D7.7 Transferability assessment analysis

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Abbreviations

Abbreviation	Full name
WWTP	Wastewater Treatment Plant
WFD	Water Framework Directive
TRL	Technological Readiness Level
IEA	International Energy Agency
IE	Inhabitant Equivalent
O&M	Operation and Maintenance
UWWTD	Urban Wastewater Treatment Directive
N	Nitrogen
OPEX	Operational Expenditure
CAPEX	Capital Expenditure
AI	Artificial Intelligence
CPI	Chemical Process Industries
ANFEVI	Association of Glass Container Manufacturers in Spain
FAVIPLA	Association of Flat Glass Manufacturers in Spain
CFCG	Continuous Filament Glass Fiber

Executive Summary

This deliverable represents the Transferability assessment of the COCOP concept to various sectors, such as Wastewater Treatment, Chemical and Glass Manufacturing sectors, using the Steel and Cooper cases from the Deliverable 7.5 as a reference. All these markets seem to be very attractive and should present good potential for successful business and exploitation of the COCOP solution.

In summary, the document will cover the following sections in order to gather basis information to evaluate a market entry of the COCOP concept: market description with market potential estimation, business model description with a financial forecast, an identification of potential competitors and the corresponding exploitation routes and teams. Concerning the exploitation team, on the one hand, Wastewater Treatment and Glass manufacturing cases will be exploited by partners of the project since in the provided solutions different technological activities like automation and data management are needed combined with specific process knowledge. On the other hand, in the chemical sector it seems appropriate to establish a team with an external partner overarching view on the sector that can select the best (both regarding environmental impact as well as financial aspects) as well as concrete implementable options (with commitment from industrial partners) for further exploration.

Regarding the methodology used in this deliverable, an exercise for pivoting has been done based on three phases: Solution definition, Market feedback and Exploitation plan. The Solution definition focused on identification of available technical solutions in the actual scope of the project, the Market feedback aims at defining a new market segment with the similar pains which can be resolved with the developed solutions and, last but not least, the Exploitation plan where a feasibility study is done by estimating the implementation costs and the expected incomes.

1 Introduction

This deliverable describes the transferability options of the outcome of the COCOP project towards other potential sectors. It was concluded that the main characteristics of the markets where the COCOP concept could be applied were the markets with:

- continuous and batch-oriented production processes
- processes with automation islands
- a relevant environmental impact
- high energy consumers

The sectors of wastewater treatment, glass manufacturing and chemical processing are considered to fulfil these criteria and, at first sight, these markets seem to be very attractive and could present good potential for successful commercial exploitation.

1.1 Methodology

Making R&D as profitable or as efficient as possible is as important as spending or investing a good amount of money in research activities. One of the key elements of making R&D as profitable as possible is putting some relevant effort in bringing the developed results to the market: the foreseen and the unforeseen market.

It is obvious that the research activities are born having in mind some application area, some customers, some market segments with more or less detail depending on the TRL (Technology Readiness Level) of the developed products. While the tasks related to market contrast and feedback are commonly placed at the end of the project, it is becoming extremely important to start from day one with the market validation, especially where products with higher TRL are expected. In the same way that the R&D activities are based on a technological hypothesis and roadmap which has to be reviewed and fine-tuned during the project execution, the market segments must be validated and reviewed also. Market feedback must be integrated from the early beginning in the development process so that it becomes a more iterative process instead of a linear execution.

This market feedback can be done in several ways:

1. End-users from the partners involved in the project have a direct contribution which should not be necessarily expected from the resources from that same organization working in the project.
2. Creating a Special Interest Group that can have access into more detailed information, protected by confidentiality agreements, which combined with their recognized background, could allow them to provide many more steering information than just market feedback.
3. End-users from other players in the market. These end users can be approached with only public information on the results (what is done without knowing how it is done), but can provide relevant information on results alignment and usage as well as other “competitor” solutions in the market.

This is a sound approach for the foreseen market, but this can be completed with information of unforeseen markets. This means that within the multiple partial developments that are done in a research project, some can be applied “as such” to other markets and others with some kind of (maybe minor) adaption. This capacity to pivot to other but similar markets is being considered key to improve the profitability of the research projects. An exercise for pivoting has been done in COCOP, and the following methodology based on three phases has been applied (see Figure 1):

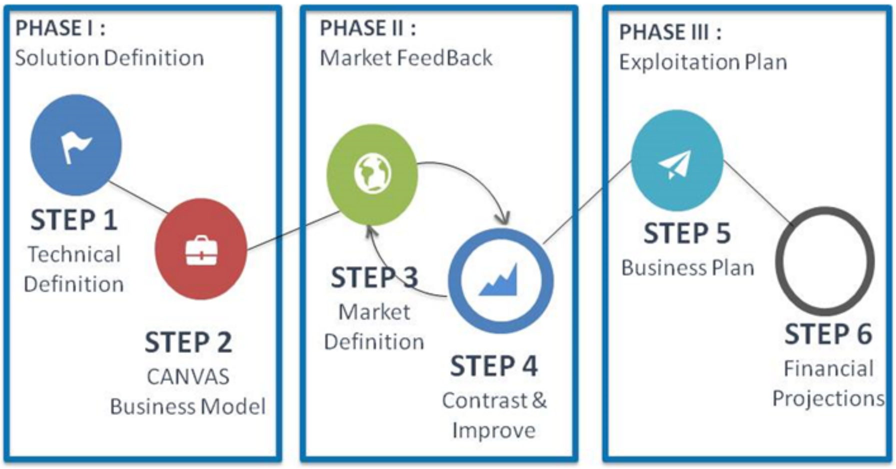

Figure 1: Used methodology to support the transfer of R&D results of a project to another sector.

- Phase I: **Solution definition**, focused on identification of available technical solutions in the actual scope of the project and with a first focus on the new market segments. This can be done in a very practical way with a workshop approach inviting people of trust from this market and applying the available methodologies like Canvas Business Model with special attention to the Value Proposition Definition.
- Phase II: **Market feedback**, aims at defining a new market segment with the similar pains which can be resolved with the developed solutions. This definition must be validated with a more detailed market study to ensure if this mental scheme is also recognized by players in the market. The market study should be set up in such a way that as a result the Canvas Business Model can be completed in a detailed manner afterwards.
- Phase III: **Exploitation plan**, in case there is a technological fit which resolves the identified problems, then must be checked whether there is an economic viability by estimating the implantation costs and the expected incomes.

When executing these three phases, the user is going through a process of abstraction of the technological solution from an existing market segment so it can be applied to another market segment by giving content to those abstract concepts. This process of abstraction & application is not only applicable for the technological part of the solution, but also to the market segment, the customer type, potential partners in the market and business model. Following this concept, in COCOP we have been able to realize a better transfer assessment from a solution designed for copper and steel towards the wastewater treatment, container glass production and chemical processing markets.

2 Wastewater Treatment Sector

Due to an advanced plant wide monitoring and control implemented in the WWTP, it is expected to increase water quality while reducing operation costs and environmental footprint merging the latest data analytics techniques with advanced automation and process knowledge. Adopting the COCOP concept helps enabling the optimization of the water treatment process in five clear steps linked with the digital maturity of the plant:

1. Data acquisition: Determine which information to collect from the process and its environment to obtain the right parameters.
2. Data centralization: Saved in a centralized database and pre-process to be converted into reliable data.
3. Plant-wide process scoreboards: KPI´s (Key Performance Indicators) are shown as comprehensive information in the specific plant-wide process scoreboard.
4. Sub-process optimization: Specialized algorithms will be implemented to optimize process units.
5. Plant-wide optimization: Integrated in the plant-wide coordinated solution to align contradictory goals and to find the best global solution for the plant.

2.1 Exploitation route

The different exploitation routes that have been raised are listed in the table below.

<table>
<tr><th>Product</th><th>Preliminary Exploitation Routes</th><th>Modality/method</th></tr>
<tr><td rowspan="4">COCOP solution for <u>WWTP Industry</u></td><td rowspan="2">Direct Exploitation</td><td>A new research project</td></tr>
<tr><td>Direct sales of software and / or associated services</td></tr>
<tr><td rowspan="2">Indirect Exploitation</td><td>Licensing</td></tr>
<tr><td>Build up a spin-off</td></tr>
</table>

Table 1: Exploitation route for WWTP industry.

Because of the actual TRL of the COCOP concept, the primary Exploitation Route is based on Direct Exploitation, where a new research project based on the concept is really feasible in different H2020 programs, since water and environment in general is an important societal concern. On the other hand, the concept can be offered to final customers in a stepwise approach via direct sales of the software and linked services. Indirect exploitation can be considered in the future also, when the solution implementations has become more standard, or even as a more configurable product, which is not the case nowadays.

2.2 Exploitation team

Since in the provided solutions different technological activities like automation and data management are needed combined with specific process knowledge, the number of companies can be limited since these capacities can be found in engineering services dedicated to the wastewater treatment sector. From the actual consortium, MSI combines great part of these capacities, although a partner for the specific data modelling for water treatment solutions should be found. Both Optimation and Tecnalia can take this role of data modelling. Concerning the market approach, MSI has direct access to the Spanish and Portuguese market, but for other Markets, business alliances should be set up to bridge language barriers and to guarantee proximity to the end user for optimum services.

2.3 Market analysis

It is a fact that water is a precious asset and essential for life, but for many years some parts of the world have taken their water supply for granted because drinking water flows from the taps. Due to this, many people do not think about the challenges that lie behind getting clean water or indeed how much of this finite resource we consume on a daily basis. Although water covers about 70% of the Earth's surface, we must rely on annual precipitation for our actual water supply. About two-thirds of annual precipitation evaporates into the atmosphere, and another 20-25% flows into waterways and is not fit for human use. This leaves only 10% of all rainfall available for personal, agricultural and industrial use.

Moreover, precipitation is not evenly distributed: 1.2 billion people are living in areas of water scarcity. What's more, pollution has made much of that water undrinkable and unsafe for use so water needs have fast become one of the biggest challenges facing society.

Another great challenge to be faced, and closely related to the above, is the energy consumption of WWTP, being one of the most expensive public industries in terms of energy. Although most of the objectives of the Water Framework Directive (WFD) in relation to water protection have been achieved, most of these aging plants show unsustainable energy consumption and must be optimized to the maximum and renovated accordingly.

According to the International Energy Agency (IEA), the energy requirements of the water sector in Europe amounted to around 80 TWh in 2014, about 2,6 % of EU electricity consumption and similar to the gross electricity generation of Belgium. This energy is used by the public water sector, which comprises the supply of drinking water, desalination for municipal use, and wastewater treatment. In the case of the US, energy consumption from the water sector is at a similar level, 4 % of the total, though it has been indicated that through energy-saving measures the energy footprint of the water sector could be reduced to 2 % or less.

Domain	Volume (billion m^3)	Energy (GWh)	Energy (share)	Share of EU electricity
Drinking water supply	49.5	35 000	43.5%	1.13%
Desalination for municipal use	2.1	20 695	25.7%	0.67%
Wastewater treatment	47.9	24 747	30.8%	0.80%
Total	99.5	80 442	100%	2.60%

Table 2: Breakdown of volume treated and energy requirements for each stage of the water sector in 2017. (Source: water volumes: [Eurostat 2018], [GWI 2018]).

2.3.1 Wastewater Treatment Context

First of all, EU Water Framework Directive (WFD) 91/271/CEE (ref. 1) made compulsory WWTPs for cities and towns. Now within the EU-28, in total, there are more than 19.000 plants across the continent, with an estimated total capacity of about 569 million IE (Inhabitant Equivalent) and total energy consumption of 24 747 GWh/year. Likewise, energy consumption from WWTPs creates emissions of more than 27 M ton/year of CO_2 in the EU.

Small plants (less than 50 000 IE) represent almost 90% of the total number of plants, but process only 31% of the IE and require 42% of electricity use. Plants from mid to very large size (more than 50 000 IE), being only 10% of the plants, process about 70% of the IE with 58% of the total electricity use. With highly stringent targets of efficiency improvement, saving of about 13 500 GWh/year could be expected through the implementation of energy efficiency measures, operational optimization of treatment plants, and addressing leakages and losses in the water network. The most easily exploitable source of energy in a WWTP is the biogas produced in the anaerobic digestion of sludge, yielding both thermal and electric energy.

Although several energy-neutral or energy-positive plants have been demonstrated at full scale of operation, for example the Viikinmäki WWTP (ref. 2) located in Helsinki, they are not yet the norm. A large-scale transition in this direction requires significant investments, usually possible only for new plants or major overhauls (and primarily for plants larger than 50 000 IE), and should be placed in a broader context. Significant improvements in the energy neutrality of plants have been reported for Germany, Austria and more recently in Denmark.

In respect of the Digital Maturity Readiness of the European facilities, it may be said that is diversified. In Central Europe area WWTP on-going fleet is more or less ready. Urbanization is trend and people want to live in cities globally. This trend requires capacity increases, modernization and in some cases also building of totally new units. Instead, situation is different in Easter Europe which is still under construction.

As a way of simplification, four management models may be distinguished across Europe:

- Direct public management: under this system, the responsible public entity is entirely in charge of service provision and their management. In the past, this system was predominant in Europe.
- Delegated public management: under this system, a management entity is appointed by the responsible public entity to execute the management tasks. Management entities usually remain the ownership of the public sector, although in the EU, in some cases, there is the possibility of a minor private shareholding.
- Delegated private management: under this system the responsible public entity appoints a private company to manage tasks, on the basis of a time-bound contract in the form of lease or concession contract. In the countries where this type of management is common, municipalities subcontract their duties to private companies. The ownership of the infrastructure remains in the hands of public authorities.
- Direct private management: under this system all management tasks, responsibilities and ownership of water utilities are placed in the hands of private operators, while public entities limit their activities to control and regulation. This system is in place in very few European countries (England, Wales, and the Czech Republic).

Apart from the general cases of England and Wales and specific cases in the Czech Republic, the ownership of water infrastructure across Europe is public. Public authorities are also in charge of approving the tariffs, determining the quality of service as well as setting and enforcing the environmental and health standards. Water tariffs contribute to recovering the costs almost everywhere in Europe, but its structure differs from country to country, but in the majority of cases, the tariff is made up of a fixed component and a volumetric component. Generally, water tariffs are proposed by the water operator to the competent authority for approval.

Concerning WWTP infrastructures, there are many similarities between all plants and from the distance they might look the same. A typical wastewater treatment plant will first employ screens and grit chambers to remove larger and denser material followed by primary settling tanks to remove slower to settle material. The water that leaves these processes is largely particle-free and fed to a biological treatment stage where high-density populations of bacteria, called activated sludge, biodegrade the carbon and nutrients in the water. The purified water is sometimes disinfected by UV light or chlorination, depending on season and local practice, and returned to rivers, lakes, and streams as a means of water reclamation (ref. 20).

Typical WWTP process is illustrated in the following figure.

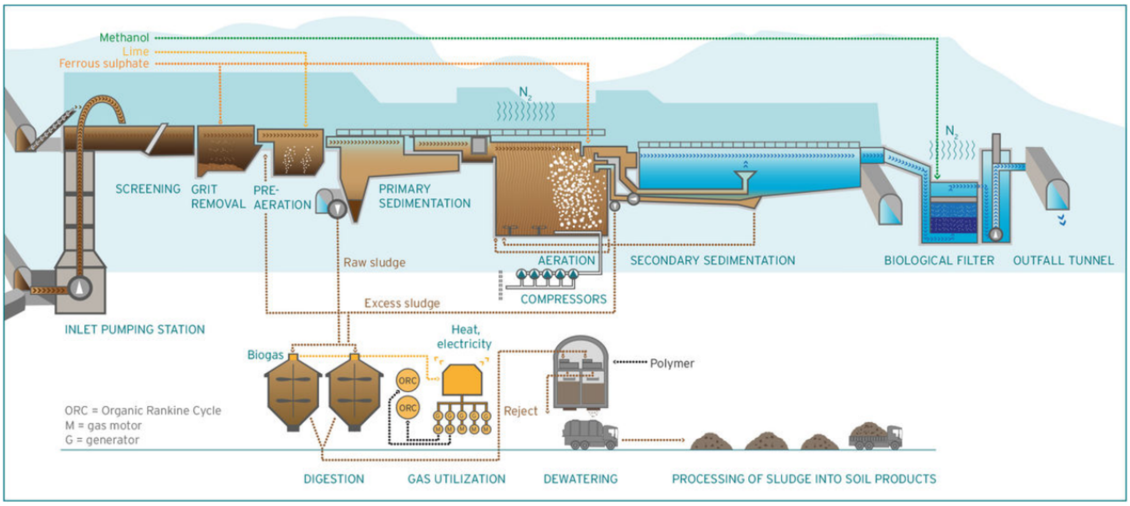

Figure 2: Viikinmäki WWTP´s process (Ref: 2).

- Mechanical treatment: In the first phase of the treatment, wastewater is screened to separate all solid waste, such as sand, grease, organic waste and other mixed waste. Removing the screenings and sand early on in the process is important so as to ensure that extraneous material does not hinder the treatment process and harm the equipment.
- Chemical treatment: Wastewater contains a lot of phosphorus originating from the protein-rich food and washing agents that we utilize, for example. In water systems, phosphorus causes strong eutrophication, which means that the water becomes overly enriched with minerals and nutrients and induces excessive growth of algae. Therefore, it is extremely important to remove it. In the chemical treatment phase, the phosphorus in the wastewater is efficiently precipitated with the help of ferrous sulphate, and it is bound to the sludge.
- Biological treatment: The organic dirt load and nitrogen of wastewater are treated biologically. The biological wastewater treatment phase utilities the natural bacterial strain of wastewater, which decomposes the organic matter contained in it. At the same time, the nitrogen contained in wastewater is processed to nitrogen gas with the help of bacteria. Some of the nitrogen is also bound to the sludge as bio-nitrogen. In secondary settling, the biomass containing organic matter and nutrients, for example, activated sludge, is separated from the treated wastewater by settling. The majority of the activated sludge is returned back to the treatment process to continue treatment.
- Biogas production: The organic matter contained in the sludge removed from water during the treatment process is further utilized by biological decomposition. Decomposition in an oxygen-free space generates biogas, i.e., methane. Biogas is used to produce fossil-free, i.e., carbon neutral, electricity and heat for the own use of the plants.
- Sludge Treatment: The sludge separated from the wastewater is, transported and can be post processed with disinfection before being composted into soil and soil condition.

It is expected that in the future these standard process steps will be extended with additional steps like removal of pharmaceutical contaminants which is becoming clearly a problem to be resolved in the next decades.

2.3.2 Market size

To determine the Market Potential, there are different information sources which can be analysed and there are at least two ways to do it (top down and bottom up), and we have used both ways as described hereunder.

2.3.2.1 "Top-down"

The "Top-down" approach is based on taking global market figures for "Operation and Maintenance (O&M)" - costs estimations and, when applying average percentages as confirmed in the literature, obtain the more detailed costs of different elements of the O&M. In the table hereunder the total cost information (for Spain) comes from Globalwaterintel, a market research company dedicated to the water sector. The percentages for the elements in a cost breakdown come from various sources of literature.

Estimated O&M WWP Cost (in M USD)	2014	2015	2016
Total Cost	2.901,00	3.039,00	3.262,00
Total Energy Cost (40%)	1160,40	1215,60	1304,80
- Aireation Energy (70%)	812,28	850,92	913,36
- Pumping Energy (30%)	348,12	364,68	391,44
Chemical Additives (20%)	580,20	607,80	652,40
Personal (30%)	870,30	911,70	978,60

Table 3: Estimated O&M WWP Cost (millions USD)

2.3.2.2 “Bottom-up”

Another way to estimate the market, is the bottom up approach, starting from the list of WWTP plants as can be found in the "Waterbase - UWWTD: Urban Wastewater Treatment Directive" (ref. 14) and summing up the plants which fit in the target market. First a distribution has been done by size, which is expressed in IE, Inhabitant Equivalent. This size expression is a design characteristic, and does not necessary match the actual treatment, since plants are designed for operation for 20-25 years and they consider population growth for the region in this time interval.

Although technically seen, the COCOP concept can be implemented in any size of WWTP, it is expected that in smaller plants, the relative impact (%) will be higher than in bigger plant. At the same time, the absolute impact will always be higher in bigger plants since there is a higher energy consumption. From Business Plan point of view the 50.000 Inhabitant Equivalent (50 kIE) has been selected as an initial lower limit for market introduction based on the following calculations. A typical energy consumption of a 50 kIE WWTP is between 1.200.000-1.500.000 kWh/year, with a cost of 0,10€/kWh, it is an annual cost of 120.000-150.000 €/year. If one can obtain an average energy reduction of 20%, it would generate an annual cost reduction of 24.000-30.000€ for customers. As specified later, this will be considered as a lower limit for profitability of our business plan.

As can be observed in the table hereunder 58,5% of the plants in Spain are rather small (<10.000 IE), but they all together represent only 6% of the treatment capacity installed. The next 26,3% of the number of plants, lies between 10.000 and 50.000 IE representing 13,2% of the treatment capacity. The last 15,2% of the plants are the ones with more than 50.000 IE, in total 328 plants and represent 80,8% of the treatment capacity. For WWTP with Nitrogen removal (N removal), this last group counts for 22,2% of the number of plants. The plants with N removal requirements, are more energy intensive than the others because of the blowers in the biologic step.

	All WWTP				WWTP with N removal Requirement			
WWTP in Spain - Sizes in Inhabitant Equivalent	Nº of plants	Nº of plants (%)	Inhabitant Equivalent (Total)	Inhabitant Equivalent (%)	Nº of plants	Nº of plants (%)	Inhabitant Equivalent (Total)	Inhabitant Equivalent (%)
	2.169	100,0	97.389.000	100,0	735	100,0	40.260.000	100,0
< 10 kIE	1.269	58,5	5.879.000	6,0	287	39,0	1.508.000	3,8
10-20 kIE	322	14,8	4.777.000	4,9	158	21,5	2.393.000	5,9
20-50 kIE	250	11,5	8.076.000	8,3	127	17,3	4.180.000	10,4
50-100 kIE	143	6,6	10.511.000	10,8	79	10,7	5.752.000	14,3
100-150 kIE	58	2,7	7.313.000	7,5	32	4,4	4.072.000	10,1
150-200 kIE	36	1,7	6.494.000	6,7	13	1,8	2.401.000	6,0
200-250 kIE	13	0,6	2.903.000	3,0	8	1,1	1.772.000	4,4
250-500 kIE	44	2,0	15.842.000	16,3	21	2,9	7.602.000	18,9
500-1000 kIE	22	1,0	15.413.000	15,8	6	0,8	4.460.000	11,1
>1.000 kIE	12	0,6	20.176.000	20,7	4	0,5	6.120.000	15,2
WWTP >50 kIE	**328**	**15,2%**	**78.652.000**	**80,8%**	**163**	**23,0%**	**32.179.000**	**79,9%**

Table 4: WWTP´s in Spain.

Applying the 50.000 Inhabitant Equivalent filter to other countries, the following list of WWTP plants with or without N removal requirement can be used as a reference.

	All WWTP				WWTP with N removal Requirement			
WWTP > 50 kIE in	Nº of plants	Nº of plants (%)	Inhabitant Equivalent (Total)	Inhabitant Equivalent (%)	Nº of plants	Nº of plants (%)	Inhabitant Equivalent (Total)	Inhabitant Equivalent (%)
Portugal	70	3,3%	12.110.000	3,0%	10	0,8%	1.413.000	0,6%
France	328	15,4%	58.765.000	14,5%	273	20,9%	46.513.000	20,7%
Italy	386	18,1%	66.538.000	16,4%	269	20,6%	49.304.000	21,9%
Germany	565	26,5%	99.178.000	24,4%	564	43,1%	99.048.000	44,1%
Belgium	40	1,9%	5.950.000	1,5%	39	3,0%	5.590.000	2,5%
UK	307	14,4%	72.429.000	17,8%	13	1,0%	2.020.000	0,9%
Holland	437	20,5%	91.354.000	22,5%	141	10,8%	20.804.000	9,3%
Total	**2.133**	**100%**	**406.324.000**	**100%**	**1.309**	**100%**	**224.692.000**	**100%**

Table 5: WWTP´s of more than 50kIE in relevant EU markets.

2.3.3 Competitors

The identification of the competitors of advanced solutions is complex due to its innovative concept. However, some organizations have been identified who are well positioned to be contacted by the customer when he needs a COCOP like solution. These companies can have a different background but are expected to be able to formulate an attractive proposal.

2.3.3.1 Technology Providers:

- Royal Haskoning (Aquasuite, PURE) (ref. 21): Is a machine learning and AI solution for the control and optimization of wastewater treatment works. It uses the proven Aquasuite AI algorithms to predict influent flow and load, enabling its virtual operator to control the wastewater treatment works with maximum efficiency and effectiveness. This data-driven solution provides a real-time, optimized response to process fluctuations, improving the operational efficiency and reducing risk. This is done by advanced automation of the treatment processes using predictive analytics, world class insight in process engineering and extensive experience of process automation. Proven AI-algorithms and the use of soft-sensors define optimal process conditions. Predictive feed-forward controls are used to adjust critical parameters. In aeration, which accounts for 45-75% of total energy consumption of a typical plant, up to 20% savings can be made. Clever use of buffer capacity ensures more stable operations and gas production (anaerobic), optimizing your assets' utilisation and lifespan.

- Hach (WTOS): Is a fast and simple system to meet all the operating requirements of sewage treatment plants, since it immediately provides stable effluent values, at the same time as lower costs, even in the case of unexpected load tips. Phosphate and nitrogen removal as well as sludge management can be optimized. The novelty of this system is that it does not depend so much on time or volume, but on the load and works in real time. This means that only the volume needed to reach the preset guide value is aerated or measured, saving energy and significantly reducing the use of precipitator and polymer.

2.3.3.2 Water Treatment Operators:

- Veolia Water Technologies (AMONIT) (ref. 22): Is an automation tool, simple and quick to implement. The system determines the optimal aeration levels of biological reactors, automatically compares the information collected with the fixed orders and continuously regulates - and in real time - the oxygen supply. This control system has been successfully introduced in other European countries and already has important references whose results support its investment: the reduction of the energy consumption of the aeration process has reached up to 20%. It is not clear if this solution covers also other aspects than biological area. Likewise, is a system suitable for all types of EDAR, whether small or large treatment flow, and allows its implementation in any biological reactor configuration.
- Suez – Degrémont (GREENBASS) (ref. 23): Is a sequenced aeration regulation process for activated sludge, fine-tuning the air-flow supplied to the biological treatment process depending on the pollution load. The key to the Greenbass control mechanism is that it is based on the fluctuating concentration of nitrogen's reduced form (ammonium) and oxidized form (nitrate). The advanced regulation program contains a patented algorithm which constantly recalculates the useful quantity of air as a function of the biological activity. Furthermore, this solution result are the following ones: up to 15 % of energy saving and a reduction of 20 to 30 % of the air flow supplied for a similar quality. Among its references are one in Guyana (60.000 IE) and the other in New Caledonia (72.000 IE).
- Acciona Agua (NIPARMOX) (ref. 24): One of the most common problems in wastewater treatment plants is the difficulty of complying with the requirement for total nitrogen in the effluent from them, particularly when it stands at 10 mg N/l. One of the main reasons is that the DQO/NTK ratio of the return flows to the biological process is lower than the initially estimated (design) ratio due to the nitrogen in the return flows that reach the head of the plant from the dehydration of sludges. The process developed by the water business of ACCIONA is based on a biological process for the partial nitration of the ammonium, where approximately 50% of the ammonium that enters the process is oxidized, and together with an autotrophic denitration through annanox bacteria of the nitrogen contained in the return water.

2.3.3.3 Global Automation Companies:

- Siemens (SIMATIC PCS 7) (ref. 26): SIMATIC PCS7 is a homogeneous and coherent system, characterized by an scalable architecture and functionalities that can be developed to suit any industrial need, making it the perfect choice at the level of implementation and profitability of an instrumentation and control facility that is the centre of a long-term industrial project. A system based on Simatic PCS7 can grow according to any project with the development and implementation of additional functionalities for the automation of batch processes, material transport control, asset management, telecontrol and security applications, evaluation / management of process or task data. Through the PCS7 software it will optimize the vast majority of processing procedures, machine operation and planning.
- Schneider and AVEVA (ECOSTRUXURE) (ref. 27): Reducing operational expenditure (OPEX) and addressing aging infrastructure with limited capital budget is a challenge for any Water & Wastewater plant. Process automation solutions from Schneider Electric allows to run operations more efficiently and safely, saving both energy and costs. Likewise, EcoStruxure provides sustainable and reliable control to wastewater treatment plants with up to 15% energy savings and 20% improvement in production efficiency.
- ABB: Throughout the world ABB has executed many projects from mid- to large water and wastewater treatment plants. ABB's offerings and solutions target to minimize the considerable energy usage in the operation of water and wastewater treatment plants. Streamlining of data handling is achieved by combining process values from the field and

deferred lab analysis measurements in one solution. Furthermore, ABB's offers complete and integrated instrumentation, control and electrification solutions, Advanced reporting functionality to meet regulatory demands and Flexible reporting system fulfilling demand of plant, service and operational managers.

Despite the fact that there are several potential competitors, during the market contact interviews, none of the plant owners was able to give a name of a solution. And when asking which type of organization they would contact for these kinds of solutions, several mentioned the University. So, apparently this is in line with the innovative aspect of the solution. On the other hand, the information found on the automation solutions, or descriptions from marketing material, so exact scope and functionality is not known and, in some cases, the descriptions are limited to the biological treatment phase. That is the reason why they are called potential competitors.

2.4 Business model

At the core of the value proposition there is the challenge to provide the customers with services in optimizing their processes, leading to decreased operating costs in terms of energy, better water quality, more stable process and lower environmental footprint. There shouldn't be doubt on that, concrete figures or perhaps even guarantees will be needed to prove the ability to optimize. Besides, remarkable gains are available from better operational resiliency in cases of heavy floods which seem to be happening more often.

Most potential customer segments are public and private wastewater treatment plant operators in EU area. The idea is to focus initially on plants with a minimum of 500.000 IE capacity plants so that the effects of the savings in terms of electricity usage compensate the needed investments. The number of targeted plants in EU is around 175. The public sector could be the most interesting segment, since it seems that privately operated plants tend go for short term optimization goals due to their contractual circumstances.

Customers awareness will be raised through internet channels where the ability of the solution can be demonstrated. Demo projects will be used also in reaching potential customers. Being proactive in public tendering can lead to first customer cases. Customer relationships are based on mutual trust, transparency and close relationships between stakeholders. Mutual trust is needed for information exchange and process understanding.

The concept for the WWTP Canvas business model is shown in the following figure.

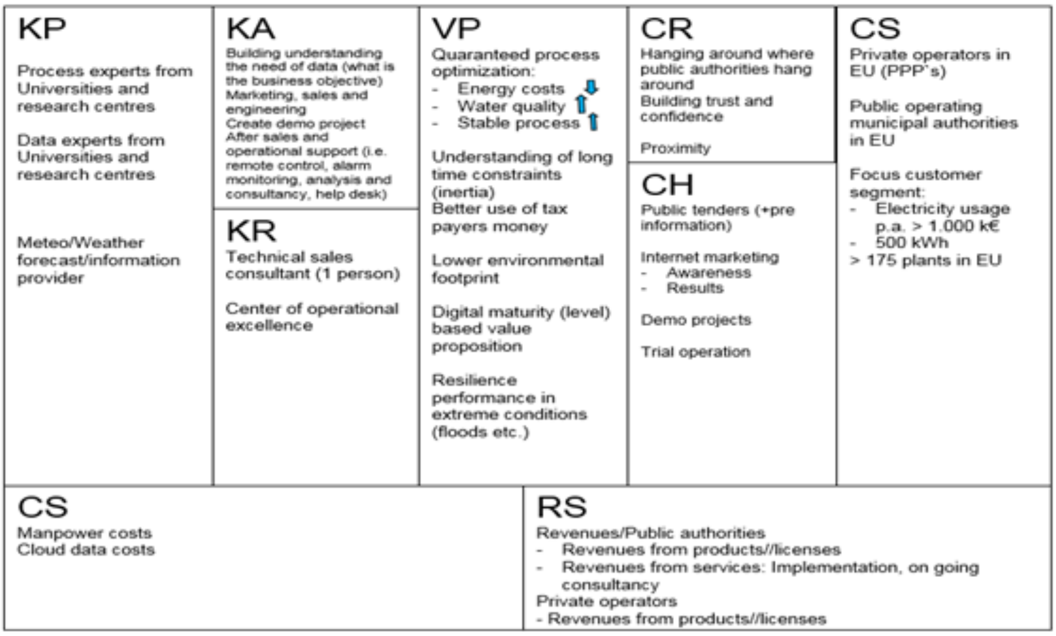

Figure 3: WWTP's business model canvas.

- Customer segments (CS) define the different groups of organizations an enterprise aims to reach and serve. An organization must make a conscious decision about which segments to serve and which segments to ignore. At first stage targeted customer segment is public wastewater treatment plant operators in EU area with a 500.000 IE capacity. Later also privately-operated plants, smaller plants or other water treatment plants like drinking water and desalination could be addressed.
- The Value Proposition (VP) is the reason why customers turn to one company over another. It solves a customer problem or satisfies a customer need. Each Value Proposition consists of a selected bundle of products and services that responds to the needs of a specific Customer Segment. WWTP's COCOP concept provides wastewater management organizations process optimization in terms of lower energy costs, better water quality and a more stable process. When the solution is in full use, it guarantees a lower environmental footprint. Better understanding of the process helps also in recovery situation after heavy floods.
- Channels (CH) describe how a company communicates with and reaches its Customer Segments to deliver a Value Proposition. WWTP COCOP channels consist of activities raising awareness, internet marketing/introduction and via public tendering. Also, demonstrations and trials will be used to convince potential customer organizations.
- Customer Relationships (CR) describes the types of relationships a company establishes with specific Customer Segments. WWTP's COCOP concept is based on mutual trust and confidence between service provider and customer organizations.
- Key activities (KA) are the most important actions a company must take to operate successfully and execute the business plan. WWTP COCOP key activities consists of building understanding the process and the need of data, marketing, sales and engineering activities. Demo development skills and also operational support activities (e.g. remote control, consultancy, help desk) are needed.
- Key Resources (KR) describes the most important resources required to make a business model work. Every business model requires resources that allow an enterprise to create and offer a Value Proposition, reach markets, maintain relationships with Customer Segments, and generate revenue streams. Important to have a highly skilled technical sales consultant and a multi-disciplinary team with capacities in Automation, Data Management and water treatment process.
- Key partnerships (KP) describe the network of suppliers and partners that make the business model work. Companies forge partnerships for many reasons, and partnerships are becoming a cornerstone of many business models. WWTP's COCOP concept value chain needs process and data experts from universities and research centres. Also, weather forecast information provider is essential in process resiliency solutions.
- Cost structure (CS) describes all costs incurred to operate a business model. This building block describes the most important costs incurred while operating under a particular business model. WWTP COCOP operation costs consist mostly of human resources needed for customer work, development, sales and consultant work. Besides, there will be also costs for cloud services for data storage, processing and visualization.
- Revenue Streams (RS) represents the cash flow a company generates from each Customer Segment. WWTP COCOP revenues come from project direct sales and selling licenses. There will be also service and consultancy-based revenues. In a more advanced phase, incomes from risk and benefit sharing can be implemented based on an ESCO model.

2.5 Business environmental map

- Key Trends: Globally urbanization goes on and people are moving to urban areas. More waste treatment capacity will be needed in form of new capacity, modernization and new plants. Lack of sufficient available water resources and low water purity in some areas may have severe consequences. After 2008 global economic crisis and more recently climate changes, wastewater treatment efficiency is more an issue than it was 10 years ago. Climate change influences wastewater treatment also through heavy rainfall and flooding, creating sudden peak loads and more complex process to control. Larger volumes and more challenging process is a business opportunity. What comes to topical microplastics, also wastewater sector needs to be alert on this issue. Digitalization goes on in every domain and cyber security needs to be considered since water treatment is part of critical infrastructure. Traditional resources of WWTP have a more mechanical background, while new resources come with a more electronic or automation background, opening the door for better acceptance of solutions based on digitization. Technology enables remotely controlled and operated processes and even automation in cloud. Could there be room for COCOP concept in Remote Operations and Control Centres?

- Market forces: Market seems to follow rules that some countries are entering towards public private partnerships, enabling feasible business opportunities. In western Europe wastewater treatment sector market focus is in OPEX, while in eastern Europe it is in CAPEX. Since wastewater composition is changing including more pharmaceutical contaminants like antibiotics, it is expected that this in the future will lead to more complex water treatment processes with more processing stages.
- Macro-Economic Forces: WWTP`s need to follow stringent laws, regulation and control. Circular economy set pressures for urban wastewater reuse and sludge utilization. However, this is apparently in contradiction with the more complex and more demanding process conditions due to changing bio-chemical compositions in the load of the incoming water.
- Industry Forces: Identified potential opportunity to make WWTP´s more efficient is to co-digest bio waste (e.g. food waste, waste from dairy industries) in wastewater treatment plants. The rationale is to realize energy self-sufficient WWTP`s. One step in that direction is combining several sludges for bio-based energy purposes. Existing WWTP`s may have unused capacities and qualified staff to handle also external waste streams. This idea follows circular economy goals but has to be analysed considering the applicable legislation.

2.6 Financial forecast

The estimated revenue is based on the three main previously described services, defined to provide maximum added value. It is understood that the fit of the different services with the need of the customer depends on the digital maturity of the WWTP in terms of outsourcing the automation engineering and optimization services of the process. It is expected that customers will evolve from service 1 to 3 in time, from the most basic service to the most complete one.

Sales forecast	**2022**	**2023**	**2024**	**2025**	**2026**
Product/Service					
1. Plant-wide monitoring implementation services.	25.000 €	120.000 €	200.000 €	350.000 €	600.000 €
2. Advanced process optimization engineering.	7.000 €	35.000 €	80.000 €	140.000 €	250.000 €
3. Operational support services.	2.000 €	10.000 €	25.000 €	60.000 €	100.000 €
Total sales forecast	34.000 €	165.000 €	305.000 €	550.000 €	950.000 €

Table 6: Estimated revenue based on the 3 main services.

The costs associated with estimated revenue have been quantified in the table below, which also lists new staff hires because the staff cost is the most important element in total expenditure.

Cost forecast Product/Service	2022	2023	2024	2025	2026
1. Personnel	70.000 €	175.000 €	280.000 €	450.000 €	665.000 €
2. Materials - Investments	12.000 €	30.000 €	35.000 €	42.000 €	50.000 €
3. Expenses	10.000 €	15.000 €	22.000 €	30.000 €	35.000 €
Total cost	92.000 €	220.000 €	337.000 €	522.000 €	750.000 €
Number of persons	2	5	7	10	14

Table 7: Costs associated to the 3 main services.

The investments shown in the table above refer to the purchase of technical equipment and financing of those energy optimization projects that are developed. The offer of the services provided by the company can include financial support to clients developing comprehensive energy efficiency projects.

Result forecast	2022	2023	2024	2025	2026
Annual result	**-58.000 €**	**-55.000 €**	**18.000 €**	**28.000 €**	**100.000 €**
Cumulative result	-58.000 €	-113.000 €	-95.000 €	-67.000 €	33.000 €

Table 8: Total results forecast between expected revenue and cost.

2.7 Action plan

Based on the exploitation routes, the following action plan will be followed:

1. Direct Exploitation – A new research project: MSI & Tecnalia are considering submitting a proposal where the COCOP concept can be used as a basis for WWTP optimization in another H2020 program (Spire, Life,…) or a national / local program.
2. Direct Exploitation – Direct sales: MSI will continue approaching the market with the plant wide monitoring solution on short term and process optimization on midterm. This should lead to new business activities as described above. Therefore, multiple marketing and commercial actions will be undertaken.
3. Indirect Exploitation – Licensing: MSI will consider some opportunities here in a later stadium, because actually several open source solutions are used and the actual TRL should be raised so it can be considered as a product. In any case, it would fit in an expansion strategy to other countries, where the services are provided by business partners. Therefore, MSI needs first some reference projects at national level. The activation of indirect Exploitation will not be earlier than in five years.

2.8 IPR management

At this moment no additional IPR arrangement have to be made since no real progress is made on product development. In any case existing IPR issues from the original COCOP project must be respected. In the future has to be defined how the company who provides the data management services will handle the IPR related to the data stored in the database and the knowledge extracted from it.

3 Chemical industry

The research and development activities in the COCOP project were focussed on the possibilities for plant-wide monitoring and control, which implies that the integrated sequence of core processes in the plant are in focus.

Generally speaking, no specific tools were generated in the COCOP copper and steel cases that allow for a direct transfer into applications in the chemical sector. Still, the methodologies applied in these case studies, legacy models (first principles) and AI (neural network in the steel case) can be applied in other process industry sectors including the chemical sector.

Taking this as a starting point, a more general approach to the generic issues related to implementation in the chemical sector. As the COCOP concept includes retaining existing DCS, MES and other existing data systems. It was interesting to learn that Emerson, a provider of DCS and other automation systems, present at the SITECH Industry 4.0 symposium in Geleen, September 2019 (www.emerson.com), is primarily focusing on predictive maintenance, e.g. when is a pump expected to fail.

Royal Haskoning was also present at the same SITECH organized symposium, and as it seemed they had interesting tools related to optimizing wastewater plant, a separate meeting was organized at Haskoning on November 6th in Eindhoven, NL. Regarding the chemical sector Haskoning only focuses on Utilities. However, as mentioned, this is not the focus of the COCOP project where we primarily look at optimizing the core production process.

3.1 Exploitation route

The different exploitation routes that have been raised are listed below:

Product	Preliminary Exploitation Routes	Modality/method
COCOP solution for Chemical Processing Industry	Direct Exploitation	A new research project
		Direct sales of software and / or associated services
	Indirect Exploitation	Licensing
		Build up a spin-off

Table 9: Exploitation route for Chemical industry.

Because of the actual TRL of the COCOP concept, the primary Exploitation Route is based on Direct Exploitation, where a new research project based on the concept is really feasible in different H2020 programs. The chemical sector is using larger quantities of resources including raw materials, (cooling) water and energy, and therefore this is of significant societal concern for becoming CO_2 neutral in 2050 or earlier than that.

3.2 Exploitation team

Regarding the state of affairs in this domain in the chemical sector, see the next paragraph, it seems appropriate to establish a team with an overarching view on the sector that can select the best (both regarding environmental impact as well as financial aspects) as well as concrete implementable options (with commitment from industrial partners) for further exploration. It also requires the input from the workers (see below) and not only a technical solution.

3.3 Market analysis

At present, it seems that few activities in the chemical sector are really Industry 4.0, but actually more further actions at the end of Industry 3.0.

Looking further into the status of plant wide optimization (Industry 4.0 level process control), the key problem regarding implementation in the chemical sector does not seem to be of pure technical kind. It was recently quoted that 'The chemical industry is very traditional, and we always talk about how we need it to include more risk-taking. Digitalization is really the area where we require that.' (ChemistryWorld October 2019, page 20: Industry delves into the digital toolbox). The question that thus pops up is why this is so, and next how to go about it. The answer is nicely summarized in a recent contribution in Chemical Engineering magazine: WORKFORCE 4.0: THE HUMAN SIDE OF DIGITAL TRANSFORMATION (by Scott Jenkins, Chemical Engineering magazine | December 1, 2019), https://www.chemengonline.comworkforce-4-0-the-human-side-of-digital-transformation/. The summary states 'As chemical process industries (CPI) companies continue to experiment with, invest in, and implement a host of digitalization tools, workforce engagement and involvement is the key determinant of success' And two more quotes 'Greg Smith, a senior consultant at the Cutter Consortium (Arlington, Mass.; www.cutter.com) who has worked with companies from across many industries on digital transformation initiatives, says "What I've found is that you can always make the technology work, but the ultimate success or failure of a digital initiative is always tied to the people." He emphasizes: "Companies don't adopt new technologies; people do."' Whether this is the full truth is doubtful, as not all may be convinced the technology may work as such. First of all, we had, e.g., a boost for methods such as neural networks and fuzzy logic and more about 30 years ago, that was not very successful (too early, technology push), and people that were young then are now the managers that remember the experts arguing this is the technology to go for now (such stories are really being told). This push by people that are only tech-experts without understanding the context and reasons why a technology should be adopted is often a barrier to implementation at a later, more mature, stage. "We tend to assume that humans will behave rationally, but that is only sometimes true," Smith says. "Workers' previous experiences, along with a large set of preconceptions, existing biases, heuristics, shortcuts, and so on, all colour their view of a new technology and affect how they will receive it," Smith says. The objective for companies then becomes how to create conditions that will motivate employees to embrace the technology.

Resistance to the introduction of new digital technologies can come from different sources. "The biggest hurdle we see is that workers have a lot of fear that digital technologies will result in job loss," says Jane Arnold, global lead for process control technology at Covestro AG (https://www.chemengonline.com/workforce-4-0-the-human-side-of-digital-transformation/ , www.covestro.com). But Arnold says the reality is different, and she's not alone. She and others view digitalization as an opportunity to liberate workers to undertake more valuable, higher-level functions that involve more creativity and imagination. "Digitalisation offers a way to change the way we work; the intent is not to reduce headcount," she says. "We have to maintain the human element in CPI ('Chemical process industries') operations. There are important differences between chemical processing and repetitive discrete manufacturing. The CPI needs many engineering, maintenance, operations and other functions that will not be eliminated by digital tools."

a-SPIRE has issued a report (11/07/2019) entitled ' ARTIFICIAL INTELLIGENCE in EU PROCESS INDUSTRY, A VIEW FROM THE SPIRE cPPP' .Next to the statement ' Artificial intelligence technologies have large potential to assist the EU Process Industry to achieve disruptive transformations that strengthen its global competitiveness as well as contributing to a carbon-neutral economy and to circular-economy solutions' and 'An ever-increasing world level competition, which must be fought by EU leadership, and a fast and efficient innovation process to generate market-minded solutions', it reads ' Despite of this, it is also been realized 'However, the Process Industry sector is currently lagging behind in some fields of AI-utilization.'

3.3.1 Competitors

There are not really well-established parties offering solutions for the chemical industry as such. There are components available though, such as companies that provide data services (to collect and store data for data driven solutions). Several tools were developed in recent EU Horizon 2020 projects, including COCOP, COPRO, Monsoon, FUDIPO, etcetera. On the other hand, large companies will still have internal capacity to develop and implement data-driven as well as physical model-based solutions.

3.4 Business model

The business model as referred to in the present context is the business model for the provider of software and hardware tools enabling plant wide control with the chemical sector being the customer. The COCOP concept Chemical Canvas business model is very similar to that for the WWTP, see Figure 3.

Following from what was written under Market Analysis, the key issues do not seem appropriately addressed in the business model canvas structure (the scheme above). It is mainly the internal affairs of the chemical industry that require analysis and elaboration: cost-benefits and human factors in that segment.

3.5 Business environmental map

As mentioned, the chemical industry is very conservative. Still, energy consumption is very significant. Projects carried out, also in EU context, have usually resulted in improvements in the 5% range, not huge compared to what needs to be done to reach the targets regarding combatting climate change. Feedstocks are still largely the same. One of few positive cases with significant environmental impact is the catalytic process developed by Prof Walter Leitner and COVESTRO in which CO_2 in built in a chemical that is subsequently used as a building block for polyurethanes (https://www.fuelcenter.rwth-aachen.de/cms/Fuelcenter/Austausch/Aktuelle-Meldungen/~ebqqm/FSC-Professor-Walter-Leitner-fuer-Deutsc/lidx/1/).

For Europe, the context is expected to change significantly in the not too distant future. Recycling is a hot topic, and some consumer products are already 100% based on recycled plastic. And, e.g., more and more citizens are mobilized against plastic. More of the chemical industry production is moving to the middle East (Saudi-Arabia) and the far-East (China). Bio-based products are coming up, but also here there is a hick-up regarding realization. There is no real incentive for main producers to go that way, so start-ups need to pave the way. In some cases.

3.6 Financial forecast

Chemical processes are mutually very different. Even in a single company production processes for a product at different continents can be very different. The consequence is that each proposition needs to be made on a case by case study.

Over the years, benefits have been grossly estimated up to 15% (savings due to plant wide optimization). However, there are few publicly known underpinned examples. It seems we need more concrete numbers, sufficiently concrete so one may expect the customer will implement when the project is successful, before large new projects should be started. Still, it may remain questionable whether such projects will deliver more compared to investments in WWTPs where 100% CO_2 and energy neutrality can be achieved, while at present such plants also use a very significant amount of energy.

3.7 Action plan

To stimulate new technologies, one can see four components each of them to be developed to a mature stage, all ingredients to be developed before the plant wide control by digitalization has the chance of becoming adopted.

1. Two techno-economical components:

   a. is the technology as such sufficiently mature allowing it to be successfully implemented. The answer to this question should be a clear YES: many tools are available and sufficient experts available to make it happen (in particular SME's throughout Europe), as long they are involved in a process in which it is precisely discussed what is expected.

   b. if the technology is implanted successfully, so if no unexpected pitfalls appear, is the benefit sufficiently large to allow for implementation. There are hardly any real, proven so the speak, numbers how much, percentage wise, a plant can be ran better, if plant wide digitalization is pursued. 'Soft' numbers go up to 15% maximum. We also need to consider the required investment. This includes making data available, almost in all cases installing (additional) sensors, implementing software and hardware, and the costs to implement in a plant environment. Finally, all these changes require a safety check of the operational environment, also adding to the investment costs. All these aspects can, however, be grossly estimated for a specific plant environment.

2. The acceptance by staff, which we should subdivide between:

   a. acceptance by staff, e.g. operators. There must be something in it for them, e.g. like Jane Arnold said (see above) 'opportunity to liberate workers to undertake more valuable, higher-level functions that involve more creativity and imagination'. This also implies staff members must be involved in the actions. Moreover, in particular long-time experienced operators are invaluable in the development of plant wide process control options. The fully automated plant is still very far away. With operators involved, a Digital Twin as an assistant to plant staff is the primary goal for the years to come and will help to lower the barrier for acceptance. In that respect the statement in the a-SPIRE document 'Transfer and formalize operators' knowledge and best practices' can not only be felt a threat for operators, but it is also unlikely to be an option for the first decade to come. Finally, we may need to realize that many of such statements might be too much the academics view. It goes without saying that proper communication is key. Efforts should be undertaken to convince staff that it is in their interest to strengthen operations, to keep Europe at the forefront of production technologies. Not accepting digitalization but NOT accepting digitalization is a threat for the jobs in Europe. It is already difficult, on several sites, to find new operators. By upgrading the tasks in combination of automation one may find the appropriate staff more easily.

   b. acceptance by (higher) management. There are several items here that can be addressed. One is the way management is able to influence the operations, operators and other plant staff members. Another item is how management can be convinced that plant wide control will contribute to the companies benefits whether it is financial or otherwise, e.g. saving material resources, energy, waste. Finally, in the long run it must be expected that 'AI will replace many management activities. The traditional way of taking decisions led by managers using adopted management tools will gradually disappear' (Prof. Michael Bordt in New Work, die Zukunft der Arbeit (the future of work), Frankfurter Allgemeine newspaper, Special issue ('Verlagsspezial') 2019, pp. 14-15). Evidently this does not apply to the governance of a company as such.

   Considering both a and b, this requires a change in company culture. The benefits may be significant though, and with the digitalization proceeding potentially faster in the East and with new plants, it could become a discriminator in future operations.

From the named SPIRE report we cite 'There is a high potential to speed-up the process from R&I to large-scale industrial implementation through orchestrated European innovation programs bringing together Process Industries with the digital industries, academic research and highly innovative SMEs across Europe.' In view of the non-technological barriers related to implementation it is indeed innovation (and not R&I) projects that are needed to demonstrate what the technology can bring in a real plant environment.

Finally, plant workers have developed a delicate understanding of the processes and equipment they use. The loss of this pragmatic expertise is also a significant threat at several sites. Individual as well as collective know-how present with operators has to be part of the tools to be developed. The integration between advanced tools and long-term knowledge aims at generating the best possible technology whilst assuring commitment of the workers at the same time.

3.8 IPR management

No comments to be made at present which are of specific consideration for the chemical industry.

3.9 Risk assessment

In the long run, not acting or not acting within a certain time-frame, can damage the competitiveness of the European industry. This can have various, or a combination of, reasons

- competitors elsewhere producing more favourably
- customers (‘the man on the street’) gradually tending to by greener products
- legislation: government or the European Commission imposing limits on, e.g., emissions, energy consumption.

With the current Industry 4.0 (SMART industries) wave, it seems industry jumps on this train, but actual actions do not seem to be primarily at making the industry greener (except for a few exceptions). Sense of urgency seems absent, in particular when one of the above mentioned three factors would become pertinent, the tools and infrastructure (as the lack of complete information is one of the larger bottlenecks at present) will not be ready.

4 Glass Manufacturing Industry

Due to an advanced plant wide monitoring and control implemented in the glass manufacturing industry, it is expected to reduce operation costs (OPEX) and environmental footprint merging the latest data analytics techniques with advanced automation and process knowledge.

Glass manufacturing is characterized by high energy use and demanding quality control standards since glass containers (Bottles, jars,...) are used to transport and store food and beverages. Since material reuse and recovery are considered very important in production cost reduction from energy and material consumption point of view, it has to be stated that material reuse can condition heavily product quality. In the glass manufacturing industry, the COCOP concept could focus on energy efficiency and also on product quality improvement and zero-defect production solutions.

4.1 Exploitation route

The different exploitation routes that have been raised are listed below.

Product	Preliminary Exploitation Routes	Modality/method
COCOP solution for <u>Glass Manufacturing Industry</u>	Direct Exploitation	A new research project
		Direct sales of software and / or associated services
	Indirect Exploitation	Licensing
		Build up a spin-off

Table 10: Exploitation route for Glass Manufacturing industry.

As stated before, glass manufacturing is good example of circular economy since glass recycling is well introduced and accepted by society. However, more improvements can be done by implementing cutting edge technology, which can be realized in other research projects like zero-defect manufacturing.

Since in the provided solutions different technological activities like automation and data management are needed combined with specific process knowledge, the number of companies can be limited since these capacities can be found in engineering services dedicated to the glass manufacturing sector. The combination of these capacities can be obtained also by implementing business alliances with partners when the in-house capacity is insufficient.

4.2 Exploitation team

From the actual consortium, MSI combines great of part of these automation and data management capacities, although a partner for the specific data modelling for glass manufacturing should be found. Tecnalia can assume this role without problems like in other collaborations, but other options like “Encirc Academy” are to be considered. The Encirc

Academy (ref. 30) is a world leading provider of training and consultancy for the global container glass making industry. MSI has direct access to the Spanish and Portuguese market, but for other Markets, business alliances should be set up to guarantee proximity to the end user for optimum services.

4.3 Market analysis

The Europe 2020 strategy is the main tool driven by the European Union to create jobs and improve the economy through sustainability. This strategy places the concept of circular economy at the heart of all policies.

The circular economy presents opportunities that the glass manufacturing sector has been able to integrate naturally for years. Among others, the recycling of materials to reduce the consumption of natural resources and thus avoid its depletion, the implementation of glass collection and recycling systems, the use of more efficient technologies and a strong commitment to local employment. Glass is a 100% recyclable material and can therefore be recycled infinite times without losing any of its intrinsic properties, neither in quantity nor in quality, which makes it a permanent and extraordinarily valuable material. A material that in production processes can replace raw materials with advantage, allowing efficient use of resources and consequently providing stability and sustainability in the long term.

4.3.1 Glass Manufacturing in Europe

The EU is the world's biggest producer of glass with a market share of around one third of total world production and about 80% of the glass produced is traded within the EU. In addition, the industry is known for the quality of its products, its capacity for technological innovation, and its skilled labour force. The glass industries comprise five sectors covering different glass products, applications and markets.: Container glass, Flat Glass, Continuous-filament glass fiber, Domestic glass and Special glass.

Container glass is the largest sector of the EU glass industries and accounts for some 61,4% of the total EU glass production. The European container glass industry provides a wide range of glass packaging products for food and beverage, perfumery, cosmetics and pharmacy to a European and world-wide customer base. With its 144 manufacturing plants distributed all over Europe, it is an important contributor to Europe’s real economy and provides direct employment to about 50,000 people, while creating a large number of job opportunities along the total supply chain.

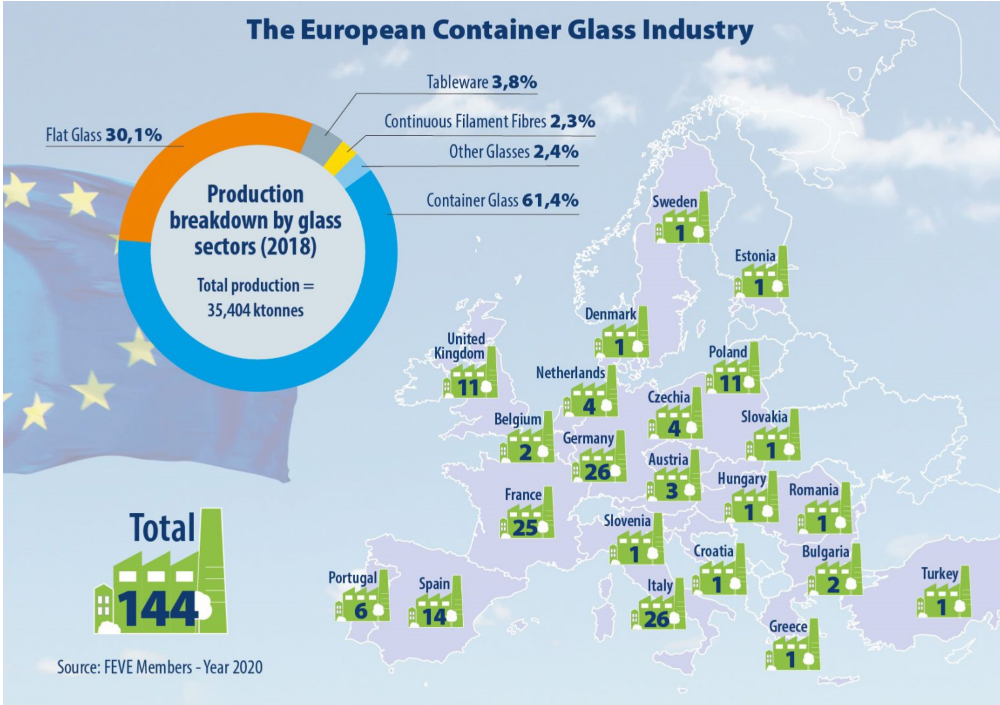

Figure 4: The European Container Glass Industry (Ref: 31)

Regarding the flat glass sector, is the second largest sector of the European glass industries and represents about 30,1% of the total EU glass production. The main markets for flat glass are the building (windows and facades), about 80%, and automotive industries (windscreens, side and rear-side glazing, back lights and sunroofs), about 15%. Flat glass is also used in solar-energy applications (photovoltaic and solar thermal panels) as well as in urban and domestic furniture, appliances, mirrors and greenhouses. Flat glass is manufactured in Europe by 7 companies operating some 60 plants. Float plants are the biggest glass manufacturing sites with production capacities of up to 850 ton of melted glass per day. The sector directly employs approximately 15.000 people in glass making.

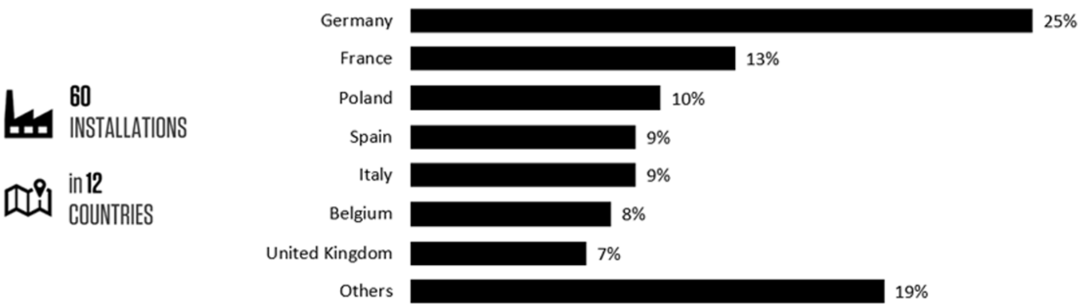

Figure 5: Flat glass production in the EU (Ref: 32)

Concerning the production of continuous filament glass fiber (CFCG) is one of the smallest sectors of the glass industry in terms of tonnage (2%) although the products have a relatively high value to mass ratio. Continuous filament glass fiber is mainly used for the production of composite materials as weight-lightening reinforcement component. Continuous filament glass fiber applications are known as fiber-reinforced polymers or glass-reinforced plastics. The sector covers applications ranging from the automotive and transportation sector (such as aircrafts) to wind energy, agriculture, construction, communication, electrical and electronic as well as sport and leisure. In tonnage, CFCG represents more than 80% of all reinforcement fibers used in composite worldwide. Approximately 5.000 people are directly employed by the European glass fiber manufacturers.

About the domestic glass sector, it accounts for about 4% of the total European glass production. This sector comprises the manufacturing of glass tableware, cookware and decorative items such as drinking glasses, bowls, plates, cookware, vases and ornaments. Domestic glass is manufactured by more than 300 facilities, mainly SMEs, which are spread throughout Europe.

Last but not least, special glasses represent approximately 3% of the glass production in Europe. These products have a high added-value linked to their intense technological content. This sector regroups a large range of products such as lighting glass, glass tubes, laboratory glassware, glass ceramics, heat-resistant glass, optical and ophthalmic glass, extra thin glass for the electronics industry (e.g. LCD panels, photovoltaics) and radiation protection glasses.

4.3.2 Glass Manufacturing in Spain

The Association VIDRIO ESPAÑA (ref. 28) represents, promotes, develops and defends the interests and activities of companies related to glass, as long as they include, in their production process, a glass fusion with a capacity of more than 20 ton/day. The companies that make up VIDRIO SPAIN account for more than 98% of the Spanish glass production affected by Directive 2003/87/EC establishing the scheme for greenhouse gas emission allowance trading, not counting on the information on the remaining 2%.

Some relevant facts of the sector in Spain are:

- The glass industry has generated a turnover of 2.084 million euros during 2016.
- 3.73 million ton of glass have been produced during 2016.
- It has provided direct employment to 6,714 professionals achieving 93% permanent employment.
- Purchases worth 1.030 million euros in raw materials and other materials, energy, transportation, warehousing, logistics, outsourcing and financial services.

VIDRIO SPAIN is composed of companies belonging to the following national associations:

- AFELMA (Mineral Wool Insulation Manufacturers Association)
- ANFEVI (National Association of Container Glass Manufacturers)
- FAOVI (Association of Other Glass Manufacturers (domestic, moulding, insulators and bottles))
- FAVIPLA (Association of Flat Glass Manufacturers)

Even though we will focus on the ANFEVI’s and FAVIPLA’s sector since this looks at first sight as the most appropriate ones.

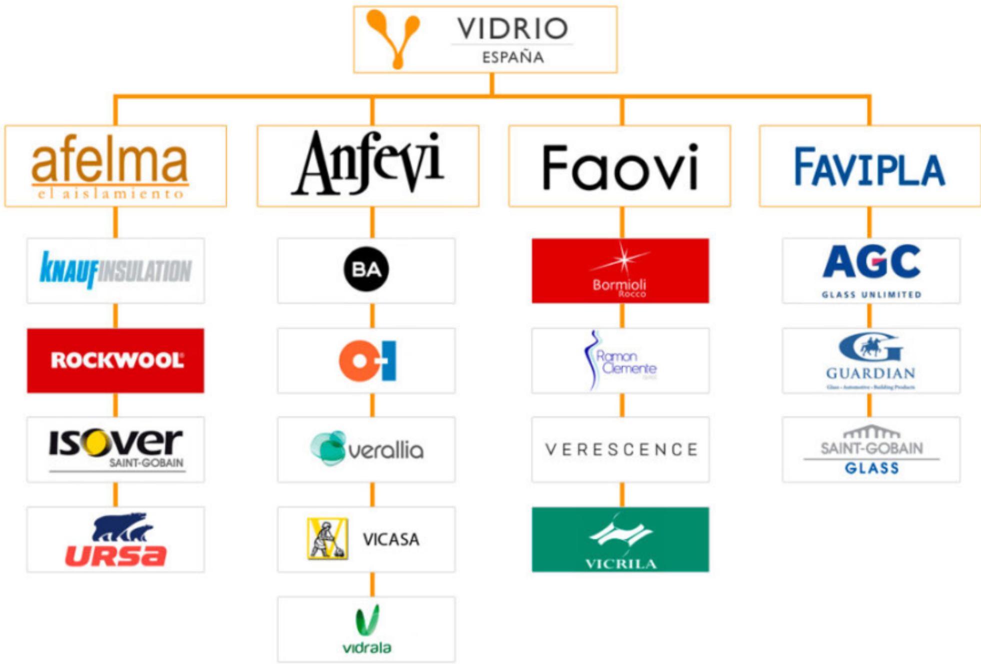

Figure 6: Vidrio Spain's associations (Ref: 28)

4.3.2.1 Production process

It is necessary to highlight the growing importance of the glass/scrap glass/calcin cullet (with different names depending on the subsector) as an alternative raw material to sands and carbonates, both of internal origin (rejections by quality control) as external source. In all processes, the internal waste they generate is recycled; but for some processes, due to quality constraints/specifications, it is not possible to ensure an external cullet supply with sufficient quality and consistency to make it economically viable. In some sectors, such as glass container, the percentage of cullet, depending on the colour, can reach very high values, with the average around 50%. In the case of the mineral wool sector, the incorporation of other secondary raw materials reaches 70%. In 2016, Vidrio España's companies incorporated 1.450.000 ton of secondary raw materials in place of raw materials. The use of a cullet requires less fusion energy than in raw materials. In addition, each tonne of cullet replaces 1.2 ton of raw materials in mixture formulation in the case of sodocalcium glass.

4.3.2.2 Economic contribution

In global figures, the evolution of ton of glass manufactured in Spain has remained close to 3.7 million in the last three years analysed. It is a sector whose products serve a large number of complementary industries: construction and refurbishment, food and beverages, vehicles, crockery, wools for insulation, etc.

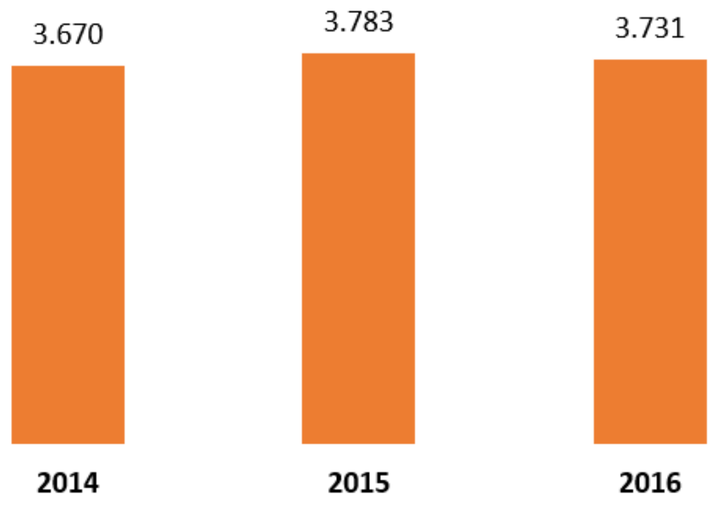

Figure 7: Evolution of ton of glass manufacture in Spain (in millions of ton)

Concerning the turnover, year after year, has grown, from 1.959 M€ in 2014 to 2.085 M€ in 2016. This demonstrates the industry's ability to generate wealth. In 2016, the maximum exceeded 2 billion euros, thanks to the contribution of the different plants of the 4 associations. In 2016, a clear trend towards higher value-added products can be seen in the sector.

Regarding the purchase, an industry like glass has a significant number of suppliers capable of enabling continuous activity 365 days a year. This calculation has taken into account the costs of acquiring raw materials and auxiliaries, energy, transport, warehousing and logistics, as well as other financial and subcontracted services.

4.3.2.3 Environmental contribution

As glass manufacturing is an energy-intensive activity, most of its environmental impacts are linked to this consumption. For this reason, a large part of the efforts have been directed, and are directed, at reducing energy consumption, through the design of more efficient fusion furnaces, the use of the latest refractory materials, the optimization of combustion, improvements in insulation and process engineering, heat utilization, etc.

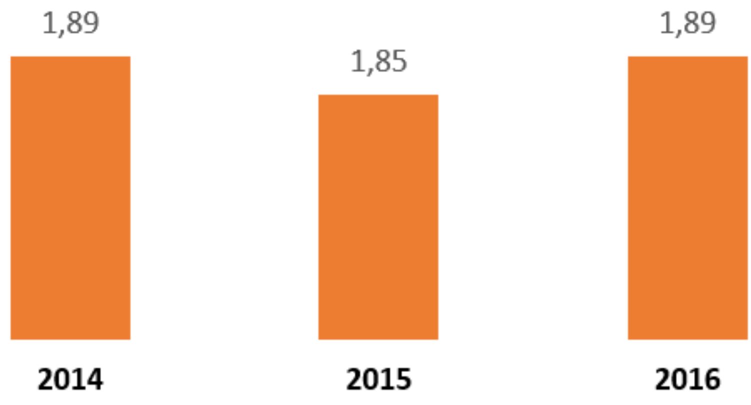

Figure 8: Evolution of energy intensity of glass manufacture in Spain (MWh/tonne of product)

4.3.2.4 Production and energy consumption

In the table hereunder an overview is given of the evolution of production and energy consumption of the glass manufacturing industry in Spain from 2014 to 2016.

	Annual production (tonnes of product)	Energy intensity (MWh/tonne of product)	Total annual consumption (GWh)	Annual average price (€/MWh)	Expenses (millions of €)
2014	3.670.000	1,89	6.936,30	42,13	292,23 M €
2015	3.783.000	1,85	6.998,55	50,32	352,17 M €
2016	3.731.000	1,89	7.051,59	39,67	279,74 M €

Table 11: Evolution of production and energy consumption of the glass manufacturing industry in Spain (2014-2016).

4.3.2.5 Container Glass Manufacturing (ANFEVI)

ANFEVI gathers and represents glass packaging production companies in Spain. In total it has 13 factories distributed throughout the national territory, providing direct employment to almost 3,000 people. The glass packaging industry, thanks to its integral recycling, closes the production cycle, and can be considered as a paradigmatic within the circular economy model.

Relevant facts of ANFEVI during 2016:

- Turnover: 1.087 million of euros.
- Production: 20,5 million containers per day.
- Direct employment: 2.887, with permanent contract: 89%.
- Purchases: 502 million of euros.
- ISO 14001: 85% of plants are certified.

4.3.2.5.1 Production process

This section explains the essentials of the Container Glass (bottles, jars,...) manufacturing process:

1. First of all, the batch plant stores the raw materials used to make glass. They include cullet (crushed recycled glass), quartz sand, soda, calcite, dolomite and feldspar. Cullet is used in variable quantities, based on availability. In some areas, it might make up 20–30% of the batch, but in developed countries the proportion can be as high as 60–90%. To achieve different colours, chemicals such as iron oxide (green), sulphur (amber) and cobalt (blue) are added. The materials are carefully sorted and mixed according to a precise formula to form the batch, which is taken by a conveyor belt to the batch charger.
2. The batch charger continuously and steadily feeds the batch into the furnace, where it is heated by electrical, gas or oil-burning systems to a temperature of 1550–1600ºC. To save energy and reduce environmental impact, waste gases are used to preheat the air inside the furnace.
3. The next stage is gob forming, turning the molten glass into shapes that can be moulded. The glass enters a feeder, where a plunger pushes it down through a narrow tube. As the stream of glass emerges from the tube, it is sheared (cut off) to form a lump of glass known as a gob.
4. Then comes container forming, the heart of glass container production, where the gob is manipulated and/or blown into its final form. Different forming techniques are used to make different types of container: blow-and-blow is primarily used for bottles, while press-and-blow is mainly used for jars.
5. Once they are fully formed, the containers are removed from the machine in the take-out stage. Then, an automated pusher transfers them to the conveyor. Functions handled by pushers and conveyors that move containers from one stage to the next are sometimes

collectively referred to as ware handling. High-speed ware handling while containers are still very hot and fragile is a significant technical challenge.

6. The wares ride the conveyor to the lehr, also known as the 'annealing lehr'. In the lehr, the containers are reheated to about 580ºC and then cooled in the process known as annealing or thermal treatment. Glass naturally shrinks as it cools, which can cause stresses within containers. So the process must be carefully managed and controlled to ensure that the finished containers are as strong as possible.
7. Ultimately, emerging from the lehr, the glassware arrives at the inspection stage, where containers that don't make the grade are rejected, and then bottles are carefully packed and placed on to pallets or into boxes.

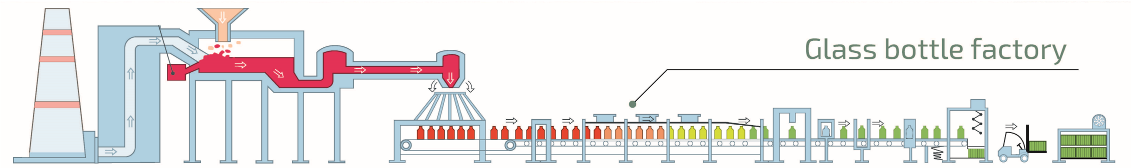

Figure 9: Container glass manufacturing process

4.3.2.5.2 Economic contribution

The economic impact of the sector is relevant: in 2016, 1.087 million euros in turnover was exceeded, with almost 2.5 million ton of glass produced. These are figures that reflect the behaviour of a strong and established sector that also impacts its environment. Each year more than 500 million euros are reinvested in materials and energy, in transport, logistics and storage or subcontracted services. The reduction in annual spending is directly related to the price of energy. In the same way, during the period 2014-2016, 1.974.620 euros were invested in R&D allocated to the following areas:

- Process automation: robotic applications and control of all the variables involved to increase flexibility and productivity.
- Fusion technology: reduced specific energy consumption by increasing the cullet of recycling and using latest furnaces.
- Moulding area: stabilization and repeatability of the process are key. Lightening techniques have allowed the weight of functionally equal packaging to be reduced by up to 40%.
- Inspection and quality control: new advances in addition to ensuring the inspection of all packaging, through a looping computer system act on the origin correcting the causes.
- Traceability: with special emphasis on packaging.
- Packaging standardization: the active participation of glass in standardization bodies enables perfect adjustment through the entire packaging, distribution and consumption chain.
- Environment: The glass industry is a paradigm of circularity. Saving water, raw materials and energy, as well as reducing emissions and avoiding waste.

4.3.2.5.3 Environmental contribution

The circular economy model supported by ANFEVI is based, above all, by the use of glass cullet in furnaces in place of raw materials. It is a fundamental aspect for manufacturers, as their use generates significant environmental benefits. As a result, significant reductions in the energy required to manufacture new packaging have been achieved, as well as by minimizing the intensity of CO_2 emissions. In addition, the replacement of raw materials by glass cullet allows to reduce the consumption of natural resources, as well as limit emissions to the atmosphere, such as nitrogen oxides, NO_x.

It is important to underline that the levels of use of glass cullet are conditioned by the offer of this material. The Spanish agri-food industry is clearly an exporter of its products, to which glass packaging serves as an ambassador, adding value and guarantee, so the availability of cullets is lower than in other European countries. Despite this situation, the levels of substitution of raw materials by glass cullet reach between 43-47% in the period 2014-2016.

4.3.2.5.4 Production and energy consumption

In the table hereunder an overview is given of the evolution of production and energy consumption of container glass production (ref. 12) and expenses due to the energy consumption (ref.13) from 2014 to 2016.

	Annual production (tonnes of product)	Energy intensity (MWh/tonne of product)	Total annual consumption (GWh)	Annual average price (€/MWh)	Expenses (millions of €)
2014	2.391.060	1,71	4.088,71	42,13 €	172,26 M €
2015	2.508.278	1,64	4.113,58	50,32 €	207 M €
2016	2.458.971	1,65	4.057,30	39,67 €	160,95 M €

Table 12: Evolution of container glass production, energy consumption and expenses (2014-2016).

4.3.2.6 Flat Glass Manufacturing (FAVIPLA)

FAVIPLA is the association that represents all manufacturers of flat glass in Spain. This type of glass is mainly intended for the building and automotive sectors. In this case, the versatility of a material such as glass is applied in different environments depending on the different needs, whether mechanical, energetic, luminous or acoustic.

The importance of flat glass in the consolidation of the circular economy derives not only from the behaviour of the companies that make up it, but also from the impact that the material itself has on the boost to sustainability. Flat glass allows architectural solutions that are more respectful with the environment, reducing the energy needs of buildings or minimizing the impact of noise on people's quality of life, among other aspects.

Flat glass manufacturers devote significant efforts both in R&D and in modernizing production lines to make energy-efficient products available to the construction industry.

According to a comparative study of single, double and double-low emissive glazing life cycle analysis, the CO_2 savings obtained are very high. Annual savings reach 227.2 kWh/m^2 in the case of normal double and 328.6 kWh/m^2 for emissive double-bass, compared to single.

Relevant facts of FAVIPLA during 2016:

- Production: 976.000 ton manufactured.
- Direct employment: 2.498 with 93% a permanent contract.
- Materials and subproducts acquired in national territory: 95%.
- ISO 14001: 80% of certified plants.
- Purchases: 371 million of euros.

4.3.2.6.1 Production process

1. In the flat glass process, a continuous strip of molten glass, heated to 1500ºC is poured from a furnace on to a large shallow bath of molten metal, usually tin.

2. The glass floats and cools on the tin and spreads out to form a flat surface. The speed at which the controlling glass ribbon is drawn determines the thickness of the glass. The glass is now perfectly flat and parallel. Rollers are used across the top of the glass, pulling or stretching it out to achieve a thinner finished product. As the glass continues through the process, it begins its cooling down phase. To complete this, the temperature is slowly cooled from almost 600ºC to around 90ºC degrees. Despite the tranquillity with which float glass is formed, considerable stresses are developed in the ribbon as it cools. Too much stress and the glass will break beneath the cutter.
3. To relieve these stresses, the ribbon undergoes heat-treatment in a long furnace known as a lehr. Temperatures are closely controlled both along and across the ribbon. After the glass is cooled, it is trimmed down and any excess glass removed. These glass remains are re-used as glass cullet in later batches.
4. Emerging from the lehr, the glass arrives at the inspection stage to ensure the highest quality. Occasionally a bubble is not removed during refining, a sand grain refuses to melt, a tremor in the tin puts ripples into the glass ribbon.
5. Finally, the glass is cut because it is sold per square meter.

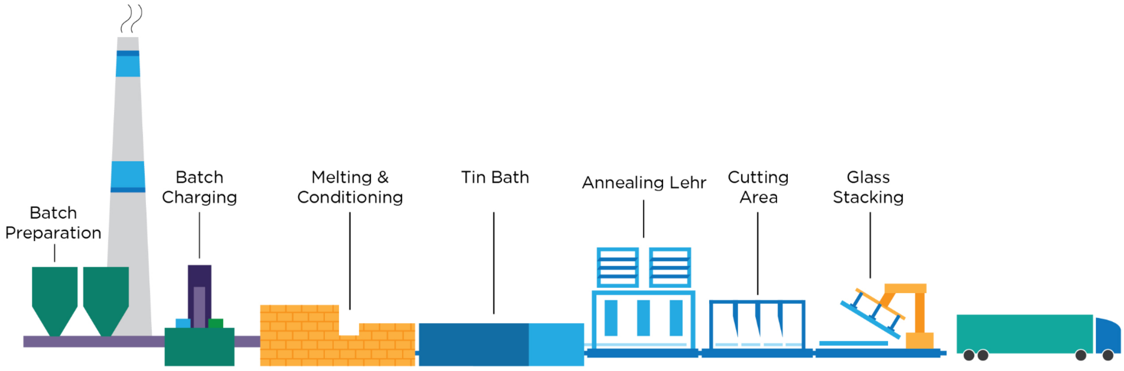

Figure 10: Flat glass manufacturing process

4.3.2.6.2 Economic contribution

The flat glass industry has been able to regain its positive trend, growing consecutively in the period 2014-2016. Aspects such as the rehabilitation of buildings and the recovery of the construction have made it possible.

The annual spending figure, despite being lower in the last year, has a big impact on society. This concept includes the acquisition of all the necessary raw materials and by-products, energy, transport, storage and logistics services, of finished products to the customer; as well as costs arising from outsourcing and financial services.

Finally, during the period 2006-2016 all production plants have made significant investments to adapt to European environmental regulations.

4.3.2.6.3 Environmental contribution

The flat glass manufacturing industry has integrated environmental impact reduction as one of the basic axes of its business strategy. In fact, the companies that form FAVIPLA combine the development of their products with innovation both in the process itself and in the final result.

In 2016, a quarter of the material needed to manufacture flat glass came from glass recovery. However, cullet incorporation levels may vary from year to year, depending on the availability of glass on the market. The use of recycled glass allows consuming fewer natural resources, reducing energy impact and minimizing CO_2 emissions associated with the use of fossil fuels.

4.3.2.6.4 Production and energy consumption

In the table hereunder an overview is given of the evolution of production and energy consumption of flat glass production (ref. 12) and expenses due to the energy consumption (ref. 13) from 2014 to 2016.

	Annual production (tonnes of product)	Energy intensity (MWh/tonne of product)	Total annual consumption (GWh)	Annual average price (€/MWh)	Expenses (millions of €)
2014	999.845	2,2	2.199,66	42,13	92,67 M €
2015	982.219	2,2	2.160,88	50,32	108,74 M €
2016	976.734	2,2	2.148,81	39,67	85,24 M €

Table 13: Evolution of flat glass production, energy consumption and expenses (2014-2016).

4.3.3 Competitors

- Vertech' (ref. 29): Since 1995, Vertech' has been the reference provider of software solutions for the glass industry. With a wide range of products, SIL provides glassmakers with very precise, real time KPIs on the performance of the whole plant. Thanks to all this shared data and the full traceability of products, production rates improve, losses decrease and customer risks are reduced.
- SIEMENS: Siemens, as a global automation partner, has to be considered always as a competitor or as a partner. The marketing messages they claim, are completely in line with the advanced solutions as COCOP want to implement. The digital glass factory of the future will provide greater productivity, quality, and transparency in glass manufacturing. Automation and digitalization solutions from Siemens cover all the steps in glass manufacturing and further processing. Find out how you can make your glass production – from engineering to operations and services – ready for the future.
- ABB: ABB has a Competence Centre for glass in Ratingen, Germany, where, based on their wide product portfolio, they build Automation solutions based on cutting-edge technology from the basis for the highest productivity, the best possible return on investment, future proofing and investment protection.

4.4 Business model

At the core of the value proposition there is the challenge to provide customers in optimizing their processes, leading to decreased operating costs in terms of energy, better quality and lower environmental footprint. Most potential customer segments are flat and container glass plants in Spain. The idea is to focus initially on the segment of glass container manufacturing plants, in which MSI has some experience, a so it is easier to obtain a first success story which can be used as a reference plant. The number of targeted companies in Spain is around 63, of which 19 are container glass manufacturing companies with several plants each. Customers awareness is raised through internet channels, such as LinkedIn, where the ability of the solution is demonstrated. A real use case will be used as interesting reference also in reaching potential customers, since the number of plants is limited, a personal approach can be considered. Customer relationships are based on mutual trust, transparency and close relationships between stakeholders. Mutual trust is needed for information exchange and process understanding.

- Customer segments (CS) define the different groups of organizations an enterprise aims to reach and serve. An organization must make a conscious decision about which segments to serve and which segments to ignore. At first stage targeted customer segment is container glass manufacturing plants in Spain & Portugal for proximity reasons and because of an established relationship. In a second phase flat glass manufacturing plants will be addressed also.

- The Value Proposition (VP) is the reason why customers turn to one company over another. It solves a customer problem or satisfies a customer need. Each Value Proposition consists of a selected bundle of products and/or services that caters to the requirements of a specific Customer Segment. COCOP concept could provide glass manufacturing companies process optimization in terms of better product quality, increasing re-use of material improving circular economy Activities. At the same hand, lower energy costs through energy efficiency projects can be set as a target also, and more stable process. When the solution is in full use, it helps definitely in lowering environmental footprint.
- Channels (CH) describe how a company communicates with and reaches its Customer Segments to deliver a Value Proposition. COCOP channels consist of activities raising awareness, internet marketing/introduction. Also, demonstrations and trials will be used to convince potential customer organizations.
- Customer Relationships (CR) describes the types of relationships a company establishes with specific Customer Segments. The COCOP concept is based on mutual trust and confidence between service provider and customer organizations, since it fits in a continuous improvement program.
- Key activities (KA) describe the most important things a company must do to make its business model work. Key Activities are the most important actions a company must take to operate successfully. COCOP key activities consists of building understanding the process and the need of data management and automation engineering services on one hand, and, technical marketing and sales on the other hand. Demo development skills and also operational support activities (e.g. remote control, consultancy, help desk) are needed.
- Key Resources (KR) describes the most important assets required to make a business model work. Every business model requires resources and these resources allow an enterprise to create and offer a Value Proposition, reach markets, maintain relationships with Customer Segments, and earn revenues. Incremental COCOP strategy needs one highly skilled technical sales consultant, together with a multidisciplinary team for data management, process automation and process knowledge. Later on, more resources might be needed.
- Key partnerships (KP) describe the network of suppliers and partners that make the business model work. Companies forge partnerships for many reasons, and partnerships are becoming a cornerstone of many business models. The COCOP concept value chain might need process and data experts from universities and research centres with special technical skills.
- Cost structure (CS) describes all costs incurred to operate a business model. This building block describes the most important costs incurred while operating under a particular business model. COCOP operation costs consist mostly of human resources needed for engineering services, development and consultancy work, besides of the sales and marketing needs. Additionally, there will be also costs for cloud services for data storage, processing and visualization.
- Revenue Streams (RS) represents the cash flow a company generates from each Customer Segment. COCOP revenues come from direct project sales, including software licenses, implementation and consultancy services.

4.5 Business environmental map

- Key Trends: Glass is present in our daily activities, from electronic device screens to doors and windows, to the insulation of houses or even in wine bottles. Therefore, it is not by chance that the glass manufacturing industry in Spain is one of the most important in its contribution to society. The role that the glass industry plays in the economic development of the Spanish territory is essential to make progress not only in economic matters, but also in social and environmental aspects. Spain is, thanks to the different glass manufacturing companies, the fourth European country, behind Germany, France and Italy, at production levels. Similarly, the energy efficiency is an unquestionable duty to conserve the environment by reducing gas emissions, to reduce household energy bills and to reduce the country's energy dependence, as well as debt externally generated. In short, energy efficiency is quality of life.

- Market Forces: In the market for mass produced glass products size matters due to the capital-intensive technology involved. For example, the container and flat glass sub-sectors are dominated by a few large companies out of which more companies are based in Europe. This is a strength since large companies have the ability to control production and distribution and may also have a broad product portfolio and R&D resources.
- Macro-Economic Forces: Glass sectors need to follow stringent regulation and control. Circular economy set pressures for glass reuse and cullet utilization.
- Industry Forces: According to the high technological innovation capacity, so far, the EU glass industry has succeeded in continually improving labour productivity by investing heavily in automation technology. This indicates a high capacity in the sector for taking up and utilizing new technology. As an example, the EU glass industry is the major innovator in the global glass industry, and at the same time is the main supplier of high-quality and high-value products so that EU producers are able to command a higher price for their products in the market.

4.6 Financial forecast

Estimated revenue is based on the 3 main services defined to provide maximum added value. It is understood that the fit of the different services with the need of the company depends on the (digital) maturity of the company in terms of outsourcing the automation engineering and optimization of the production processes. It is expected that customers will evolve from service 1 to 3 in time, from the most basic to the most complete.

Sales forecast Product/Service	2022	2023	2024	2025	2026
1. Plant-wide monitoring implementation services.	25.000 €	120.000 €	200.000 €	350.000 €	600.000 €
2. Advanced process optimization engineering.	7.000 €	35.000 €	80.000 €	140.000 €	250.000 €
3. Operational support services.	2.000 €	10.000 €	25.000 €	60.000 €	100.000 €
Total sales forecast	34.000 €	165.000 €	305.000 €	550.000 €	950.000 €

Table 14: Estimated revenue based on the 3 main services.

The costs associated with estimated revenue have been quantified in the table below, which also lists new staff hires because the staff cost is the most important element in total expenditure.

Cost forecast Product/Service	2022	2023	2024	2025	2026
1. Personnel	70.000 €	175.000 €	280.000 €	450.000 €	665.000 €
2. Materials - Investments	12.000 €	30.000 €	35.000 €	42.000 €	50.000 €
3. Expenses	10.000 €	15.000 €	22.000 €	30.000 €	35.000 €
Total cost	92.000 €	220.000 €	337.000 €	522.000 €	750.000 €
Number of persons	2	5	7	10	14

Table 15: Costs associated to the 3 main services.

The investments shown in the table above refer to the purchase of technical equipment and financing of the projects that are developed. The offer of the services provided by the company includes financial support to customers developing comprehensive energy projects.

Result forecast	2022	2023	2024	2025	2026
Annual result	**-58.000 €**	**-55.000 €**	**18.000 €**	**28.000 €**	**100.000 €**
Cumulative result	-58.000 €	-113.000 €	-95.000 €	-67.000 €	33.000 €

Table 16: Total results forecast between expected revenue and cost.

4.7 Action plan

Based on the exploitation routes, the following action plan will be followed.

1. Direct Exploitation – A new research project: MSI & Tecnalia are considering a proposal submission where the COCOP concept can be used as a basis for zero defect manufacturing in another H2020 program (Spire, FoF,…) or a national / local program.
2. Direct Exploitation – Direct sales: MSI will continue to approach the market with the plant wide monitoring solution on short term and process optimization on mid-term. This should lead to new business activities as described above, however with an expected slower market penetration since MSI has less experience in this segment. Multiple marketing and commercial actions will be undertaken.
3. Indirect Exploitation – Licensing: MSI will consider some opportunities here in a later stadium, because actually several open source solutions are used in COCOP concept and the actual TRL should be raised so it can be considered as a product. In any case, it would fit in an expansion strategy to other countries, where the services are provided by business partners. Therefore, MSI needs first some reference projects at national level.

4.8 IPR management

At this moment no additional IPR arrangement have to be made since no real progress is made on product development. In any case existing IPR agreements from the original COCOP project must be respected. In the future has to be defined how the company who provides the services will handle the IPR related to the data stored in the database and the knowledge extracted from it.

References

1. Urban Wastewater Directive - Environment - European Commission. https://ec.europa.eu/environment/water/water-urbanwaste/legislation/directive_en.htm.
2. *Viikinmäki wastewater treatment plant*. https://www.hsy.fi:443/en/experts/water-services/wastewater-treatment-plants/viikinmaki/Pages/default.aspx.
3. The governance of water services in Europe. http://www.eureau.org/resources/news/1-the-governance-of-water-services-in-europe.
4. «Publications». Water Europe, https://watereurope.eu/publications/.
5. «Latest». European Environment Agency, https://www.eea.europa.eu/es/publications/latest.
6. Environment at a Glance - OECD Indicators - OECD. https://www.oecd.org/environment/environment-at-a-glance/.
7. Resource Efficiency Scoreboard - European Commission. https://ec.europa.eu/environment/resource_efficiency/targets_indicators/scoreboard/index_en.htm.
8. EurEau - Resources - Publications. http://www.eureau.org/resources/publications.
9. «Industrial Wastewater Treatment Pressures on Environment». European Environment Agency, https://www.eea.europa.eu/publications/industrial-waste-water-treatment-pressures.
10. Agency (EPA), Environmental Protection. «Urban Wastewater Treatment in 2018». Environmental Protection Agency (EPA), https://www.epa.ie/pubs/reports/water/wastewater/uwwreport2018.html.
11. Estadísticas – Vidrio España. https://www.vidrio.org/que-es-vidrio-espana/estadisticas/.
12. Informe Vidrio España y la Economía Circular. Balance 2014/2016 – Vidrio España. https://www.vidrio.org/medio-ambiente/informe-vidrio-espana-y-la-economia-circular-balance-20142016/.
13. Publicaciones*. OMIE*. https://www.omie.es/es/publicaciones/informe-anual.
14. «Waterbase - UWWTD: Urban Wastewater Treatment Directive – Reported Data». European Environment Agency, https://www.eea.europa.eu/data-and-maps/data/waterbase-uwwtd-urban-waste-water-treatment-directive-6.
15. Ministerio para la Transición Ecológica y el Reto Demográfico - Balances energéticos. https://energia.gob.es/balances/Balances/Paginas/Balances.aspx.
16. Ministerio para la Transición Ecológica y el Reto Demográfico - Estadísticas eléctricas anuales. https://energia.gob.es/balances/Publicaciones/ElectricasAnuales/Paginas/ElectricasAnuales.aspx.
17. «Glass». Internal Market, Industry, Entrepreneurship and SMEs - European Commission. https://ec.europa.eu/growth/sectors/raw-materials/industries/non-metals/glass_en.
18. Union, Publications Office of the European. Final Report for a Study on Composition and Drivers of Energy Prices and Costs in Energy Intensive Industries: The Case of the Flat Glass Industry. http://op.europa.eu/en/publication-detail/-/publication/b43ca37c-ae26-49f3-9341-7558a75d52da.
19. plants.glassglobal.com - Glass producers and market studies. https://plants.glassglobal.com/login/.
20. *Wastewater Treatment Plant - an overview | ScienceDirect Topics*. https://www.sciencedirect.com/topics/earth-and-planetary-sciences/waste-water-treatment-plant.

21. «Aquasuite PURE». *Aquasuite® | EN*, https://aquasuite.ai/en/products/pure/.
22. Veolia lanza AMONITTM, un sistema que permite reducir los costes de operación de las EDAR. http://www.veoliawatertechnologies.es/news/Prensa/2012-06-27,26382.htm.
23. Wastewater – Urban wastewater treatment – IWW UWW - Degremont®. https://www.suezwaterhandbook.com/degremont-R-technologies/wastewater-treatment.
24. Tecnologías propias. https://www.acciona-agua.com/es/innovacion/tecnologias-propias/.
25. «Room for New Perspectives: Process Control System SIMATIC PCS 7!» Siemens.Com Global Website, https://new.siemens.com/global/en/products/automation/distributed-control-system/simatic-pcs-7.html.
26. Maval. «Siemens Simatic pcs7. Control de proceso industrial ¿Que és?» , https://www.maval.es/siemens-simatic-pcs7-control-proceso-industrial/.
27. EcoStruxure for Water and Wastewater Solutions. https://www.se.com/ww/en/work/solutions/for-business/water/index.
28. ¿Qué es Vidrio España? – Vidrio España. https://www.vidrio.org/que-es-vidrio-espana/.
29. «Productos». Vertech', https://vertech.eu/es/produits/.
30. Encirc Academy | Home. http://www.encirc-academy.com/.
31. «FEVE Members». *FEVE*, https://feve.org/about-feve/feve-members/.
32. «Key Data - Flat Glass Market». *Glass for Europe*, https://glassforeurope.com/the-sector/key-data/.