies and subsidiaries[145]. Acea group is currently present in 9 different regions, including Valle d'Aosta, Piemonte, Tuscany, Lazio, Umbria, Marche, Abruzzo, Molise, and Campania[146].

Business model

The 2019-2022 business plan provides for an increase in infrastructural investments (over 1.9 billion € for the water sector), promoting a vision of industrial development that includes aspects of sustainability and stakeholder expectations. Acea intends to strengthen both its water and its electricity infrastructures and make them progressively more resilient as well as innovative with an increasingly customer-oriented approach. Reducing water losses, encouraging decarbonisation and promoting circular economy (recovery of energy and raw materials), by using an increasingly sustainable system based on dialogue with the local community are two of the pillars of Acea's strategy to improve its long-term performance[146].

Water business areas

Acea manages the integrated water service for four regions (Lazio, Tuscany. Umbria, and Campania), serving over 9 million citizens and more than 230 municipalities. Acea is committed to safeguarding springs and sustainably managing water resources. It ensures that, prior to reaching the end users, water has been inspected and is drinkable. In 2019, Acea Elabori, Acea's division in charge of engineering, laboratory, research, and innovation services, carried out 426,586 analysis to ensure high quality water. With 58,000 km of water supply networks, Acea distributed 538 million m^3 of water in 2019.
Southern Lazio and the Frosinone area are served by seven large aqueduct systems that transport water to the distribution networks, from 14 primary supply sources for a total flow rate of over 21,000 litres/second. Acea also deals with the purification of wastewater. In 2019, the company treated 855 million m^3 of wastewater aiming to protect and improve water resources at every stage of the supply chain. The integrated water service is Acea's most important business. A total investment of 1,9 billion euro is allocated to developing this sector through the installation of smart water meters, reducing network leaks, rationalisation and automation of water treatment plants, division of the networks into districts and improved technical quality. Lastly, Aceamanages water as a source to generate electricity, through its hydroelectric power plants, which in 2019 produced a total of 122 MW.

IRETI SPA

Category classification: Distribution

Business overview

- Headquarters: Genoa (GE), Liguria
- Turnover: 590.955.632 €
- Number of employees: 1,354
- Water users: over 2.9 million
- Water supply network: 23,000 km
- Distributed water: 187 million m3
- Sewerage network: 9,600 km
- Wastewater treatment plants: 1,323

Brief company description

IRETI manages the distribution of electricity, gas and water in an integrated and widespread manner throughout the country, seeking to offer its customers efficiency, effectiveness, cost-effectiveness and high-quality services, fully respecting the environment as well as the safety of workers and citizens. Founded in 2016, the company operates in Northern Italy, serving 369 municipalities in Piedmont, Liguria and Emilia-Romagna in addition to some municipalities of Lombardy, Valle d'Aosta, and Veneto[147].

Business model

It has a diversified business model, characterised by a mix of market-based activities and regulated and semi-regulated activities which ensures solidity, development prospects and reduced risk levels. The company is driven towards consolidation of areas where it is already a sector leader (waste, water, district heating and energy commodity distribution) strengthening its position in the energy market and in the local public services by exploiting the advantages and benefits of economies of scale and integrating the value chain. To reach its goal, the company's new business plan provides for increased investments, leading to a total of around € 3.3 billion[148].

Water business areas

IRETI's activities in the integrated water service sector consist of the design, construction, operation and maintenance of wothdrawal, treatment, storage and pumping plants and networks for the supply, distribution and connection to the water mains service, the sewage service and the wastewater treatment plants[148]. IRETI supplies drinking water to over 2.9 million people in the provinces of Genoa, Savona, La Spezia (Liguria), Parma, Piacenza and Reggio Emilia (Emilia-Romagna) and in other Northern Italian regions (especially Piedmont) for a total of 265 municipalities and approximately 2.9 million inhabitants. Through a water network system of about 23,360 kilometres, in 2019, IRETI distributed 187 million cubic metres of water from various supply sources (reservoirs, springs, surface watercourses, water table) that guarantee the continuity of the supply and the quality of water. The Group manages several drinking water treatment plants of various sizes depending on the specific characteristics of the area served and 4 analysis laboratories, which carry out over 1 million analyses per year, of which over 640,000 are carried out on drinking water[149]. The wastewater management service is provided through 11,162 km of sewerage networks and 1,323 wastewater treatment plants, ensuring a high-efficiency treatment[150]. IRETI's technologies in the wastewater treatment sector are highly innovative. One of the most advanced technologies used in Ireti plants is the 'membrane' bioreactor treatment (MBR - Membrane Bioreactor), which provides four levels of filtration and guarantees the elimination of all pollutants. At the Mancasale plant, (Reggio Emilia), the installation of a tertiary treatment station, based on rapid multilayer filtration and a combined treatment with hydrogen peroxide and UV rays, allows water to be reused for irrigation purposes on an area of over 2000 hectares. The Group also manages 5 phytodepuration plants, occupying a total area of approximately 18,100 m^2, in Emilia-Romagna that make use of the plant's purification activities[151].

ACQUEDOTTO PUGLIESE

Category classification: Distribution

Business overview

- Headquarters: Bari (BA), Puglia
- Turnover: 560,698,549 €
- Number of employees: 2,014
- Water users: over 4 million
- Water supply network: 20,369 km
- Distributed water: -
- Sewerage network: 12,930 km
- Wastewater treatment plants: 184

Brief company description

Founded in 1902, Acquedotto Pugliese is one of the largest and the most time-honoured Italian companies operating in the water supply service. After 100 years, it currently manages the Integrated Water Service (IWS) in the Puglia Optimal Regional Area, the largest Italian ATO in terms of an extension with over 4 million inhabitants served. It also manages the water supply service in some municipalities of Campania and supplies water to Acquedotto Lucano S.p.A. which in turn manages the Integrated Water Service in Basilicata. In particular, AQP serves 242 Municipalities in Puglia and 12 in the Province of Avellino (Campania) in terms of drinking water distribution, 238 municipalities in Puglia and 2 in the province of Avellino for sewerage services and 252 municipalities in Puglia and 2 in the province of Avellino for wastewater treatment services. AQP manages various types of users, including domestic, non-domestic, industrial, and other users, with an increase of 7,860 users compared to 2018.

Business model

The AQP business model aims to create sustainable value for the company and for the area in which the company operates. In particular, AQP aims to improve the quality of life of citizens and businesses that interface with society, through the management of the integrated water system, ensuring high standards of quality and efficiency of the service. This action is also guided by the progressive advancement of regulation by ARERA, such as the new tariff method for the 2020-2023 period which involves considerable innovation efforts by introducing the promotion of management efficiency and environmental sustainability in investment choices, such as quality regulation technical and contractual conditions of the water service and the relevant incentive systems. These measures develop several opportunities for the integrated water manager related to the ability to adopt advanced technological systems, efficient information and organisational models capable of allowing an improvement in company performance.

Water business areas

With a network of over 32,000 km of extension (20,000 for water distribution and 12,000 for the sewerage network), AQP serves 254 municipalities mostly in Puglia and partially in Campania. AQP collects water from artificial lakes, which is treated and disinfected prior to distribution in 5 potabilisation plants located in Puglia, Campania and Basilicata. Ten laboratories that carry out 15,000 analysis checking 600,000 parameters per year ensure the excellent quality of water supplied by the company. AQP's infrastructures include 2,200 tanks, dividers and lifting systems, 184 wastewater treatment plants and nine refining plants for the reuse of treated wastewater, one of the largest and most advanced plants in Italy in terms of technologies used and the quality of results. The leading technologies used for wastewater treatment combine traditional activated sludge technology as well as membrane and disinfection technology with UV rays. The company is committed to an ambitious plan to strengthen and upgrade its infrastructures investing 160 million euro in 2019, mostly dedicated to the upgrading of wastewater treatment plants and the planning of interventions for the reuse of treated wastewater[18, 152]

SOCIETA' METROPOLITANA ACQUE TORINO – SMAT S.P.A

Category classification: Distribution

Business overview

- Headquarters: Turin (TO), Piedmont
- Turnover: 437,640,000 €
- Number of employees: 946
- Water users: over 2.3 million
- Water supply network: 12,483 km
- Distributed water: 358 million m3
- Sewerage network: 9,000 km
- Wastewater treatment plants: 413

Brief company description

SMAT S.p.A. was founded in 2001 and today serves 289 municipalities in Piedmont, especially in ATO3 (Turin Area), on an area of over 6,000 km2. It operates through the design, construction and management of diversified sources for water supply, technologically advanced purification plants, urban wastewater treatment and reuse plants, wastewater collection, treatment and purification networks, in addition to energy recovery plants. SMAT is a fully public company with around 1,000 employees and uses one of the most modern and advanced systems for the collection, production and distribution of drinking water, as well as collection and wastewater treatment for domestic and industrial uses[18].

Business model

Through continuous improvement and the upskilling of its employees, SMAT operates as a flexible system aimed at maintaining and constantly raising the already excellent standards of its water quality and customer service. To reach its goals, SMAT invested approximately 1.2 billion euro for the 2020-2033 period. SMAT Group participates in global initiatives aimed at promoting access to water and providing specialised technical assistance for the construction of water infrastructures and systems. The Group is also engaged in training activities in collaboration with Hydroaid, Water for Development Management Institute, of which it is a supporting member[153].

Water business areas

SMAT annually produces over 300 million m3 of drinking water of good and constant quality, complying with current legislation and verified each year by approximately 740,000 laboratory analyses. About 82% of water is withdrawn from groundwater sources: over 71% of the water distributed comes from wells, which is drawn from one or more underground aquifers, while the remaining 11% is withdrawn from the springs of Pian della Mussa and Sangano. SMAT, the first company in Italy to have used surface-origin water, has created a system that allows the purification of up to 2,500 litres per second of water withdrawn from the Po river, which represents 18% of the water introduced into the network. Through a distribution network of 12,483 km, SMAT delivers an average daily flow rate of 6,137 litres to more than 2.3 millions of inhabitants distributed over 289 municipalities in Piedmont.
The management and maintenance of over 9,000 km of black, white and mixed municipal sewerage networks, allows the constant collection of urban wastewater of domestic, industrial and meteoric origin throughout the area served. This service is implemented through the use of video inspection systems and automatic sampling robots on the network. In 2018, 358 million cubic metres of wastewater were treated through 413 small, medium and large purification plants. The centralised collection plant built and managed by SMAT in Castiglione Torinese is the largest chemical-physical-biological treatment plant in Italy and represents a technological reference point for the high-quality standards achieved. Acknowledging the importance of innovation and the fundamental role of scientific research applied to water resources issues, in 2008, SMAT opened its own Research Centre which aimed to contribute to innovation and industrial development in the water sector and became a pole of excellence, ranking among the major Italian companies in the field of applied research and in the control of drinking and wastewater, equipped with advanced technologies[18],[154].

VENEZIANA ENERGIA RISORSE IDRICHE TERRITORIO AMBIENTE SERVIZI – VERITAS SPA

Category classification: Distribution

Business overview

- Headquarters: Venezia (VE), Veneto
- Turnover: 375,749,000 €
- Number of employees: 2,819
- Water users: 930,000
- Water supply network: 5,700 km
- Distributed water: 85.4 million m3
- Sewerage network: 3,100 km
- Wastewater treatment plants: 13

Brief company description

Veritas S.p.A. is an entirely public multi-utility, the first in Veneto in terms of size and turnover and one of the largest in Italy. Veritas manages environmental services, the integrated water service, some collective urban services and the generation of energy from renewable sources and biomass.

Veritas provides environmental services to citizens and businesses in an area of over 2,650 km2 and 930,000 inhabitants, in addition to over 40 million tourists who visit Venice, the coast and the surrounding areas every year. Veritas manages urban hygiene services in Eastern Veneto through the associate company Asvo S.pA. The capital of Veritas is entirely public, owned by 51 municipalities: 44 belonging to the metropolitan area of Venice and 7 to the province of Treviso[155].

Business model

Company policy is based on a twenty-year investment plan aimed at the renewal and technological efficiency of infrastructures and environmental protection that requires a responsible use of resources. The supply of services efficiently and economically is increasingly accompanied by the decrease of environmental impacts. At the heart of the strategy are also the containment of energy consumption, the reuse of purified water, the minimisation of waste produced and its reuse and treatment with the best technological solutions[156].

Water business areas

The drinking water supplied by Veritas is mostly drawn from wells at a depth of up to 300 metres. Only a small part is withdrawn from rivers, including the Adige, Sile, and Livenza rivers and then treated in 7 purification plants using a chlorine disinfection process.

The company laboratory analyses 200,000 parameters every year, periodically checking temperature, pH of total organic carbon (TOC), cyanide, turbidity, ammonium, colour, free and total residual chlorine, the dry residue at 180 ° C and checks conductivity, alkalinity, calcium, magnesium, hardness, aggressiveness index. The presence of microorganisms and pollutants such as, for example, organically halogenated compounds, metals (including arsenic) and pesticides are subject to an in-depth analysis. Veritas serves 36 municipalities, with 5,700 km of aqueducts. From Chioggia to Caorle, Veritas deals with the withdrawal of water, purification, transport, and distribution through the domestic and industrial aqueduct. It also manages the sewerage and purification of used water, with 3,100 km of sewers and 13 wastewater treatment plants[157,158].

AGESAPAPSMAGA

Category classification: Distribution

Business overview

- Headquarters: Trieste (TS), Friuli-Venezia Giulia
- Turnover: 368,986,000 €
- Number of employees: 1,196
- Water users: 257,000 families
- Water supply network: 2,951 km
- Distributed water: 81 million m3
- Sewerage network: 1,866 km
- Wastewater treatment plants: 11

Brief company description

AcegasApsAmga, a company wholly owned by Hera Group, is the first multi-utility in the Northeast and operates in the environmental, water and gas and electricity distribution sectors in Veneto and Friuli Venezia Giulia, serving approximately a total of 250 municipalities and over 1.5 million citizens. In addition, due to the activities of the subsidiaries ASE and Hera Luce, it carries out energy efficiency and public lighting projects throughout the country. Furthermore, AcegasApsAmga is the second-largest gas operator in Bulgaria with activities in both the sale and distribution of methane gas. AcegasApsAmga was created by the aggregation of several former municipal companies in the Northeast of Italy. More specifically, in 2003, Acegas Trieste and Apsdi Padova merged, breathing life to AcegasAps which ten years later, in 2013, integrated into Hera Group. The following year, Amgadi Udine was combined with AcegasAps, giving the company its current name.

Business model

AcegasApsAmga aims to be the best multi-utility for its customers, employees and shareholders, through the design of constantly evolving services and a strong regenerative impact in support of the resilience of the environment and intelligent use of resources. A business model characterised by a strong commitment to the circular economy and environmental sustainability.

Water business areas

AcegasApsAmga manages the collection, supply, and distribution of drinking water in Trieste, Padua and various municipalities of these provinces. Through 3,000 km of network, it brings water to 257,000 families. AcegasApsAmga places a central emphasis on innovation and sustainability, embodied in various projects, including eAqua, through which network losses and energy consumption of the aqueduct management are reduced every year. The areas served by AcegasApsAmga use abundant water sources of excellent quality, both from a chemical-physical and an organoleptic point of view. The city of Trieste and its municipalities withdraw waters of high purity from the Isontina plain and karst origin water, transported to the city by two pipelines, one of which is submarine. In the Padua area, water of the Venetian Pre-Alps, drawn from the 180 wells located within the oasis of Villaverla (VI) and from artesian wells in the Vicenza area, is transported through three supply lines to feed the water networks of Padua and its municipalities. AcegasApsAmga guarantees continuous and efficient monitoring of the water service 365 days a year. The company is also adopting a Water Safety Plan to ensure the monitoring and a decrease of the risks of drinking water distributed in various areas.
Moreover, AcegasApsAmga manages the entire sewage and wastewater purification system in 17 municipalities in the areas of Trieste and Padua. A sewerage network of 1,866 kilometres in total conveys over 68 million m3 of domestic and industrial wastewater produced in the areas served by the 11 purification plants managed by AcegasApsAmga. In Trieste, the company has built one of the most advanced purification plants in Europe. Due to its biological treatment, the plant is able to interpret the needs of nutrients expressed by the sea and consequently dynamically adjust the intensity of the treatment[159].

ABBANOA SPA

Category classification: Distribution

Business overview

- Headquarters: Nuoro (NU), Sardinia
- Turnover: 292,087,625 €
- Number of employees: 1,331
- Water users: 712,000 families
- Water supply and sewerage network: 13,000 km
- Distributed water: - million m3
- Wastewater treatment plants: 360

Brief company description

Abbanoa S.p.A., founded in 2005 from the transformation of Sidris Scarl following the merger of the consortium companies, is wholly owned by public bodies. It is made up of 342 shareholder municipalities as well as the shareholder the region of Sardinia and serves 712,000 families distributed over an area of 24,090 km_2[79].

Business model

Abbanoa SPA has as a priority the homogeneous and unitary management of the integrated water service of Sardinia, to guarantee, while fully respecting the environment, the supply of water with the same quality, the same level of service and the same tariff throughout the region from the capital to the most isolated municipality. Abbanoa considers water as a social commodity that, if managed rigorously and ethically, could promote the island's economic and social development[160].

Water business areas

Water supplied by Abbanoa is always controlled by an internal laboratory that carries out more than 12,000 analyses to monitor 315,000 chemical and microbiological parameters. The controls affect the entire water supply chain, verifying the quality of the raw material, the state of purification carried out by 49 purification plants and the chemical and bacteriological properties of the product being distributed to ensure maximum safety for the end users.

Following the regional legislation that promotes the reuse of treated wastewater for agricultural, urban, and industrial sectors, Abbanoa is committed to guaranteeing an excellent quality of the wastewater treated by 360 plants to meet the quality limits required by law. In 2019, 1.2 million m3 of water was reused both for agriculture and for public parks. The urban wastewater treatment plant of Alghero represents, through the reuse of wastewater, a strategic source for the supply of unconventional water resources deemed useful for satisfying the irrigation water needs of the various end-users of the region, more specifically for the irrigation of areas falling within the Consorzio di Bonifica della Nurra. Abbanoa also represents excellence in the reuse of sewage sludge. Over 327 plants have produced sludge with chemical, physical and biological characteristics that are deemed constantly suitable for spreading in agriculture. The majority of sludge treated (96.8%) was reused in agricultural practices[79,86].

PUBLIACQUA S.P.A

Category classification: Distribution

Business overview

- Headquarters: Florence (FI), Tuscany
- Turnover: 260,571,000 €
- Number of employees: 602
- Water users: over 1.3 million
- Water supply network: -
- Distributed water: -
- Sewerage network: -
- Wastewater treatment plants: -

Brief company description

Publiacqua S.p.A manages, since 2002, the integrated water service from the Optimal Regional Area Medio Valdarno, an area known asthe backbone of Tuscany, which is made up by four provinces: Florence, Prato, Pistoia and Arezzo. One-third of the regional population (about 1,305,000 inhabitants) live in the 45 municipalities served and where the main economic activities of Tuscany are located. Acque Blu Fiorentine SPA is composed of several public and private companies andaccounts for 40% of the company's share capital. The remaining 60% is entrusted to public bodies, including the municipality of Florence which holds 22% of the share capital.

Business model

The mission of Publiacqua S.p.A is to ensure the quality and continuity of the service throughout the area served at low costs, even in the event of an emergency and in the event of a drought climate, and to ensure the constant protection of water resources and the environment. With the aim of protecting the environment and reducing greenhouse gas emissions, the company is implementing programmes to reduce electricity consumption. It has created, among other things, a hydroelectric plant for generating energy from renewable sources. Publiacqua SPA has introduced the promotion of socially responsible behaviour for the correct use of drinking water by citizens among the priorities of the company policy. Therefore, it has carried out a multi-year project to raise awareness against waste which involves the use of various means and tools of communication and information.

Water business areas

Publiacqua manages the collection from both groundwater and surface waters, treatment, and distribution of drinking water. The company manages a complex and articulated plant system, starting with the large structures in Florence (the Anconella and Mantignano drinking water treatment plants).

The company carries out the collection of wastewater and its treatment, with a plant of excellence in San Colombano. The integrated management of the purification system by a single entity, in such a vast area, is an essential prerequisite for its upgrade and efficiency, also to reduce the level of pollution of the region's river waters[161].

To guarantee a greater efficiency of the network, Publiacqua has also launched real innovations, such as the experimentation of automatic and computerised leakage research and the analysis of the risk of breakage of water pipes. Due to an investment plan of 45 million for the 2016-2021 period, the goal is to reduce losses by two percentage points annually[162].

CAP HOLDING SPA

Category classification: Distribution

Business overview

- Headquarters: Milan (Mi), Lombardy
- Turnover: 271,744,000 €
- Number of employees: 398
- Water costumers: 2.4 million
- Water supply network: 6,442 km
- Distributed water: 195,481,416 m3
- Sewerage network: 6,611 km
- Wastewater treatment plants: 40

Brief company description

CAP Group, a public corporation owned by the local authorities, is the leading water service management company in the communities of the Provinces of Milan, Monza and Brianza, Pavia, Varese, and Como. It guarantees the integrated water service to a customer base of 2 million inhabitants, managing a legacy of networks and plants, plans and makes investments and carries out ordinary and extraordinary maintenance operations.

Business model

Cap Holding deals with the complexity of a structured system consisting of a network of thousands of km of aqueducts and sewers, as well ashigh-tech systems such as cleaners and purifiers. CAP Holding is the parent company that manages the legacy of networks and plants for the Integrated Water Service of the Municipalities. It is responsible for the strategy and financial control, investing in knowledge and infrmation technology. Amiacque is the Group operating company and guarantees the water supply service - the supply of drinking water and connected services, from the collection of groundwater through to the management of wastewater and its treatment - to over 2 million users due to the strong presence of teams and operators across the area. Attentive to the consumers' needs, it focuses on ensuring the thorough monitoring of the quality of its water, safeguarding the environment and guaranteeing the management of plants and infrastructures that cover over 10,000 km in the Provinces of Milan, Monza and Brianza, Pavia, Como and Varese. A domestic leader in terms of the water service supplied to its users (bills, on-line assistance, …), it has developed a policy that seeks to detect f water leaks and maximise the use of information technology.

Water business areas

CAP Group is the manager of the Water Service Integrated in 154 municipalities belonging to the City of Milan underground and the provinces of Monza Brianza, Como and Varese. It serves a user base of about 2.2 million resident inhabitants, although actually the number is higher if you add up the people who commute and work in one of the most industrialised and productive areas in Italy. CAP Holding is involved in all stages of the water cycle, water quality, sewers, treatment, distributing, collecting and treating of wastewater and new applications such as biomethane from sludge.

With a network of over 6,442 km of extension, it serves a total of 2.4 million customers. Cap Holding's infrastructures include 345 water purification plants and 765 wells. Also, CAP Group manages 6,574 kilometres of sewage networks, of which 487 km of inter-municipal collectors. CAP Group is involved in considerable knowledge, innovation and development projects to guarantee the excellence of its design solutions, making use of the best available technologies and minimising environmental impact as well as health and safety risks for its workers. Sone investments in sustainability[163] have been planned for the 2020-2024 period, for an amount of approximately 524 million euro.

MM SPA

Category classification: Distribution

Business overview

- Headquarters: Milan (Mi), Lombardy
- Turnover: 262,657,000 €
- Number of employees: 1,273
- Water costumers: over 50,000
- Water supply network: 2,228 km
- Distributed water: 230 million m3 / year of water distributed
- Sewerage network: 1,500 km
- Wastewater treatment plants: 3

Brief company description

MM is one of the largest and most diversified engineering companies in Italy, with a growing international presence able to provide customised solutions in the design and upgrading of urban ecosystems. The company is a partner of institutions, managing agencies and public companies operating in the sectors of infrastructure, extensive public works and design and planning of networks and services. Established in 1955, as engineering company aimed at the design and construction of Milan's underground lines, in 2003 MM was entrusted the management of the Integrated Water Service of the city of Milan. MM Spa serves a population of 2 million people, including residents and city users, totalling almost 50,000 customers, providing the following primary services: provision of drinking water and its constant monitoring; collection, treatment and purification of wastewater; customer management throughout the entire service delivery process. MM Spa also provides the Municipality of Milan with technical and administrative support for the study, design, implementation and management of projects related to the network of covered natural and artificial waterways and the necessary interventions for their protection, exploitation and upgrading.

Business model

MM Spa makes use of professional skills to meet the specific needs of each metropolitan area. The company adopts a local approach, but with a global perspective. MM Spa carries out the collection, purification and distribution of water, collecting water from sewage drains and purifying it before releasing to the environment. Furthermore, MM Spa plans, designs and builds new networks and systems and performs the maintenance of existing ones, mainly dealing with four areas: Mobility, Water Management of water purification and disposal, Housing and Smart Cities.

Water business areas

MM spa carries out the supply, treatment and distribution of drinking water in the city of Milan. The water distribution network of Milan and neighbouring municipalities has a total length of about 2,228 km. The water supply system supplies the town with about 220 million cubic metres of drinking water per year. The water is withdrawn from the aquifer through the wells, which are connected to 29 pumping stations. Each station operates through 12 - 24 wells from a total of 587 in Milan, around 400 of which operate simultaneously. MM also manages domestic and industrial wastewater coming from the municipal district of Milan. Currently, the network consists of over 1,500 km of piping with a service coverage of over 98%. About 290 million cubic metres of wastewater from the district of the municipalities of Milan and Settimo Milanese flows into the sewer system. The wastewater is then transferred to the treatment system, which is divided into three plants: Milano San Rocco, Milano Nosedo, and Peschiera Borromeo. The plants of Milano San Rocco and Milano Nosedo constitute the main structure of Milan'swastewater treatment system, while the plant of Peschiera Borromeo, the 2nd line of treatment serving the eastern area of Milan, had to be constructed to meet technical and hydraulic requirements[164,165].

APPENDIX 7 - List of addressesof top players by sector

CONSULTING & SUPPLY OF TECHNOLOGY

ARAP SERVIZI S.R.L. Cepagatti (PE), Abruzzo http://www.arapservizi.it info@arapabruzzo.it	**ECODIESSE S.R.L.** Anagni (FR), Lazio http://www.ecodiesse.it/ ecodiesse@libero.it
CODEMAR S.C.A R.L. Pozzuoli (NA), Campania http://www.codemar.it/ codemarscarl@legalmail.it	**EURO D S.R.L.** Piacenza (PC), Emilia-Romagna http://www.consamb.it/ info@consamb.it
CO.R.D.A.R. VALSESIA SPA Serravalle Sesia (VC), Piedmont http://www.cordarvalsesia.it info@cordarvalsesia.it	**F.LLI ZAPPETTINI S.R.L.** Albino (BG), Lombardy www.ecozappettini.it info@ecozappettini.it
ECO AMBIENTE S.R.L. Poggibonsi (SI), Tuscany https://www.ecoambientetrescore.com/ ecoambientesrl@hotmail.com	**IDRAULICA F.LLI SALA S.R.L.** Concordia sulla Secchia (MO), Emilia-Romagna www.fratellisala.it info@fratellisala.it
ECOGREEN S.R.L. Campobasso (CB), Molise http://www.ecogreensrl.com ecogreen1@tin.it	**SIRAM VEOLIA WATER S.R.L.** Roncoferraro (MN), Lombardy www.siramacqua.it info.SVW@veolia.com

DECENTRALISED WASTEWATER TREATMENT

CM ECOSERVIZI S.R.L. Lamezia Terme (CZ), Calabria https://cmecoservizi.com/	**GEOINSEA SOCIETA' A RESPONSABILITA' LIMITATA SEMPLIFICATA** Aprilia (LT), Lazio https://www.facebook.com/geoinseaevapotraspirazione/ Info@geoinsea.it
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ECOSMART S.R.L. Riccione (RN), Emilia-Romagna http://eco-smart.it info@eco-smart.it	**LAZZARINO DRAINAGE S.R.L.** Varano Borghi (VA), Lombardy www.lazzarinodrainage.com info@lazzarinodrainage.it

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ACQUEDOTTO PUGLIESE SPA Bari (BA), Puglia www.aqp.it info@aqp.it	**SOCIETA' METROPOLITANA ACQUE TORINO SPA(SMAT SPA)** Turin (TO), Piedmont www.smatorino.it info@smatorino.it
ACQUE SPA Empoli (FI), Tuscany http://www.acque.net/ info@acque.net	**UNIACQUE SPA** Bergamo (BG), Lombardy http://www.uniacque.bg.it info@uniacque.bg.it
AMAP SPA - AZIENDA MUNICIPALIZZATA ACQUEDOTTO DI PALERMO Palermo (PA), Sicily https://www.amapspa.it/ info@amapspa.it	**VENEZIANA ENERGIA RISORSE IDRICHE TERRITORIO AMBIENTE SERVIZI - V.E.R.I.T.A.S. SPA** Venice (VE), Veneto www.gruppoveritas.it info@gruppoveritas.it

INDUSTRIAL WASTEWATER TREATMENT

A.O.C. SRL Genoa (GE), Liguria www.aoc-genova.it info@aoc-genova.it	**IDROTECNICA - S.R.L.** Rome (RM), Lazio www.idrotecnica.net info@idrotecnica.net
CONSORZIO PER LA GESTIONE DEI SERVIZI DELLA PROVINCIA DI SALERNO SRL Salerno (SA), Campania www.cgssalerno.it info@cgssalerno.it	**RAVENNA SERVIZI INDUSTRIALI SOCIETA' CONSORTILE PER AZIONI (RSI S.C.P.A.)** Ravenna (RA), Emilia-Romagna www.ravennaserviziindustriali.it info@ravennaserviziindustriali.it
ECOLOGICA NAVIGLIO SPA Robecchetto con Induno (MI), Lombardy www.ecologicanaviglio.it info@ecologicanaviglio.it	**S.A.I. S.R.L. SERVIZI AMBIENTALI INDUSTRIALI** Milan (MI), Lombardy www.sairavenna.com
EREDI RAIMONDO BUFALINI S.R.L. - SERVIZI AMBIENTALI Falconara Marittima (AN), Marche http://www.bufarini.it info@bufarini.it	**SERVIZI PORTO MARGHERA (S.P.M. S.C. A R.L)** Venice (VE), Veneto http://www.servizipm.it/ info@servizipm.it
GEA DEPURAZIONI INDUSTRIALI S.R.L. Castel Guelfo di Bologna (BO), Emilia-Romagna www.geadepurazioni.com info@geadepurazioni.com	**UNIPROJECT S.R.L.** Maltignano (AP), Marche www.uniproject.it info@uniproject.info

POTABLE WATER TREATMENT

ACQUE POTABILI SERVIZI IDRICI INTEGRATI S.R.L. Rende (CS), Calabria http://acquepotabilisii.it info@acquepotabilisii.it	**SICILIACQUE - SPA** Palermo (PA), Sicily www.siciliacquespa.it info@siciliacquespa.it
ALTO CALORE SERVIZI SPA Avellino (AV), Campania www.altocalore.it contatti@altocalore.it	**SIDRA SPA UNIPERSONALE** Catania (CT), Sicily www.sidraspa.acquistitelematici.it info@sidraspa.it
C.A.D.F. SPA Codigoro (FE), Emilia-Romagna www.cadf.it info@cadf.it	**SOCIETA' DELL'ACQUA POTABILE** Sestri Levante (GE), Liguria http://www.saponline.it sap.srl@veolia.com
GESTIONE ACQUA SOCIETA' PER AZIONI SIGLABILE IN GESTIONE ACQUA SPA Cassano Spinola (AL), Piedmont www.gestioneacqua.it info@gestioneacqua.it	**TEA ACQUE S.R.L.** Mantua (MN), Lombardy www.cometea.it info@cometea.it
SANIPUR SPA Flero (BS), Lombardy http://www.sanipur.it sales@sanipur.com	**VEOLIA WATER TECHNOLOGIES ITALIA SPA** Milan (MI), Lombardy www.veoliawaterst.it info@idraflot.com

PROCESS WATER TREATMENT AND MAINTENANCE

CID S.R.L. Colloredo di Monte Albano (UD), Friuli-Venezia Giulia http://www.cid-srl.net info@cid-cn.si	**I.A.M. SPA** Reggio di Calabria (RC), Calabria www.iamspa.it info@iamspa.it
DEPURACQUE SERVIZI S.R.L. Salzano (VE), Veneto www.depuracque.it com.servizi@depuracque.it	**IDRAULICA F.LL SALA S.R.L.** Concordia sulla Secchia (MO), Emilia-Romagna http://www.fratellisala.it info@fratellisala.it
ECOTEC S.R.L. Lamezia Terme (CZ), Calabria http://www.ecotecweb.net info@ecotecweb.net	**IDROVELOX DI PETRELLI FRANCO & FIGLI S.R.L.** Carmiano (LE), Puglia www.idrovelox.it info@idrovelox.it
GARRAMONE - SPA Viggiano (PZ), Basilicata www.garramonesrl.com	**ITALSERVIZI 2000 - S.R.L.** Rome (RM), Lazio http://www.italservizi2000.it info@italservizi2000.it
GIMA WATER & AIR S.R.L. Anagni (FR), Lazio http://www.g-wa.it info@g-wa.it	**S.I.F.A. SOC. CONSORTILE P.A.** Venice (VE), Veneto www.sifambiente.it info@sifambiente.it

SEWAGE SLUDGE

AMBIENTE ENERGIA S.R.L. Schio (VI), Veneto www.ambienteenergiasrl.it info@ambienteenergiasrl.it	**G.L.M. S.R.L.** San Martino dall'Argine (MN), Lombardy www.glmsrl.net info@glmsrl.net
ABORGO SPURGHI S.R.L. Castenedolo (BS), Lombardy www.borgospurghi.it info@borgospurghi.it	**PAVIND S.R.L.** Sulmona (AQ), Abruzzo www.pavind.it info@pavind.it
CANDEO AGOSTINO S.R.L. Rubano (PD), Veneto www.spurgopozzineripadova.com candeo@candeoagostino.it	**SEA - SERVIZI ECOLOGICI AMBIENTALI - S.R.L.** Camerata Picena (AN), Marche www.seaambiente.it info@seaambiente.it
CONSULECO S.R.L. Bisignano (CS), Calabria www.consuleco.net info@consuleco.eu	**SHIFT SPA** Cagliari (CA), Sardinia www.shiftspa.it info@shiftspa.it
FRANCHINI SPA SERVIZI ECOLOGICI Alzano Lombardo (BG), Lombardy www.franchiniservizi.com info@franchiniservizi.com	**TOSCANA ECO FANGHI - S.R.L. O T.E.F. SRL** Pisa (PI), Tuscany www.toscanaecofanghi.it cecina@toscanaecofanghi.it

URBAN WASTEWATER TREATMENT

BRONI-STRADELLA PUBBLICA S.R.L. Stradella (PV), Lombardy www.bronistradellapubblica.it info@bronistradellapubblica.it	**PADANIA ACQUE SPA** Cremona (CR), Lombardy www.padania-acque.it info@padania-acque.it
BNG SPA Ferrandina (MT), Basilicata http://www.gruppoiula.com/bng.html info@gruppoiula.com	**PLANETARIA S.R.L.** Avellino (AV), Campania http://ltheme.com info@planetariasrl.it
CONSORZIO AQUARNO SPA Santa Croce sull'Arno (PI), Tuscany http://www.depuratoreaquarno.it info@depuratoreaquarno.it	**PREALPI SERVIZI S.R.L.** Varese (VA), Lombardy www.prealpiservizi.it info@prealpiservizi.it
CORDAR SPA BIELLA SERVIZI Biella (BI), Piedmont www.cordar.it segreteria@pec.cordarbiella.it	**RICCOBONI SPA** Parma (PR), Emilia-Romagna www.riccoboniholding.com ecoimpresa@riccoboniholding.com
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