Digitisation in the workplace

Case study: Consorcio de Aguas Bilbao Bizkaia (Spain)

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Author: Rafael Grande and Alberto Vallejo-Peña (University of Malaga)
Research Manager: Sara Riso (Eurofound)
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European Foundation for the Improvement of Living and Working Conditions
Telephone: (+353 1) 204 31 00
Email: information@eurofound.europa.eu
Web: www.eurofound.europa.eu

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Case summary

Bilbao-Bizkaia Water Consortium (Consorcio de Aguas Bilbao-Bizkaia, CABB) is a publicly owned company located in the Basque Country (Spain). CABB operates in primary water supply, sanitation in the primary water network, water treatment and purification and control of industrial waste discharges (NACE code E36 Water collection, treatment and supply).

This case study explores the use of Internet of Things (IoT, TRL9) and Virtual and Augmented Reality (VR/AR, TRL6-7) applications at the main CABB establishment - the control plant and administrative offices (headquarters) in Bilbao, employing 160 people. The CABB headquarters manage the full water supply and treatment network, including the wastewater and drinking water treatment plants in the city of Bilbao and its metropolitan area.

In 2015, CABB introduced and fully deployed smart grid technologies based on Internet of Things (IoT) type of technologies for SCADA monitoring of the water supply and treatment network. These include online monitor sensors, smart flow and pressure meters, water quality sensors, smart water consumption meters and leakage monitoring sensors, intelligent predictive alarms. The data collected from sensors installed throughout the water network is transmitted and processed to the centralised SCADA system with data analytics capabilities.

In 2018, the establishment adopted the BIM (Building Information Modelling, BIM) methodology through a software with integrated VR capabilities. This tool is used for the drafting of construction/building projects in the water network, the execution of works and their subsequent operation and maintenance. The tasks related to the entire life cycle of the assets are integrated into a single software programme. BIM incorporates geometric (3D), time (4D), cost (5D), environmental (6D) and maintenance (7D) information, and it has been the platform for implementing VR. In 2020, virtual reality glasses started to be used for better modelling and visualisation of water network installation projects managed using the BIM methodology. In 2019, AR drones were deployed for predictive maintenance improving efficiency and reducing occupational risks. Although predictive maintenance is a prerogative of IoT, IoT and AR are integrated for this activity making it a use case of combining technologies. In this specific case, the use of AR with drones equipped with IoT sensors has facilitated specific activities of maintenance by visualising the water network in augmented reality. Overall, according to the innovation strategy of the establishment, the deployment of these technologies followed different pilot phases for each use case.

From the management and middle management perspective, this case study highlights a positive impact of digital technology adoption on the establishment's efficiency and productivity. The use of the three digital technologies also have generated a significant increase in the quality of water services offered by CABB. With regard to changes to the work organisation, the use of this technologies involved a shift towards more cognitive skills and tasks and less physical tasks. In terms of job quality, the IoT technologies had an overall positive impact by increasing work autonomy, job satisfaction and responsibility for employees in engineering, technical and managerial positions. The use of the technologies (IoT, VR and AR) contributed to lower occupational risks and greater control over processes and systems.

Introduction

Background and objectives

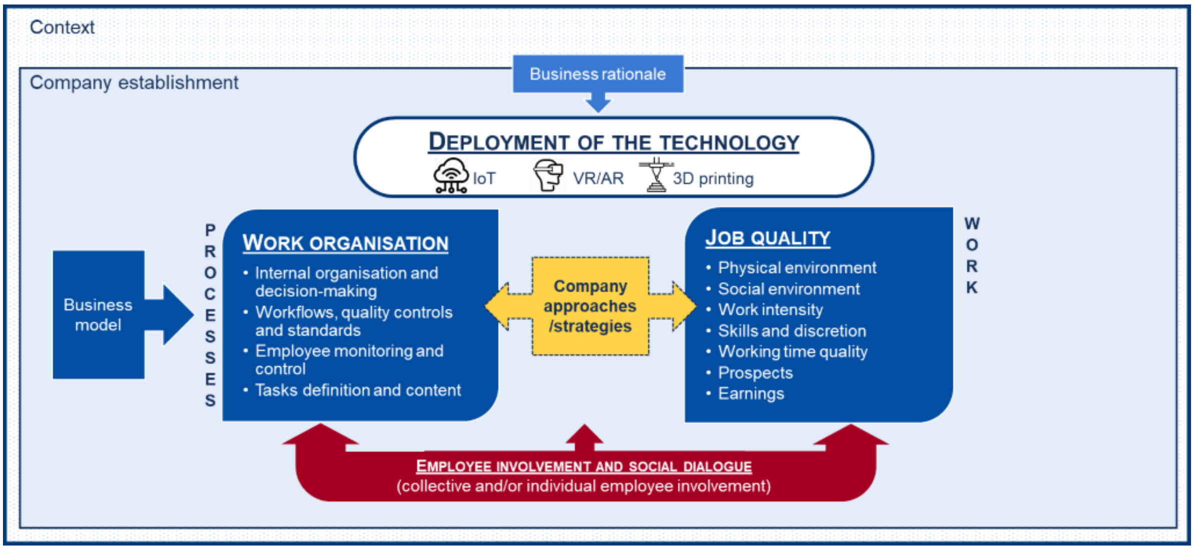
This working paper illustrates the case of Bilbao-Bizkaia Water Consortium (Consorcio de Aguas Bilbao-Bizkaia, CABB), located in city of Bilbao and its metropolitan area (Basque Country, Spain), in relation to the introduction and deployment of the Internet of Things (IoT), Virtual Reality (VR) and Augmented Reality (AR). The working paper explores the impact of these digital technologies on the work organisation and job quality, as well as the extent of the employee involvement in relation to the digitisation process.

This case study has been conducted in the context of a Eurofound research on the impact of digitisation on the nature of work. This research is set against a conceptual framework elaborated by Eurofound (Eurofound, 2018), which differentiates between three vectors of change, of which one is digitisation and is associated with three digital technologies. These are additive manufacturing or 3D printing, the Internet of Things and Virtual and Augmented Reality.

Eurofound's conceptual framework on the digital age (Eurofound, 2018) proposes that the effect of digitisation is most direct on working conditions, as it involves a change in the work environment and nature of work processes. It also involves changes in tasks and occupations and has an indirect effect on employment conditions and industrial relations.

Based on this conceptual framework, Eurofound has developed an analytical model (reproduced in Figure 1) that serves to guide the analysis of nine case studies (including the CABB case) conducted for this research. According to this model, the nature of work consists of two core dimensions, namely work organisation and job quality. Employee participation and social dialogue is a cross cutting dimension as it can both influence and be influenced by the way the technology is deployed in the workplace. Typically, the technology changes the establishment's business model, which in turn impact the work organisation and elements of job quality (partly depending on how the technology is applied in the workplace). Both contextual factors and establishment or company specificities may drive the digitisation efforts. These factors should be taken into account for a better understanding of what has either constrained or facilitated the digitisation process within each establishment.

Figure 1: Conceptual model for this study



Source: Eurofound, 2019.

This case study provides insight into the introduction of three digital technologies CABB and illustrates the impact on job quality and work organisation, which is the core of this study. This case study draws primarily from five qualitative interviews conducted in the establishment with an HR manager, an innovation manager, an employee representative and two workers (see Table 1). All the interviews were conducted in March 2021, in Spanish, and virtually due to the health and movement restrictions imposed by COVID-19.

Table 1: Profiles interviewed in the Consorcio de Aguas Bilbao Bizkaia (CABB)

Interviewee type	Department and fieldwork date
HR manager	Human Recourse Department 11/03/2021
Innovation manager	Asset Management Department 04/03/2021
Employee representation	Works Council member and Trade Unionist 05/03/2021
Workers	Project and Building Department 02/03/2021
	Innovation Department 09/03/2021

Source: authors' own elaboration.

In addition to the qualitative interviews, the case study also draws from desk research and documentation provided by the company management, supplementing the information about the establishment profile, the innovation strategy and changes to the business model.

Reason for selecting this particular case

Bilbao-Bizcaya Water Consortium (CABB) was selected for in-depth investigation for the insight it offers on to the adoption and deployment of three complementary digital technologies: IoT, VR and AR. This case study illustrates the impact of an advanced IoT technology on the business model, by making service delivery processes effective and efficient, and improving environmental sustainability throughout the water collection, treatment and supply. For employees, the digitisation process entailed an important shift in methods and organisation of work. In addition, the introduction of these three technologies resulted in increasing autonomy and responsibility for several groups of employees, especially line managers and highly skilled employees (e.g. engineers, designers, data analysis jobs, etc.)

Based on the implementation and improvements achieved through IoT, the establishment introduced VR to add value in the design and development of construction/building projects in the water supply network installations and AR with a view to reducing ambient risks, exposure to biological and chemical risks, and posture-related and ergonomic risks for employees.

In addition, the establishment has a high level of employee trade union participation and the works council has traditionally played an important role in social dialogue (for example prevention of health and safety risks and wage bargaining), it is therefore interesting to know their role in the technological change in the workplace.

This case also highlights the value of digital technologies for a public company, whose aims are far removed from market competitiveness. The deployment of smart technologies is key to the improvement of the quality of public services, including water service, increasing the competitiveness of European cities and reaching European energy and climate targets. The digitisation of public services is regarded by the European Commission as an important step towards the implementation of the Smart Cities Marketplace (EIP-SCC, 2020). This is a European Commission's initiative which brings together cities, businesses, research providers and other stakeholders to develop and upscale smart city solutions in Europe.

Finally, the economic and cultural context in which the establishment is located is another reason for selecting the case. Spanish regions are heterogeneous in their level of digitisation, with the Basque Country (region in which CABB is located) being one of the leading regions in the implementation of advanced digital technologies (Grande, 2018). After deindustrialisation, from the 1990s onwards, the Basque Country – especially the city of Bilbao – underwent a major economic reconversion. Since the first decades of the 21st century the region has made an important commitment to Industry 4.0 with the support of the public regional administration. The role of clusters, especially in the industrial sector, has been a factor determining a greater uptake of digital technologies compared to other Spanish regions. These clusters are multi-level governance and public-private partnerships (involving companies, public administration and research centres) to promote local and regional networking initiatives designed to facilitate innovation (Aranguren et al, 2010, 2016; Holl and Rama, 2016). Therefore, public-private partnerships encouraged by regional innovation strategy are another reason for the interest of this case study.

In particular, CABB is part of different innovation clusters including the Spanish sector water collection, treatment and supply cluste (*Asociación Española de Abastecimientos de Agua y Saneamiento)*[1], the regional environmental cluster of the Basque Country (*Aclima)*[2] and the regional innovation cluster of the Basque Country (*Innobasque)*[3].

Report structure

In the following chapters more context will be provided by describing the establishment in more detail (chapter 1) and the process of the introduction and implementation of the technologies, including the role of employee involvement throughout the digitisation process (chapter 2). Chapter 3 describes the impact of the two technologies on the business model, work organisation and job quality. The working paper ends with lessons learnt and some take-aways.

[1] See more details at *Spanish Association for Water Supply and Treatment (AEAS)* on their website: http://www.aeas.es/servlet/mgc

[2] See more details at *Aclima*, environmental cluster of the Basque Country, on their website: https://aclima.eus/en/

[3] See more details at *Innobasque* cluster on their website: https://www.innobasque.eus/

1. Establishment profile

Type of entity and ownership structure

The *Bilbao-Bizcaya Water Consortium* is a public entity of a supra-municipal nature, founded on 17 March 1967, under an agreement between 19 municipalities in the province of Bizkaia and the Greater Bilbao Administrative Corporation (no longer existing). In 1997, it changed its name to the current *Bilbao-Bizkaia Water Consortium* (Consorcio de Aguas Bilbao-Bizkaia, CABB). The new agreement was signed between the Basque Government, the Provincial Council of Bizkaia, and the municipalities involved. Although the CABB initially involved the city of Bilbao it has been growing over time, with the gradual incorporation of most of the municipalities in its metropolitan area.

As of 2021, the Consortium covers almost the entire province of Bizkaia: 85 municipalities – out of a total of 112 – and almost 95% of its inhabitants, providing water supply services to a population of more than one million inhabitants. In general, these are small municipalities in the Bilbao metropolitan area that are within walking distance of each other, which makes it possible to provide water supply and treatment services from a single establishment. Bizkaia is one of the three provinces of the Basque Country, a region located in the north of the country, on the Cantabrian coast that has historically stood out as an important industrial centre.

CABB headquarters – the establishment in focus in our case study – manages the integral water cycle: primary water supply, sanitation in the primary network, water purification, control of industrial waste discharges and customer relations. The tasks carried out include: (1) the operation of the drinking water distribution system and (2) technical assistance to the City Councils in the execution of the network replacement plan (substitution and modernisation of the water distribution network).

Activities and geographic location

Located in Bilbao (Bizkaia), CABB carries out the following activities:

- **Primary water supply**. This includes the functions of catchment, reservoir, transport, water treatment and supply to businesses and citizens.
- **Sanitation in the primary network**. This includes the development and maintenance of the sewer system, the wastewater treatment plants (with annexes for waste treatment and recovery), and the outfalls that return treated water to the environment.
- **Control of waste discharges**. The activity includes the monitoring and inspection of wastewater discharges, both to the primary sewage network and the sewer system.
- **Customer relations**. CABB serves all the customers of the municipalities in the consortium (public entities, private companies and individuals), including the control of measuring equipment, contracting of services, control of consumption, billing and collection management of water consumption, the resolution of claims, as well as the imposition of derived sanctions (CABB, 2020).

Size and workforce composition

CABB employs 160 people at its headquarters in Bilbao. In addition, a further 220 workers provide various services in the metropolitan area, related to the water distribution network; for example, Galindo WWTP (Waste Water Treatment Plant); Venta Alta DWTP (Drinking Water Treatment Plant)

CABB is characterized by a highly-qualified workforce (45% with university education), with a prevalence of technical professionals (58% of highly educated), most of them being engineers. Furthermore, the staff of establishment has a very balanced gender distribution: 51% men compared to 49% women. The average age is 48 years, and ranges between 30 and 65 years (with staff typically retiring at 65). In 2021, the company employs 56% of its staff as civil servants or permanent employees, compared to 44% of temporary employees, all of them employed on a full-time basis. Considering that it is a public-sector entity, temporary share of employment in the company is somewhat high, due to slow contract consolidation, i.e. a long process to transform temporary contracts into permanent ones. A small proportion of positions are outsourced, mainly for software maintenance work on the water network, in both cases due to the growth of activities that cannot provided by the public sector because during the economic crisis, recruitment in public services slowed down.

The establishment has a hierarchical organizational structure, with several layers of middle management. The establishment has four levels of management in total (chair and management, department directors, deputy directors, and heads of unit), the latter three being considered as middle management. At the top level, there is a General Assembly (97 members) giving way to an Executive Committee (nine members): a president and an executive manager. At the next level down, there are five large departments, each headed by a director. These departments are 1) technical services; 2) operations and asset management; 3) commercial and quality management; 4) human resources and legal services and 5) economic and financial services. Each of these large departments is further divided into smaller sub-departments, each led by a deputy director.

- Technical services department: supply projects and works sub-department; sewerage projects and works; sustainability, technology and innovation.
- Operations and asset department: operations and supply; operations and asset Management.
- Commercial and quality management: customer relations sub-department and quality sub-department.
- Economic-Financial Services: IT, contracting, financial controlling and land management.
- Human resources and legal services: contracting, legal and administrative services, personnel and security sub-department, and occupational hazard prevention sub-department.

Most of the staff in the technical services and operations and asset management departments are occupations with managerial, engineering, and ICT orientations (including data analysis). The commercial management and quality management and economic and financial services departments are more diverse in terms of educational profiles, with economists and law graduates. The latter is the dominant profile in the human resources and legal services departments. In addition, in the laboratories (in operations and asset department) there are some chemistry professionals, both university graduates and vocational training graduates. The least qualified positions are occupied by administrative and operations staff distributed across various departments.

The establishment has worked persistently on the gender issue over the last 20 years, with a progressive increase in the number of women in the workforce, reaching the current 49 %. This is deemed as a satisfactory target, given the dominance of men in engineering professions, both in the Basque Country and Spain as a whole. However, only one woman is part of the management team – which offers a total of 25 positions – as deputy director of asset.

Form of employee representation

The establishment has a Works Council and trade union representation. The Works Council has 13 members. This is made up of a Chairman and a Vice-Chairman. At present, the majority representation   is held by a regional union: Eusko Langileen Alkartasuna (Basque Workers Solidarity) with seven representatives (after receiving 47.8% of the vote in 2019 elections). The minority representatives are Langile Abertzaleen Batzordeak (Nacionalist Workers Comissions) – with 29.2% – , also regional, and the Union General de Trabajadores (General Workers Union) – with 23% – with three representatives each, the latter being the only majority trade union at national level. The interviewed committee representative stated that the digitisation process is frequently addressed in the works council meetings. But digitisation is not a key topic on their agenda and the role of the Works Council in digitisation is limited to information and consultation only. In general terms, the Committee has supported the implementation of the new technologies introduced, considering that it has a positive impact on the quality of employment and the service offered by the company to its customers.

In general, union membership is high and participation rate in election is enough (68% in 2019), although the workers' participation in other activities is weak (low attendance at meetings and low involvement in campaigns), according the interviewed Works Council representative. Both from a management and employee representative perspective, labour relations in the establishment are friction-free and based on open social dialogue. Both the steady increase in employment in the establishment over the last decades and the high share of permanent employment (56% of the total) has contributed to reduce the scope for conflicts. In addition, the public nature of the institution significantly reduces the salary negotiation range, defined at regional level. Last February 2021, the 17th Collective Bargaining Agreement was signed –valid until 2022- without major issues. This agreement regulates wages, working hours, holidays and other working conditions; in addition, aspects linked to digitisation are updated, for example new skills and training requirements or prevention of employee data protection and privacy, etc.

2. Introducing and deploying digital technologies

Previously, the old water supply network system did not collect data in real time, so the facility relied on manual reports based on data collected on paper and manually by operators during on-site visits, resulting in poor data management practices. Since the 1990s, the establishment has been incorporating SCADA systems and real-time communications based on the technologies existing at the time (e.g. radio communications, programmable controllers, etc.). In 2015, CAAB introduced and installed IoT sensors throughout the water supply and treatment network which are connected to a SCADA system for real time monitoring. The sensor-based system is used to control water flow, water pump pressures, advanced industrial discharge control, water quality monitoring and monitoring of the performance of other small machines. All data is displayed on computer monitors in the plant control center and on dashboards accessible to the employees in managerial positions at the headquarters. This has transformed the communication of information within the establishment and facilitated remote working as on-site inspections and manual data gathering was no longer required.

In addition, in 2015, CABB introduced an IoT based employee monitoring system relying on data collected from digital video surveillance, thermographic cameras and car sensors in the company's vehicles, and connected to a real time monitoring terminal. According to the management, all data protection measures have been taken to ensure proper data collection always in consultation with the works council on this matter and informing employees about the purpose of data collection. The main objective of this data collection is to improve employee safety. Although a lot of data is collected, information on employees is not analysed at the moment for employee performance purposes and this is known to the workers. Data analysis in the establishment focuses on processes and safety, but not on employees' personal data because management does not consider it necessary.

Given the great complexity of the infrastructure (its construction, maintenance and upgrading) of the water supply and treatment network, AR/VR technologies were introduced to improve information, evaluation, and collaborative coordination between different units and engineering jobs. Since 2018, using the BIM methodology, the drafting of construction/building projects in the water network, the execution of works and their subsequent operation and maintenance were integrated into a single programme with VR capabilities, i.e. throughout the entire life cycle of the asset.

As opposed to the traditional multitude of different plans that resulted in different, inaccurate versions, the BIM software incorporates geometric (3D), time (4D), cost (5D), environmental (6D) and maintenance (7D) information. All information, plans and digital data, generated through the BIM methodology and software, are stored in ‘the cloud‘ via the Internet and are available to all employees of the facility. In 2020 virtual reality glasses started to be used for better modelling and visualisation of water network installation projects in the BIM software.

In addition, in 2019 an AR application was introduced for predictive maintenance improving efficiency and reducing occupational risks (e.g. handling of chemicals, difficult access areas, exposure to excessive noise, etc.). Although predictive maintenance is a prerogative of IoT, the use of AR with drones equipped with IoT sensors has facilitated maintenance tasks by visualising the water network in augmented reality, making it a use case of combining technologies.

The IoT, AR and VR solutions adopted in the establishment were mainly acquired from external suppliers (through the purchase of software and other digital tools) and were slightly adjusted to CABB's specific needs. For example, the design of the software underlying the functioning of the SCADA system was outsourced; the IoT sensors installed throughout the water supply and distribution network were provided by Siemens (a monitoring system based on Wonderware software). IoT, VR and AR are used in three departments within the establishment: technical services department, operation and asset management department, and commercial and quality management department.

CABB's commitment to innovation and digitalisation led to the creation of the Innovation Unit in 2018, part of the sub-directorate for sustainability, technology and innovation in the technical services department. The objective of the innovation strategy, developed by the Innovation Unit, is, on the one hand, to promote and manage innovation through the active participation of the entire workforce in the development of innovation projects and by encouraging staff to put forward their ideas and provide feedback. On the other hand, Innovation Unit putting forward and implementing the innovation strategy, incorporating, where appropriate, a Technology Watch System with the aim of assessing its impact and designing training programmes with the direct involvement of the employees.

In parallel, CABB also collaborates with different scientific-technological providers, promoting the execution of various R&D projects and acquiring the expertise required in different fields of action. These public-private partnerships are promoted by the regional innovation strategy provide incentives and funding to support these collaborations. The Research and Innovation Strategy for Smart Specialisation (Ris3) in the Basque Country is a public programme for territorial economic transformation that concentrates available resources on a set of R&D and innovation priorities together with the region's business and scientific-technological capacity, with the aim of generating added value that creates economic growth and employment.

Within this set of strategies, CABB has been collaborating for several decades with public institutions (for example the University of the Basque Country and Basque Water Agency) and private companies (for example Acciona or Cadagua-Ferrovial). For example, CABB together with the university's Basque Center for Applied Mathematics are developing time series data analysis models, thanks to IoT and real-time data. As part of this collaboration, CABB makes available public data collected via the IoT system for the University to develop time series data and analysis model that can be later used by CABB for their data analysis and therefore enhance the data analytical capabilities in the establishment. In 2019, the CABB/BBUP Water Classroom was created together with the Engineering School of the University with the aim of collaborating in the field of scientific and technological research and university teaching and eventually enhancing the training of CABB staff. For CABB, the purpose of these collaborations is to make the most of the technologies introduced and to encourage the development of innovative solutions.

Motivation for the introduction of the technologies

The main motivation for the introduction of the IoT and AR technologies was to improve control and efficiency related to the maintenance and repair processes, drinking water service, pollutant wastewater control, and the design and construction of water supply and treatment installations. Beyond this main motivation, the adoption of the new digitised technologies served several purposes.

The intention was to improve the efficiency of water supply and treatment services to both internal customers (municipalities) and end-users (citizens and businesses). To this end, CABB implemented more efficient and environmentally sustainable wastewater treatment technologies, while at the same time improving data collection, transfer, analysis and storage for the entire water supply and treatment network. This also allowed CABB to improve the coordination and organisation of work among employees. Previously, there were multiple manual paper records that were not easy to review, lacking details, and their collection was slow as it required operators collecting the data manually and recording it on site.

The introduction of the technologies was also driven by the need to improve the accessibility of the water supply network and perform predictive maintenance, particularly due to the large distance and orographic difficulty of the area served by CABB (in the Bilbao metropolitan area it has 2,200 km of distribution water network). Another important challenge was the obsolescence of some of its infrastructure.

Finally, from a management perspective, it was important for CABB not to lag behind in terms of innovation, especially in consideration of the technological advances in the sector at European and international level. The CABB management representatives mentioned in this respect the forums of Digital Water Programme organised by the International Water Association (IWA) where successful experiences are shared. Nevertheless, all interviewees agree that being a public administration slows down the implementation of the innovation strategy and gives less flexibility for example in the area of public procurement and recruitment.

According to all interviewees, the innovation strategy follows a top-down approach, but driven by the middle management (including department directors, deputy directors, and heads of unit) rather than the top management. The middle management plays a significant role because, on the one hand, they put forward digitisation projects to the top management and, on the other hand, they are responsible for their implementation and communication of changes in work organisation to the employees directly involved.

Place in the workplace for the technology and its embeddedness

The company has implemented (IoT technologies with the aim of digitising the data collection and analysis, and maintenance and administrative management of the water supply and treatment network. After 6 years of implementation, the IoT technology is now fully embedded in the work processes of the establishment.

The SCADA (Supervisory Control & Data Acquisition) system was introduced to remotely supervise and control all the installations and the water supply and treatment network, being able to integrate data collected from different sensors, PLCs (Programmable Logic Controller) and equipment through different protocols in a single place. The SCADA system uses the industrial software Wonderware. The collection and exchange of data enabled by datalogger and digital devices (for example IoT sensors), and cognitive computing on the cloud made it possible to move from a traditionally implemented SCADA system to an integrated IoT-based system. This enables resource optimisation, more efficient predictive maintenance and system monitoring with detailed real-time and historical data. However, according to interviewees, the facility is not yet fully using big data and data analytics in its processes, so the use of the data is reduced to the optimal functioning of the water network and predictive maintenance.

Asset management and predictive maintenance with IoT smart devices and advanced sensors (includes online monitor sensors, smart flow and pressure meters, water quality sensors, smart water consumption meters and leakage monitoring sensors, intelligent predictive alarms, etc.) managed jointly in the SCADA platform was the first step taken in the establishment towards future Smart Water Networks. The installation of digital IoT sensors throughout the water supply system enables predictive maintenance to save costs and improve security and cybersecurity by detecting possible consumer fraud thanks to detailed real-time data.

For example, digital meters equipped with remote radiofrequency transmitters are used to obtain the meter reading and billing rate for citizens (the reading is done from vehicles that can be more than one kilometer away of the meter). This results in significant savings and greater efficiencies by making manual reading superfluous and reducing reliance on estimates of water consumption. This is achieved by leveraging a wide range of digital devices such as online monitor sensors, smart flow and pressure meters, water quality sensors, smart water consumption meters and leakage monitoring sensors, intelligent predictive alarms, etc.

These technologies also improve environmental protection. For example, IoT digital sensors and digital preventive alarms (also IoT based) are used for continuous real-time control and monitoring of critical pollution parameters in companies and industries, ensuring optimal operation of wastewater treatment plants (WWTP). Initially, in order to test the effectiveness of the technologies, an area with a high concentration of fish processing industries was selected as a pilot project done by CABB. In these industries, improvements were introduced for the secure integration and digital IoT measurement of their industrial discharges into the urban wastewater network with remote control, digital flow meters, digital preventive alarms, management software and a connected Early Warning Device.

The installation of some of these digital devices was realised thanks to EU co-funding via the European Regional Development Fund (ERDF). For example, the industrial wastewater reduction pilot project, named "LIFE Vertalim", was carried out between 2016 and 2019 with the EU's LIFE Programme.

On their own part, **Virtual Reality (VR) and Augmented Reality** (**AR)** type technologies have been embedded in different processes in the establishment.

The establishment introduced the BIM (*Building Information Modelling*) methodology and software with the aim of centralising all the information of each construction, renovation and maintenance of physical infrastructure projects using a digital information model created by those involved in the different stages of the project cycle (providers, engineers, maintenance technicians, operators, etc.). In this way, it follows a collaborative work methodology. BIM is the improved evolution of traditional design systems based on a lot of paper plans whose quality was questionable. BIM incorporates geometric (3D), time (4D), cost (5D), environmental (6D) and maintenance (7D) information. The use of BIM goes beyond the design phases, covering the execution of the project and extending throughout the life cycle of the facilities, including management and maintenance and thus reducing operating costs. This is deemed by the management an important aspect to guarantee the good quality public water service. Moreover, this methodology and its software provides the data used for VR visualisations.

As to the implementation of **Virtual Reality**, VR glasses have been used since the beginning of 2020 as a demand for innovation from middle management (specifically, deputy directors from technical services and operations and asset departments) to support and enhance the building information modelling (BIM) methodology. Representation of building structures and system infrastructures created using the BIM methodology can now be viewed in VR, instead of instead of relying on 2D drawings and plans. On the one hand, the technology improves the quality of the presentation of water network installation projects models to Operation and Asset Management Department of the establishment and customers (for example, when projects are submitted to the municipalities). On the other hand, VR enhances collaboration between different units within the establishment working on the improvement and evaluation of these projects. The integration of VR technology in the BIM software has many other advantages, for example it makes it possible to analyse all projects in their true magnitude and with many details, it saves time in the design evaluation process, and it facilitates visualization tasks in difficult to see environments. The use of VR glasses (with built-in microphone and headset) is combined with video conferencing via Microsoft Teams for evaluation and brainstorming meetings within the VR models (see Figure 2). One of the workers interviewed describes this significant change as a shift from working with paper based projects stored in drawers to working on a centralized virtual model stored on the cloud that can be accessed and visualized in virtual reality. However, VR are currently only used for specific jobs, by the engineering design team for example for labour risk evaluation or the location of elements in the water network.

Figure 2: Use of **Virtual Reality** Glasses at CABB.

Source: CABB.

Augmented Reality (AR) has been introduced since 2019 in asset management tasks and predictive maintenance of the water supply and treatment network. Drones equipped with IoT sensors are used to make a virtual 3D mapping of the water network, and to detect and transmit data about malfunctions doing maintenance operations of the water network more effectively. In this case, the technology is applied where it can be complicated or costly to do the work manually, for example atmospheres surrounding waste water treatment plants, work areas that are difficult for operators to access, etc. (see Figure 3). As a result, the technology saves time and costs, and improves the efficiency of maintenance work.
Augmented Reality (AR) Training was also introduced in the establishment with the aim of teaching employees before performing certain high-risk activities to improve workplace security. For example, Augmented Reality (AR) Training has been used in tasks that require training such as high voltage work or the handling of chemicals (for example water chlorination). In 2019 CABB also digitized the maintenance of water supply network manuals and instructions based on AR technology.

Figure 3: Use of Augmented Reality with Drones in predictive maintenance at CABB (Ordunte canal, Bizkaia).

Source: CABB & Hovering Solutions Ltd

Timing of the introduction and progress thus far

While the original SCADA system was implemented in 2000s, the IoT-based SCADA system was adopted in 2015. Back then IoT sensors began to be installed throughout the water supply network, including online monitor sensors, smart flow and pressure meters, water quality sensors, smart water consumption meters and leakage monitoring sensors, intelligent predictive alarms, etc. These were integrated and managed via a central (SCADA) monitoring system. The introduction of these new digital devices has been progressive over the last few years with the upgrade of the entire water supply and treatment network. The pilot phase for the Installation of IoT based sensors measuring water quality and the industrial discharges into the urban wastewater network was launched between 2016 and 2019.

The PLM (Product Lifecycle Management) methodology has been adopted since 2016. PLM has been applied for the administrative area of the establishment, for a holistic change of all processes and workflows. This is very important in a public administration that previously had a paper-based bureaucracy. Windchill software is used which has been procured externally. PLM training was offered to all employees involved in the use of PLM, especially in administration and management jobs. Its implementation has made it possible to integrate and involve all areas of the company: a) improving the access of information, templates and documents to all areas and to all workers directly; b) improving the flow of signatures so that there is less dependence on time-consuming bureaucratic management; and c) being a guide or manual for workers (especially new workers), clearly marking the workflow. This technology is not directly linked to IoT or VR/AR, but it has facilitated the integration of IoT into management water processes supply, distribution and treatment, by fostering a digital organisational culture among employees.

With regard to new VR type technology, the establishment adopted the BIM methodology in 2018. Training on BIM was given to all employees linked to its use (design engineers, asset management, maintenance workers). The integration of BIM with AR and VR technologies occurred respectively in 2019 and 2020. These technologies were initially tested in pilots by the establishment's engineering team (in the technical service department) before full deployment.

Initial expectations of the introduction of the technology

The initial expectations of the management were that digital technology would help to improve the organisation of workplace; they also anticipated greater efficiency and effectiveness of processes that would benefit the quality of services offered by CABB.

According to the interviews, the middle management and other highly qualified employees (engineers, data analysts, etc) were fully involved in the digitisation process from the beginning giving a strategic orientation to the innovation efforts, participating in the pilot tests and providing feedback which was then taken into account in the technology implementation. At the same time, the new technologies aroused curiosity and extra motivation for the middle management and other highly qualified employees which triggered new innovation projects and fostered a change in the technological culture of the establishment.

In contrast, maintenance operators and less qualified employees (for example manual maintenance workers, and other employees in water network servicing occupations), were more cautious towards technological change. They participated in the pilots but their feedback was not systematically taken into account in the technology implementation. On the one hand, employees were concerned about their ability to learn to use new technologies and the need to adapt to new ways of working. In all jobs, the older employees experienced the greater difficulties for learn to use new technologies and adapting to technological change. In addition, from the perspective of the Works Council representative, most employees were uncomfortable with the increased level of supervision of activities in the establishment due to the introduction of the IoT technologies. Although most permanent employees felt secure in their jobs as a public company, some blue-collar workers (e.g. maintenance operators) had initially some concerns about the transformation or possible disappearance of their jobs.

Initial strategy for the introduction of the technology and adjustments during its deployment

The approach adopted for the introduction of the technologies was a top-down model, but it was not explicitly defined by the top management but by middle management, who formulated the Innovation Strategy in the first place in 2015. This Innovation strategy evolved during the transition process with no specific timeframe for implementation, thus ensuring its long-term sustainability. As a result, different pilot phases were developed for each technology before the full roll-out. In general, those responsible for innovation and technological change - department and deputy directors, and managers in the Innovation Unit - were given the freedom to solve problems as they arose and to assess the different stages of technology implementation. In addition, according to the interviewed managers, the rejuvenation of the workforce has favoured change and adjustments during the introduction of the technologies.

The Innovation strategy of the establishment indicated the specific objectives CABB wanted to achieve with the introduction of the digital technologies. An explicit strategy included the following elements: first, identification of mechanisms for monitoring impacts through pilot testing of the technologies; second, informing employees about new technologies to ensure compliance with changes and new working procedures; third, a training plan for new skills requirements arising from the use of the technologies. Staff training in the use of the software mentioned above was provided to the staff directly involved in each case. Training courses have been developed and delivered both in-house and by external software suppliers.

The creation of an innovation unit in 2018 aimed to support the implementation of the innovation strategy in the workplace and encourage employee participation in the change process. The setting up of the Innovation Unit led to the creation of a new position with engineering and management orientation. On the downside, the establishment has not a specific change management strategy or initiative to accompany the digitisation process during this process. Set up a change management strategy and training in change management or agile methodologies is an important challenge for the coming years, this being a demand from middle management and staff, according to all interviews.

Role and involvement of employees before, during and after the technological change

Both the human resources manager and the Works Council representative agree that collective bargaining and social dialogue in the establishment have not been affected by technological change. From this particular point of view, they had little influence on the decision to implement the new digital technologies and their development, including a discussion of the results of the pilot tests. However, an important role of the Works Council and employee representatives in the establishment in relation to technological change is to ensure labour rights and a safe working environment in terms of legal standards and protocols. Trade unions and the Works Council regularly ask the company's management for risk impact assessments, especially in the context of employee monitoring and the use of IoT in relation to data protection and privacy. Thus, the Works Council and the trade unions have played an important role in some aspects of technological change in the workplace, especially in relation to IoT. For example, they participated in the risk impact assessments carried out during the pilots and the monitoring of potential risks – mainly health and safety risks – during the roll out of the technology.

First, management consulted with employee representatives regarding the purpose of data collection to ensure that it is legitimate and proportionate, and that data minimisation is applied. The Works Council also ensured that the technology is not extended to other uses not foreseen or different from those previously agreed. However, according to the interviews, only information on the implementation of the technology was provided and established protocols were reviewed, but no involvement in decision-making. To this end, the management team held collective meetings with employee representatives and explained to them why the new technologies are necessary and how they will affect the work and tasks of the staff.

Second, the Works Council carried out a supervisory task in the changes of profile and functions assigned to some jobs caused by the new technologies. These changes in the profile of public competitions are slow and bureaucratic as it is a public company, but it signifies a major transformation. For example, public employment offers with competitive examinations now require knowledge and expertise in working with the BIM methodology (linked to VR) and SCADA (linked to IoT).

Third, Works Council and trade union representatives participate regular in the Safety Committee that assesses the occupational risks of implementing changes and instructions for use of new tools linked to IoT, VR and AR. This was organised with the direct participation of Works Council representatives in the pilot phase and meetings on the evaluation of the results of these pilots.

The direct involvement of employees in the digitisation process is considered important by the company. But it is limited to those workers most directly affected by the technology or those with the greatest interest or concern, in general, middle management and other highly qualified workers. Although there is no comprehensive strategy for employee participation in innovation processes, the interviewed innovation manager confirmed that consultations are carried out to seek the opinion of the workers involved as end users of the new technology-based tools on the changes to be introduced. Face-to-face regular meetings between department directors and deputy directors, and employees directly involved in the introduction of the technologies, for example, engineers' teams in charge of technology development. In contrast, the Works Council states that in relation to technology, as it is a top-down process, information is usually provided on how the digital technology will be introduced, the impact it will have on work practices, compliance with data protection, etc.

Also, participation is allowed once the introduction of the technology has already been approved; for example, in terms of raising concerns or provide feedback which are usually addressed by management. These concerns are channelled via line managers. The main concerns that workers expressed were related to the monitoring capabilities derived from IoT tools and training required to operate the new digital based systems. In general, both top management and middle management are working on improving the communication on innovation and creating direct and more effective channels for participation.

3. Impact of the technologies in the workplace

Changes to the business model

Overall, digitisation has enabled CABB to adapt to new requirements in the water sector and become more efficient, which is of significant value as a publicly owned company. These new requirements were: (1) accessing a large amount of networked information in real time using IoT; (2) reduce commuting and physical presence of workers for inspections and maintenance operations thanks to the technology (by enabling the supervision of the water distribution network using drones equipped with IoT sensors) and (3) replacing fault detection with an alarm system and predictive maintenance that facilitates the anticipation of problems. In the business model preceding the changes, the limited digitisation required more physical presence of workers (e.g. to take water consumption records and manual data collection), more travel for tasks related to the maintenance of the water network, as well as much more time to manage and analyse the information generated by work processes, which is now promptly recorded by SCADA system through IoT monitoring (for example data on water flow, chemical properties or consumption at different points in the network, etc.).

The adoption of IoT enabled the company to have more information on the performance and status of equipment and the water network, leading to a more efficient business model. In addition, digitisation has made it possible to adapt to new challenges. Digitisation has favoured CABB's contribution to (1) the preservation of natural and environmental resources (for example water reuse), (2) improving occupational health and safety and (3) safety (for example less driving to check possible breakdowns in the water network). CABB reports to the Basque government on their contribution to the SDGs (United Nations Sustainable Development Goals) and its annual environmental declaration[4] is a testimony of their commitment to the SDGs. Digitisation has also enabled greater transparency and enhanced communication both internally and in terms of customer service: workers know the exact time when an order is issued (for example real time control of ammonium dosage of water being purified or customers can check the status of their consumption at any time).

Being more recent implementation, VR and AR have not yet affected CABB's business model in depth, but they have improved the efficiency of work processes and reduced the need for travelling. While VR has made possible virtual visualisations of construction and installation projects through the BIM software, AR - with drone support - has enabled more effective and accurate preventive maintenance dealing more efficiently with the challenges posed by infrastructure obsolescence.

Impact on work organization

Internal organization and decision making

The introduction of the SCADA monitoring system fed by data collected and transmitted from a range of IoT sensors installed throughout the water supply and distribution network has facilitated the control and management of water treatment and purification processes, and improved

[4] CABB Environmental Declaration (2019): https://www.consorciodeaguas.eus/web/GestionAmbiental/PDF/Declaraciones/Declaracion_Ambiental_2019.pdf

communication across different departments. In addition, the installation of IoT based smart water consumption meters and leakage and flow monitoring sensors have enabled the collection of more reliable and detailed data about water consumption, enhancing the efficiency of water delivery and use and significantly improving information management: ‘*you no longer have to go and write down the data, the data come to you’*, according to an interviewed middle manager. These conditions facilitate decision-making by technicians, deputy directors, and heads of unit (especially in the technical services and operations and asset departments), given the quality and timeliness of the information recorded (for example recording the water flow in a given area of the network to check if it needs to be increased).

The integration of BIM with VR enables technical staff in the operations department to cooperate with the asset and technical services department in visualising projects in the initial phase, as well as in their subsequent development phases. These are usually engineers or other technical professionals. Asset and technical services require both the construction of new facilities (e.g. tanks, pipelines, warehouses) as well as the renovation and maintenance of existing ones (e.g. improving the water supply). For this, BIM allows a comprehensive visualisation of waster network infrastructure and installation projects (including building, renovation and repair work), thanks to VR-generated models, which provide quality images and data in real time. In fact, the work team can arrange meetings within the model, all of them making a simultaneous visit using the VR goggles, discussing online the strengths or weaknesses of the project (for example possibilities to ease access of operators to the sewers).

In terms of decision-making processes, BIM enhanced by VR capabilities enables data-rich models facilitating individual decision-making and eliminating a large part of the communication between team members, as well as reducing requests for approval within the line of command. VR also makes it possible to visualise safely the different parts of CABB water network in a virtual environment, allowing decisions to be made with significant savings in time and travelling.

Moreover, the use of AR drones equipped with IoT sensors makes it possible to visualise the entire water network by mapping and generating high quality images. This is particularly useful for maintenance operations, as faults and breakdowns are located without the need for manual point-by-point checks. Once the main source of the problem has been analysed, the necessary personnel are dispatched to execute the fixes. This way the AR application significantly simplifies decision-making processes for technical staff in the asset and technical services department.

Workflows, quality controls and standards

With regard to workflows, the technologies have brought important changes in four aspects as reported by the directors and middle managers interviewed. These are:

Streamlining of operations: the use of SCADA and AR drones -both IoT based- and BIM+VR has enabled real time access of quality data to workers at all levels.

The introduction of the IoT-based SCADA system was an important technological leap for CABB, which has enabled the transition from hand-held records taken by operators to purely digital data. Thanks to this advanced IoT application, there has been a shift from ad-hoc supervision in case of malfunctions to continuous monitoring and predictive maintenance. The comprehensive monitoring of the entire water network allows potential failures to be detected before they occur, helping to develop the company's new culture of ‘predictive maintenance’. In addition, the use of AR drones equipped with IoT sensors has facilitated maintenance tasks by visualising the water network in augmented reality, making it a use case of combined technologies.

The work carried out with BIM and VR allows technical staff in the operations department and asset and technical services department to have a comprehensive visualisation of projects (for example construction work, renovations or repairs), thanks to the models generated with VR, which provide quality images and data in real time, greatly facilitating the development of the maintenance and building tasks. Work teams can enter the virtual model generated in BIM at any time, holding online work meetings that greatly facilitate coordination.

Overall, digitisation in CABB had boosted communication and data exploitation, and resulted in less travelling for on-site inspections and more generally time savings. As a consequence of all the above, greater efficiency has been achieved in the management of operations at CABB.

Simplification of bureaucratic processes: since the early 2000s, the innovation department has been tenaciously promoting a complex process of replacing paper with digital data. Today, with the IoT contribution to SCADA, in addition to the adoption of BIM with integrated VR capabilities, a high level of digitisation has been achieved, which makes it possible to streamline procedures, reduce time and improve internal communication.

Reduction of errors: in the areas of supervision and maintenance, the company has developed the so-called 'culture of preventive maintenance', as noted above, because of the high level of digitisation achieved, particularly, through IoT developments with SCADA (new alarm-based system) and AR drones. In the first case, any failure related to water distribution (e.g. inadequate flow, excessive consumption) is automatically detected, and in the second case, any deficiency in the network infrastructure is automatically detected (e.g. failure of pipelines).

On the other hand, the combination of BIM with VR has enabled the development of projects by the department of operations (construction work, renovations, expansion of existing facilities), while minimising errors thanks to the visualisation of models that allow the anticipation of possible malfunctions.

On the whole, the digitisation process increased productivity (and profitability), but certain efforts in its transition to obtain further return on investments (in particular, new investments in high technology and staff training). Moreover, as the innovation manager pointed out, technological advances in the establishment have facilitated the adaptation to more specific and advanced environmental regulations (ISO 24512). This has been an additional motivation for the introduction of new digital technologies. In addition, the introduction of IoT and AR/VR-based technologies allowed for more accurate updating and development of quality protocols, instruction manuals for machinery and systems in the water network and rules on labour risk prevention.

Employee monitoring and control

The current IoT and VR/AR applications at CABB greatly increased the company's possibilities to control and monitor workers' movements and the operations they perform. In fact, given the intense digitalisation of data in the company, everything can be recorded (e.g. entry and exit of workers into and out of the different facilities; checks made on the flow or composition of water), and almost all information is recorded and analysed. This has greatly simplified the work of staff in control functions.

The use of SCADA makes it possible to control the operations carried out by workers (e.g. plant operators, or maintenance operators) by providing complete data (about operations performed, quality of the work, start and end time, etc.). If there was an error, a malfunction, or simply an operation did not go well, the controller can always go back to the starting point and review the steps taken. In addition, over time, SCADA logs data that can be processed individually or in groups for later analysis. Taking some examples, this is the case for the deputy director of the asset management department, who can monitor closely maintenance operations performed, including execution time, persons involved and adjustments made, among other data. Or the case of the deputy director of municipal networks, who can keep an accurate record of the problems that have occurred in the sewage system of a particular locality in the metropolitan area, as well as the interventions carried out there by the operators. In addition, the use of AR drones perfectly complements the possibilities of monitoring maintenance work, once it has been carried out.

The use of BIM and VR allows the comprehensive recording of every step in the building projects, renovation work or expansion of existing facilities executed in CABB. If there are errors or simply discrepancies about the interventions carried out, it is easy to go back in the model to review the process and identify the reasons. In this way, the director of technical services or the deputy director of projects and sanitation works can review the work of the operations department technicians during the development of the project, identifying problems, errors, solutions, etc. In turn, technicians can review the different interventions of work operators during the development.

Combining the described technologies, the possibilities of inspecting the fulfilment of the tasks of a specific worker are wide-ranging. However, despite these extensive possibilities, a strong monitoring culture has not developed, and the majority of staff does not perceive excessive control enabled by the technologies.

Regarding the data protection and employee privacy policy, the company is applying the current General Data Protection Regulation, following Directive 95/46 (EU), which has been implemented since 2018. According to CABB HR department, the regulation is routinely communicated to employees and the implementation of the Directive within the company is strictly enforced. However, no specific committee has been set up in CABB to deal with data protection issues and privacy rights of workers. Beyond the legal issues, management emphasised the importance of the exclusive use of data to meet the strict requirements linked to work processes, as well as the need to look after the data protection and privacy aspects of the employees. There have been no major conflicts or complaints about data protection issues so far. The management stated that performance metrics are not applied and IoT is used for the monitoring of water network processes and staff interactions with machines and equipment.

Task definition and content

The evolution of CABB staff tasks has been very significant, based on the implementation of IoT and VR/AR. In general terms, management points to a progressive substitution of operational, manual and routine tasks by complex and cognitive tasks. In addition, there is a shared feeling that bureaucracy has been simplified, time spent on administrative tasks reduced, and an overall improvement in the quality of service achieved.

The weight of the technological revolution in the company has fallen mainly on the two more technical departments: operations and asset management and technical services.

BIM, enhanced by VR capabilities, is used by the operations department to design and execute renovations at various points in the plants and the water network, as well as to carry out new constructions (e.g. extension of the water supply). This work is mainly carried out by engineers as well as other technical professionals. BIM allows a perfect modelling of the projects in execution, with high quality images and data with continuous updates. Technicians can enter the model at any time, making visualisations with VR goggles, both of the modelling and the work in progress, detecting possible errors before they are made on the building site, thus allowing rectification in time (e.g. the observation in the space being planned that access for an operator with all his tools is going to be complicated due to the narrowness of a corridor).

The main internal customer of the operations department is the neighbouring asset management and technical services department (mainly composed of engineers). They are the most interested in the correct development of the works, as they are responsible for their subsequent operation and maintenance. Therefore, technicians and middle managers from both departments work regularly as a team. The asset and technical services managers access the modelling provided by BIM and VR and observe every detail of the project, as well as the gradual evolution of the works. At the same time, they can share their day-to-day needs and difficulties with the operations department staff, generating a constructive exchange of feedback. This agility and flexibility in the development of operations was inconceivable in the previous model. At that time, the management and technical staff of both departments had to travel regularly to review, on the ground, each step taken in construction, renovation and repair work.

Also, the SCADA system was boosted by IoT, promoting the development of preventive systems based on the use of sensors and alarms that have simplified control functions. The intense monitoring of the water distribution network allows the technicians in the asset and technical services department to control the water flow and detect and analyse leaks in the entire network, in both cases thanks to the new digital sensors, which also incorporate an advanced alarm system. This greatly facilitates the proper control and maintenance of the water network, developing a culture of prevention in which potential errors are addressed before they occur (e.g. if the dosage of a chemical product in the water has to be decreased, detection is given in advance).

In addition, thanks to SCADA with IoT, a system has been developed in which all water meters in the distribution network are connected to each other by radiofrequency. This includes the registers of private consumers as well as those of large institutions. This allows complete control and supervision by technicians and middle managers of this department from the office itself. Thanks to these technological advances, the data generated are exploited and analysed with computer support, generating very useful feedback (e.g. by observing the evolution of water consumption in a certain area, you can predict the flow levels to be maintained there). This set of circumstances has changed the performance of technical staff in this department. In the pre-digital era, leak detection and water flow measurement were less accurate, and could not be performed with such regularity. In addition, water consumption meters depended on manual, one-by-one data collection, so obtaining consumption data - both separate and aggregated - was much more time-consuming and coordination between departments was difficult.

AR with the support of drones has greatly facilitated the maintenance work of this department. The drones - in continuous communication with the offices via IoT - record images of the entire CABB. In this way, technicians can identify any type of malfunction that may occur, as well as the exact location to which the operators must travel to carry out the intervention. Consider that, in the previous model, these operations involved a complex coordination of tasks, both for the diagnosis of failures and for the execution of repairs. Thanks to these improvements in work processes, technicians and managers have gained time to submit innovation proposals or participate in new added value projects for the company. Among them, the innovation director highlights the introduction of the “innovation tips”, taken advantage of these temporary margins: 3-minute videos about technological innovations introduced in the establishment, that each department broadcasts for the whole CABB, trying to improve the knowledge of the entire workforce, while keeping them informed.

At the middle and lower occupational levels, as the main changes in tasks has involved a shift "from annotation to electronic recording". Guards, plant operators and shift supervisors are particularly affected by these changes. Guards monitor wastewater treatment plants, alerting about possible security lapses or trespassing. These guards, in the pre-digital stage, had to carry out these functions by making continuous tours of the plants. Physical proximity to the monitored element was important (e.g. tanks, pipes). However, with the new alarm-based monitoring system powered by SCADA, there is no need for a continuous physical check of each plant. On the other hand, plant operators - in the pre-digital stage - were responsible for carrying out checks and records manually, covering operations such as: controlling water leaks and the flow rate in the distribution network, checking the dosage of chemical products in water treatment, and recording water consumption at the different distribution points, by decentralised meters. The new digital IoT based system has significantly reduced the number of staff needed to cover night and weekend shifts, both in guard and plant operator positions, with the consequent gain in quality of life for these workers. On the other hand, shift managers are in charge of reviewing the work of guards and plant operators. In the pre-digital stage, they were in charge of collecting the work reports that the guards and plant operators handed out on paper. Now, however, paper is no longer used, having been progressively replaced by digital devices. In addition, the information generated by each shift is largely collected in SCADA (e.g. for plant operator the state of the flow, or data on chlorine in the water), greatly simplifying the supervision work. The shift supervisors have still to organise shift coverage of the plants on a 24/7 basis. CABB's advanced monitoring –powered by SCADA– has however eased the pressure of shift work for plant operators and guards, as fewer staff are now needed to cover nights and weekends

Impact on job quality

Physical environment

IoT and VR/AR has had a moderate impact on the physical environment of employees. According to interviews, the influence of this technologies is observed in the daily use of new digital tools (digital online monitor sensors, smart flow and pressure meters, smart water consumption meters and leakage monitoring sensors, intelligent predictive alarms, virtual reality glasses, etc.). As a result of the introduction of IoT in the SCADA system, some older meters and flowmeters were replaced and the need for manual contact with the machines was reduced. Thus, for example, reading flow meter or performing diagnostic tests can be done remotely now from the monitoring station, reduces the requirement for water network visits and manual data capture. Now, the data is collected automatically with data loggers (for example data on flow, pressure, potential leaks, etc.) and processed by a centralised SCADA system with data analytics capabilities. The implementation of both IoT and VR/AR technologies has entailed a shift from exposure to some ambient and chemical risks particularly for operators to more ergonomic risks, due to more sedentary work by changing the physical environment (e.g. doing work in front of a computer monitor; tablets, smartphones or drones are now commonly used instead of paper or traditional machines and tools).

The impact of new digital technologies has been very significant in the prevention of occupational risks and the creation of internal specific protocols and regulations, that instruct operators on how to perform the tasks and what steps are involved. This is a very relevant aspect for the establishment given that the traditional activities of blue-collar workers or water network operators involve very diverse risks (for example ambient risks for example exposure to very high or very low temperature, high humidity, noisy environment, bad odour pollution, ergonomic risks in manual operations, exposure to chemicals, etc.). As a result, the adopted IoT and VR/AR technologies have slightly increased safety of the working environment because they reduced the necessity of on-site inspections and daily contact with machines and the exposure to risky environments to perform monitoring, data collection and maintenance operations.

Furthermore, the IoT with SCADA system does not automatically allow an operation to be carried out without remote permission, which facilitates and guarantees compliance with occupational safety and environmental sustainability protocols. The introduction of AR has been an even more important improvement because it greatly improves work in more dangerous or difficult to access environments because the rugged terrain. Concerning VR, construction and renovation of infrastructure projects are now reviewed by the different departments involved easily and without the need to visit the sites (which saves time and costs). This allows better measurement of occupational risk assessment and correction of designs ex-ante.

The physical environment of white-collar workers has not been affected as much, although more employees access data on their computers to operate IoT and VR/AR software. Several employees and works council representatives expressed however concerns about ergonomic risks due to long hours of sitting in front of their computers. This concern has increased with more staff teleworking due to Covid-19 given the poorer ergonomic conditions at home compared to those in the workplace.

Social environment

The use of IoT has facilitated more detailed access to information on all processes of the water cycle in a systematic way, making employees' tasks easier (in particular, employees in technical occupations and managerial positions at the headquarters where the information is centralized and analysed). For example, shift changes for operators are now made easier and more efficient thanks to the IoT technology because information is always available in real time. This has changed the social environment by making more information about the functioning of the water supply and treatment network, and a better company overview available to employees in managerial and engineering positions.

While there was no specific approach to change management, there has been an ongoing commitment to communicating changes to employees directly involved in the changes. Thus, the Innovation Unit has held regular meetings with different employees involved in the use of these technologies or launched a newsletter on innovative activities. According to the interviews, there is an important role for informal channels in communicating these innovations. For example, in addition to the formal training provided by the company, informally a part of learning new software and solving small technical questions is based on peer support and collaboration. As a result, the team cohesion among employees has increased.

More generally, the digital devices introduced over the last years have greatly facilitated the running of operations remotely during the Covid-19 pandemic. In particular, IoT has allowed managers and technicians to access real time data remotely from home for also. Remote working has however weakened the social climate among employees. To reduce the negative impact of teleworking, the facility's middle management has made efforts to maintain direct and frequent communication with employees through a range of digital tools. Both interviewed employee representatives and workers say that although teleworking is here to stay in some not inconsiderable proportion, the human factor and face-to-face contact is necessary to facilitate teamwork, so the company must seek soon a balance between the two models.

In terms of the technologies focus of study, IoT has reduced face-to-face communication between employees and reduced paperwork by making all data available in real time on accessible dashboards in the control center. VR/AR has also reduced the need for site visits and travel between sites for water network infrastructure projects and facilitated occupational risk assessment through virtual reality or predictive maintenance with augmented reality. VR and BIM have contributed positively to the social environment by improving communication, information sharing and collaboration between different departments. As mentioned, its main effect in this sense is to allow remote inspection of projects or to show preventive maintenance elements in a simple way to the different work teams, as opposed to the difficulties to work with 2D plans. For example, evaluation of water network infrastructure projects with virtual reality glasses is streamed via a video conference that allows for a direct communication between employees who are in and out of the VR model. Although all this may lead to less social contact, it is positive in that it makes information more transparent, reduces the need for travelling and favours compliance with restrictive measures in the context of COVID-19.

Work intensity

In general, the autonomy has increased in the establishment with the introduction of digital technologies (IoT and VR/AR) for the middle management (department and deputy directors, and heads of unit), staff in professional technical positions (for example engineers), and administrative roles. The opposite is true for plant and maintenance operators for whom the technology sets the order of tasks and the speed and pace of work via SCADA system. For example, a flowmeter cannot be opened or closed unless the system gives the command. While the introduction of the IoT system has resulted in less physical work for operators and enhanced occupational safety, it has increased work intensity.

According to the interviews, the workload remained at a similar level, as the time freed up by the new technologies was filled with new tasks. A slight increase in employee stress levels was recorded during the process of learning the software and adapting to new tasks and responsibilities. Once the technologies were fully deployed, the increased process monitoring and control capabilities of IoT technologies, as well as predictive maintenance mechanisms enabled by IoT and AR, reduced the likelihood of errors and, to some extent, stress levels.

This shift towards greater work intensity and flexibility has been particularly noticeable for white-collar workers (engineers, designers, administrative staff) and especially for middle management. The innovation manager and the employees comment that the introduction of IoT technologies and BIM methodology has greatly increased performance and productivity, largely because each employee now performs many more tasks than before with the support of integrated digital tools (networked sensors attached to outputs and inputs, components or electronic monitoring systems), such as data analysis and interpretation, design and innovation, system evaluation, etc. So, this increased employee productivity is related to the support provided by digital technologies, while increased efficiency is related to higher pressure for staff by system monitoring, better real-time data collection and predictive maintenance of the water network due to IoT. As reported in the interviews, the learning curve was high in the initial phase of technology deployment with a slowdown in performance; once employees have become familiar with the new digital-based working methods, performance and productivity have increased significantly.

The use of VR/AR had less effect as it is being used for specific, one-off tasks, affecting less work intensity. AR has facilitated some processes in predictive maintenance work by improving overall well-being at work because the workload in risky environments has been reduced. VR has facilitated occupational risk assessment tasks or evaluation of water network infrastructure projects tasks.

Working time quality

Digitisation has made it possible to improve the working hours of a plant operators because some night shifts and weekend shifts have disappeared (during night shifts operators performed control and data measurement of the water supply and treatment network). Although the establishment continue to operate 24/7, digitisation with IoT through monitoring, digital sensors, SCADA visualisation from the control centre, etc. has made it possible to reduce the number of employees on night shifts and holidays, thus overall improving working time quality. Also, the use of AR in maintenance tasks is reducing the time operators are exposed to risky environments (sewage atmospheres, difficult access areas, etc.). In contrast, for employees in technical and managerial positions the working time quality has not much improved because they have a continuous flow of data to analyse and the technology has expanded the range of tasks to perform.

In general, CABB employees welcome the change brought about by the IoT and VR/AR. According to the interviews, employees positively value the ability to monitor and control processes remotely, better data management, more flexible working hours and opportunities to telework. As a result, employees report higher job satisfaction because along with the increase in their productivity and work efficiency, there is a positive effect on the working time and work life-balance. However, for the white-collar professionals in technical and managerial positions, a further challenge is the reduced ability to disconnect due to the ease of accessing information and systems at any time.

Skills and discretion

The change in skills and autonomy plays a crucial role in the digitisation process in CABB. According to all interviewees, the introduction of IoT technologies supported the development of a range of new skills (data analysis, programming, problem-solving, etc.) and has resulted in increased autonomy and responsibility for all employees in the establishment, especially for engineering, technical and managerial positions. Access to better quality data generated and shared through the new BIM and SCADA systems allowed employees to have a better oversight of processes for which they are responsible, reducing reliance on management in their day-to-day work. For example, employees can take more decisions autonomously on the basis of the data collected and analysed by the system without checking with the managers.

For all employees, the learning of new skills has mostly occurred via specific training courses and on the job training. An increasing diversity of tasks has also resulted in more opportunities for learning on the job. For most employees and management, learning to use new digitized tool was a challenge, but overall technological change has increased job satisfaction among employees.

In the case of manual and middle-skilled blue collar workers (e.g. plant operators), a large number of manual data recording and control tasks have been fully digitised, with workers taking on more supervisory, analytical and interpretative roles, which requires new analytical skills. This implies a change of job profile for the blue-collar workers and involve an upgrade of their jobs. Although, as explained above, this change implies a lower level of autonomy because technology sets the tasks and the speed for this job profile. For example, plant operators now execute tasks when flagged by the SCADA system through the IoT intelligent alarm system.

For the white-collar workers (e.g. engineers, designers or managers), the availability of more information through digital technologies has facilitated: a) a greater autonomy in decision-making through pre-modelling with IoT data, b) predictive maintenance with IoT and AR technologies, and c) infrastructure assessment and occupational risk assessment with VR. This transformation has improved the communication and availability of much more detailed and real-time information. The weight of the technological revolution in CABB has fallen mainly on middle management, with these positions being the ones that have most transformed their skills and tasks due to their importance in the control of processes, project design and implementation of innovation. Thus, the new skills required and the new tasks performed by white-collar worker are related to data analysis and processing, programming, problem-solving, networking, etc. In addition, the HR manager highlighted the importance of other soft skills and competencies including adaptability, ability for doing varied tasks, and continuously upskilling.

The training that employees receive is of a mixed nature, i.e. it is provided by the company itself and external providers. Training can be classified into three main types: technical skills, occupational safety and health training, and soft skills and languages.

First, technical skills training is intensive and is intended exclusively for workers who will be using the specific technology and includes, for example, software, data analysis, programming, etc. In addition, the digital transformation at CABB opened up opportunities for plant operators to use computers or tablets in the workplace, to familiarise themselves with industrial software such as SCADA and BIM, or even communication software, such as Microsoft Teams. Employees and the works council value positively this training and the opportunities it offers to improve employees' careers. For some older employees this was a major achievement because they benefited from this and felt more comfortable with the use of the new digital devices. Although, according to the interviews, informal mechanisms and peer support and on the job learning are equally important.

The occupational safety and health training is a more general training for the whole workforce applied to the peculiarities of each position and has been reinforced by new internal regulations since the introduction of digitalisation. Digital technologies made it necessary to create and comply with stricter quality standards and regulations than before the digitisation process. For example, the implementation of digital sensors and digital flow meters, remote access to data on the water network, pooling of 3D spatial information using BIM, etc. required specific training of staff on the new protocols. Also, AR enhanced training and helped to prepare employees for certain high-risk activities (for example high voltage work or the handling of chemicals such as water chlorination), thus improving workplace security. In general, these new trainings and skills have been well received by the employees and have improved the job quality.

Finally, soft skills and languages are of some importance, especially the learning of Basque (co-official language with Spanish in the region and which awards points in public competitive examinations) and proficiency in English which is necessary for programming and handling specific software (SCADA and BIM for example).

According to the information obtained in the interviews, important obstacles and challenges are identified regarding the training of employees to adapt to digitalisation. First, one of the main internal barriers to digital transformation in CABB has been the significant age gap in terms of digital skills and open-mindedness towards innovation. This is because CAAB has an ageing workforce, with some interviewees mentioning the risk of some older employee being left behind in this phase of profound technological change. This manifests itself in slower acquisition of new skills and daily difficulties in the advanced use of specific software. Secondly, employees on temporary contracts have less access to training and fewer opportunities to develop specific technology related skills. In addition, the public competitive examinations and, in the last year, the COVID emergency take up a large part of the HR area's work, leaving less resources and time for training plans. Thirdly, the interviewees also point to the lack of a culture of innovation in the workforce, which they relate to the peculiarities of being a public company and the scarce training linked to change management to foster greater openness to change, AGILE methodologies and innovation among employees. The lack of an integrated training plan on innovation is pointed out by several of the interviewees as one of the main challenges to be faced by the company in the coming years.

Finally, there has been a change in employee recruitment profiles due to the needs imposed by the introduction of new digital technologies. According to HR managers and the workers' representative on the works council, there has been a progressive demand for employees with higher university education, especially in the field of engineering, telecommunications and design. On the other hand, job offers with lower qualifications have disappeared. As it is a publicly owned company, all recruitment and the profiles offered must follow a strict and time consuming administrative process. This implies that the recruitment of staff with qualifications in new technologies is not a solution for this establishment in the short term. However, as a result of the important technological change, in recent years, specific subjects on digitalisation and some of the tools and software used (SCADA based on IoT and BIM methodology linked to VR/AR) have been incorporated into the competitive examinations for merit for recruitment of new staff.

Prospects and earnings

Digital technologies are not directly used to assess employee performance at CABB and are not linked to earnings. Being CABB a public company, the wage policy is highly regulated and has an important weight in collective bargaining led by the trade unions. CABB's salary level is comparable to that of other public companies, which means that most of the staff receive a medium-high salary by Basque Country standards (higher than average Spanish standards). In the medium to long term the increase in the number of higher qualified jobs and new skills (through training, reskilling and upskilling linked to new digital technologies) may result in higher average salaries in the establishment.

The 2016 collective bargaining agreement introduced a new employee performance appraisal system, which only slightly impacts on employees' final earnings, but is not directly linked to technological change or use of digital technologies. This performance appraisal system only evaluates generic aspects of employee's performance by a superior. This performance appraisal system offers employees the possibility of flagging training needs and proposing specialised training courses. According to the management, it may be used in the future, to assess employees' innovative attitude and used as a tool to encourage and compensate a commitment to technological change.

Both from a management and employee perspective, new digital technologies also open up opportunities for career prospects based on experience and training. However, staff turnover in the establishment is low and retention of qualified staff is not a major issue because of the security of public employment. Apart from basic computer skills developed by all employees to adapt to a more digitized way of working, the quantitative analytical, programming or engineering design skills developed by employees are of added value for the establishment and creates opportunities for occupational mobility. This is especially true among engineers, staff in administrative and managerial positions for whom the use of IoT and VR/AR technologies may advance their professional development within the establishment (and also are easily transferable to other industrial companies), provided that they continue learning and gaining experience in new digital tools.

The interviews with employees highlighted some concerns of a potential long term effect of digitisation and automation in terms of lower-skilled jobs losses, but only to a limited extent in consideration of the high level of job security in CABB due to its public ownership.

Lessons learnt and take-aways

The digital technologies introduced over the last decade in Bilbao-Bizkaia Water Consortium (CABB) have made business and work processes more efficient. The digital transformation started with the introduction of smart grid technologies based on IoT to monitor, control, manage and optimise the water supply and treatment network, as well as to improve information flow and communication across the organisation. These digital technologies are seen as enabling a shift towards a smart city model and environmental sustainability aimed at improving the quality of water service to citizens (for example, through the use of digital smart meters providing real-time data on water production and consumption, smart flow and pressure meters, water quality sensors or monitoring of industrial discharges).

This case study stands out for the combination of technologies as exemplified by the use of AR drones equipped with IoT sensors to assist in predictive maintenance operations. This introduction of AR has led to improvements in asset management in the water network. In addition, AR has also been used for the training of employees to prepare them for high-risk tasks (for example high voltage work and handling of chemicals). The establishment also introduced VR for better modelling and visualisation of water network installation projects using the BIM methodology, which has improved the assessment of occupational risks.

The main lessons learnt from the digitisation of this establishment are the following:

- The introduction of IoT technologies had the most significant impact on the business model, work organisation and job quality in the establishment. The adopted VR and AR solutions were less impactful because both technologies have been introduced only for specific activities affecting fewer employees in specific occupations (teams of engineers and designers from technical services and operations and asset department). However, both VR and AR are regarded by the management as technologies on which to invest more and with greater untapped potential for the establishment.
- With regard to changes to work organisation, the introduction of digitisation technologies has contributed to streamline workflows with a general reduction in execution times (for example data analysis tasks and industrial spill control tasks with IoT, predictive maintenance tasks with IoT and AR, occupational risk assessment tasks with VR, etc.) and improved efficiency in the management of the water network. This has also entailed a shift towards more cognitive skills and tasks and less physical tasks. According to the interviewed managers and technicians, the adoption of the technologies has contributed to streamlining operations, simplifying bureaucratic processes, reducing errors in all areas and improving decision-making processes.
- The increase in control over work systems and processes has brought significant change to the workplace. Although some workers were initially concerned about the increase in digital control enabled particularly by IoT, this has not led to major labour disputes, thanks to the involvement and supervision of the introduction of digital technologies by the Works Council. For example, management consulted with employee representatives regarding the purpose of data collection to ensure that it is legitimate and proportionate and that data minimisation is applied.
- Overall job quality improved for all employees as a result of the introduction of the three types of technology studied in this establishment.

  - Occupational risks were reduced in the establishment: for example the use of IoT reduced the need of daily human contact with machines in risky environments to perform monitoring, data collection and maintenance operations. AR with drones equipped with IoT sensors facilitated specific activities in risky physical environments for maintenance by visualising the water network thus reducing physical risks for employees. AR also enhanced training and was used prepare employees for high-risk activities, thus again improving workplace safety. The integration of VR in the BIM software enhanced visualisation and modelling of water network installation projects with the aim of assessment of occupational risks in the construction and maintenance of water network infrastructures.
  - Employees in occupations with managerial and engineering orientation benefited the most from the implementation of IoT in the establishment, as their work autonomy and responsibilities increased. Also, the increased data flow generated by the IoT system improved communication within and between departments. By contrast, IoT reduced work discretion for maintenance operators setting the methods, pace of work and order of tasks via the centralised SCADA monitoring system.
  - The deployment of IoT and AR/VR technologies has created new skill requirements (including data analysis, programming, problem-solving, etc.). This change entails a greater demand for new qualifications, which in the medium term may lead to an increase in average salaries in the establishment. Upskilling and reskilling should however also target low skilled employees, fostering potential advancement to higher skilled roles and better employment conditions, otherwise a tangible risk is the downgrading of lower skilled occupations.
- Public ownership is associated with excessive level of bureaucracy and lack of flexibility, which sometimes hinders innovation. Therefore, in addition to the natural resistance to technological change among employees that is likely to happen in any establishment, it is necessary to deal with bureaucratic barriers inherent to public administration. This requires an adjustment of the communication approach to staff addressing all arising concerns. In this sense, having a solid and well-defined innovation strategy and a change management strategy are key factors for a successful implementation of digitisation in the workplace. Although the establishment does not yet have a change management approach, the plan for the near future is to have one to foster an innovative mindset among all employees and new ways of working that encourage greater direct employee involvement.
- One of the main obstacles encountered in the introduction of technology in CABB's day-to-day work is the significant digital divide by age. The workforce in this establishment has a high average age, which may have slowed down the extent of digitisation, with the risk of leaving some workers behind. In this respect, training is of great importance. A viable solution would be offering upskilling (providing employees with training to optimise their performance) and reskilling (training to retrain workers for new positions). Also, AR training is a simple solution with great potential with much wider applicability within the establishment.
- The establishment does not have governance around monitoring of employees' data and they do not use the data for employee performance monitoring. There is nonetheless the technical capability to exploit the data and employee representatives have a key role to play to ensure that employee data usage is legitimate and proportionate. In CABB, the Works Council ensured

that the IoT technology is not extended to other uses not foreseen or different from those previously agreed.

- Public funding has played an important role in the digitization of CABB (for example EU co-financing of the digital sensors project for monitoring of critical pollution parameters in industries). Similarly, the collaboration with other public institutions and companies as part of innovation clusters has equally facilitated the digitisation process in the establishment. These cross-cutting collaborations were essential to experiment with the technologies and ultimately paved the way to technology adoption and implementation.

Annex 1: Definitions and terms used in this report

Term	Explanation
Internet of Things (IoT)	Networked sensors attached to outputs, inputs, components, materials or tools used in production. This also encompasses electronic monitoring systems and wearable computing devices used for different purposes including monitoring work processes and employee performance and ultimately guiding management decision-making.
Virtual and augmented reality (VR/AR)	Technology blending the digital and physical worlds by superimposing digital information over human perception of physical reality. While VR is a computer-generated scenario that simulates a real-world experience, AR combines real-world experience with computer-generated content.
BIM (Building Information Modelling)	Software based on the use of virtual 3D models linked to databases of computer files which can be extracted, manipulated and exchanged to support decision-making. BIM makes it possible to produce and store all the information necessary to operate in the different phases of the life cycle of a construction in building and civil engineering.
SCADA (Supervisory Control & Data Acquisition)	System of software and hardware that allows industries for remote control and monitoring of industrial processes. It is gathering and processing real-time data, provides feedback to field devices and controls the process automatically which direct interaction with smart devices, and records events into a log file.
Programmable Logic Controller (PLC)	Is an industrial digital computer for the reception information from connected sensors or input devices, processes the data, and triggers outputs based on pre-programmed parameters. A PLC can monitor and record real-time data such as machine productivity or water temperature. It can also automatically start and stop processes, and generate alarms. It is used running parallel to SCADA.
PLM (Product Lifecycle Management)	Is a class of software for managing the entire lifecycle of a product from inception, through engineering design and manufacture, to service and disposal of manufactured products. Thus, PLM integrates people, data, processes and business systems and provides a product information backbone for companies.

Wastewater Treatment Plants (WWTP)	Is a facility in which a combination of various processes (e.g., physical, chemical and biological) are used to treat industrial wastewater and remove pollutants.
Drinking Water Treatment Plant (DWTP)	Is a facility in which a combination of various processes (e.g., physical, chemical and biological) in which water is treated so that it becomes fit for human consumption and supply pure drinkable water safe, reliable drinking water to population.

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