LIFE Project Number

LIFE12 ENV/ES/000477

Final Report

Covering the project activities from 1/10/2013 to 30/06/2017

Reporting Date

08/03/2018

LIFE+ PROJECT NAME or Acronym

Supercritical water co-oxidation (SCWcO) of urban sewage sludge and wastes - LIFE+ LO2X

Project Data

Project location	Paterna (Valencia), Spain
Project start date:	01/10/2013
Project end date:	31/12/2016 **Extension date:** 30/06/2017
Total Project duration (in months)	45 months (including **Extension of 6 months**)
Total budget	2,948,698.00 €
Total eligible budget	2,948,698.00 €
EU contribution:	1,474,348.00 €
(%) of total costs	50%
(%) of eligible costs	50%

Beneficiary Data

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2. Executive Summary

2.1 General progress.

The main objective of the project LIFE+ Lo2x was **to demonstrate the environmental and socio-economic benefits of a synergic co-treatment of sewage sludge and wastes** (raw/digested manure, high load food processing wastes, pesticides and leachates) **with energy and phosphorus recovery with supercritical water oxidation.**

The objectives set to demonstrate the technology performance have been:

O1. Design and construction of a prototype for the oxidation in supercritical water of mixtures of sludge (main matrix with phosphorus (P) and embedded energy from organic content) and other wastes for synergistic enhanced performance: manure (for ammonia elimination and P recovery), food wastes (for extra carbon) and complete destruction of organic toxic substances (pesticides and leachates), contributing to the water quality objectives of the Water Framework Directive and the Urban Waste Water Directive and the Nitrates Directive.

Determination of:

O2. Operating conditions and mix ratios for best process yield and energy balance, linking water/energy and contributing the achievement of climate neutral waste water systems and a 20% energy improvement in wastewater treatment for 2020.

O3. Operating conditions to optimise P recovery from wastes. Contributing to the objectives of the Resource Efficiency Roadmap (Wastewater Treatment Plants WWTP as resource factories).

O4. Reduction in the final amount of waste generated in a WWTP and better quality for safe disposal, contributing to the objectives of the Waste Directive and the phasing out of land filling of organic wastes.

O5. Economic balance linking environment, innovation & socio-economic growth, particularly:

- Reduction of costs of sludge management versus current sludge management scheme.
- P cost of recovery compared to current market prices and tendencies of P from P-rock
- Cost of the treatment wastes compared to current treatment/disposal pathways.
- Economic balance of energy.
- Local socioeconomic assessment
- Dissemination effectiveness and social awareness assessment

The project has involved the construction and operation of a prototype that allows for the treatment of a significant fraction of the raw sludge generated in a representative medium sized urban WWTP and wastes collected from the surrounding area. It was decided to be constructed at the WWTP of Paterna (Valencia).

A series of actions were conceived to achieve the objectives

- A. Preparatory work: To obtain preliminary experimental specific data at bench scale so that design parameters may be established for detailed design of the prototype.

- B Implementation: Detailed design of the prototype, construction and assembly in the WWTP, start up, operation and performance assessment to demonstrate that the system works and the environmental benefits of the new technology versus the baseline scenario.

- C. Monitoring of the impact of the project: Specific indicators were monitoring the improvement of the environmental problems targeted, considering the initial situation. At the end, the progress achieved was quantified. The socioeconomic impact on the local economy and population was assessed.

- D. Communication and dissemination: The project has been disseminated to the relevant stakeholders throughout the Project lifetime.

- E. Project management: The project management has ensured the successful completion of the project and the coordination of all the parties involved.

The project has been performed through a cross border collaborative project (Spanish and Irish). AINIA technological centre with twenty years of experience in supercritical fluid and environmental technologies, IMECAL specialist in equipment construction, URBASER sanitation engineering, IVEM responsible of the WWTP that will hold the prototype and SCFI Irish specialist in supercritical oxidation.

This Final report describes the progress made along the duration of the project. The achievement of the first of the particular objectives O1, as the building up and starting-up activities (B2 &B3) were carried out standing on previous tasks already reported in previous occasions (A1 and B1), make possible to progress on tho the rest of objectives, since they only could be approached once O1 was fulfilled. As a result, the demonstration prototype, essential to perform the experimental activities needed to assess the proposed process (Supercritical Water Co-Oxidation of Sewage Sludges) and to get the expected outputs (pretty removal of pollutants, recovery of phosphorus, energy balance, and reduction of treatment costs), that constitutes the most essential among key deliverables D.B2.2 “Demonstration prototype constructed”, is available and may be visited. In order to get sounder results and to reinforce the demonstrative character of the project, the Consortium decided to take the chance of involving in the prototype some units that became available for enlarging the size of the prototype without any increase on the overall project budget. The activities carried out involving the prototype demonstrated the feasibility of the proposed technology for the treatment of sludges and other cosubstrates through Supercritical Water Co-Oxidation (SWcO) and the objectives (O2, O3, O4 and O5) were covered. All deliverables were developed, with special attention to B4.4, B.C.2 and B.DX standing on other previous ones, such as D.B3.1 “Handbook of the demonstrative pilot plant”, DB3.2 “Certification of the demonstrative plant (documents)" and D.B4.1 "Experimental design specifications to assess the SCWO process (document)".

This Final Report addresses the main information that describes the development of the project along the reporting period up to the end of the project (30/06/2017). A summary of the different tasks performed is presented along with the dissemination activities performed in parallel to the technical tasks in Technical Part of the midterm report. Project Timetable is addressed to reflect graphically in a Gantt Diagram the schedule of the Preliminary Actions (A1), Implementation actions (B1, B2, B3 and B4) and Monitoring Actions (C1) as well as Dissemination actions (D). Later on, details regarding each of these actions are addressed, describing the progress, the deliverables and the milestones involved.

As a summary of the main results, the following ones were achieved along the LIFE Lo2x project:

- **> 99% elimination of organic matter.** The COD of SCWcO effluent is in average lower than 200 mgO_2/L, reaching values even lower than 25 mgO_2/L.
- **100% elimination of pesticides.** Imazalil is degraded through SCWcO up to 350 mg/kg, four orders of magnitude higher than the concentration removed by anaerobic digestion.
- **100% elimination of pathogens.** *Escherichia coli*, *Clostridum perfringens* and *Salmonella spp*. are completely eliminated. SCWcO leads to complete sterilization.
- **>85% heavy metals are recaptured for safe handling.** Heavy metals are mainly detected in inorganic solid fraction of the SCWcO effluent.
- **Recovery of nutrients.** Mineralization of nitrogen and phosphorus facilitates the nutrient recovery in order to be used as building blocks of fertilizers. Nitrogen occurs in the liquid phase (NH_4~2 g/L) while phosphorus is present in the inorganic solid fraction of the SCWcO effluent (P_2O_5~25%).
- **No highly harmful gases are produced.** CO_2 is the main gas generated by SCWcO. Typical undesired gaseous products from the combustion processes as NO_x and SO_x are not produced.
- **98% reduction of sewage sludge leaving WWTP.** Total solid reduction higher than 90%. The inorganic solid fraction from SCWcO is a resource for phosphorous industry whereas wastes from anaerobic digestion may end up in the landfills.
- **Zero heat consumption.** The heat produced by the oxidation under supercritical conditions (highly exothermic reaction) makes pumping to be the only significant energy-consuming step (*i.e.*, 1 kWh/kg dm) through SCWcO.
- **>10% reduction in sludge treatment cost.** The gate fee thanks to co-substrate treatment by SCWcO allows reducing the cost of sludge treatment below the cost of anaerobic digestion.

These sound results derived from the activities performed along the whole LIFE LO2X project.

Along this final report, first of all, Preparatory Actions A1 and Action B1 (detail engineering project) are pointed out as reported in previous reports and summarized the most relevant figures.

In the same way, B2 Actions (Building up Activities), Action B3 (Start up of the prototype) and Action B.4 (Operation of the prototype and assessment of the Co-Oxidation process) are summarised and updated with respect to previous reports. The start-up comprised different kind of test, from static tests from low to high pressures, temperature monitoring checking, electrical checking etc and was completed with the required certifications applications for the facility carried out. Experimental activities were progressively developed, updating design of experiments fitted taking into account the results of successive tests and carrying out the tests designed.

In parallel to Implementation Actions, Action C1 for monitoring of the impact of the project action was carried out as scheduled. The selection of both environmental and socio-economical indicators jointly with information regarding the assessment performed standing on these indicators are addressed in the next section.

The Dissemination Actions are addressed in Annex 5.2. Jointly with the objectives for this kind of activities, a general overview of the Dissemination activities per Actions is provided, related to the website updates, elaboration of poster, notice boards, film, technical articles, press releases, presentation in events, presentations to stakeholders and relevant authorities, and foreseen actions as a technical leaflet and a Layman's report.

Afterwards, the Project Impact highlights are addressed, discussing environmental benefits, replicability, demonstration, transferability, cooperation, best practice lesson, etc. in the same line expressed in the Midterm Report. Environmental benefits and the relevance for environmentally issues or policy areas is presented with especial mention to concepts such as water quality, sludge management and the Roadmap to a Resource Efficient Europe turning waste into a resource, as LO2X project aims to. Also long term benefits and sustainability are addressed, taking into account environmental and socio-economic aspects. Because the own nature of the demonstrative project, the continuation of the project is clear as its reproducibility and transferability may be feasible to other places with similar features in line with EU policies and the Consortium Cooperation in the project may be extended in future after the LIFE+ project. This may happen due to the sound innovation and demonstrative value of the LO2X project from different points of view: technological innovation because of its environmental application and the synergistic co-oxidation of different wastes as well as model innovation because of changing the concept of the WWTP towards a resource recovery plant.

Finally, comments on the financial report are included in point 6. "Comments on the Financial Report"

2.2 Assessment as to whether the project objectives and work plan are still viable.

Life+ LO2X project main objective is still viable, since the prototype built-up has allowed to carry out experimental test to demonstrate the environmental and socio-economic benefits of a synergic co-treatment of sewage sludge and wastes by means of supercritical water co-oxidation. The dimension of the prototype developed reinforces the soundness of the results for the demonstrative purposes and thus the workplan with the extension dates agreed in the 2nd amendment may be considered as well as still viable and adequate to achieve LO2X project objectives.

2.3 Problems encountered.

The project faced first of all an organisational problem due to the need to replace a partner leaving the consortium, that was solved successfully with a new enterprise with a valuable profile for the LO2X project.

After that, some technical problems were faced, that may be summarised as follows:

- The unexpected behaviour of specific units in the pilot plant, the occurrence of assembly difficulties in some parts and the need of additional elements to reach the target performance affected the development of Action B2, since more time was required to get the prototype built up. This way more efforts were needed and this action took longer than expected. Contingency plan was applied and B2 labours were developed simultaneously with B3 to maximise the progress of the project and B4 experimental design was adapted to the reduction of available time for experimental activities.

- Also, the time finally needed for being ready to carry out the applications to Industry Authorities was larger than initially allocated and also applying contingency plan, B4 experimental design was fitted to complete the objectives within the duration of the project without needing a project amendment.

- Nevertheless, reaction tests revealed relevant operative problems such as corrosion and pluggings causing flow and pressure troubles making impossible to carry on the experiments. Technical solutions were applied to replace affected parts and made process reengineering to avoid such a kind of problems. This way, it was studied the impact on project development and an extension for six months was asked and agreed.

- Due to the technical problems, it was decided to revise the Dissemination Plan and to fit it in order to strength this area in the last part, once these difficulties may be solved and some sounder results may be available.

3. Introduction

Water quality remains an issue across Europe, with implications for public and environmental heath and biodiversity. Pollution (excess nutrients, pesticides, toxic substances, waste discharges etc.) is still a **top priority** and a concern for all water users and the need to supply clean water in sufficient quantity for use at a reasonable cost remains a challenge EU wide. According to the **European Innovation Partnership (EIP) on water in 2020 Europe** must have safe, available and affordable water supply and wastewater treatment for all water in place, based on sustainable management of the water resources and most innovative, competitive and cost effective solutions.

Sludge management has become one of the most critical issues for the wastewater industry worldwide, due to the very fast increase in sludge production resulting from increasing numbers of new wastewater treatment plants, more inhabitants connected to existing sewerage systems and upgrading of existing facilities to meet stricter discharge criteria. The project's objectives fit the needs set in the baseline scenario resulting from the assessments on sewage sludge management carried out by the DG Environment of the European Commission in the process engaged for the revision of Directive 86/278/CEE, on application of sewage sludge in agriculture. LIFE LO2X is coherent with the **Roadmap to a Resource Efficient Europe** regarding the objective of **turning waste into a resource**.

3.1 Description of the background, problem and objectives

The main issue tackled in this project is water quality through the links between wastewater treatment, sewage sludge management and pollution derived from sludge application (organics, nitrates and phosphorous) and the water energy-nexus. New technology solutions should allow for other major societal challenges related to water such as climate change, resource and energy efficiency strengthening the water/energy interactions.

The objective of the **LIFE LO2X project** is to demonstrate the environmental, energetic and socio-economic benefits of a **synergic co-treatment** by means of **oxidation in supercritical water of sewage sludge and others highly loaded organic wastes** such as raw/digested manure, high load food processing wastes, pesticides and leachates. The system allows energy and phosphorus recovery: **turning waste into resources**. The project involves the design, construction and operation of a prototype in Paterna WWTP to treat up to 1 TM DM/day of sludge. The LIFE LO2X project is addressed to reach: 100% elimination of pesticides; 100% elimination of ammonia; Positive energy balance (net production); 100 % recovery of phosphorous; 90% reduction of sewage sludge, and > 10% reduction in sludge cost treatment, in all cases compared with baseline scenario.

3.2 Expected longer term results

Mitigation of overall environmental pollution, since the multi-waste treatment and resource recovery approaches of the Lo2x project contributes to reduce the environmental impact of traditional WWTPs.

Improvement of water cycle, since a high-quality effluent is produced, as contaminants (i.e. pesticides, pathogens, etc.) are eliminated and heavy metals are mainly in the final solid residue.

Enhancement of nutrient cycles, thanks to mineralisation and the potential use of effluent fractions as valuable sources to recover nitrogen and/or phosphorus for fertilising uses.

Enhancement of air quality, due to clean direct emissions without undesirable and toxic compounds (NOx, SOx, etc.) and reduction of indirect greenhouse emissions linked to residue disposal transport.

Reduction of quantities of sludge to be managed and their associated **economical costs** (sludge management costs represents the 50% of the total cost related with conventional WWTP´s operation.

Availability of a treatment alternative suitable for dangerous wastes

Positive contribution to highly-qualified human resources and entities, as the ones involved in the project have integrated new knowledge and skills and they are needed both to build up new plants and to operate WWTPs involving the tecnology.

The main **European legislation** in connection with the project is: Water Framework Directive; Directive 86/278/CEE, of 12 June 1986, on application of sewage sludge in agriculture; Directive 91/271/EEC of 21 may 1991, concerning urban waste water treatment; Directive 91/676/CEE, of 12 December on water protection against nitrates pollution from agriculture; Directive 99/31/CE, of 26 April 1999, on landfill of waste; Directive 2006/12/CE of 5 April 2006, on wastes. Moreover, LIFE LO2X is an interesting technology that will allow facing the new and more restrictive regulations in relation to the application of sewage sludge in agriculture: 4th draft of Directive 86/278/CEE, on application of sewage sludge in agriculture, working document on sludge is ongoing.

4. Administrative part

4.1 Description of the management system

Presentation of the coordinating beneficiary, associated beneficiaries and project organization:

AINIA is the general coordinator of the project. AINIA is responsible for the reporting to the European Commission and to inform it in case any problem or question needs to be solved. AINIA also is responsible for the preparation and coordination of meetings. As coordinator, AINIA is responsible for the payments to the rest of the partners. The rest of partners inform AINIA of the project advancement and provide AINIA the requested information for the production of internal and official reports. They also inform AINIA of relevant situations (i.e. technical or economical problems). In case they consider necessary to consult the consultative group, they ask AINIA to prepare the meeting in the most appropriate way.

The consortium is organised in different coordination and management bodies, in order to guarantee the achievement of results and their compliance with the Grant Agreement.

The management bodies include: Project coordinator (CO), Steering Committee (SC) (one representative in each organisation) and Technical Committee (TC) (Activity leaders).

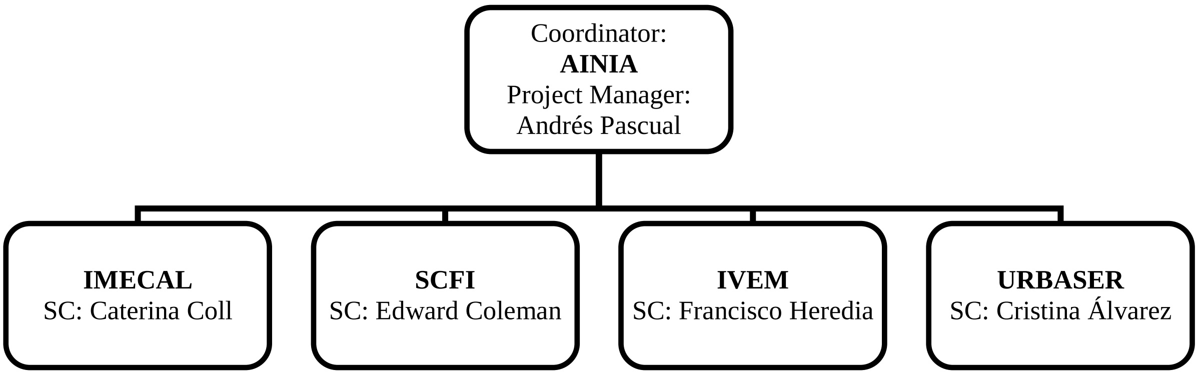
The different responsibilities and duties are as follows:

Project Coordinator (CO): To guarantee the compliance of the Consortium Agreement; To guarantee the implementation of the foreseen activities; To monitor the financial and technical aspects of the project; To communicate all deviations and changes to the EC; To send the corresponding reports (technical and financial); To transfer the funds to the partners in the consortium.

Steering Committee (SC): To follow the Coordinator's guidelines, To abide the Consortium Agreement and the Grant Agreement, To commit to the execution of the foreseen activities; To ensure the quality of the results obtained under their responsibility; To meet deadlines set by CO for administrative or financial issues; To contribute to technical reports.

Activities leaders (TC): To execute the project Activities and Tasks; To guarantee the quality of the results; To make decisions about the project; To surveil for risks mitigation.

Organigramme of the project team and the project management structure



Actions, tasks and leaders:

ACTION	LEADER
A1 Preparatory actions	SCFI
B1 Detail engineering project	AINIA
B2 Building up activities	IMECAL
B3 Start up of the prototype	URBASER
B4 Operation of the prototype and assessment of the co-oxidation process	IVEM
C1 Monitoring of the impact of the project actions	AINIA
D1 Dissemination and communication action plan	AINIA
D2 Project website	AINIA
D3 Project materials	AINIA
D4 Notice boards	AINIA
D5 Layman's report	AINIA
D6 Film: virtual tour prototype	AINIA
D7 Technical articles	AINIA
D8 Press releases	AINIA
D9 Events	AINIA
D10 Presentation to the relevant authorities	AINIA
D11 Presentation to stakeholders	AINIA
E1 General management	AINIA
E2 Project management and monitoring the project progress	AINIA
E3 Networking activities	AINIA

Management Guidelines establishing detailed management main tasks and cooperation aspects was delivered to all partners at the beginning of the project. This document is the deliverable D.E.2 and includes a description of the project management structure, project lifetime, a list of work packages, tasks outputs and their deadlines, information about the project workplace and login/password details and information about the content of the scheduled reports and their deadlines.

Management tools development and use: To facilitate the management of the project and the flow of information, AINIA has created an intranet linked to the project website, available for all partners. The intranet will allow the consortium members to access to all the relevant project documents, share information, etc. All the relevant documents are stored in it and can be uploaded and retrieved by partners as they create, modify or need to consult them. Intranet also includes monitoring procedures and tools. **Workplace Guidelines** to facilitate the use of the tool by the participants were prepared and sent to the partners.

Day-to-day coordination and monitoring was done remotely: continuous communication was achieved by phone, e-mail, skype and videoconferences to comment specific matters with the partners. Through these channels, the coordinator has exchanged and provided all the information requested to and from the partners, and has monitored the correct development of the project. On the other hand, partners kept regular internal team meetings for coordination purposes and to prepare Coordinating Meetings and its further debrief.

A series of 10 face-to-face **coordination meetings** have been held to monitor progress, exchange points of view, information and results, review any deviations and solve eventual problems, propose corrective/preventive actions and ensure the quality of the results. The consortium discussed the activities already carried out as well as the ongoing and foreseen activities. Calling meetings and organising the agenda was done by the project coordinator. Agenda of each meeting was discussed and sent to attendants before the event in order to help all partners to prepare their participation in the meeting. Minutes of each meeting were handed to attendants after the event including all decisions, agreements, follow-up actions and commitments made during the meeting by the participants, accompanied by due dates and any other necessary details.

Amendments to the Grant Agreement

The participation of the former beneficiary ISOLUX INGENIERIA S.A. was terminated from the date 30th of June 2014. As reported in the Inception Report, the company has undergone an important restructuring process and has abandoned all ongoing R+D projects. A resignation letter was sent to the coordinator communicating this decision and waiving recovery of any expenses executed during its participation. In order to replace the outgoing company, A **first amendment** to the Grant Agreement was done to add URBASER S.A. as beneficiary with effect from the date 1st of July 2014. All the actions and tasks scheduled for the outgoing entity ISOLUX INGENIERIA S.A. were since then executed by the new beneficiary URBASER S.A. as a general approach to the workplan. A **second amendment** to the Grant Agreement was performed in order to extend the duration of the project in 6 additional months, being the new end date the 30/06/2017.

Partnership agreements.

P.A were signed by all partners with date of signature 27 June 2014 and submitted to the commission with the Inception Report. **Addendum Nr1** was issued by request of the commission after the evaluation of the Inception Report. It was duly submitted thereafter to the commission. **Addendum Nr2** was issued to adapt specific provisions for the better security of the joint and several liabilities between the parties in the framework of the Partnership.

Reports

Three reports have been delivered to the EC since the beginning of the project: Inception Report, Midterm Report and Progress Report. This Final Report is the last one.

4.2 Evaluation of the management system

At present, we have not problems with partners or with their work on the project. On the contrary, the involvement of the partners is considered by the coordinator as very favourable. We haven't had changes in the role of partners.

Monitoring Team has visited the project three times (Valencia 23/04/2014, 27/05/2015 and 31/03/2016) with the presence of all partners. In the last two visits, the monitor could visit the prototype. Apart from the meetings, fluent communication, via email and phone, is maintained with Monitoring Team along the whole project. Amendments, deliverables and justification reports (Progress reports) have been sent to the monitoring team for first review prior to its sending. A visit of the Desk Officer and Financial Officer with the Monitoring Team presence was done on 5th May 2017.

5. Technical part

5.1. Technical progress, per task

A. Preparatory actions

A.1 Preparatory actions

B. Implementation Actions

B.1 Detail engineering project

B.2 Building up activities

B.3 Start up of the prototype

B.4 Operation of the prototype and assessment of the co-oxidation process

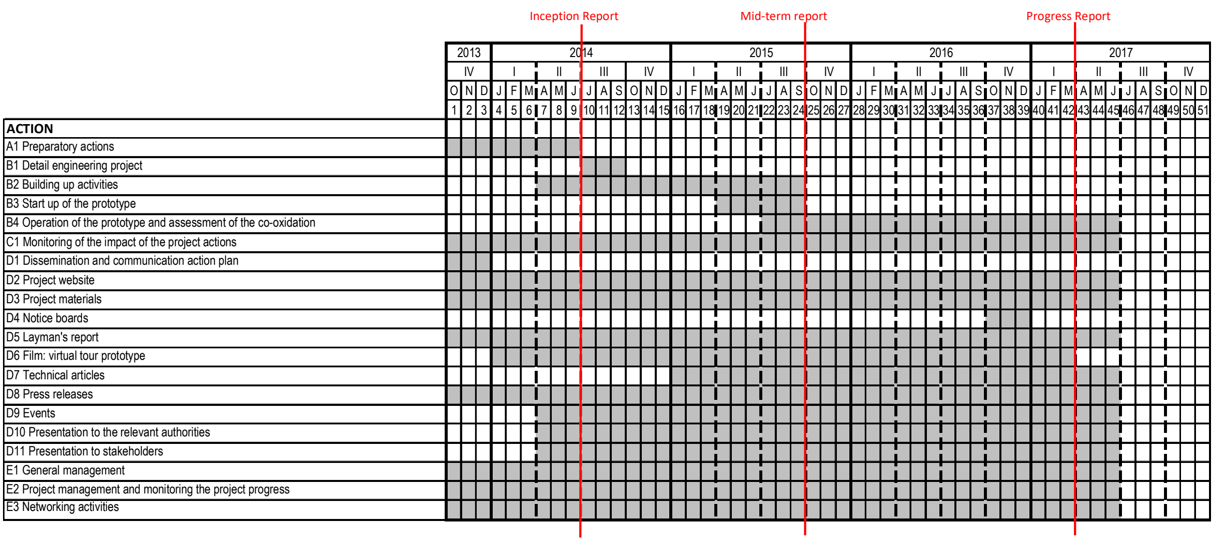
C. Monitoring of the impact of the project actions

C.1 Monitoring of the impact of the project

The A actions are preliminary actions to determine experimentally some key points for B, C actions. These actions have comprised the previous tasks required to select and test different wastes added to the feed stream to be oxidized, the preliminary adjustment of the process to the selected feed substances and the elaboration of the basic engineering project. The activities undertaken and outputs achieved within this action were already reported in previous reports.

The B actions regarding to the detail engineering project and building up activities have been developed according to scheduling (Figure 1). In parallel monitoring actions (C) with the identification of specific indicators have been done.

Figure 1. LO2X Project Timetable.



Action A1: Preparatory actions

Preparatory actions were scheduled to take place from October 2013 to June 2014 and they were carried along this period. SCFI led these activities carried out with the collaboration of other partners, especially AINIA.

Selection and provision of feed samples for preliminary studies were carried out in order to run bench scale tests (see annexes, D.A.1.1 Preparatory activities report). The list of manure, wastes and/or toxic substances candidates to be supercritically oxidized with the sludge stream (kind, producer, availability, current treatment) was done. Samples of selected co-substrates for the performance of the experimental SCWO tests were identified. This way, 11 different feeds were tested with solid loads in feeds up to 17% along a series of tests grouped (26 trials) lasting from 3.5 up to 13 hours under operation (discounting start-up and finishing times). In each test, COD in the feed and in the effluent were determined and other complementary parameters have been also collected depending on the feed type such as pH, total nitrogen, TDS or conductivity. Samples along the processes were taken and also determined with frequencies depending on each trial (from every 20 minutes up to hours). Taking into account the trials at lab scale, leading to removals over 99% in best conditions for each case, a series of suitable feed compositions were identified (% solids, COD levels) and an experimental protocol were defined to be used as a basis for the prototype engineering.

Preliminary results pointed out possible technical issues with some feed types to be taken into account due to factors such as narrow inner diameters for proper velocities causing blocking and pressure drops as well as pumping constraints due also to internal dimensions of these elements for initially proposed flowrates. Particular specifications were proposed to be adapted to come up to a suitable demonstrative prototype to be able to carry out experimental test with selected feeds keeping the scope, aim and budget of the whole project.

The design basis of the demonstrative pilot plant was established, as compiled in the Deliverable D.A.1.2 for detailed project: flowchart with main units, piping, auxiliary services, preliminary layout (placement plan in IVEM facilities) and control basis of the process. Finally, preliminary planning for the construction of the plant was agreed by the Consortium.

Start date: *October 2013*. End date: *June 2014*.

Deliverable A.1.1. *Preparatory activities report "List of potential substances considered to be oxidized", "Data sheet of selected co-substrates", "Design of the preliminary tests"* was carried out (achieved).

Deliverable A.1.2. *Basic Engineering project & Estimated program of the tasks for the construction of the plant* was carried out (achievedt).

Milestone A.1. *Preliminary actions completed: cosubstrates selection and compilation; basic engineering project elaboration and preliminary assays performance* (achieved)

Action B1: Detail engineering project

Although this action B1 was previously scheduled to start on July 2014, it started three months in advance. It was carried out with the collaboration of all partners, with special contribution of SCFI and of AINIA as a leader.

Process definition and description with the detail of each operation were performed. Besides a process flow diagram was ellaborated including the main streams and units. A list of units and main specifications of them was done including parameters such as internal volume, material, working temperature, working pressure, or general dimensions.

List of main streams and mass balance drafts for them were also prepared, considering besides the main requirements of auxiliary water for the cooling exchangers.

The project execution plan was been revised, detailed and updated taking into account detail engineering inputs as well as new information coming true as the tasks moved forward. Considering all this information, next tasks focused on the detailed process diagrams including instrumentation and control requirements. P&I diagrams were drawn including process valves, and their type, and instrumentation (temperature, pressure, flow indicators). In parallel, specifications regarding different streams and elements were detailed. Once these diagrams completely defined, pipes and instrumentation elements were specified and selected from current commercial options.

Start date as addressed in the proposal: *July 2014*. End date: *September 2014*.

Deliverable B.1. *Detail engineering project with: process diagram, list of equipments, list of streams, pipes and instrumentation. Data sheets: equipments, pipes, instruments and layout* (achieved)

Milestone M.B.1. *Equipment Specification, P&ID and piping and Instrumentation Datasheets elaborated and layout defined* (achieved)

Action B2: Building up Activities

The objective of this action was to build up the SCWO plant in WWTP of Paterna.

Action B2 started as scheduled with the contribution of all partners and IMECAL as leader. An initial plan was defined considering the dimensions and characteristics of the units and the requirements and particular aspects of the process (connexions, proximity to optimize piping and occupied area, security, etc) defined in the Action B1 (Detail engineering project). This initial lay-out was used to begin with the tasks involving holding are adaptation and legal permits submission. A study of the area required for the placement of the prototype, an analysis of constraints and specifications, etc. were performed to choose the most suitable placement. With this basis, the water local authority (EPSAR) and owner of the Paterna´s WWTP were asked to allow the works needed to adapt the area identified.

Once this permit achieved, this area was prepared for later constructive works and other legal requirements were studied. Moreover, mechanical works to manufacture and/or to adapt equipments as well as selection and buying of elements (pipes, valves, instruments, etc.) were carried out. Each main unit constructed, acquired and/or adapted for the prototype was inspected prior to installation in order to detect any fabrication or delivery failure and to avoid any wrong performance with associated negative impacts on schedule and on budget.

On the other hand, the automation of plant operation with the sequences to be used for operation and as bases for control loops development were studied and defined, to be afterwards implemented in a control program specially designed for the operation of the LO2X plant with the support of an automaton commanded from an interactive interface with the operator.

After the construction, reception and acquisition of the different elements of the pilot plant, the main elements of the LO2X plant were allocated and the mechanical and electrical assembly and plant building up thereof was approached. Likewise, the auxiliary services necessary for the operation of the plant (gas, compressor, water, etc.) were installed. Finally the insulation works were prepared to be performed once the assembly works may be over.

The unexpected behaviour of specific units in the pilot plant, the occurrence of assembly difficulties in some parts and the need of additional elements to reach the target performance affected the development of Action B2, since more time was required to get the prototype built up. Some difficulties regarding the oxygen and nitrogen system installation required some additional works to be implemented by the provider to solve some unconformities (which also affects some insulation activities as they must be implemented in these specific parts of the installation) as well as some specific and unusual material with very broad delivery response due to their high technical specifications (Inconel 625 and others). This situation joined with other technical issues concerning B3 start-up activities also affected the schedule of some insulation activities as they needed to be implemented in these specific parts of the installation. This way, it was required to overcome the contingency plan described for the project and some extra months were required to finally get B2 completed and this had an impact also on B3 action, but did not affect the overall final project scheduled and results. Some B2 labours were developed simultaneously with B3 to maximise the progress of the project and B4 experimental design was adapted to the reduction of available time for experimental activities. With this updated design, it was considered that the whole project duration may be kept as initially established and it would not be necessary to extend the project.

Start date: *April 2014*. End date: *September 2015*.

> Deliverable B.2.1. “*Main units data sheets: special elements list: building plans for the assembly of the main units; document with main software instructions: control loops and alarms*” (submitted)
>
> Deliverable B.2.2. “*Demonstrative plant physically constructed (prototype)* (achieved).

Milestone M.B.2.1. *Main units and special elements designed and manufactured, acquired and /or adapted if required; control software developed and programmed* (achieved)

Milestone M.B.2.2. *Prototype mechanically and electrically assembled: plant ready to its start-up* (achieved)

B.2.1 Holding area adaptation and legal permissions submission

IVEM, as responsible for the holding area adaptation for the prototype, took care of activities dealing with the consortium resources and external collaborators to get the holding area fully ready to perform next tasks on place.

This way, the prototype placement inside the urban waste water treatment plant in service located in Paterna (Valencia) was studied in accordance to foreseen layout and to other factors including among others: ground features (composition, existing distribution pipes and wires, connections for auxiliary services or technical fluids such as tap water, electricity, etc.), high power distribution wires, internal access for workers, needed accesses for gases supply (oxygen, nitrogen). The conclusions of the study were shared with the partners and also some key aspects were checked with external collaborators dealing with gases supply, concrete, etc. Afterwards, labours made by externals to get the basements ready were prepared and supervised directly on site by IVEM to make holding area usable for prototype constructions. As drawbacks, the later progress of other activities led to identification of the need to extend the dimensions of some of the supporting structures in order to stand all the instruments, insulations, etc. in the reactor area. Pictures in Figure 1 show several moments regarding these on site works for holding area adaptation.

Figure 1. Holding area adaptation works

On the other hand, legal requirements to the “High Pressure Equipment” and “Heaters Equipment” laws were studied with the support of external services, since special documentation is needed and certification issues of high pressure elements for CE certification imply the participation of a called OCA (Organism of Authorized Control). As expected, the most critical aspects identified as a result of this study were the tests for assuring the performance of the high pressure units at the due high pressures, the way of performing such tests, the complete compilation of the proper documents, and the administrative application itself.

B.2.2. Main SC units (reactor and heat exchangers) and process chambers construction:

As the project progressed, SCFI addressed the possibility of using some already existing units that had available instead of manufacturing new ones in order to be able to come up to a larger prototype to get sounder data for demonstrative purposes keeping the same budget. The pilot plant LO2X has different elements or main equipment that can be divided into high pressure equipment and Other process chambers and Pilot Plant units

About the high pressure units, SCFI was focused on preparing the reactor vessel and heat exchangeunits for its shipment from Ireland to Paterna, where IMECAL may revise, test and adapt them to the LO2X supercritical co-oxidation processing requirements. In reference the other chamber and pilot plant units different elements were built up and adapted by IMECAL during this action.

A series of process units to be used in the Prototype were sent from the SCFI installations in Ireland to WWTP of Paterna in Q3 of 2014. IVEM was in charge of the reception of them and jointly with SCFI, IMECAL and AINIA perform a revision of the elements. After making an inventory and review of major equipment defined in the engineering stage process (Action B1), IMECAL focused on specific works dealing with high pressure equipment, such as inspections, tests, constructive works for adaptation and conditioning of units to be adapted to LO2X supercritical co-oxidation conditions, and carryng out the required tests to assure correct performance of each unit in line to CE labels.

High pressure equipments involved in the prototype that imply constructive chambers are: one Reactor (R2005), two Economisers (E2001, E2003) and one Cooler for the output stream (E2011). Radiographic Inspections, constructive works, welding inspections, high hydrostatic pressure tests were carried out involving high pressure units.

Other units such as the liquor storage tanks or the main feed tank were reviewed, modified and finally conditioned for use in the LO2X pilot plant. Visual and non-destructive superficial tests were done, which pointed out the need to reinforce the weld or the structure thereof in some elements.

The other equipment necessary for the installation were built up and adapted, in order to improve the quality of sludge conditioning. All the processing units of the plant were performed with Stainless steel in order to prevent the corrosion of equipment.

Design and construction of the different units for the supercritical oxidation LO2X plant took into account the installation of the necessary flanges and connecting elements to equip them with systems to measure process parameters, as it can be seen in Figure 2. Once prepared the units in accordance with future processing need, a welding inspection and a pressure leak test were applied to every of these elements.

Figure 2. Equipment Construction for LO2X pilot plant

B.2.3. Piping, Valves, Vessels and instrumentation: special elements for the prototype

The items needed to build up the facility were revised in accordance with the conclusions of action B.1, where pipes, flanges and instrumentation and other elements were listed and described the list of equipment and the detailed equipment Specification Datasheets.

All partners involved in the LO2X project got involved in the search for providers, in contacts with externals to address technical data, in the checking of items, etc. Identification of suppliers took into account previous knowledge but also new ones through special search in specialized databases, following hints from other suppliers, etc. Contacts were made by phone, by email and by face-to-face meetings. During the definition and acquisition of materials there was a close contact between the various companies involved in the work. For all items were required different offers based on the specifications indicated in the data sheets, with the aim of making a comparison of specifications, prices and guarantees offered from various suppliers to select the most convenient one in each case.

IMECAL managed piping, flanges and accessories search and acquisition, while other partners dealt with valves, instruments, etc. SCFI got involved in preparing some existing items in Ireland to be sent to Paterna as well as in contacts to ask for offers and checking of technical specifications and AINIA provided also support in contacting suppliers, checking of elements, revision of specifications, etc. Reception of elements were usually made by IVEM, since the items were shipped to the WWTP of Paterna in order to easy latter works, although piping materials were served to IMECAL warehouse and later on put in place.

According to the detailed pipe lines list description, the Piping and Instrumentation Diagram details (PID) and valve list, all the piping material, valves, special tubing, flanges, racords, fitting connections and other connections needed were acquired, mainly by IMECAL (some elements acquired by URBASER). All connections (racords, flanges, fitting connections, elbows etc) required for connecting the lines with different plant elements were acquired with the same material as the pipe.

Automatic, manual and safety valves necessary to assure the plant security were revised and tested and additional safety valves were acquired and installed. Part of the instrumentation and special items detailed in process engineering were sent along with the main elements (Reactor, Economisers, etc) from Ireland as detailed previously. All the instrumentation and other plant elements were tested, repaired or adapted, if necessary in accordance to the detailed equipment specification datasheets. Other instrumentation (temperature sensors, gases analyser and pH probes, pressure valves,…) was acquired due to the requirements established for the new operating parameters of the LO2X plant.

The circuit sludge conditioning pump and the necessary equipment for their homogenization (grinder and homogeniser) were specified and purchased in base of the parameters obtained from the wastewater sludge produced in the WWTP. For this purpose various characterization analysis of plant sludge of Paterna was performed. The other pumps used in the pilot plant were tested in order to assure their correct performance.

B.2.4. Individual elements performance tests

Each main unit constructed, acquired and/or adapted for the prototype was inspected and tested prior to installation in order to detect any fabrication or delivery failure and to avoid any wrong performance with associated negative impacts on schedule and on budget. Technical specifications were revised and doubts were discussed with providers to follow proper procedures.

The identified high pressure equipment (Reactor, Economisers and Cooler) were certified in accordance to Pressure Equipment Directive 97/23/CE guidelines. For these equipments all the technical documentation for the conformity evaluation to the Directive 97/23/CE was prepared, and the entire required test were performed and certified by an official certification entity. Final assessment of pressure equipment was carried out, including an endurance test in the form of Hydrostatic pressure testing, requirement contained in section 3.2.2 of Annex I of RD 769/1999. IMECAL was the partner in charge of this test and the whole procedure was verified by a Notified Body (Authorised Control Organism).

The other tanks of the pilot plant were checked through low pressure hydrostatic testing and welding reviews were performed. Hydrostatic testing pressure was maintained for 5 hours to ensure that there was no leakage or deformation of the tanks.

As previously addressed, automatic, manual valves and safety valves were checked first visually to avoid to be installed with some troubles. Later on, their performance from both mechanical and electrical (electrovalves) point of view once connected to proper circuit to do so, so that specific installation sequences were defined for B2.7 and B2.8 tasks. First tests led to some repairing and adaptation works and to search for some new elements.

Instruments were carefully inspected in order to test them prior to final installation as far as possible, since full performance of them may be checked once installed (B2.7 and

B2.8). In the same way, the pumps used in the pilot plant were inspected and tested in order to assure their correct state prior to full installation and starting-up activities.

The elements involved in the circuit for sludge conditioning associated to tank T1003 were tested and due to the results, some additional adaptations were identified as needed for proper performance by the supplier.

B.2.5. Definition of Control Loops and Sequences

In accordance to the information established in B1 actions, the sequences to be used for operation and as bases for control loops development were studied and defined. SCFI with the collaboration of IVEM and AINIA were the main participants of this task. First of all, the modes of operation were analysed and defined to be able to control the facility in any condition that may take place on site. These modes were summarised as:

⇒ Start-up: this mode compiles the routines needed to get the facility ready under appropriate conditions before beginning with the supercritical oxidation processing itself. As a result, it will be possible to pass to the hold mode.

⇒ Hold: this mode is a transition phase in two cases, when start up phase has been fulfilled before beginning with the Processing mode or when feed is stopped along processing mode (e.g. feed tank empty).

⇒ Processing: this mode comprises all the routines and actions required for commanding and controlling the supercritical oxidation process of the selected feeds.

⇒ Shutdown: this mode is conceived to manage the facility variables in an appropriate and safe way to stop the plant if it is necessary for any reason (feed lack, operator selection, critical non-managed alarms, etc.).

⇒ CIP: this mode includes a series of actions to be commanded in a manual way by the operator when shutdown mode has been applied in order to make possible to apply the CIP system for cleaning up.

The main control loops were selected and described by the process variable and the control element. Sequences of actions were defined for each element to be controlled and for diverse general events for the overall control. These may be summarised as:

⇒ Tanks (Main Feed Tank, Clear Water Tank, Quench Water Tank).

⇒ High Pressure Feed Pumps.

⇒ Reactor, Heat Exchanger and Heaters.

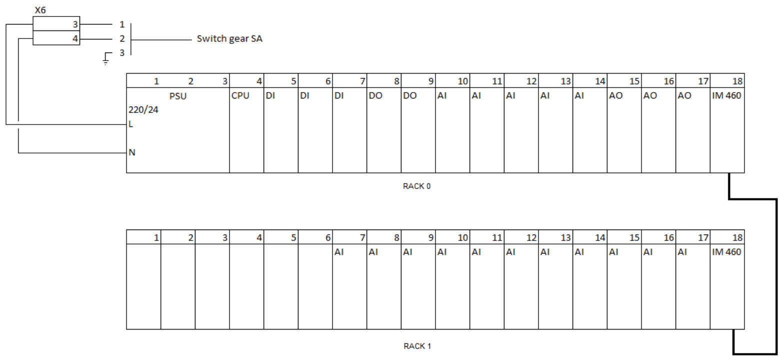
⇒ Process end effluent (Effluent Cooling System, Separation Tank, Divert Valve, Liquor Storage Tanks).

Details of sequences in Deliverable B.2.1.

B.2.6. Automation programme and implementation

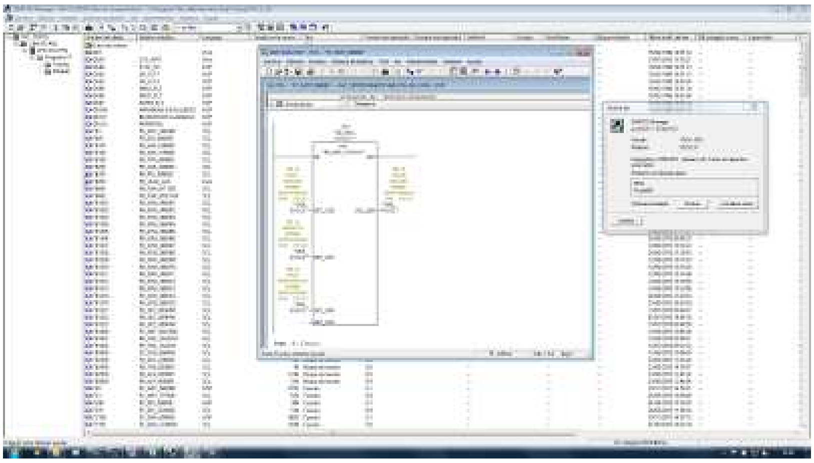
Process and control routines and loops for all control variables defined in activity B.2.5 were included in a control program specially designed for the operation of the LO2X plant. IVEM was the partner developing the activities required for this issue, having the collaboration of the rest of the partners, especially SCFI and AINIA for the revision of the routines dealing with programming doubts. A specific hardware was selected for controlling the process variables. Actually, it is a SIEMENS S7-400 automaton with the following parts that are shown in Figure 3:

Figure 3. SIEMENS S7-400 automaton configuration.



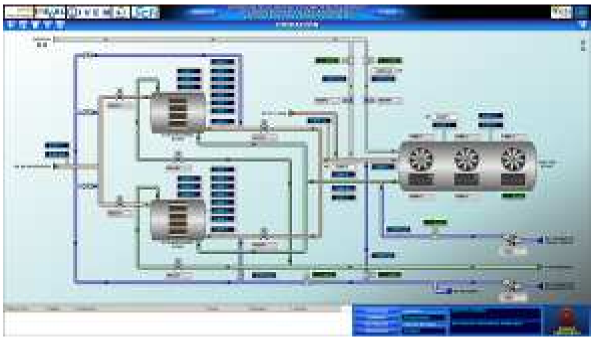
The control programme implementing the control loops and sequences, alarms, etc. was developed through SIMANTIC environment software STEP7 Version 5.5. The program was built integrating both function and standard data blocks under a fully editable source code. Some screenshots with parts of the code of the control programme are shown in Figure 4.

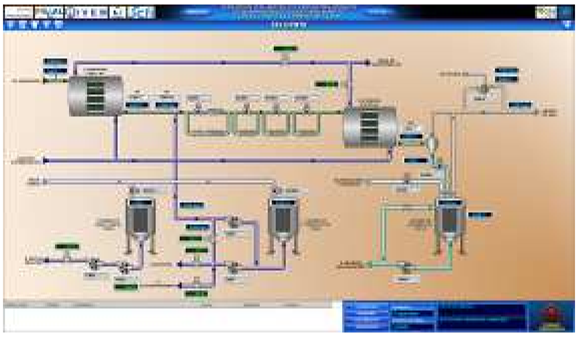
Figure 4. Control programme screenshots.



The control interface was installed in a desk computer Dell Pc Optiplex 3020 MT,i5-4590,4Gb,500Gb,DRW,W7P,W8.1P, with a 22” monitor and the program SCADA Intouch from the brand Wonderware. A series of interactive graphic screens with menus and buttons to communicate with the operator were designed and developed in an intuitive manner. This strategy was applied in order to easy quick recognition of the elements, loops, etc. not only for training but for operating activities, avoiding mistakes through supervision tasks. Some of these control screens are shown in Figure 5.

Figure 5. Control interface screenshots.





Simulation tests were carried out to debug the control programme and the control interface performance. Analogue and digital input/output signals were checked once elements were being installed on site (engines, flow-rate signals, temperature signals, etc.).

B.2.7 Mechanical Assembly

After the construction, reception and acquisition of the different elements of the pilot plant, the assembly thereof was performed.

IMECAL, as authorized installer, approached the mechanical assembly of the elements with the collaboration of the rest of the partners, especially AINIA and SCFI because of their knowledge and experience in building and operating facilities dealing with supercritical fluid processes. For these interactions, frequent meetings on site between IMECAL and AINIA specialist were carried out and virtual contacts with SCFI, as well as periodic on site meetings for general revision. On the other hand, URBASER was in charge of the pneumatic installation with the support of the rest of partners, especially IVEM and AINIA because of their experience in such a kind of auxiliary services.

URBASER was also leading the gases supply assembly, especially installation of oxygen supply facilities from the delivery tank up to the consume points, with the collaboration of IVEM with regard to access for periodic delivery and installation of the oxygen tank, of SCFI regarding the definition of specifications and the connections with existing units, and AINIA due to its experience dealing with gases delivery facilities (CO_2).

The plant assembly program conducted by IMECAL was based in different stages, some of them illustrated in Figure 6: [Main tanks positioning; Medium elements positioning (pumps, small tanks, etc.); High pressure elements positioning (reactor, economisers and cooler); Equipment and Elements mechanical piping and connections, and placement of instrumentation].

Main tanks positioning

Medium elements positioning

Figure 6. Positioning and connection works.

Once the Mechanical Assembly was completed with exception of the oxygen supply line, a series of leakage and pressure test were conducted at the facility in order to ensure the absence of leaks and to check the performance from a mechanical point of view under ambient temperature conditions.

On the other hand, pneumatic connection for commanding the automatic valves with compressed air was carried out. Also, activities to make possible to have the required delivery of oxygen and nitrogen to the process were carried out. Finally the installation of auxiliary services equipment of the plant, such as gases, compressed air, water softener among others, was carried out.

The plant assembly program conducted by IMECAL was based in different stages. Once the Mechanical Assembly was completed with exception of the oxygen supply line, a series of leakage and pressure test were conducted at the facility in order to ensure the absence of leaks and to check the performance from a mechanical point of view under ambient temperature conditions. Some parts exhibited a non satisfactory behaviour, so that new actions for assessing and adjusting those parts to achieve the appropriate performance were implemented.

On the other hand, pneumatic connection for commanding the automatic valves with compressed air was carried out. Also, activities to make possible to have the required delivery of oxygen and nitrogen to the process were carried out. Finally the installation of auxiliary services equipment of the plant, such as gases, compressed air, water softener among others, was carried out. The detailed plan for positioning the oxygen tank was prepared by the gas supplier and modified to deal with the special situation of high power supply lines very close to the prototype. Due to some unsatisfactory performance during the checking tests of the elements included in the oxygen supplying lines prior to their delivery, some additional works were scheduled by the provider to solve the unconformities.

Figure 7. Overview of auxiliary services of LO2X plant.

B.2.8 Electric Assembly and heat isolation

This task includes activities required to get the facility fully built up after the mechanical assembly. This comprises the electrical assembly after the preparation of the elements needed for so, development of electrical diagrams, wire tendering works, and the final insulation of elements standing high temperature or to be protected from undesirable heat exchange flux.

IVEM was the partner carrying out the electrical activities with the support of SCFI regarding the configuration of previously existing elements and URBASER with regard to connection of new elements and instruments. IMECAL was leading the heat insulation works with the collaboration of SCFI to define specifications and analyse offers from suppliers, of AINIA for checking specifications and offers including in situ analysis, and of URBASER to coordinate insulation works with other works.

The one-line electrical diagram of the electrical installation was developed in base to the calculations of the electrical protections and of the sections of the wires. With this base, the multiwire diagrams were prepared for the later manufacturing of the electrical panels for power and control and for the wiring of the elements. Once multiwire diagram had been approved in March 2015 and its internal distribution also set, manufacturing of the general panel, the engine control panel and the automaton control panel started in workhouse. The general distribution panel was conceived to provide the general power supply of high power elements. The engine control panel included a general switch, protections for every panel, contactors and frequency controller and on/off button. The automaton control panel contains the connections of commanding and controlling the facility.

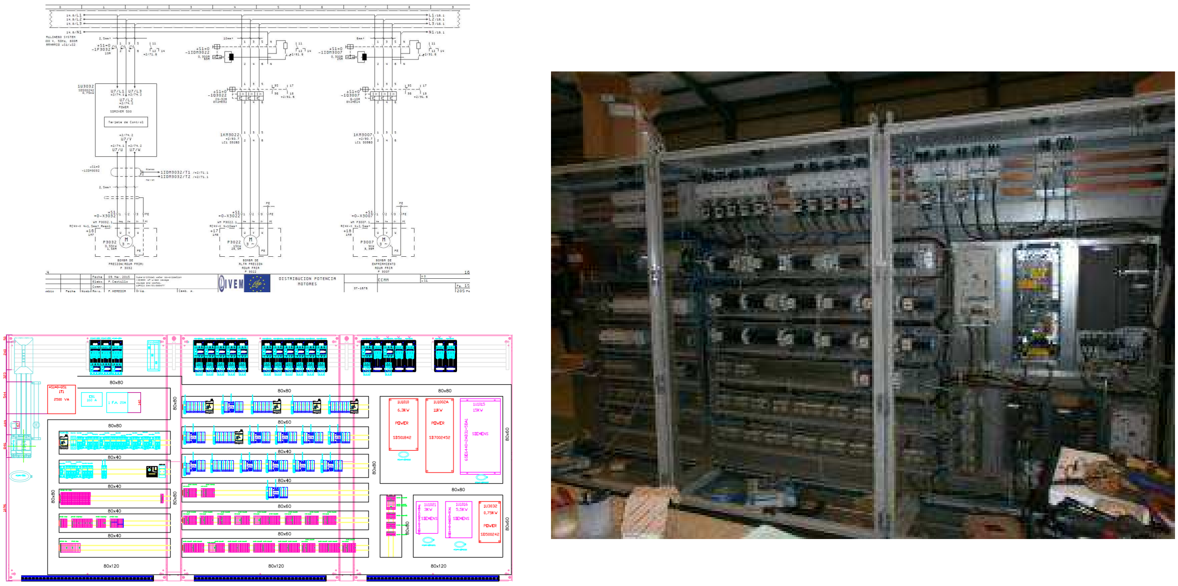


Figure 8. Wiring diagrams, Electrical Panel scheme and pictures..

The manufactured panel was moved to the WWTP in May 2015 to be connected to the equipments of the facility using the electrical trays previously mentioned in B2.7. Once electrical trays installed, wire tendering works were carried out for distributing power to the engines and for connecting instrumentation signals and emergency buttons in accordance to layout. Metallic elements in the facility were ground connected to avoid any undesirable electrical loads.

A major part of the electrical installation was completed in Mid June 2015, so that it was possible to star with the checking of elements and signals not only from the electrical but from the control point of view, giving the possibility of checking the automaton behaviour on site. The rest of the wiring was approached as other pending equipments and instruments were arriving.

Insulation

Elements and Pipes that work at high temperature were conceived to be isolated to avoid energy losses in the process, making it more efficient, to avoid undesirable heat transfer from heat zones to other not to be heated up, and to guarantee the safety of the personnel working in the installation and to get the process more efficient from the energy consumption point of view.

The insulation work started in September of 2015, and was coordinated by IMECAL with the support of SCFI and AINIA. The reactor was isolated with several insulation ceramic fiber inner tubes with a maximum working temperature 1260°C. From the outside of the metal structure with a ceramic fiber layer and a layer of wool army blanket of volcanic rock type Rockwool were applied. Protecting the insulation boards made of brushed aluminium properly folded and secured with rivets were used.

Economisers were insulated with ceramic fibers. Protection tubes aluminium plate flanges bridge between cylindrical tubes were insulated with aluminium sheet boxes with seamed lids and closures, inside a ceramic fiber insulation was installed..

The pipes isolation was developed as the specifications stated, with different materials. The protection of all isolates were performed with tubes of aluminium plate.

Along the initial testing activities it was proved that these initial insulation structures were found to be insufficient to achieve the high temperature values scheduled and they had to be redesigned/reinforced as required. So, the insulation work was rescheduled to match the gases delivery lines situation and the designed insulation items were installed, being fulfilled at the beginning of 2016.

Figure 9. Overview of prototype after B2 works.

Action B3: Start up of the prototype

This action covers the tasks required for starting-up the demonstrative prototype built-up in Action B2.

The prototype start-up began as conceived in the project led by URBASER and SCFI and with the participation of the rest of the partners of the Consortium regarding different aspects that are described below in more detail for each task.

Within the project period, definition of plant operation and emergency protocols was approached, analysing warning and alarm situations. As a result, relationships between incidents and actions were discussed. In the same way, the definition of guidelines for preventive and corrective maintenance works was started, with special attention to critical/delicate elements for safety or performance issues. In order to develop the Plant Operation and Maintenance Handbook, information from previous actions jointly with these protocols and guidelines was analysed and organised in different chapters to be understandable and useful for operators.

On the other hand, the preliminary non-feed tests were started as soon as the major part of mechanical assembly was developed instead of waiting for the full assembly of the plant. As a result, a series of static test were carried out with water at low pressure up to higher pressure in order to check leakages of the mechanical assembly. Low temperature tests were used to contrast the right electrical connections of thermocouples on site and with the automaton system. Also, progressively increasing flowrate tests were carried out once the full installation tested under the hydrostatic test pressure.

In addition, activities focused on applying for the required certifications for the facility were carried out with the participation of several of the partners, each of them because of its contribution to previous tasks. The application for Industry Authorities and official requests for additional complementary documents took place up to June 2016, having an impact on Action B3 duration and Action B4 development with regard to reaction tests.

Start date: *April 2015*. End date addressed in proposal: *September 2015*. End real date:
Deliverable B.3.1. "*Handbook of the demonstrative pilot plant": including the information of the general preventive and maintenance guidelines prepared"* (achieved).
Deliverable B.3.2. "*Certification of the demonstrative plant (documents)"* (achieved).
Milestone M.B.3.1. *Preventive and maintenance guidelines defined and Handbook of the demonstrative plant prepared* (achieved).
Milestone M.B.3.2. *Demonstrative plant successfully started after inert tests* (achieved).
Milestone M.B.3.3: "*Demonstrative plant certified"* (achieved).

B.3.1 Detailed definition of Plant operation and emergency protocols

This action was led along the period by SCFI with the active collaboration of AINIA, as well as the participation of other partners for contributions and is conceived to be continued in the same way upon the end of the task.

Control loops and sequences were established in task B.2.5 to go ahead to the analysis of the detailed protocols and their implementation therefore for automatisation of the process control in B.2.6. These protocols were conceived as joining manual actions to be taken by the human operators and actions commanded by the automaton in accordance to control loop configuration and the operator´s orders.

These protocols were developed keeping in mind the five modes already mentioned (Start-up, Hold on, Processing, Shutdown and Cleaning CIP) and the occurrence of pre-defined sequences in several stages to come up to full description.

The main warning and alarm situations were analysed to discuss the operating routines and the emergency protocols as well. As a result, the process variables and elements involved and actions to be taken were discuss in order to develop the procedures to manage them in a convenient manner and put the facility in an adequate state within the desirable variable process ranges not generating warnings or alarms. Four value levels were defined for the most relevant control variables (very high, high, low and very low).

Also, a series of incidents were identified to give rise to a series of actions to keep the facility in a safe status while the causes giving rise to them are being solved. The oxygen supply implies specific risks and special actions to handle them without stopping the whole plant and on the other hand, general emergency stop involves actions not only in the water lines but in the whole plant including the oxygen supply zone. Thus, two general scenarios were distinguished to manage delicate situations: one regarding overall plant trip and another one focusing specifically in oxygen trip.

Additionally, conditional relationships were established between incidents in specific items and particular actions to be taken over individual elements without the need of activating overall protocols. This information may be seen in Deliverable DB2.1.

B.3.2 Definition of Preventive and maintenance guidelines

This task was approached with all partners taking part, with special contributions from each of them depending of the type of items and their particular knowledge (for instance, SCFI regarding the elements received from Ireland, IMECAL regarding high pressure mechanical installation, URBASER regarding the new acquired items and, AINIA especially regarding high pressure pumps and equipments, IVEM regarding sludge and effluent management and electrical, etc.).

In addition to revision of inspection requirements for high pressure equipments according to current regulations, special attention was paid to especially critical/delicate elements for safety or performance issues. HAZOP conclusions were taken into account to rank the most critical ones. Handbooks of the individual equipments were considered to compile and highlight the main maintenance guidelines, both for preventive or corrective purposes. Specific register sheets were conceived for such operations to get quick updated information for each. Others such as replacement of internal parts (membranes, hoses, etc.) were established as corrective operations.

For promoting an appropriate performance of gas analyser, periodic calibration with external patrons of known concentrations were indicated. Different lapses were established depending on the parameter to be calibrated (once a month for carbon monoxide, once half a year for oxygen).

Oxygen supply up to the consume point in the process facility was decided to be done by the supplier, that will be also in charge of the maintenance procedures to be applied on site. This also applies to the procurement of nitrogen, but not to the piping of the nitrogen from source (cylinders) to consumption points.

B.3.3 Plant operation and maintenance Handbook

All partners contributed in actions to get the Plant operation and maintenance Handbook prepared, being leaded by AINIA. It is foreseen to carry on in a similar way up to the end of the task aiming to produce an understandable and useful Handbook for B4 Actions.

Results coming from B3.1 and B3.2 were discussed together in order to be included in the final overall Handbook for the LO2X prototype. Handbook was organised compiling these results jointly with some of the information developed previously in actions B1 and B2. This way, the Plant Operation and Maintenance Handbook developed was summarised in English in DB3.2 and was organised into several chapters each of them with different sections.

“Plant overview” was devoted to compile information to address general concepts and the main features of the plant. This chapter has the aim to describe the main equipments and devices involved in the facility and the main basic operations taking place in each one or in groups composed by some of them.

“Processing protocols” was structured in accordance to the modes and the operations established in task B2.5 and the protocols developed in task B3.1. This way, the description of the operating actions to be carried out or supervised by the operators was conceived within the protocols defined (Start-up, Hold on, Processing, Shutdown, Cleaning CIP and Emergency protocol). Each protocol was established to comprise the actions included in the process mode of the same name and the manual instructions to be followed by the human operator, as well as useful warnings to highlight the most relevant points to look at.

“Maintenance guidelines” chapter was outlined focusing in the main points described in B3.2 task. For simplicity and usability reasons, the same order used in chapter “Plant overview” to describe the main equipments and devices was preferred instead another specific one in a priority basis.

“Annexes” was conceived to compile relevant drawings, plans, tables, etc.

B.3.4 Inert Start up of the pilot plant: preliminary non-feed tests

The partners more involved in the physical activities of this task were: IVEM regarding the electrical and control aspects, IMECAL regarding the mechanical performance, SCFI regarding the protocols and AINIA providing support in the mentioned activities and in the execution of the test themselves.

The preliminary non-feed tests were started as soon as the major part of mechanical assembly was developed instead of waiting for the full assembly of the plant. This strategy was applied to avoid delays on the project progress since some specific elements would be delivered some time later. This way, the sequence of elements to be included in each test was carefully studied to progress with the start-up of the plant without additional risks on the tests performance and on the safety of the people involved.

A series of static test were carried out with water at low pressure up to high pressure in order to check leakages of the mechanical assembly. An external pressure pump was used for providing pressure to the selected zone in each case without using the high pressure pumps inside the own process. This alternative was chosen since pressure testing in the lines according to calculations for the hydraulic testing of the installation has to be much higher than the maximum working pressure of the water pumps.

According to the legislation in force when manufacturing the equipments and preparing the tests (Pressure Equipment Directive 97/23/CE guidelines, Spanish transposition RD 769/1999) final assessment of pressure equipment shall include a test for the pressure containment aspect, which will normally take the form of a hydrostatic pressure test at a pressure at least equal, where appropriate, to the value laid down in point 7.4. [..] For assemblies, the final assessment shall also include a check of the safety devices intended to check full compliance with the requirements referred to in point 2.10." As these articles were kept without changes in the last update published very recently (Directive 2014/68/EU Of The European Parliament And Of The COUNCIL of 15 May 2014 and in Spanish transposition, Real Decreto 709/2015, de 24 de Julio 2015) that was entering in force mainly the 19th July 2016, it was decided to calculate the pressure test for the piping as an equipment to identify and apply the most restrictive conditions for the hydrostatic test pressure. According to the same regulations, the applied value "[…] shall be no less than either of the following:

- that corresponding to the maximum loading to which the pressure equipment may be subject in service taking into account its maximum allowable pressure and its maximum allowable temperature, multiplied by the coefficient 1.25,

- the maximum allowable pressure multiplied by the coefficient 1.43, whichever is the greater.

The most restrictive of these two criteria led to a value of 426 bar as addressed for individual high pressure test in B2.4. As a generally recognised engineering rule of thumb consists of applying a 1.5 factor to the design pressure and this calculation leads to 435 bar, this value was chosen as the maximum one to be apply in the high pressure non-feed test at ambient temperature. These tests were carried out in the last part of the start-up actions period. Also, progressively increasing flowrate tests were carried out once the full installation tested under the hydrostatic test pressure. Previously, all required checks from electrical and mechanical point of view over the high pressure pumps were conceived to be done. This way, the providers were contacted to solve important questions as the turn direction for the engine before the starting up of the pumps without damaging any internal element. Low pressure and flowrate tests were identified as first required for supporting the checks on flowrate meter performance, especially on the most important ones.

Low temperature tests were used to contrast the right electrical connections of thermocouples on site and with the automaton system. Higher temperature tests were scheduled to test dynamic behaviour under changing values and reliability in other temperature ranges, although not yet in the range for processing. Last temperature test without feed were defined to be executed once the insulation installed, to contrast both the capability of retaining heat inside the isolated areas and the protection of other zones from undesirable heat transfer. As described, temperature tests pointed out some thermocouples not performing as required and needed to be replaced as well as insufficient insulation to avoid energy losses, leading to undesirable process conditions. Thus, specific actions to solve these performance issues were approached to get the demonstrative plant successfully started as desired.

B3.5 Certification of demonstrative plant

Activities focused on applying for the required certifications for the facility were started with the participation of several of the partners, each of them because of its contribution to previous tasks.

IVEM dealt with the documentation regarding the electrical installation, IMECAL managed the part covering the mechanical installation, URBASER focused on the same aspects regarding pneumatic installation and AINIA provided support to supervise the overall process. Additionally, the selected provider for gases supply was in charge of all issues linked to the gases supply installation, including all steps needed for its certification.

Each installation part was described as required by in force current regulations to get the proper certifications. Once these parts got, documentation for the installation was prepared to apply for the permissions to the Regional Authorities involved. Some issues arose along this, as explained.

- Documentation for all elements required for Industry Application Regional Authorities were revised and mismatches were detected in the certificates for the new Safety Valves with respect to technical specifications. Technical data were revised and the external supplier was asked to check the delivered units and the documentation to avoid unforeseen problems in technical performance and to have the correct documents for further applications.

- The application form called “Solicitud de puesta en servicio de instalaciones con equipos a presión no incluidas ITC EP Específica (categorías I a IV)” was submitted to the Conselleria d’Economía, Industria y Comerç. Servici Territorial d´Industria on 13th May 2016, as soon all required documents to be attached were available.

- After all installation protocols were fulfilled with regard to Oxygen Supply System, the gas supplier made the application to the authorities with all compiled documentation required. The application form with name “Solicitud de puesta en Servicio de Depósitos Criogénicos ITC EP-4” was presented by Carburos Metálicos on 1st June 2016.

- Additional documents were asked for some applications on the 8th June and the requirements were fulfilled within the deadline.

The applications regarding installation were fulfilled and experiments involving reaction were approached as foreseen in B4.

Action B4: Operation of the prototype and assessment of the co-oxidation process

This action covers the tasks required for starting working with the prototype and assessing the SCWO process, including the preparation of a experimental plan, starting-up operations with feed, the assessment of the influence of the main process variables, steady performance monitoring, assessment of the corrosion and calculating mass and energy balances of the system.

Activities concerning B.4 Action were started as foreseen with the beginning of task B4. and once the demonstrative prototype was successfully started up (B3), experimental task were also approached IVEM, due to its role, was the leading partner of the overall B4 Action, although SCFI and AINIA were the most active partners within the initial works in order to develop the design of the experimental plan to come to a general agreement and later on, as the partners with a more intense involvement in the experimental activities.

Start date: *July 2015*. End date: *September 2016* as addressed in proposal.

End date agreed in 2nd Amendment: June 2017

Deliverable B.4.1. “*Experimental design specifications to assess the SCWO process (document)”* (achieved).

Deliverable B.4.2. “*Summary of the results of the tests performed to assess the main SCWO variables and phosphorus recovery and conclusions of the corrosion assessment study and the mass and energy balances"* (achieved).

Milestone M.B4.1. *Experimental plan for the starting up of the plant and for the assessment of the main SCWO process variables prepared* (achieved).

Milestone M.B4.2. *Plant started up successfully with feed* (achieved).

Milestone M.B4.3. *Main SCWO process variables assessed* (achieved).

Milestone M.B4.4 *Sensitivity analysis, process for phosphorus recovery identified and corrosion study performed. Mass and energy balances calculated for the tests with best results observed alter action B.4* (achieved).

B.4.1 Experimental plan: design of experiments (DOE)

After inert start-up tests, different series of tests were conceived to optimise the curve of learning operating with the prototype and to be able to maximise the results to assess the target process (supercritical water co-oxidation of sewage sludges). Test series were organised into three blocks in a basis of type of feed used in each one, first of them carried out with a model feed and the other two, with real feeds.

- Synthetic Feed Block: a series of test using Methanol as feed, as this reactive behaviour is known beforehand and the initial facility performance may be characterised in order to detect any operating problem in order to solve it and to adjust any required physical or logic element.

- Single feed Block: a series of test to apply supercritical water oxidation process to feeds composed by only a type of sludge as feed in each separated test.

- Mixtures feed Block: a series of test dealing with feed composed from mixtures of sludges and other wastes in order to assess supercritical water co-oxidation process.

Each series was defined as a group of runs, devoted to get processing data for monitoring parameters in different conditions to study the processing variables (pressure temperature, flowrate, oxygen rate, composition of the feed stream) and the reliability of the overall performance.

As it was identified as a valuable target to carry out some long-lasting test, the number of final tests and runs as well as the variables to be studied had to be balanced keeping the overall objectives, schedule and budget of the project. Also, the design of experiments (DOE) was fitted progressively as results were available. The reaction tests performed up in Action B4 lead to interesting results but also special difficulties appeared and a specific non-foreseen assessment was required in order to go in depth in the causes to avoid the undesired effects and unacceptable risks.

In accordance to experimental findings and decision taken, methodologies, protocols and resources required to carry out the experimental research had to be modified taking into account the need of working and assessing in an alternative mode to avoid severe operating problems and overall, undesirable safety impacts. Along the tests, special attention were paid to the selection of operating conditions for key SCWO variables and their application to determine the stability and soundness as important factors for demonstration, fitting the duration to be relevant enough to assess the key issues but without compromising other factors such as resources availability. In accordance to current results, it was considered as crucial to balance the resources (time, manpower and budget) devoted to look at critical issues such as feed conditioning, assessment, etc. Indeed, the problems faced pointed out deeper reengineering needs to minimise the corrosion and plugging problems. This way, the modified experimental plan, including the possibility of facing other unforeseen situations that may require additional extra measures to go ahead and as a result, pointed out that the challenges cannot be solved within the original duration of the project but with an extension up to 30/06/2017. As a consequence, an application for an amendment was carried out and it was accepted by the Commission.

<u>B.4.2 Starting-up operations with feed</u>

Initial reaction tests were carried out with methanol as feed and afterwards, reaction tests with sludge as feed were carried out. Methanol tests were very useful for diverse purposes: to fit and improve the control software and sequences, to train manpower with oxidation test; to solve operational problems to promote the reliability of the performance, to start-up the supercritical oxidation assessment, etc. These methanol tests proved that the prototype may be operated and pointed out that the rate of reaction may be significant. Nevertheless, the appearance of a yellowish effluent pointed out the potential occurrence of corrosion phenomena, since it may be an indicator of the presence of metals such as Nickel or Chromium, present in certain materials used in the prototype such as stainless steel or other particular alloys.

As to the oxidation between the organic load in the sludge and the oxygen under supercritical conditions may follow a cascade of reactions more complex than for methanol, it was decided to move on the foreseen test with sludge.

B.4.3 Assessment of key SCWO operation variables

Different operating conditions were assayed regarding temperature, pressure, flowrates, load in the feed, heating up speed, etc. and important removal rates were achieved. More specifically, pressures up to 230 bar and a maximum temperature up to around 570ºC of in the reactor were applied at a series of test. The results showed high removal rates both on organic matter (COD) and on total solids (TS). In fact, percentages higher than 97 and 80% were achieved for COD and TS, respectively.

Nevertheless, relevant operative problems were identified such as corrosion, since yellowish colour also appeared in the effluent and plugging causing flow and pressure troubles making impossible to carry on the experiments. Plugging required not only chemical but also mechanical cleaning and indeed, in one test the reactor´s entrance pipe had to be removed and replaced by new pipe in order to carry on with experimental activities. These operations took more time than expected since there were geometrical constraints to get the reactor´s liner out due to shape changes and also the presence of additional inorganic material that could not be easily cleaned out. Thus, conditioning and cleaning efforts were further larger than initially foreseen and new protocols and strategies had to be developed.

Operation under more severe conditions in orderto improve or to balance the removal rates was discarded due to the potential risk (materials limitations) and economically inconvenience. This way, it was decided to develop ad hoc a methodology to enhance the feed to keep potential risks as minimum as reasonably possible, while heading towards the operation optimization. A specific time was needed to get this ready in addition to foreseen experimental time, as new reengineering labours were required, that implied to apply modifications in the process and the facility features needed to operate in accordance to this adapted processing configuration, leading to relevant results in line with the project objectives.

The figure below (Figure 10) shows some experimental samples showing the clear differences between the feed (left) and the output effluent (centre), which soluble phase was similar to the softened mains water sample (right).

Figure 10. Experimental samples: feed (in) and outlet (out) vs softened tap water

As some highlights from the results regarding the assessment of some of the key variables:

- Process temperature (temperature of feed into the reactor 110-384 ºC, maximum reaction temperature 250-570ºC): one of the important parameters. it had a clear impact on heat requirements for the process but also on the efficiency of the process (COD removal).

- Process pressure (reaction pressure, 190-230 bar): one of the important parameters. Jointly with reaction temperature had an impact on the phenomena and reactions taking place in the process, so that having a potential influence on the appearance of differences of pressure in the reactor and plugging, although other variables such as feed composition or oxygen flowrate may have an stronger effect.

- Feed features (solid content, 1,6-10 d.s%, unconditioned vs conditioned sludge, cosubstrates): one of the most crucial parameters. The content of organic matter in the feed is directly related with the demand of oxygen to process it, the amount of energy that may be produced (exothermic reaction) but also the concentration and type of other substances had an impact on the performance of the process. This way, conditioning steps through reengineering measures were found as key for overall satisfactory behaviour without evidences of corrosion or plugging appearance and differences in composition due to type of cosubstrates did not change overall behaviour but had an impact on some results.

- Oxygen flowrate (12-35 O_2 kg/h): this parameter importance was stressed specially once reengineering measures were taken to surpass detected constraints and limitations.

B.4.4 Steady performance monitoring and sensitivity analysis

In accordance to processing results, some tests were carried out along several hours along the periods of three months initially considered, so that accumulated effect of operation may be observed despite of plugging occurrences. Some test considered small variations of some processing variables as an approach to sensitivity analysis.

Along the test, the values for the most important variables were monitored and analysed afterwards. The prototype performance showed that pressure values were quite stable, despite of small fluctuations on other parameters. Nevertheless, differences of pressure in key parts such as high pressure chambers acted cearly such as indicators of potencial process difficulties if trends maintained along certain times. On the other hand, once process conditions attained, temperature values kept quite stable despite of slight variations on other parameters. Nevertheles, temperatures and especially, maximum temperature in the reactor confirmed its sensitivity with regard to other parameters such as oxygen flowrate, with a strong relationship due to its role in the reaction itself. Regarding the composition or nature of the feed, the results pointed out this parameter is directly related to the number of hours of stable operation without high ΔP. This statement stands especifically on the differences observed among results with unconditioned and conditioned sludges. Also, tests with mixed feed using Olive Oil Mill co-waste yielded the shortest stable continuous operation time, although the mixtures composed by sludges and different cosubstrates did not make a difference on overall stable operation time before experiencing high pressure drops.

On the other hand, as foreseen, specific attention was paid on the solid fraction separated from the effluent, in order to assess phosphorous recovery. A revision of methodologies was carried out and specific procedures to handle the samples were established and applied.

B.4.5 Corrosion assessment and reengineering

As foreseen in this task, as experiments were carried out and results pointed out to potential corrosion, specific assessment was performed to assess the occurrence and extension as well as to design reengineering actions if needed.

Samples were taken from the removed piping part in order to study the nature of the substances leading to blockage problems. Additional tests by ultrasounds and by electronic microscopy were carried out in order to go in depth in the features of the walls of the high pressure elements (reactor, heat exchangers) to know if corrosion evidences could correlate with losses of thicknesses or with clear differences in surface appearance. Electroscopic images showed evidences of corrosion, that was assessed by quantifying the loss of thickness, being compatible with expected structural evolution. Although corrosion levels were under safe range, some units could have been becoming more brittle. Therefore, reengineering possibilities were studied to deal with the most likely factors with a major impact on the phenomena taking place, involving different process steps with special mention to feed preparation, injection for reaction,…These precautionary measures consumed extra time not considered initially in the experimental design leading to a re-scheduling of the experiment plan.

Later on, after carrying out co-oxidation experiments with real feed, digital radiography was utilised to generate real images of larger sections of the pipes internals, that showed as yet no evidence of significant corrosion on equipment subjected to the most aggressive process conditions. These conclusions support the demonstration of the supercritical co-oxidation technology.

Regarding system reengineering, a total of 7 general and specific actions were performed during the project period, concerning the following issues:

- Water supply line modification with a softener due to the high hardness and high Chloride concentration (detrimental regarding system corrosion resistance) of water effluent coming from the WWTP and main water supply.

- LO2X´s blend tank configuration, removing the Mixer from the tank´s recirculation line due to unsatisfactory performance.

- Gas analyser placement from outdoors to inside, in the control room together with a better gas pump and optimized filters/dryers to get a good timing and quality of the measurement.

- LO2X tubular reactor´s entrance features to avoid plugging issues.

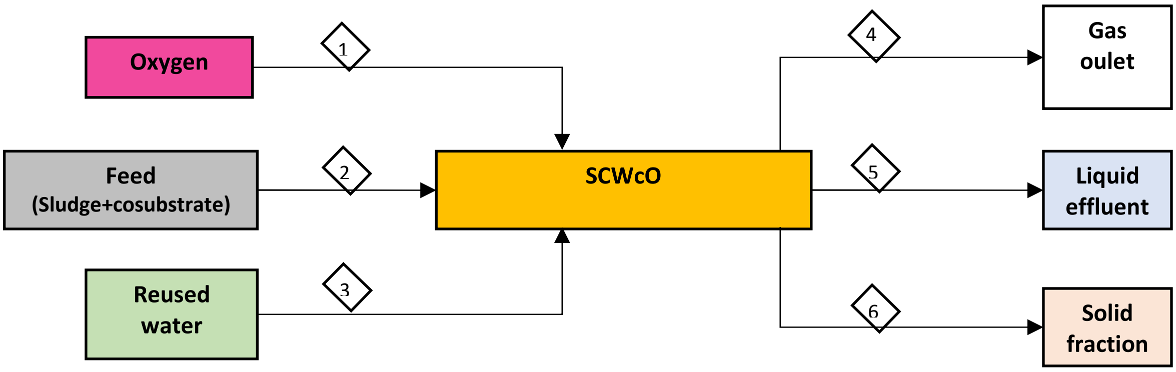
- Configuration of O_2 injections to redesign how the reaction oxidant was to be injected in the system..

- On-site sludge dewatering system: the Paterna´s WWTP, to provide sewage sludge with up to 8-10% dry matter content.

B.4.6 Mass and Energy Balances: yield and efficiency

Results from experimental activities performed in B4.3 and B4.4 were assessed to calculate the mass and energy balances and to determine the yield and efficiency of the processes applied. Calculations had into account values such as flowrates, compositions in the streams, temperatures, oxidation efficiencies, etc. In order to resume the process flowchart to come up to the most important result indicators of efficiency, a simplified representation of the process flowchart was used, shown in the Figure 11 below for one of the co-oxidation tests (specifically with a cosustrate representing food type wastes, with pesticides pollution, a imazalil concentration determined about 300,000 µg/L turned into a neglible one below 0.1 µg/L).

Figure 11. Mass balance flowchart



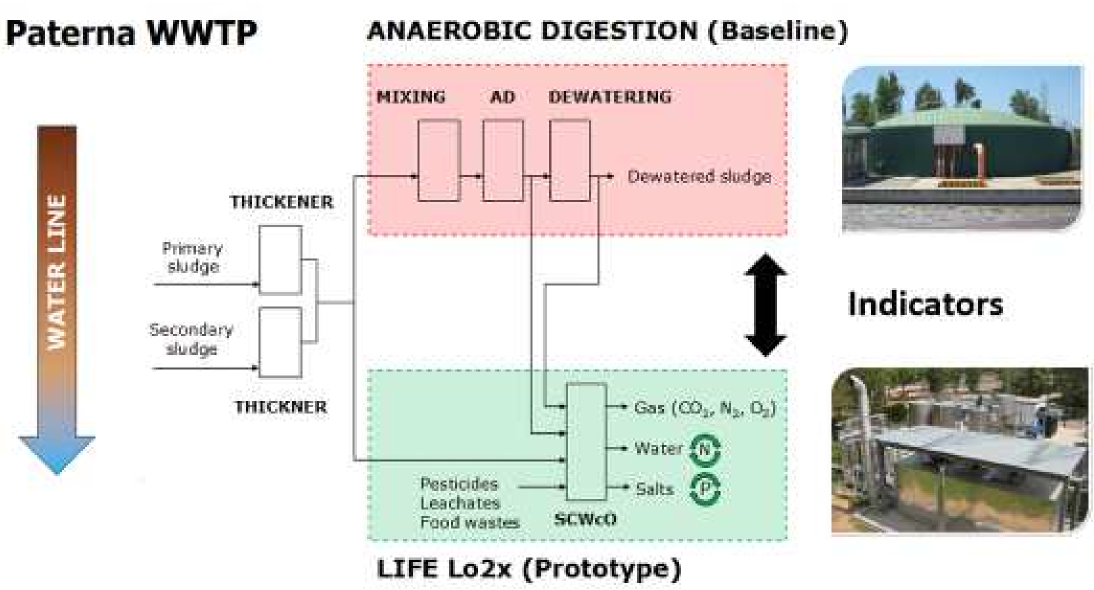
As a summary of the main results, the following ones were achieved along the LIFE Lo2x project:

- **> 99% elimination of organic matter.** The COD of SCWcO effluent is in average lower than 200 mgO_2/L, reaching values even lower than 25 mgO_2/L.
- **100% elimination of pesticides.** Imazalil is degraded through SCWcO up to 350 mg/kg, four orders of magnitude higher than the concentration removed by anaerobic digestion.
- **100% elimination of pathogens.** *Escherichia coli*, *Clostridum perfringens* and *Salmonella spp*. are completely eliminated. SCWcO leads to complete sterilization.
- **>85% heavy metals are recaptured for safe handling.** Heavy metals are mainly detected in inorganic solid fraction of the SCWcO effluent.
- **Recovery of nutrients.** Mineralization of nitrogen and phosphorus facilitates the nutrient recovery in order to be used as building blocks of fertilizers. Nitrogen occurs in the liquid phase (NH_4~2 g/L) while phosphorus is present in the inorganic solid fraction of the SCWcO effluent (P_2O_5~25%).
- **No highly harmful gases are produced.** CO_2 is the main gas generated by SCWcO. Typical undesired gaseous products from the combustion processes as NO_x and SO_x are not produced.
- **98% reduction of sewage sludge leaving WWTP.** Total solid reduction higher than 90%. The inorganic solid fraction from SCWcO is a resource for phosphorous industry whereas wastes from anaerobic digestion may end up in the landfills.
- **Zero heat consumption.** The heat produced by the oxidation under supercritical conditions (highly exothermic reaction) makes pumping to be the only significant energy-consuming step (*i.e.*, 1 kWh/kg dm) through SCWcO.
- **>10% reduction in sludge treatment cost.** The gate fee thanks to co-substrate treatment by SCWcO allows reducing the cost of sludge treatment below the cost of anaerobic digestion.

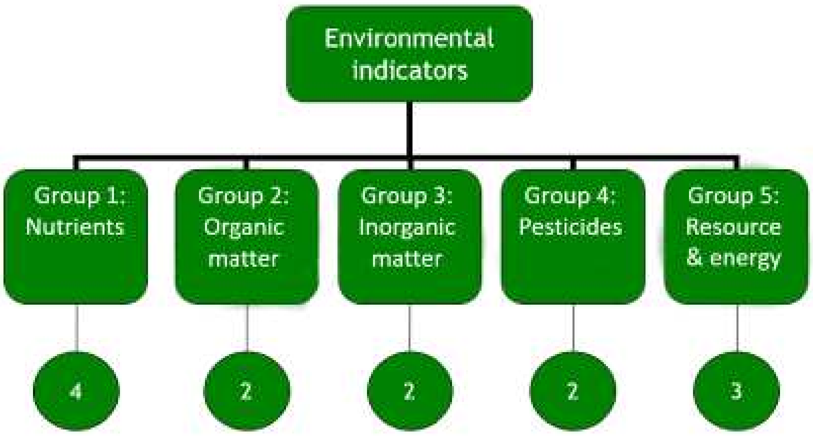
The achievement of such high ellimination rates with different mixtures as feeds confirms the potential of the technique for managing wastes such as the tested co-substrates. This possibility remains as feasible not only from the technical but the economical point of view since the treatment of polluted co-substrates may imply important treatment cost through other alternative current ways. Thus, the overall sludge treatment costs may be more advantageous taking into account the same gate fees for the co-substrates that are managed sinergically.

Action C1: Monitoring of the impact of the project actions

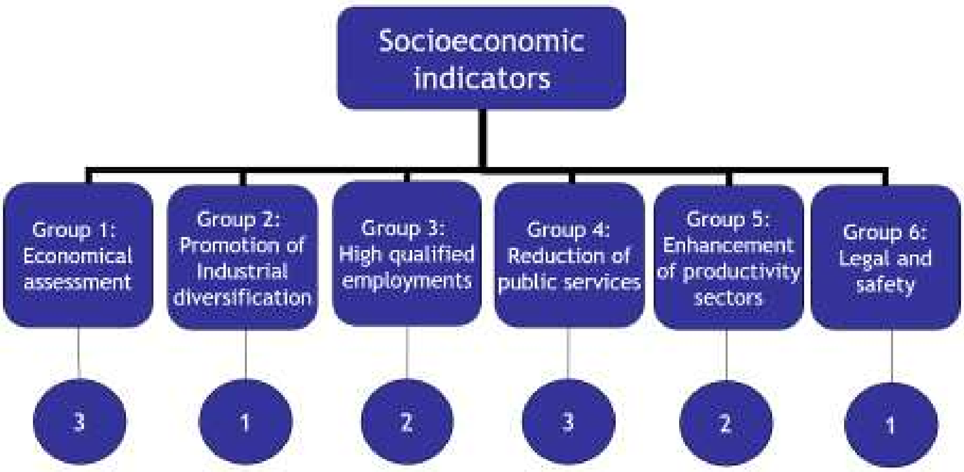
This action covers the tasks required for the monitorization and assessment of the impact of LO2X project, including the indentification of specific indicators, the monitorization of the identified indicators of the SCWO process versus the baseline (*i.e.*, Paterna WWTP) and the assessment of the socioeconomic impact of the project.



Action C1 started as scheduled and during the first months of the project a total of 25 indicators were defined in order to assess the implementation project actions: 13 environmental sorted out into 5 groups, 12 socio-economical indicators organised into 6 groups. List of specific indicators were included in the Deliverable D.C.1.1.

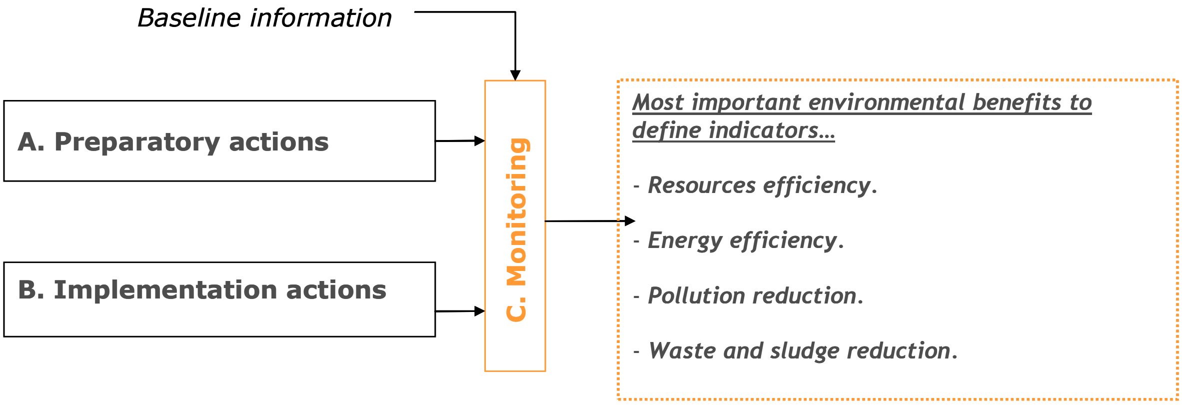


Environmental aspect	Indicator	Description
Nutrients	N removed / DM_{in} (kg/kg)	Nitrogen pollution reduction from sewage sludge and other wastes.
	N removed (%)	Nitrogen pollution reduction from sewage sludge and other wastes.
	P removed / DM_{in} (kg/kg)	Phosphorus pollution reduction from sewage sludge and other wastes.
	P recovered (%)	Phosphorus recovered from sewage sludge and other wastes in the solid.
Organic matter	OM removed / DM_{in} (kg/kg)	Organic matter pollution reduction from sewage sludge and other wastes.
	OM removed (%)	Organic matter pollution reduction from sewage sludge and other wastes
Inorganic matter	IR produced / DM_{in} (kg/kg).	Final wastes inertization from sewage sludge and other wastes
	TS removed (%)	Total solid removed from sewage sludge and other wastes
Pesticides	Pesticides removed / DM_{in} (kg/kg)	Pesticides abatement
	Pesticides removed (%)	Pesticides abatement
Resources and energy	Oxygenconsumed / DM_{in} (kg/kg)	Reactive consumption through SCWO
	Temp max (ºC)	Maximum temperature detected through SCWO
	Energy consumed / DMin (KWh/kg)	Energy consumed through SCWO



Socioeconomic aspect	Indicator
Economical assessment	Total Costs by Lo2x technology treatment / DM_{in} (€/kg)
	Total Costs by baseline technology treatment / DM_{in} (€/kg)
	Costs: (investment + running cost + final disposal costs / $DM_{treated}$) (€/kg)
Promotion of industrial diversification	Number of different providers for the prototype construction (#)
High qualified employments	Number of high qualified employment generated during the whole project (#)
	Number of high qualified employment generated according to the actions (#)
Reduction of public services	Cost of sewage sludge final disposal (baseline vs Lo2x process) (€/kg)
	Total cost of water sanitation without returns of digested sludge dehydration (€/m^3)
	Cost of wastes treatment (baseline vs Lo2x process) (€/m^3)
Enhancement of productivity sectors	Number of companies from different productivity sectors interested to treat their wastes by co-oxidation with sewage sludge in LO2X technology (#)
	Cost saving in the treatment of wastes from productivity sectors in comparison with current treatment or disposal (%)
Legal and safety	Number of licenses accomplished in order to compliance legal environmental and safety requirements (#)

Along whole project information from process evolution have been collected and analysed. Results obtained during the demonstration trials period (B. Implementation actions) generated enough information to assess the environmental and socioeconomic benefits standing on more real data.



On the one hand, environmental indicators such as nutrients recovery, reduction of wastes and pollution caused by contaminants such as pesticides were proved. In addition, another advantage is the thermal self-sufficient character of the process, pointing out that there is still potential to produce electric energy. The following results were achieved during the experimental campaign of the LIFE Lo2x project:

- **Nutrients**. Mineralization of nitrogen and phosphorus facilitates the nutrient recovery in order to be used as building blocks of fertilizers. Nitrogen occurs in the liquid phase (NH_4^+ ~ 2 g/L) while phosphorus is present in the inorganic solid fraction of the SCWCO effluent (P_2O_5~25%) where is recovered up to 82%

- **Organic matter**. ≥ 99% elimination of organic matter. Kg of COD removed per kg of sewage sludge and wastes (dry matter) is higher than 1.40 in all of scenarios.

- **Inorganic matter**. Total solid reduction higher than 90%, which means 98% reduction fo sewage sludge leaving WWTP. The inorganic solid fraction from SCWCO is a resource for phosphorous industry whereas wastes from anaerobic digestion may end up in the landfills.

- **Pesticides**. Imazalis is fully degraded through SCWCO up to 350 mg/kg (5,000 mg/kg dm). None of the more than 50 pesticides studied was detected in the effluent of the SCWCO process.

- **Resource and energy.** On one hand, oxygen dose is lower than 2.5 kg O_2/kg dm in all studied scenarios. On the other hand, the heat produced by the oxidation under supercritical conditions (highly exothermic reaction) makes pumping to be the only significant energy-consuming step through SCWCO.

On the other hand, the main socioeconomic benefits were the demonstration of the competitive price of the technology, the reduction on public services especially related to the disposal of residues, the enhancement of productivity sectors since this novel technology feeds from several technological leading sectors, what has contributed to the creation of high-qualified direct and indirect employments. The following results were achieved during the experimental campaign of the LIFE LO2X project:

- **Economical assessment**. 10% reduction in sludge treatment cost. The gate fee thanks to co-substrate treatment of drencher wastewater by SCWcO allows reducing the cost of sludge treatment below the cost of baseline (*i.e.*, anaerobic digestion).

- **Promotion of industria diversification**. WWTP diversification via co-oxidation. Other liquid wastes, including very pollutant streams such as pesticides, leachtes, can were successfully co-treated.

- **High qualified employments**. Four high qualified employment generated during the whole project: Jose M. Abelleira, Jordi Casas and Esteban Bardallo from SCFI and Raúl di Silvestre from IVEM.

- **Reduction of public services**. The gate fee thanks to co-substrate treatment of drencher wastewater reduce significantly the cost of sewage sludge, which represent 35% of total water sanitary price.

- **Enhancement of productivity sectors**. Emerging market. Legislation on water quality or sludge use, nutrient management and phosphorous recover / circular economy policies will generate opportunities in the near future.

- **Legal and safety**. 7 licences has been accomplished. LIFE LO2X aims to be in line with the upcoming regulatory and normative requirements.

A complete report of environmental and socioeconomic assessment of the project, with the table of both types of indicators is included in the Deliverable D.C.1.2.

Start date: *October 2013*. End date: *June 2017*.

Deliverable D.C1.1. *“List of specific indicators: specific indicators selected for the environmental and socioeconomic assessment of the project actions”* (achieved).

Deliverable D.C1.2. *“Environmental and socioeconomic impact assessment report”* (achieved)

Milestone M.C1.1. Specific indicators selected and defined (achieved)

Milestone M.C1.2. *Data for the assessment of the specific indicators collected and organized. Calculation of impact indicators performed (LO2X data vs baseline)* (achieved).

Milestone M.C1.3. *Environmental and socioeconomic impact assessment done* (achieved).

5.2 Dissemination actions

5.2.1 Objectives

The general objective of the communication strategy of LO2X is to define the communication bases to disseminate the results and best practices identified throughout the project and to highlight the added value of the European intervention within the LIFE programme to demonstrate its relevance in terms of support, mentoring, and promotion of cooperation networks. The key message is that a synergic co-treatment with energy and phosphorus recovery through supercritical water co-oxidation (SCWcO) may be an economically viable technique to reduce the environmental impact of sewage sludge and wastes (raw or digested manure, high load food processing wastes, pesticides, leachates and others).

At a general level, four operational objectives are set:

- **Better exploitation of project results**. This will encourage the transfer of the lessons of the project to other users, other policies and maybe the European legislative process;

- **Involve the beneficiary States of LIFE to a greater extent**, by giving them an active role in the improvement of the communication on LIFE;

- **Implement specific communication activities for the candidate countries**, through greater participation of these countries in the LIFE instrument;

- **Increase the institutional and general visibility of LIFE** by projecting a positive overall image of the program, within the European Commission, beneficiary States and general public.

The specific goal of the plan is to **publicize results and experience from the project to different stakeholders and promote the uptake of these technologies**.

Target audience: because water and waste field is linked different sectors, the target audience includes a wide variety of stakeholders from many disciplines. Stakeholder group at National and European level are:

1. Public authorities
2. Water treatment RTDs
3. Platforms
4. Policy Makers
5. Industries
6. General public

A list of specific stakeholders in these categories is set in deliverable D.0.0. – Communication and Dissemination Plan.

5.2.2 Dissemination: overview per activity

Action D1: Dissemination and Communication plan (DCP)

The DCP sets the dissemination strategy of LO2X, including goals of the plan, target audience, messages and channels, implementation, activities, schedule and proposal of ideas for technical articles and press releases.

It constitutes the deliverable D.0.0 – Dissemination and Communication plan. A detailed implementation schedule was included upon request of the Commission. Several updates have been issued whenever necessary along the lifetime of the Project. The consortium has agreed in scheduling these activities in a twofold way. Actions during 2015 and 2016 were scheduled in a more generalist way (low-profile) through blogs, webs and social media. They focused in reaching the attention to the problems addressed in the project. Actions during 2017 were scheduled in a more specific way (high-profile) through specialised press, with the focus in disseminating the results.

The corporate image of the Project was developed in the beginning of the project, including the project logo, templates for reports and deliverables. The projects logo, colours and visual image was applied to the dissemination materials such as notice boards, Layman's report, film, technical articles, leaflets, technical poster, web page and slideshow.

Action D2: Project Website

Project virtual site was started as foreseen and it will continue under development along the duration of action D2 (up to the end of the project). URL: http://www.lo2x.com. Web page is active in Spanish and English versions.


The sections in the website are: project (description, objetives, activities, results and benefits), partners (participants and contact details), documents (downloadable versions of project's elements, press releases and photo gallery), links (to other LIFE related projects) and agenda (future events related Lo2x). All sections are active.

A "Members Area" has been specially developed to make easier the information exchange among partners. A Workplace Guidelines document has been issued to help partners with the use of the tool.

Following the project external monitor indications, a revised version of the Outputs Indicators, affecting some of the goals regarding Dissemination that were set in the Grant Agreement, was sent to the Commission on July 2014 with this specific change:

- The expected average number of website visitors per month has been reduced from the initial 10.000 to a more reasonable number of 100.

OUTPUTS

Part 3 - Awareness raising and communication

Table 4 - Workshops, seminars and conferences

Target audience	General public			Specialised audience (e.g. decision-makers)			Very specialised audience (e.g. experts, academics)		
Number of participants:	Local/ Regional	National	EU/ International	Local/ Regional	National	EU/ International	Local/ Regional	National	Local/ Regional
0-25 participants					1			2	
25-75 participants					1	1		1	1
75-100 participants									
More than 100 participants									
Total budgeted cost (€)	37500								

Table 5 - Media and other communication and dissemination work

Type of media	No.
Project website: average number of visitors per month	100
Press releases made by the project	3
General public article in national press	
General public article in local press	
Specialised press article	3
Internet article	
TV news/reportage	
Radio news/reportage	
Film produced	1
Film played on TV	
Film presented in events/festivals	
Exhibitions attended	4
Information centre/information kiosk	
Project notice boards	2
Other (please specify)	
Total budgeted cost (€)	140000

Table 6 - Publications

Type of publication	No. published	No. of copies	Languages
Layman's report	1	Electronic copies	ES, EN
Manuals			
Leaflets	2	500	ES, EN
Brochures			
Posters	1	10	ES, EN
Books			
Technical publications			
Other (please specify)			
Total budgeted cost (€)	23000		

Table 7 - Educational activities

Establishment involved	No. of students
Kindergartens/Primary schools	
Secondary schools	
Higher education establishments	
Total budgeted cost (€)	

From January 2014 to September 2017 (45 months), more than 16.500 visits to the web have been received, close to 370 visits per month (approximately 367 visits per months). The Communication's plan objective is to reach 100 visits per month, objective that has been widely surpassed. See below Website Analytic for the period.

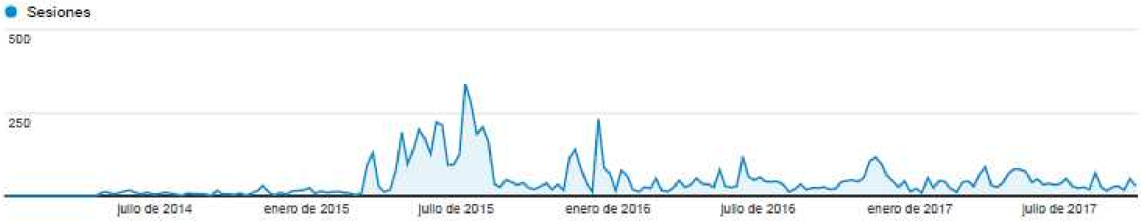
www.lo2x.com
Todos los datos de sitios web
IR AL INFORME

Visión general de la audiencia

Todos los usuarios
100,00 % Sesiones

1 ene. 2014 - 4 oct. 2017

Visión general



Sesiones
8.606

Usuarios
6.980

Número de visitas a páginas
16.553

Páginas/sesión
1,92

Duración media de la sesión
00:01:20

Porcentaje de rebote
69,52 %

% de nuevas sesiones
81,11 %

	Idioma	Sesiones	% Sesiones
1.	(not set)	4.184	48,62 %
2.	es	1.195	13,89 %
3.	es-es	842	9,78 %
4.	en-us	730	8,48 %
5.	en-gb	496	5,76 %
6.	pt-br	202	2,35 %
7.	en	190	2,21 %
8.	Secret.ɢoogle.com	120	1,39 %
9.	zh-cn	92	1,07 %
10.	ru	75	0,87 %

www.lo2x.com
Todos los datos de sitios web
IR AL INFORME

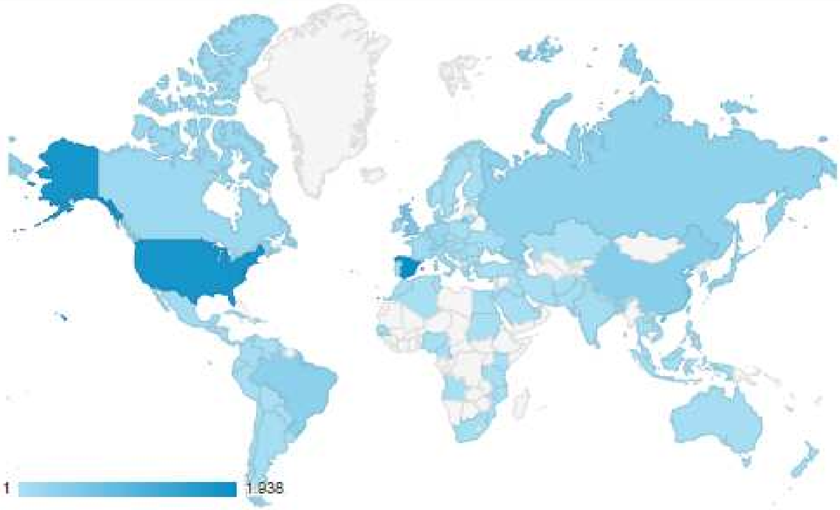
Ubicación

Todos los usuarios
100,00 % Sesiones

1 ene. 2014 - 4 oct. 2017

Gráfico de visitas por ubicación

Resumen



País	Adquisición			Comportamiento			Conversiones		
	Sesiones	% de nuevas sesiones	Usuarios nuevos	Porcentaje de rebote	Páginas/sesión	Duración media de la sesión	Porcentaje de conversiones del objetivo	Objetivos cumplidos	Valor del objetivo
	8.606 % del total: 100,00 % (8.606)	82,31 % Media de la vista: 81,11 % (1,49 %)	7.084 % del total: 101,49 % (6.980)	69,52 % Media de la vista: 69,52 % (0,00 %)	1,92 Media de la vista: 1,92 (0,00 %)	00:01:20 Media de la vista: 00:01:20 (0,00 %)	0,00 % Media de la vista: 0,00 % (0,00 %)	0 % del total: 0,00 % (0)	0,00 $ % del total: 0,00 % (0,00 $)
1. Spain	1.938 (22,52 %)	53,72 %	1.041 (14,70 %)	39,47 %	3,48	00:02:46	0,00 %	0 (0,00 %)	0,00 $ (0,00 %)
2. United States	1.741 (20,23 %)	97,42 %	1.696 (23,94 %)	83,46 %	1,30	00:00:36	0,00 %	0 (0,00 %)	0,00 $ (0,00 %)
3. (not set)	1.194 (13,87 %)	99,92 %	1.193 (16,84 %)	86,52 %	1,15	00:00:19	0,00 %	0 (0,00 %)	0,00 $ (0,00 %)
4. United Kingdom	486 (5,65 %)	92,59 %	450 (6,35 %)	73,46 %	1,79	00:00:43	0,00 %	0 (0,00 %)	0,00 $ (0,00 %)
5. China	408 (4,74 %)	84,80 %	346 (4,88 %)	78,68 %	1,63	00:01:47	0,00 %	0 (0,00 %)	0,00 $ (0,00 %)
6. Brazil	349 (4,06 %)	94,84 %	331 (4,67 %)	86,53 %	1,21	00:00:31	0,00 %	0 (0,00 %)	0,00 $ (0,00 %)
7. Russia	310 (3,60 %)	16,45 %	51 (0,72 %)	51,29 %	1,54	00:02:41	0,00 %	0 (0,00 %)	0,00 $ (0,00 %)
8. Germany	185 (2,15 %)	95,68 %	177 (2,50 %)	77,30 %	1,54	00:00:28	0,00 %	0 (0,00 %)	0,00 $ (0,00 %)
9. Canada	168 (1,95 %)	100,00 %	168 (2,37 %)	95,83 %	1,14	00:00:06	0,00 %	0 (0,00 %)	0,00 $ (0,00 %)
10. Italy	150 (1,74 %)	94,00 %	141 (1,99 %)	54,00 %	2,15	00:00:38	0,00 %	0 (0,00 %)	0,00 $ (0,00 %)

Webpage visitors come from Spain and United States of America. In fact, between both countries amount to close to 50% of the visits.

Following indications from the EC, it has been included in the website a photo gallery section and the date of the last update (https://www.flickr.com/photos/lo2x/albums) and the website provides information of the project technical progress (http://www.lo2x.com/eng/actividades.html) and downloable version of the project technical documents such article, poster or leaflet (http://www.lo2x.com/eng/documentos.html).

Project website and workplace constitutes Deliverable D.D.2.

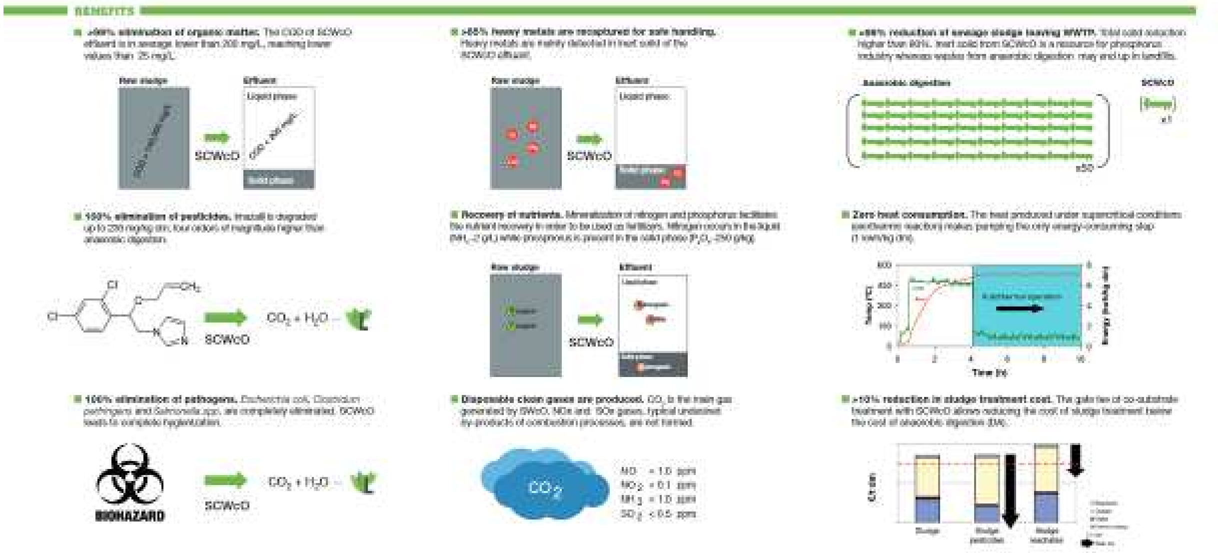
Action D3: Project materials

The project materials have been used to disseminate in technical and industrial events, and to present the project to the general public. Activities to generate project materials have been implemented as foreseen.

GENERAL AND TECHNICAL LEAFLETS

General project leaflet content has been produced by AINIA both in Spanish and English to disseminate the project in mainstreaming activities. The electronic version is available in the web page (http://www.lo2x.com/documentos/general_leaflet.pdf in English and http://www.lo2x.com/documentos/folleto_general.pdf in Spanish). Two versions have been necessary as a result of the departure of ISOLUX and its replacement by URBASER. Last version of the leaflet is annexed in point 7.3.3 "Other dissemination annexes". 500 copies in English and 500 in Spanish were printed in colour.

The technical leaflet with technical information of the project for dissemination in congresses and trade fairs is also available in the website (http://www.lo2x.com/documentos/Technical_Leaflet_Lo2x.pdf). 200 copies were printed in colour in order to use this material for presenting LO2X project to the authorities and other scientific or technical stakeholders.



Project leaflets constitutes Deliverable D.D.3.

POSTERS

One poster was foreseen in the proposal. Instead of one, two posters, general and technical, were designed with relevant information of the project for dissemination in congress, trade fairs and events at European level such as “LIFE Water Platform Meeting Water Works” in Mancheter (United Kingdom) or “European Innovation Partnership on Water” in Porto (Portugal) in order to ensure appropriate impact of the project to stakeholders. Moreover, poster, general and technical, were used in LO2X Event “Urban Sewage Sludge: from Waste to Resource” celebrated in Valencia (Spain). Posters will also be used in future events framed in the AfterLife Plan.

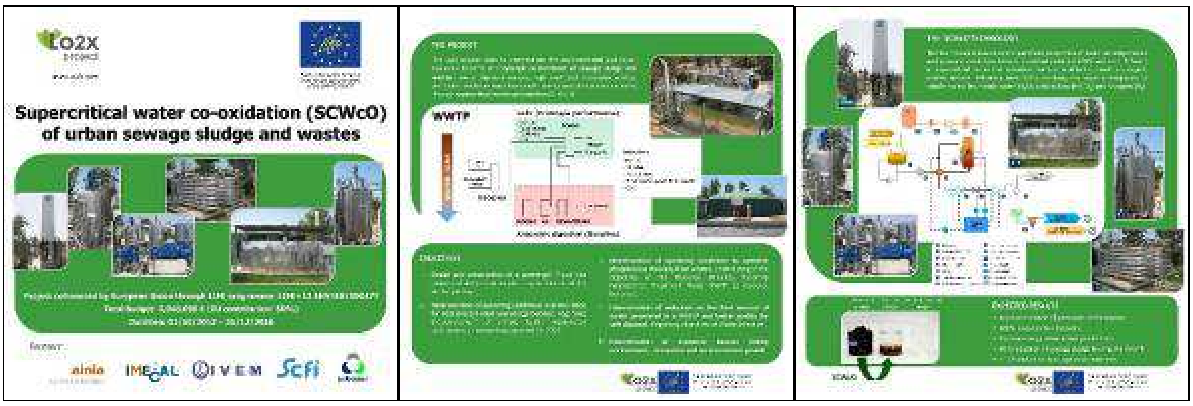
The electronic versions are available in the web page both of the general poster (http://www.lo2x.com/documentos/General_Poster_Lo2x%20(English).pdf in English and http://www.lo2x.com/documentos/General_Poster_Lo2x%20(Castellano).pdf in Spanish) and the technical poster (http://www.lo2x.com/documentos/Technical_Poster_Lo2x.pdf).

Technical poster:

Action D4: Notice Boards

A notice board describing the project was produced and displayed in a visible place, accessible to the public. Visual material and descriptive texts were used. The design is in accordance with the visual identity of the project established in Action D1 and used in other dissemination elements, such as the website and leaflets. The LIFE and project logos are included.

On the one hand, 3-panel notice board in English was displayed at the prototype site in order to disseminant the project and facilitate the explanation of LO2X plant.



On the other hand, 1-panel notice board (poster) was displayed in a visual place, accessible to the public in each partners facilities to disseminat the project. Notice board was produced in Spanish for AINIA, IMECAL, IVEM and URBASER and in English for SCFI to be used by partners in their own language.

IVEM

URBASER

IMECAL

AINIA

SCFI

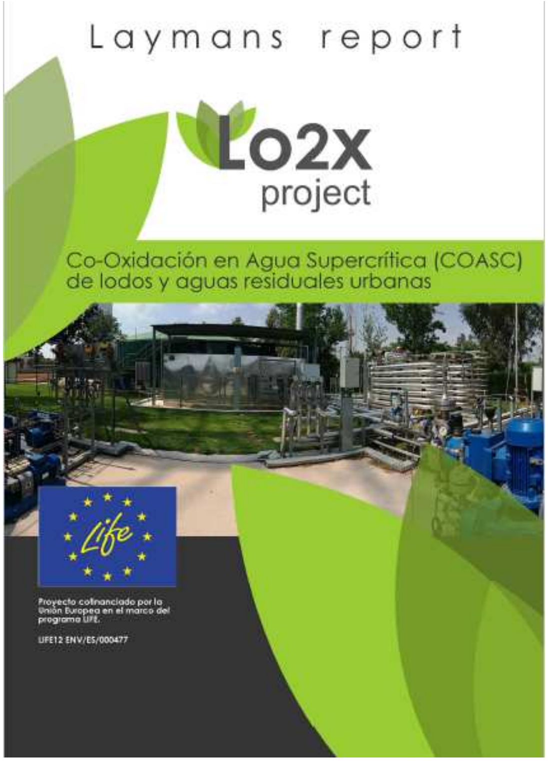
More pictures of the notice boards displayed both at LO2X prototype and can be also found in the webpage (https://www.flickr.com/photos/lo2x/albums/72157673115884066).

Notice boards are part of Deliverable D.D.5.

Action D5: Layman´s report

A Layman's report was produced at the end fo the project, both in paper and electronic format (http://www.lo2x.com/documentos/Laymans-lo2x-eng.pdf in English and http://www.lo2x.com/documentos/Laymans-lo2x-esp.pdf in Spanish). 50 copies in English and 50 in Spanish were printed in colour.

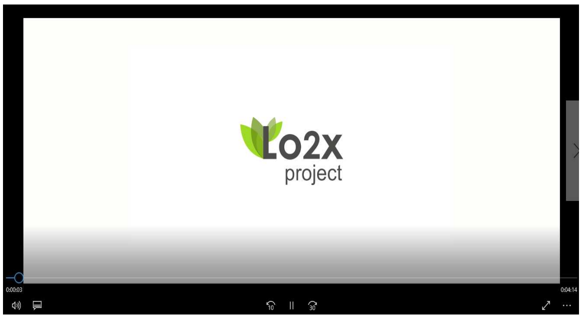
The report has 10 pages and present the project, its objetives, actions and results to the general public. The desing of the report is consistent with the rest of the dissemination elements and include the LIFE and project logos.

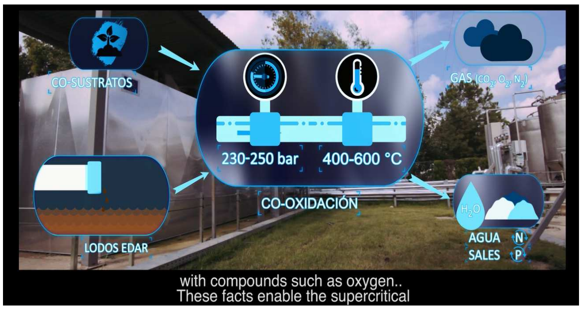


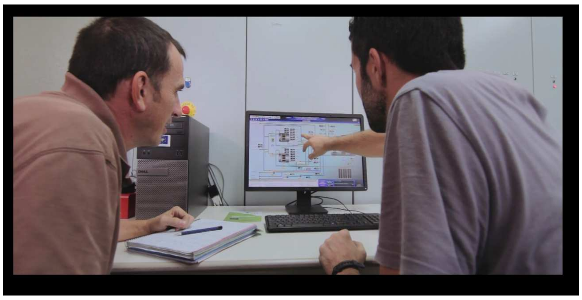
Layman's report constitutes Deliverable D.D.3.

Action D6: Virtual tour of the prototype

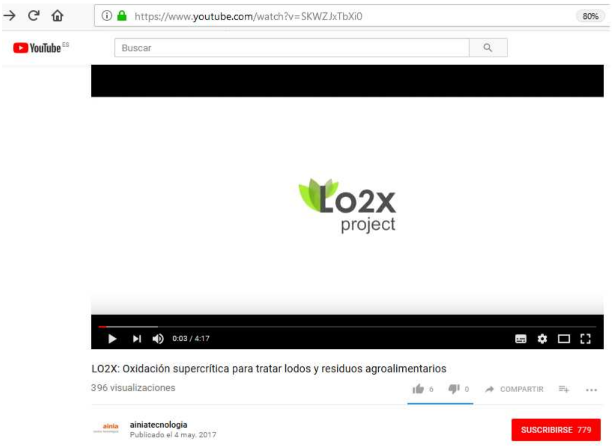
A film was produced to show in detail the final prototype and its performance. The video has voice-over and subtitles in English and Spanish. The duration is 4:17 min. The film constitutes Deliverable D.D.4.

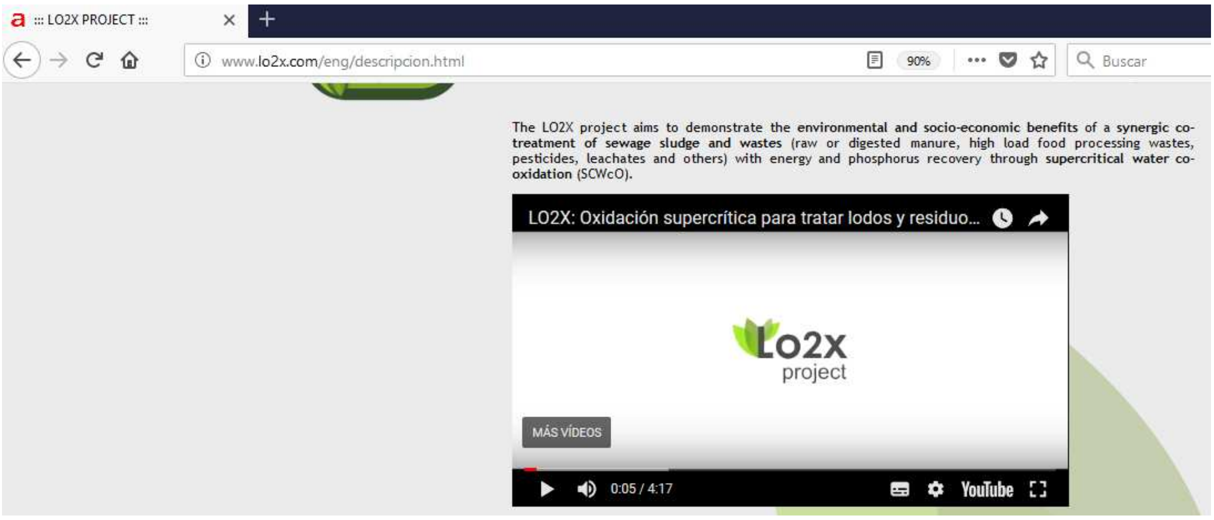






The video was published and posted in YouTube in May 2017 (https://www.youtube.com/watch?time_continue=5&v=SKWZJxTbXi0), in the project website www.lo2x.com and in AINIA webpage through the article by Andrés Pascual "Primera planta demostrativa de co-oxidación supercrítica que consigue valorizar lodos contaminados de depuradoras urbanas junto a otros residuos" (http://www.ainia.es/noticias/prensa/primera-planta-demostrativa-de-co-oxidacion-supercritica/). By September 2017, the video was downloaded close to 400 times, approximately 80 downloads per moth.





Action D7: Technical Articles

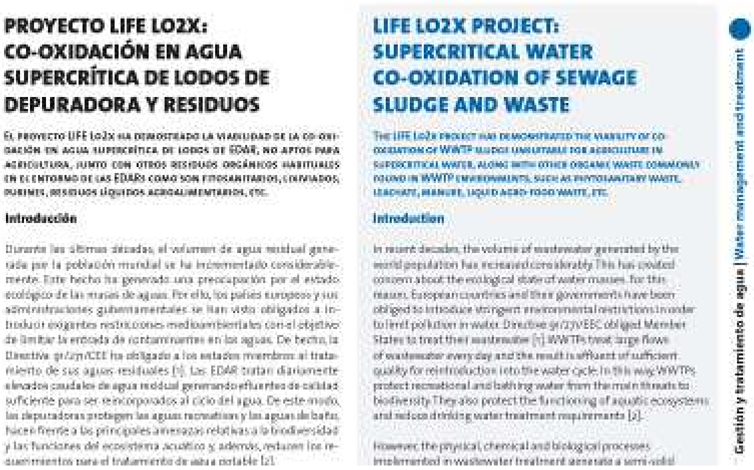
Four technical articles were reported by the consortium in order to disseminate and promote the use of environmental-friendly technologies, such as the one demonstrated by the project. The technical journals that published the articles are both national and international ones and they were selected on basis the impact that their publicantions could cause on the society. The technical articles are available in the web page: http://www.lo2x.com/eng/documentos.html.

1) RETEMA, in its 196 issue, published the article “Oxidación en agua supercrítica de lodos de EDAR: Proyecto LIFE Lo2x”. This paper reviewed the environmental issues of urban sewage sludge: increasing sludge generation, the main polluntants detected and the new European Union legislation framework. RETEMA is technical journal of environment, which is published bimonthly with a print-run of 6,500 copies and read on the Internet by 23,500 readers. Web address: https://www.retema.es/

OXIDACIÓN EN AGUA SUPERCRÍTICA DE LODOS DE DEPURADORA: PROYECTO LIFE LO2X

Oxidación en agua supercrítica de lodos de EDAR: Proyecto LIFE Lo2x

2) FUTURENVIRO, in its 43 issue, published the article “LIFE Lo2x project: Supercritical water co-oxidation of sewage sludge and waste”. This paper brings a review of the main results achieved in LIFE Lo2x. FUTURENVIRO is a technical journal of water, wastewater and waste treatment, which is published bimonthly with of print-run of 7,000 copies. The distribution magazine online reaches over 110,000 water professional from around the world. Web address: http://futurenviro.es/en/



PROYECTO LIFE LO2X: CO-OXIDACIÓN EN AGUA SUPERCRÍTICA DE LODOS DE DEPURADORA Y RESIDUOS

Introducción

LIFE LO2X PROJECT: SUPERCRITICAL WATER CO-OXIDATION OF SEWAGE SLUDGE AND WASTE

Introduction

Gestión y tratamiento de agua | Water management and treatment

3) TECNOAGUA, in its 27 issue, pubished the article “LIFE Lo2x: Demostración de los beneficios de un co-tratamiento sinérgico de lodos de EDAR y residuos”. This paper describes the LIFE Lo2x prototype as well as shows the main benefits achived through supercritical water co-oxidation technology. TECNOAGUA is a technical journal of water and wastewater, which is published biomontly with of print-run of 6,000 copies. Web address: https://www.tecnoaqua.es/


Artículo Técnico

Life Lo2x: Demostración de los beneficios de un co-tratamiento sinérgico de lodos de EDAR y residuos

4) WATER & WASTEWATER INTERNATIONAL, in its 6 issue 32 volume, published the article "SUPER SLUDGE: Spain Spearhead Development of Supercritical Water Oxidation". This paper brings a general overview of the basic principles of main treatments employed in Spain on sewage sludge treatment. Given the advantages of supercritical water oxidation of sewage sludge treatment technologies, including SCWO and its potentialities as a promising and innovative technology. The main LIFE Lo2x results are presented. WATER & WASEWATER INTERATIONAL is a technical journal of water and wastewater, which is part of WATER WORLD, a web portal that has 61,005 subcriptors. Web address: http://www.waterworld.com/


SUPER SLUDGE

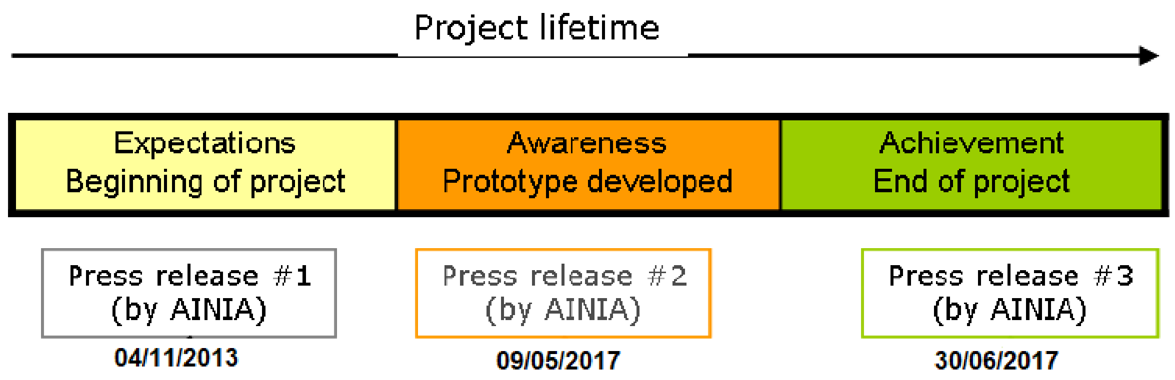
Spain Spearheads Development of Supercritical Water Oxidation

A European Union funded project set out to demonstrate the environmental and socio-economic benefits of a synergic co-treatment of sewage sludge and wastes. This article addresses the findings and how the technology could fit in with existing sludge treatment processes.

The technical articles are part of Deliverable D.D.5.

Action D8: Press releases

Press releases were issued at 3 key milestones of the project: beginning of the project, prototype validation and end of the project. The press releases were written by AINIA and distributed to th consortium partner and its press contacts.



First press release after kick-off meeting was published on 04/11/2013 with close to 30 impacts. Second press release was published on 09/05/2017, which coincided with the visit of technical and financial desk officers from European Commission. The main objective of the second press realse was showed the awareness of prototype developed. In fact, the video, which shows in the final prototype and its performance, was presented in this second press realease. Finally, the third press release was published on 30/06/2017 at the end of the project. This press realese emphatise the main achievements of LO2X. Both the second and third press releases achieved more than 10 impacts. Specially important was the impacts of the third press realease with two radio interview in national programs. Other 14 press publications were issued.

Type	Media	Title	Date
Other	Eneco 2	Pequeña reseña al final del artículo. http://www.eneco2.org/fr/actus/un-supermercado-de-eroski-se-autoabastecera-con-trigeneracion-de-biomasa	26/08/2013
Other	Retema	Ainia coordina el proyecto LO2X, tratamiento conjunto de lodos de depuradora y otros tipo de residuos mediante cooxidación supercrítica. https://issuu.com/r.retema/docs/retema170_sept-oct_2013	1/10/2013
Press Release #1	AINIA	Instalarán la primera planta en Europa de agua supercrítica en una depuradora urbana de Valencia para demostrar su eficacia. http://www.ainia.es/noticias/prensa/instalaran-la-primera-planta-en-europa-de-agua-supercritica-en-una-depuradora-urbana-de-valencia/	04/11/2013
Press Release #1	Agencia EFE	Se instalará en España la primera planta de agua supercrítica de Europa.	04/11/2013
Press Release #1	Blog del Agua	Instalarán la primera planta en Europa de agua supercrítica en una depuradora urbana de Valencia para demostrar su eficacia. http://blogdelagua.com/tematica/depuracion/primera-planta-europa-agua-supercritica-depuradora-valencia/	04/11/2013
Press Release #1	Fruittoday	Instalarán la primera planta en Europa de agua supercrítica en una depuradora urbana de Valencia para demostrar su eficacia.	04/11/2013
Press Release #1	Futurenviro	Primera planta en Europa de agua supercrítica en una depuradora urbana de Valencia. http://futurenviro.es/node/444	04/11/2013
Press Release #1	Iagua	Una novedosa tecnología permitirá tratar lodos de depuradora, residuos agroalimentarios, lixiviados de vertederos y plaguicidas de forma conjunta. http://www.iagua.es/noticias/depuracion/13/11/04/una-novedosa-tecnologia-permitira-tratar-lodos-de-depuradora-residuos-agroalimentarios-lixiviados-d	04/11/2013
Press Release #1	Retema	Instalarán la primera planta en Europa de agua supercrítica en una depuradora urbana de Valencia para demostrar su eficacia. http://www.retema.es/noticia/instalarn-la-primera-planta-en-europa-de-agua-supercrtica-en-una-depuradora-urbana-de-valencia-para-demostrar-su-eficacia	04/11/2013

Press Release #1	LaVerdad	La primera planta de agua supercrítica en Europa se instalará en Paterna. http://www.laverdad.es/innova/investigacion/20131105/agua-supercritica-201311051216-rc.html	04/11/2013
Press Release #1	Agrodigital	Novedosa tecnología que permite tratar en una misma instalación lodos de depuradora junto con residuos agroalimentarios, plaguicidas residuales o lixiviados de vertederos. http://www.agrodigital.com/PlArtStd.asp?CodArt=92904	05/11/2013
Press Release #1	Diario Vasco	Instalan la primera planta de agua supercrítica en España. http://www.diariovasco.com/innova/investigacion/20131105/agua-supercritica-201311051216-rc.html	05/11/2013
Press Release #1	ClubDarwin	Instalarán la primera planta en Europa de agua supercrítica en una depuradora urbana de Valencia para demostrar su eficacia.	05/11/2013
Press Release #1	Innovaticias	Instalarán la primera planta en Europa de agua supercrítica en una depuradora urbana de Valencia para demostrar su eficacia. http://www.innovaticias.com/innovacion/19983/resultado-busqueda-eyf.php?fecha=2015-02-7&sec=eventos	05/11/2013
Press Release #1	Las Provincias	La primera planta de agua supercrítica en Europa se instalará en Paterna. http://www.lasprovincias.es/agencias/20131104/comunitatvalenciana/comunitat/primera-planta-agua-supercritica-europa_201311041725.html	05/11/2013
Press Release #1	Las Provincias	L'Horta acogerá la primera planta de agua supercrítica de Europa. http://www.lasprovincias.es/v/20131105/horta-morvedre/horta-acogera-primera-planta-20131105.html	05/11/2013
Press Release #1	Las Provincias	Instalan la primera planta de agua supercrítica en España. http://www.lasprovincias.es/innova/investigacion/20131105/agua-supercritica-201311051216-rc.html	05/11/2013
Press Release #1	Ideal	Instalan la primera planta de agua supercrítica en España. http://www.ideal.es/innova/investigacion/20131105/agua-supercritica-201311051216-rc.html	05/11/2013
Press Release #1	Residuos Profesional	Una sola instalación para tratar lodos, residuos agroalimentarios, lixiviados y plaguicidas. http://www.residuosprofesional.com/una-sola-instalacion-para-tratar-lodos-residuos-agroalimentarios-lixiviados-y-plaguicidas/	05/11/2013
Press Release #1	La Verdad	Instalan la primera planta de agua supercrítica en España http://www.laverdad.es/agencias/20131104/comunidad-valenciana/primera-planta-agua-supercritica-europa_201311041721.html	05/11/2013
Press Release #1	Hoy	Instalan la primera planta de agua supercrítica en España. http://www.hoy.es/innova/investigacion/20131105/agua-supercritica-201311051216-rc.html	05/11/2013
Press Release #1	Diario Sur	Instalan la primera planta de agua supercrítica en España. http://www.diariosur.es/innova/investigacion/20131105/agua-supercritica-201311051216-rc.html	05/11/2013
Press Release #1	El Correo	Instalan la primera planta de agua supercrítica en España. http://www.elcorreo.com/innova/investigacion/20131105/agua-supercritica-201311051216-rc.html	05/11/2013
Press Release #1	El Comercio	Instalan la primera planta de agua supercrítica en España. http://www.elcomercio.es/innova/investigacion/20131105/agua-supercritica-201311051216-rc.html	05/11/2013
Press Release #1	La Voz Digital	Instalan la primera planta de agua supercrítica en España. http://www.lavozdigital.es/innova/investigacion/20131105/agua-supercritica-201311051216-rc.html	05/11/2013
Press Release #1	Radio 9	Radio interview at Agropopular program	5/11/2013
Press Release #1	EFE Verde	La primera planta de agua supercrítica en Europa se instalará en Paterna. http://www.efeverde.com/noticias/la-primera-planta-de-agua-supercritica-en-europa-se-instalara-en-paterna/	06/11/2013
Press Release #1	Vitenergía	Instalarán la primera planta en Europa de agua supercrítica en una depuradora urbana de Valencia para demostrar su eficacia. http://www.vitenergia.es/?noticias=instalaran-la-primera-planta-en-europa-de-agua-supercritica-en-una-depuradora-urbana-de-valencia-para-demostrar-su-eficacia	06/11/2013
Press Release #1	ABC	La primera planta de agua supercrítica en Europa se instalará en Paterna. http://www.abc.es/natural-desarrollorural/20131107/abci-planta-agua-supercritica-paterna-201311071104.html	07/11/2013
Other	El Mundo	Newspaper supplement – Mercados. Medio Ambiente	11/11/2013
Other	Aguas Residuales	Francisco Heredia, Director-Gerente de la empresa IVEM S.L., nos comenta los detalles más destacados de esta empresa dedicada a la O&M de	06/11/2014

		instalaciones relacionadas con el Ciclo Integral del Agua. http://www.aguasresiduales.info/revista/entrevistas/francisco-heredia-director-gerente-de-la-empresa-ivem-s-l-nos-comenta-los-detalles-ma-thn2r	
Other	El Levante	El poder del agua supercrítica.	01/10/2015
Other	Retema	Oxidación en agua supercrítica de lodos de EDAR: Proyecto LIFE Lo2x. https://www.retema.es/articulo/oxidacion-en-agua-supercritica-de-lodos-de-edar-proyecto-life-lo2x-kZzIc	01/01/2016
Other	AINIA	Oxidación en agua supercrítica, aplicaciones para tratamientos de depuración de aguas residuales. http://www.ainia.es/tecnoalimentalia/tecnologia/oxidacion-en-agua-supercritica-aplicaciones-para-tratamientos-de-depuracion-de-aguas-residuales/	01/06/2016
Other	El País	Las diez ideas españolas para ahorrar agua frente al cambio climático. http://tecnologia.elpais.com/tecnologia/2017/02/16/actualidad/1487257232_818990.html	10/03/2017
Press Release #2	AINIA	Primera planta demostrativa de co-oxidación supercrítica que consigue valorizar lodos contaminados de depuradoras urbanas junto a otros residuos. http://www.ainia.es/noticias/prensa/primera-planta-demostrativa-de-co-oxidacion-supercritica/	09/05/2017
Press Release #2	Iresiduo	LO2X: ¿Cómo valorizar lodos contaminados de depuradoras urbanas junto a otros residuos?. http://www.iresiduo.com/noticias/espana/ainia/17/05/09/lo2x-como-valorizar-lodos-contaminados-depuradoras-urbanas-junto	09/05/2017
Press Release #2	Aguas Residuales	Primera planta demostrativa de co-oxidación supercrítica que consigue valorizar lodos de EDAR junto a otros residuos. http://www.aguasresiduales.info/revista/noticias/primera-planta-demostrativa-de-co-oxidacion-supercritica-que-consigue-valorizar-lodos-1NzVY	09/05/2017
Press Release #2	Retema	Primera planta de co-oxidación supercrítica que valoriza lodos de depuradora con otros residuos. http://www.retema.es/noticia/primera-planta-demostrativa-de-co-oxidacion-supercritica-que-valoriza-lodos-contamina-hWZDM	09/05/2017
Press Release #2	Ecoticias	Resultados del proyecto LIFE LO2X, liderado por AINIA, y en el que han participado otras cuatro empresas: IVEM, URBASER, IMECAL y SCFI. http://www.ecoticias.com/residuos-reciclaje/135821/Resultados-del-proyecto-LIFE-LO2X-liderado-por-AINIA-y-en-el-que-han-participado-otras-cuatro-empresas-IVEM-URBASER-IMECAL-SCFI	09/05/2017
Press Release #2	Innovaticias	Resultados del proyecto LIFE LO2X, liderado por AINIA, y en el que han participado otras cuatro empresas: IVEM, URBASER, IMECAL y SCFI. http://www.innovaticias.com/innovacion/41605/2017/05/09/resultados-del-proyecto-life-lo2x-liderado-por-ainia-y-en-el-que-han-participado-otras-cuatro-empresas-ivem-urbaser-imecal-scfi	09/05/2017
Press Release #2	La Vanguardia	La Planta EDAR de Paterna recupera el 95 % de los fósforos presentes en lodos. http://www.lavanguardia.com/local/valencia/20170509/422416002531/la-planta-edar-de-paterna-recupera-el-95--de-los-fosforos-presentes-en-lodos.html	09/05/2017
Press Release #2	Las Provincias	La Planta EDAR de Paterna recupera el 95 % de los fósforos presentes en lodos. http://www.lasprovincias.es/agencias/valencia/201705/09/planta-edar-paterna-recupera-958694.html	09/05/2017
Press Release #2	Residuosprofesional	LO2X: OXIDACIÓN SUPERCRÍTICA PARA TRATAR LODOS Y RESIDUOS AGROALIMENTARIOS. https://www.residuosprofesional.com/lo2x-lodos-residuos-agroalimentarios/	10/05/2017
Press Release #2	Tecnoagua	El proyecto Life LO2X crea la primera planta demostrativa de co-oxidación supercrítica que consigue valorizar lodos contaminados de depuradoras urbanas junto a otros residuos. https://www.tecnoaqua.es/noticias/20170511/ainia-proyecto-life-lo2x-planta-cooxidacion-supercritica-valorizar-lodos-contaminados-depuradoras-urbanas-residuos#.WT--5dQtCHs	11/05/2017
Press Release #2	Biotecnologia al día	Primera planta demostrativa de co-oxidación supercrítica que consigue valorizar lodos contaminados de depuradoras urbanas junto a otros residuos. http://www.biotecnologiaaldia.es/index.php/comunicadosprensa/2412-primera-planta-demostrativa-de-co-oxidacion-supercritica-que-consigue-valorizar-lodos-contaminados-de-depuradoras-urbanas-junto-a-otros-residuos	11/05/2017
Press Release #2	El Mundo	Newspaper supplement – Mercados. Medio Ambiente	14/05/2017
Press Release #2	Economía 3	Ainia, primera planta que valoriza lodos contaminados de depuradoras urbanas. http://www.economia3.com/2017/06/21/108598-ainia-primera-planta-que-valoriza-lodos-contaminados-de-depuradoras-urbanas/	12/06/2017

Other	Ategrus	AINIA informa sobre la jornada "LODOS DE EDAR: DEL RESIDUO AL RECURSO_ Jornada Proyecto LIFE Lo2x (LIFE12 ENV/ES/000477)" – Martes, 20 de junio de 2017 en Paterna (Valencia) http://www.ategrus.org/wp-content/uploads/2017/06/LIFE_Lo2x_PROGRAMA_espa%C3%B1ol.pdf	15/06/2017
Press Release #3	AINIA	Consiguen eliminar cerca del 100% de los compuestos químicos orgánicos presents en lodos de EDAR. http://www.ainia.es/noticias/prensa/consiguen-eliminar-cerca-del-100-de-los-compuestos-quimicos-organicos-presentes-en-lodos-de-edar/	30/06/2017
Press Release #3	Biotecnología al día	Consiguen eliminar cerca del 100% de los compuestos químicos orgánicos presentes en lodos de EDAR. http://www.biotecnologiaaldia.es/index.php/comunicadosprensa/2412-consiguen-eliminar-cerca-del-100%-de-los-compuestos-quimicos-organicos-presentes-en-lodos-de-edar	30/06/2017
Press Release #3	Química y Socidad	Eliminan cerca del 100% de los compuestos químicos orgánicos presentes en lodos de EDAR. http://www.quimicaysociedad.org/2017/07/03/eliminan-cerca-del-100-de-los-compuestos-quimicos-organicos-presentes-en-lodos-de-edar/	03/07/2017
Press Release #3	Aguas Residuales .info	Consiguen eliminar cerca del 100% de los compuestos químicos orgánicos presentes en lodos de EDAR. https://www.aguasresiduales.info/revista/noticias/consiguen-eliminar-cerca-del-100-de-los-compuestos-quimicos-organicos-presentes-en-lo-LUbbF	03/07/2017
Press Release #3	Retema	Consiguen eliminar casi el 100% de los compuestos químicos orgánicos en lodos de depuradora. https://www.retema.es/noticia/consiguen-eliminar-casi-el-100-de-los-compuestos-quimicos-organicos-en-lodos-de-depur-mPmww	03/07/2017
Press Release #3	Interempresas	Consiguen eliminar cerca del 100% de los compuestos químicos orgánicos presentes en lodos de EDAR. http://www.interempresas.net/Reciclaje/Articulos/189820-Consiguen-eliminar-cerca-del-100-por-ciento-compuestos-quimicos-organicos-presentes-lodos.html	04/07/2017
Press Release #3	Iresiduo	Eliminar los compuestos químicos orgánicos presentes en lodos de EDAR ya es possible. http://www.iresiduo.com/noticias/espana/ainia/17/07/05/eliminar-compuestos-quimicos-organicos-presentes-lodos-edar-ya-es	05/07/2017
Press Release #3	Tecnoaqua	Consiguen eliminar cerca del 100% de los compuestos químicos orgánicos presentes en lodos de EDAR. https://www.tecnoaqua.es/noticias/20170705/ainia-eliminar-compuestos-quimicos-organicos-lodos-estacion-depuradora-aguas-residuales#.WndS8-dG01k	05/07/2017
Press Release #3	La Ser	Radio interview at La Llavor program.	08/07/2017
Press Release #3	El Mundo	Newspaper supplement o – Mercados. Medio Ambiente	9/07/2017
Press Release #3	La Cope	Radio interview at Agropopular program.	15/07/2017
Other	La Razón	Líderes en regadío responsible. https://www.larazon.es/economia/lideres-en-regadio-responsable-CD15705502	30/07/2017
Press Release #3	Interempresas	Eliminan cerca del 100% de los compuestos químicos orgánicos presentes en lodos de EDAR. http://www.interempresas.net/Agua/Articulos/195503-Eliminan-cerca-del-100-por-ciento-de-los-compuestos-quimicos-organicos-presentes-en-lodos.html	15/09/2017
Other	Futurenviro	LIFE Lo2x: Co-oxidación en aguas supercrítica de lodos de EDAR y residuos. http://futurenviro.es/digital-versions/2017-09/files/assets/basic-html/page17.html	09/2017
Other	Tecnoaqua	LIFE Lo2x: Demostración de los beneficios de un co-tratamiento sinérgico de lodos de EDAR y residuos. https://www.tecnoaqua.es/kiosco/revista27/visor	09/2017
Other	WWI	SUPER SLUDGE: Spain Spearhead Development of Supercritical Water Oxidation.http://www.waterworld.com/articles/wwi/print/volume-32/issue-6/technology-case-studies/super-sludge-development-in-spain.html	11/2017

The press releases are available in the web page (http://www.lo2x.com/eng/documentos.html) and are part of Deliverable D.D.5.

Action D9: Events

The consortium organized a Final Dissemination Event titled "Urban Sewage Sludge: From Waste To Resource. LIFE Lo2x EVENT (LIFE12 ENV/ES/000477)" on 20/06/2017 in Valencia. The aim was disseminate the main results of the project among the most relevant stakeholders and increase the synergies and cooperation among other related projects.

It was a 9 to 17h full day event, that included:

- a review of the current status and future development of urban sewage sludge management by EPSAR authorities,
- several presentations of the project, actions and results by AINIA, IVEM, IMECAL, SCFI and URBASER,
- the presentation of related LIFE projects such as STO3RE, iCirBUS-4Industries, RecoPhos, LEMNA, ANADRY, ECODIGESTION and NEWAPP (FP7) by its coordinators,
- a parallel networking session
- a technical visit to LIFE LO2X plant

Programme of the event is available in website both in English (http://www.lo2x.com/documentos/Event_Lo2x%20(English).pdf) and in Spanish (http://www.lo2x.com/documentos/Event_Lo2x%20(Castellano).pdf). Some picture of the event can be foun here: https://www.flickr.com/photos/lo2x/albums/72157685714396204.

The event attracted close to 50 people from public autthories (i.e., EPSAR), Water Treatment RTD (e.g., FACSA or GLOBAL OMNIUM), platforms (i.e., PTEA), waste managers (e.g., SAV-DAM or EDAFO) and industries (e.g., CARBUROS METÁLICOS or INGELIA).

Further dissemination, of a more environmental and technical profile, was done at relevant events at European level particulary forum, congresses and trade fairs. Thus, LIFE+ LO2X has been presented in twenty-eigth forums for companies and stakeholders from the environmental and innovation sectors. It is important to emphatize the presentation of LO2X project in EU LIFE Programme Announces Water Platform Event (Manchester, United Kingdom), 16th European Meeting on Supercritical Fluids (Lisbon, Portugal), Green Week 2014 (Brussels, Belgium) and 2017 Conference of the European Innovation Partnership on Water (Porto, Portugal).

Type	Event	Title	Date
Presentation	LIFE12 Regional Kick-off Meeting (Spanish projects). *Madrid*	Supercritical water co-oxidation (SCWcO) of urban sewage sludge and wastes LIFE+ LO2X	08/10/2013
Presentation	Jornada de Ofertas Tecnológicas en el Sector Energético y Medioambiental. Organised by: INNDEA Valencia, Ayuntamiento de Valencia, SEIMED y REDIT. *Valencia*	Oxidación supercrítica de lodos de EDAR y otros residuos. El royecto LIFE+ LO2X (Oral communication by Andrés Pascual)	14/11/2013
Presentation	LIFE Waste Platform meeting at Grenn Week. *Brussels (Belgium)*	LIFE+ LO2X: Supercritical water co-oxidation (SCWcO) of urban sewage sludge and wastes	02/06/2014
Presentation	Satellite event at Envifood Meeting Point. Organised by: FIAB, IFEMA. At the national fair “Foro de Soluciones Medioambientales Sostenibles”. *Madrid*	Oxidación supercrítica de lodos de EDAR y otros residuos. El proyecto LIFE+ LO2X (Oral communication by Elvira Casas)	12/06/2014
Presentation	Food for Life Platform Spain. Meeting of the Working Group on Sustainability. *Madrid*	Supercritical water co-oxidation (SCWcO) of urban sewage sludge and wastes LIFE+ LO2X	14/11/2014
Presentation*	Bio-Based Industries	Ainia. Life Cycle Assessment Experience. (Poster communication)	03/02/2015
Presentation	Plataforma FOOD FOR LIFE. Grupo de Trabajo “Calidad, Producción y Sostenibilidad” *Madrid*	Life Project LO2X: Supercritical water co-oxidation (SCWCO) of urban sewage sludge and wastes. (Oral communication by Andrés Pascual)	24/03/2015
Presentation	Taller sobre gestión de subproductos	Gestión de subproductos	12/05/2015

	en la industria alimentaria - MAGRAMA/FIAB *Madrid*	(Oral communication by Andrés Pascual). http://blog.fiab.es/index.php/fiab-y-el-magrama-apuestan-por-la-eficiencia-en-la-gestion-de-subproductos-dentro-de-la-industria-alimentaria/	
Presentation	Reunión Semestral de Young Water Professionals. Online presentation from AINIA.	Supercritical water co-oxidation (SCWcO) of urban sewage sludge and wastes (Oral communicatio by Javier Claros)	09/02/2016
Presentation	EU LIFE Programme Announces Water Platform Event in UK WATER WORKS – overcoming challenges to achieving good water status in urban areas. *Manchester (United Kingdom)*	Supercritical water co-oxidation (SCWcO) of urban sewage sludge and wastes (Poster communication by Elvira Casas)	24/05/2016
Presentation**	Asamblea General Ainia *Valencia*	Life Project LO2X: Supercritical water co-oxidation (SCWCO) of urban sewage sludge and wastes. (Oral communication by Andrés Pascual)	23/06/2015
Presentation*	Infoday Regional Programa Life. *Valencia*	LO2X: Co-oxidación en agua supercrítica (SCWcO) de lodos y residuos de depuradora. (Oral communication by Javier Claros)	14/07/2015
Presentation**	Climate KIC “The Journey”. *Valencia* *Valencia*	LO2X: Co-oxidación en agua supercrítica (SCWcO) de lodos y residuos de depuradora. (Oral communication by Javier Claros)	28/07/2015
Presentation	LIFE Infoday - Networking Event. IVACE. *Valencia*	Supercritical water co-oxidation (SCWcO) of urban sewage sludge and wastes (Oral communication by Javier Claros)	14/07/2016
Presentation	Climate KIC “The Journey” Ainia centro tecnológico visit. *Valencia*	Supercritical water co-oxidation (SCWcO) of urban sewage sludge and wastes wastes (Oral communication by Javier Claros)	21/07/2016
Presentation*	Jornada técnica EPSAR: Nuevas tecnologías aplicadas al sector de la depuración de aguas residuales. *Valencia*	Co-oxidación en agua supercrítica (COASC) de lodos de depuradora y residuos (Oral communication by Raúl di Silvestre)	03/11/2016
Presentation*	Tecnologías Innovadoras para el Tratamiento de Aguas Residuales, Lodos de Depuradora y Residuos. *Madrid*	Retos tecnológicos de la oxidación hidrotérmica de lodos. (Oral communication by Jose M. Abelleira-Pereira)	03/11/2016
Presntation	Seminario Técnico: Innovación y Soluciones Circulares para un Uso más Sostenible del Agua en Industrias Agroalimentarias. *Valencia*	Experiencia y beneficios potenciales de la tecnología oxidación supercrítica en EDAR del Pol. Fuente del Jarro Paterna (Valencia) (Oral communication by Francisco Heredia)	08/11/2016
Presentation	Seminario Técnico: Innovación y Soluciones Circulares para un Uso más Sostenible del Agua en Industrias Agroalimentarias. *Valencia*	Co-oxidación Supercrítica de Lodos Contaminados no Aptos para Uso Agrícola (Oral communication by Jose M. Abelleira-Pereira)	08/11/2016
Presentation*	SMAGUA – 23 Salón internacional del agua y del riego. *Zaragoza*	Proyecto LIFE Lo2x: Co-oxidación en agua supercrítica (COASC) de lodos de depuradora y Residuos (Oral communication by Cristina García-Vera)	07/03/2017
Presentation	Jornada de Innovación Biorrefinerías: transformando biomasa en bioenergía y bioproductos *Madrid*	Proyecto LIFE Lo2x: Co-oxidación en agua supercrítica (COASC) de lodos de depuradora y Residuos (Oral communication by Cristina Álvarez)	28/03/2017
Presentation	Building LIFE capacities in Lithuania Environmental Projects Management Agency. *Valencia*	Supercritical water co-oxidation (SCWCO) of urban sewage sludge and wastes (Oral communication by Jose B. Carbajo)	30/03/2017
Presentation*	16th European Meeting on Supercritical Fluids (EMSF) Organiser: International Society for Advancement of Supercritical Fluids (ISASF). *Lisboa (Portugal)*	Supercritical water co-oxidation (SCWCO) of urban sewage sludge and wastes (Oral communication by Elvira Casas)	26/04/2017
Presentation*	Programa LIFE 2017. Infoday Regional. *Valencia*	Proyecto LIFE Lo2x: Co-oxidación en agua supercrítica (COASC) de lodos de depuradora y Residuos (Oral communication by Jose B. Carbajo)	30/05/2017

Presentation*	2017 Conference of the European Innovation Partnership on Water. *Porto (Portugal)*	LIFE LO2X: Supercritical water co-oxidation (SCWCO) of urban sewage sludge and wastes (Oral communication by Andrés Pascual)	26/09/2017
Presentation	Jornada Técnica: Eliminación de nitrógeno y fósforo en aguas residuals. *Cordoba*	LIFE12ENV/ES/000477 LIFE LO2X (Oral communication by Cristina García-Vera)	28/06/2017
Presentation	Technical Workshop on Advance Solutions for Sustainable Management in Water Treatment. Organized by Carburos Metálicos. *Barcelona*	Co-oxidación supercrítica de lodos de depuradora y residuos. LIFE LO2X (Oral communication by Cristina García-Vera)	21/11/2017
Presentation	VII Jornada sobre gestión y tratamiento de lodos de EDAR *Barcelona*	Proyecto LIFE LO2X: Co-oxidación en agua supercrítica de lodos de depuradora y residuos. (Oral communication by Jose B. Carbajo)	22/11/2017

Poster presented in Event “Biobased Industries” on 03/02/15

Oral communication presented in along relevant events:

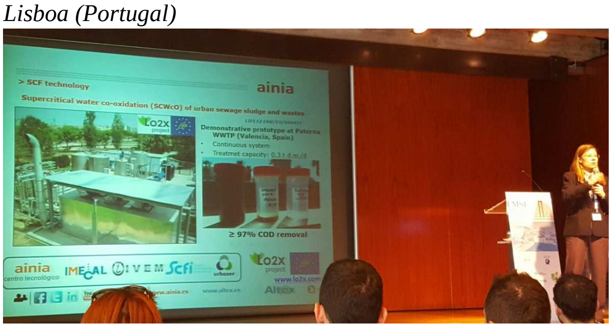
Tecnologías Innovadoras para el Tratamiento de Aguas Residuales, Lodos de Depuradora y Residuos. *Madrid*

Jornada técnica EPSAR: Nuevas tecnologías aplicadas al sector de la depuración de aguas residuales. *Valencia*

SMAGUA – 23 Salón internacional del agua y del riego. *Zaragoza*

Infoday. Reginal Programa LIFE. *Valencia*

16th European Meeting on Supercritical Fluids (EMSF). *Lisboa (Portugal)*



Conference of the European Innovation Partnership on Water. *Porto (Portugal)*

Some pictures of the events and related networking action can be found here: https://www.flickr.com/photos/lo2x/albums/72157677522694182

Action D10: Presentation to the relevant authorities

The project results, environmental impact and the benefits for the stakeholders have to be presented to the relevant authorities in order to further disseminate the project.

In this field, the project was presented to the regional public entity for wastewater sanitation public sanitation **Entitat Pública de Sanejament d’Aigües Residuals (EPSAR)** of the Valencian Region, which helps in the initiative by lending one of its facilities and infrastructure to hold the pilot plant (WWTP of Paterna). This entity is responsible of the construction and management of wastewater treatment plants in the Valencian Region. Thus, its support ease the implantation of the demonstrative plant as well as dissemination of results and future implantation of industrial facilities.

Also, bilateral meetings with the relevant Environmental Spanish authorities (Ministry, Regional government, Water platform), are foreseen to be undertaken in the sencond semester of 2016, specially with: MAGRAMA (in relation with SANDACH regulation), Ministerio de Sanidad, Servicios Sociales e Igualdad; and Conselleria de Industria C.V.

So far, the project has been presented to:

- Margarita Ruiz, Deputy Assistant Director-General for Residues (MAGRAMA).
- Leonor Algarra, General Sub-directorate for Livestock production (MAGRAMA).
- EPSAR (Water Regional Entity of Valencia/plant owner).
- ACA (Water Regional Entity of Cataluña/plant owner).
- ESAMUR (Water Regional Entity of Murcia/plant owner).
- EMACSA (Water Regional Entity of Cordoba/plant owner).
- AGUAS de NAVARRA (Water Regonal Entity of Navarra/plant owner).
- Enrique López, Head of Servicio General de Residuos (Dirección General de Calidad Ambiental) from Conselleria de Infraestructuras, Territorio y Medio Ambiente.

Some pictures of the presentation to authorities can be found here:

https://www.flickr.com/photos/lo2x/albums/72157678060100650

Action D11: Presentation to stakeholders

The project has been presented to more than 20 stakeholders of relevant interest in order to promot technologies that solve environmental challenges such LO2X.

Stakeholder	Group	Date
European Sustainable Phosphorus Platform - ESPP	Platform	11/07/2017
DAM	Water treatment RTD	20/06/2017
PTEA	Platform	20/06/2017
Edafo	Waste manager	20/06/2017
FACSA	Water treatment RTD	20/06/2017
Ingelia	Industry	20/06/2017
SAV – Agricultura de la Vega de Valencia	Waste manager	20/06/2017
Egevasa - Global Ominum	Water treatment RTD	20/06/2017
Estonian and Lithuanian LIFE capacity building projects‘ delegations	Public authorities	29/03/2017
University Polytechnic of Valencia (UPV)	Academic and R&D center	09/03/2017
BVALVUE	Industry	30/01/2017
ARCAMO Controls, S.A.	Industry	18/01/2017
Scottish Water	Water treatment RTD	10/02/2017
Carburos Metálicos	Industry	06/02/2017
Pangea, S.L.	Industry	07/02/2017

Hydro-Water	Industry	20/01/2017
University of Cadiz (UCA)	Academic and R&D center	22/12/2016
University of Valencia (UV)	Academic and R&D center	03/11/2016
GEMWATER	Water treatment RTD	12/10/2016
University of Santiago de Compostela (USC)	Academic and R&D center	07/07/2016
Ministry of Agriculture of Hungary	Public authorities	10/05/2016
Food for Life	Platform	12/05/2015
FIAB	Platform	21/03/2015
Bio-based industry	Platform	03/02/2015

The presentations have been performed in the different kind of events and, specially, in the prototype plant. More than 30 visits have been welcomed to the Paterna's WWTP by LO2X staff. As soon as visitors are introduced, they register their visit by introducing the following information in the provided LO2X facility´s login folder: name of the visitor, ID, name of the company, date & time, brief reason of the visit. Visitors attend to a brief safety explanation and are supplied with the following PPE´s: helmet with face shield or lab safety glasses, gloves and ear protectors. Then, visitors attend to the explanation on the process flow diagram of the whole WWTP where the Lo2x facility is located; a WWTP´s mock-up located in the control room is used to aid this part of the visit. Afterwards, visitors and staff walk in the LO2X facility where firstly an overall introduction is given on LIFE Projects, and in particular on the LO2X Project and the Partners involved. The LO2X´s process flow diagram is also introduced at that moment of the visit, before visitors enjoy of a walk around the real system. The type of specific visit has a flexible nature, since we are able to offer, either visits with the system off (for instance, in the case of stakeholders visiting to discuss about certain components of the system) or demonstration visits (most of the cases) with the system operating on water, methanol (model compound), sewage sludge and/or co-wastes. Visitors are also introduced on the basics of the LO2X´s control room: power and control cabinets, as well as the control SCADA used to operate the system. In the case of demonstration visits with waste feedstock, the attendees have the opportunity of checking how the influent and effluent streams look like by in-situ sampling.

Some pictures of the presentation to stakeholder can be found at the LIFE LO2X webpage: https://www.flickr.com/photos/lo2x/albums/72157678060100650

To ensure an acqurate regiter of the visits of stakeholders and authorities to the plant, a Visitor’s Register was set on place. Also, a set of security rules was stablished in a Visitor’s Rules document that was handed to the visits before entering the prototype site.

Visitor’s Register (template)

Lo2x project

REGISTRO DE VISITAS
VISITOR'S REGISTER

Document Nº1 Documento Nº1

Organisation name /Nombre de la organización

Date of visit / Fecha de la visita

Entrance hour Hora entrada	Exit hour Hora salida

Visitors / Visitantes

(Visitor Name)	(Identity Number)

Reason for the visit
Motivo visita

Action E3: Networking Activities

The consortium performed serveral networking activies with other LIFE+ projects both ongoing and completed. First, the consortium identify several projects in the field of wastewater and waste treatment sectors that have synergies with LIFE Lo2x. The networking activities were included in the project schedule and included visits, meeting and exchange of information and even participation in open meeting. Exchange of information by face to face meeting were hold during the life time of the projects. In fact, these networking activies of LO2X ensured and efficient transfer of their own generated know-how and experience.

Project	Coordinator	Synergy
LIFE STO3RE: Synergic TPAD and O3 process in WWTPs for Resource Efficient waste management.	FACSA (Spain)	Sewage sludge and organic waste (*i.e.* slurry) treatment
LIFE ANADRY: Dry anaerobic digestion as an alternative management & treatment solution for sewage sludge.	DAM (Spain)	Sewage sludge treatment
LIFE iCirBUS-4Industries: Innovative Circular Businesses on Energy, Water, Fertilizer & Construction Industries towards a Greener Regional	CTAEX (Spain)	Sewage sludge treatment

Economy.		
LIFE ECODIGESTION: Automatic control system to add organic waste in anaerobic digesters of WWTP to maximize the biogas as renewable energy.	AGUAS DE VALENCIA (Spain)	Sewage sludge treatment
LIFE SOSTRICE - CO2 Emission Reduction of the Rice Cultivation Through Energy Valorisation of the Rice Straw	IAT (Spain)	Waste treatment
LIFE-EMPORE - Development of an efficient and sustainable methodology for EMerging POllutants REmoval in WWTPs	LTL (Spain)	Wastewater treatment
NEWAPP (FP7): Application of Hydrothermal Carboniza tion Technology to Biomass Waste Streams.	INGELIA (Spain)	Waste treatment
LIFE PHORWATER: Integral Management Model for Phosphorus recovery and reuse from Urban Wastewater	DAM (Spain)	Nutrient valorisation
LIFE LEMNA: Duckweed technology for improving nutrient management and resource efficiency in pig production systems.	AINIA (Spain)	Nutrient valorisation
LIFE SAVING-E: Two-stage autotropic N-removal for mainstream sewage treatment.	UAB (Spain)	Wastewater treatment
RecoPhos–Recovery of Phosphorus: Recovery of Phosphorus from Sewage Sludge and Sewage Sludge Ashes with the thermo-reductive RecoPhos Process.	M. Leoben (Austria)	Nutrient valorization
P-REX (FP7): Sustainable sewage sludge management fostering phosphorus recovery and energy efficiency.	KWB (Germany)	Nutrient valorisation

LIFE LEMNA

LIFE ECODIGESTION

LIFE ANADRY

LIFE STO3RE

The consortium has been actively involved in differnte events that were a networking and meeting space among ongoing LIFE Project.

- Spanish LIFE+ Projects 2012 celebrated in Madrid on 8/11/2013 and already mentioned, provided the chance to meet colleagues involved in other LIFE projects leaded by other Spanish entities.

- The LO2X project was also disseminated during the Green Week 2014 held in Brussels from the 2-5/06/2014. Andrés Pascual participated in the Waste Seminar were LIFE+ projects related with waste were shown and an intense networking was on during those days.

- LIFE LO2X was presented to a Climate KIC group on 28/06/2015 and 21/06/2016. Both the meetings were held in AINIA. In the last meeting, 43 Technicians from different more than 15 different Universities of EU and Canada assisted where different projects were discussed.

- Coinciding with the celebration of the 25th anniversary of the LIFE Programme, on 30/05/2017 took place the Regional Infoday of LIFE Programme Call 2017, organized by REDIT and Chamber of Valencia. At the event, the new call was presented as well as the main results and experiences of 22 LIFE Projects coordinated by Valencian entities.

- European Sostainble Phosphorus Platform (ESPP) considered LIFE LO2X as relevant R&D project to nutrient recycling and nutrient management. It will include EU H2020 (FP), LIFE, INTERREG and national funded R&D projects on nutrient recycling and management, for networling of companies, public bodies and other.

A report of networking activities is included in Deliverable D.D.13.

1. Moreover, it has been possible to know about other projects funded by other programmes apart from LIFE along other events. This has been the case through the participation in the 10th International Conference on Renewable Resources and Biorrefineries that took par from 4th to 6th June 2014 in Valladolid (Spain). Along the sessions, several interesting initiatives were addressed. As some examples, contents involving the P-Rex project, funded by FP7 program (**www.p-rex.eu**), were presented. This project deals with technologies aiming for the recovery and recycling of phosphorous, which is much related with one of the objectives of Lo2x project. Also with regard to phosphorous Christian Kabbe presented a talk that addressed different points, including the European Sustainable Phosphorous Platform (ESPP **www.phosphorusplatform.eu**).

2. Another research initiative with some points in common with LO2X project but from other point of view since involved WWTP treatments was addressed in the same event. One of the oral talk was related to some research aiming for a new pre-treatment using green chemicals to promote energetic autonomy of the primary treatment by digestion of sludges and for energy recovery. This initiative was addressed by Veolia and the speaker was contacted afterwards during the conference. This was also the case for other speakers and conference participants, giving place to networking regarding supercritical technologies, waste processing and upgrading, biorefinery, etc.

3. An internal meeting in Brussels in the framework of BBI (03/02/15). Mr. Andrés Pascual commented some results related with LCA of LO2X technology.

4. Several meetings were done with providers in ACHEMA - World Exhibition Congress on Chemical Engineering, Environmental Protection and Biotechnology (**http://www.achema.de/en/home.html**). One of the meetings was with Sr. Jenn Vogl of Feluwa Company who was interested in the prototype developed and its components (pumps).

5. The LO2X project was also presented in the framework of AINIA annual meeting. The assistants of the meeting are belongs to companies and associations from food industry interested in technologies available for valorisation of wastes **(www.ainia.es).**

5.3 Evaluation of Project Implementation

Methodology assessment

Each action required specific methods to carry out the activities and to get the results in accordance to the objectives.

Internal organisation foreseen at the beginning of the project was adapted as the consortium had to be modified because of ISOLUX leaving. Distribution of activities and methodologies were adapted in order to keep the same objectives with the same budget but taking into account the profile of the new partner URBASER and the moment of approval of its participation.

B1 Detail engineering project

This task was carried out combining different procedures. Basis for developing the main technical information was discussed with participation of the major part of partners and later on, shared by email once developed by the partner in charge (back-office). This procedure was proved as efficient to go ahead with a most of the task to minimise delays in the project progress. Nevertheless, because of the kind of activities and the need of solving difficulties, adaptations were taking place for some issues and it was necessary to coordinator reinforced updates through the partners. The importance of the issues to be discussed increased from the originally foreseen as a consequence of the decision of developing a demonstrative prototype with larger size.

This was especially relevant in case of URBASER, as the project was already under development when it got involved and there was a lot of detailed information produced to be understood before being in position of providing feedback and participating in an active manner. Thus, it was agreed to devote specific internal working sessions with the support of the coordinator to ease the understanding of the information already developed and to be able to make adaptation period as short as possible.

B2 Building up activities

Building up activities were carried out combining different methodologies leading with the diverse classes of works:

- emails, phone contacts, and/or face-to-face meetings among partners to clarify specifications, agree decisions, etc.
- emails, phone contacts, and/or face-to-face meetings to clarify doubts to address offers, to follow up the offers and the delivery of items from providers, etc.
- procedures for different physical tasks: holding area adaptation; positioning of main units; positioning of valves, accessories, instruments, etc.; mechanical assembly, electrical assembly, etc.

The scope of this task became more complex not because for methodological reasons but because of the impact and importance associated to a demonstrative facility with larger dimensions. This way, aspects such as weight, size and dimensions, energy demands, etc became important, as resources needed for building up activities changed and coordination among steps became more important.

Physical activities regarding assembly tests according the assembly plan, that was organised taking into account factors such as:

- physical requirements for a task regarding other elements or previous tasks.
- availability of elements (delivery times).
- allowance for access and movements for an element that may block other ones.

A pull of the mentioned methodologies showed to be needed in order to handle arising points in an efficient manner. For instances, depending on the case, written instructions or messages showed to be more effective to avoid misunderstanding whereas in other cases phone calls were the most useful manner to solve difficulties promptly. In some occasions the most clarifying way was to arrange an in situ meeting to see issues physically and together in a cost-effective manner although this method was proved to be so useful in combination with the others.

B3 Start up of the prototype

Start up activities were carried out combining different methodologies leading with the diverse classes of works:

- emails, phone contacts, and/or face-to-face meetings among partners to clarify actions, agree decisions, discuss open points, etc.
- back-office work to produce information, documents, etc.
- procedures for on site tasks: inert non-feed tests.

Physical activities regarding inert non-feed tests were carried out studying specifically the piping circuit to be active in each test and the actions to be taken by hand or from the automaton, as these tests differed from the operation test considered in B4 Action.

An iterative approach was applied to revise the results produced in a certain test because of its impact on the prototype itself, the actions to be taken and the methodologies to be follow for so and vice versa.

Periodical revisions of resources involved in start-up activities were carried out, since larger scale of the prototype required a different organization and more administrative requirements to be fulfilled up to have all applications for the authorities ready and managed.

B4 Operation of the prototype and assessment of the cooxidation process

Operation activities were started out regarding the preparation of the design of experiments (DOE) combining different methodologies already mentioned (emails, phone contacts, and/or face-to-face meetings among partners to discuss open points, to assess proposals, to agree decisions, etc.

An iterative approach was applied to revise the hypothesis standing the operating scenario with a potential impact on the DOE, the economic and human resources derived from a DOE proposal and new adjustments to fit both technical aims and economic constraints and so on.

As addressed in previous tasks, experimental activities in the developed Lo2x prototype involved more resources than the initially estimated for a test due to the larger size of the prototype, as more human resources were needed at any moment to carry out the test and more feed and auxiliary services were used. Thus, estimated experimental program and allocated resources were periodically revised.

Results achieved

The results expected for each action were analysed by comparison with the results achieved within the reporting period.

	Task	Foreseen in the revised proposal	Achieved	Evaluation
A1 Preparartory actions	A.1.1 Selection of potential cosubstrates	List of potential substances considered to be oxidized and data sheet of selected cosubstrates	Fully (100%)	Complete without troubles
	A.1.3. Basic engineering project	Global concept design of the plant	Fully (100%)	FEED (Front End Engineering Design) revision and basic engineering project. Basis of the demonstrative plant design and the preliminary scheduling for the construction of the prototype

B1 Detail engineering project	B.1.2 Process Description and PFD	PFD and P&ID	Fully (100%)	Completed PFD without troubles Identified as crucial for training and dissemination
	B.1.4 List of equipments and detailed equipment. Specification Datasheets	Geometric design and specifications of all the main units and elements that comprise the plant including: reactor, heat exchanger, pumps, homogenizator, separation chamber, and oxygen supplying system.	Fully (100%)	List of main equipments and datasheets completed excepting gases supply system, not to be considered at this stage for future similar initiatives
	B.1.5 Process control description: P&ID and Piping Instrumentation List	PFD and P&ID.	Fully (100%)	Completed taking into account small changes due to adaptation and assessment along B2 and B3 actions. First versions to be considered within the Initial Detail Engineering project and further updates of considered at the end of the B2+B3 Actions before certifications
	B.1.5 Process control description: P&ID and Piping Instrumentation List	Design and location of the piping elements that will comprise the prototype: valves, pipes, fitting pieces, racords, sealing elements.	Fully (100%)	Completed taking into account small changes due to adaptation and assessment along B2 and B3 actions. First versions to be considered within the Initial Detail Engineering project and further updates of considered at the end of the B2+B3 Actions before certifications
	B.1.5 Process control description: P&ID and Piping Instrumentation List	Design and specifications of the instrument and control elements that will comprise the prototype and will be required for control an monitoring of the process.	Fully (100%)	Completed taking into account small changes due to adaptation and assessment along B2 and B3 actions. First versions to be considered within the Initial Detail Engineering project and further updates of considered at the end of the B2+B3 Actions before certifications
	B.1.6 Layout (2D/3D): Holding area and Skid specifications	Layout	Fully (100%)	completed including gases supply system
B2 Building up activities	**B2 Building up activities**	**Demonstrative prototype constructed**	Fully (100%)	Completed including elements with long delivery times and changes due to B2 and B3 actions affected by weather impact among other factors
	B2.2 Main SC units (reactor and heat exchangers) and process chambers construction	Main units designed and built up (reactor, heat exchanger, pressure vessels, etc)	Fully (100%)	Completed, affected by the delivery times of special materials
	B.2.3 Piping, pumps, vessels and instrumentation	Special elements required selected, acquired and fitted	Fully (100%)	Completed including elements with long delivery times and changes due to B2 and B3 actions results
	B.2.5 Definition of control loops and sequences	Control loops and alarms defined	Fully (100%)	Completed including adaptations and/or changes due to B2 and/or B3 actions results
	B.2.6 Automation programme and implementation	Control software implemented and tested	Fully (100%)	Completed including adaptations and/or changes due to B2 and/or B3 actions results
	B.2.7 Mechanical assembly	Main units physically assembled	Fully (100%)	Completed including elements with long delivery times and changes due to B2 and B3 actions results Specific training and supervision applied to personnel to deal with high pressure materials
	B.2.8 Electric Assembly and heat isolation	Elements electrically wired (wiring checked) and heat isolated.	Fully (100%)	Electrical wiring completed excepting elements with long delivery times and changes due to B2 and B3 actions results Insulation materials installed in the last part of the task

	Task	Foreseen in the revised proposal	Achieved	Evaluation
B3 Start up of the prototype	B.3.1.Detailed definition of plant operation and emergency protocols	Operating protocols, alarms and emergency protocols defined.	Fully (100%)	Basis established successfully to develop the automation software Completed with adaptations and/or changes due to B2 and/or B3 actions results
	B.3.2. Definition of preventive and maintenance guidelines	General preventive and maintenance guidelines for the demonstrative plant.	Fully (100%)	Completed trying to compile and organise information in an easy manner and taking into account adaptations and/or changes due to B2 and/or B3 actions results
	B3.3. Plant operation and maintenance handbook	Plant operation and Maintenance Handbook.	Fully (100%)	Developed in accordance with revisions taking into account adaptations and/or changes due to B2 and/or B3 actions results
	B.3.4. Inert start up of the pilot plant:preliminary non-feed tests	Demonstrative plant tested without sludge feed	Fully (100%)	Performance issues detected and solved to achieve the required conditions needed for reaction tests with sludge feed.
	B.3.5. Certification of demonstrative plant	Project for the certification. Plant certified	Fully (100%)	Individual projects for mechanical, Electrical, fire protection, gas storage and pneumatic installations developed
B4 Operation of the prototype and assessment of the cooxidation process	B.4.1 Experimental plan: design of experiments (DOE)	Experimental design to assess the SCWO process.	Fully (100%)	DOE balanced to invest in an efficient manner both economical and time availability coping with rescheduling needs
	B.4.2. Starting-up of operations with feed	Demonstrative plant started-up with feed	Fully (100%)	Plant successfully started-up with sludges and cosubstrates
	B.4.3. Assessment of key SCWO operational variables	Identification of the compositions that may be treated with SCWO and influence of main process variables on the obtained results	Fully (100%)	Experiments carried out with different conditions and compositions
	B.4.4. Steady Performance Monitoring and sensitivity analysis	Identification of the sensitivity and stability of the main process variables.	Fully (100%)	Experimental evaluation of system performance and resuls
	B.4.5. Corrosion assessment and reengineering	Corrosion assessment of the critical units and elements	Fully (100%)	Evaluations carried out and characterisations performed
	B.4.6. Mass and energy balances: yield and effciencies	Energy and mass balances for different feed compositions treated in the demonstrative plant Yield of phosphorus recovery and process conditions that led to best results	Fully (100%)	Data treatment and evaluation oerformed to define result scope and efficiency of treatments
C1 Monitoring of the impact of the project	C.1.1 Identification of specific indicators, monitoring and environmental improvements assessment	Identification and evaluation of specific indicators	Fully (100%)	List of environmental indicators identified and evaluation of each indicator performed.
	C.1.2 Assessment of the socioeconomic impact of the project.	Identification and evaluation of specific indicators	Fully (100%)	List of socio-economics indicators identified. and. evaluation of each indicator performed

Task	Foreseen in the revised proposal	Achieved	Evaluation
D1 Communication and Dissemination action plan	Update of the Dissemination and Communication Action Plan. Design of projet logo and corporate image.	Fully (100%)	DCAP has been updated several times and is allowing a effective dissemination of the project.
D2 Project website	Creation of project website. Contributions and updates from all partners. Creation of worplace in the website	Fully (100%)	Website updated peridically. 3.972 visits to the website. Workplace in use
D3 Project Materials	Design and of Project Leaflet (General). Design and of Project Leaflet (Technical). Design of poster	Fully (100%)	Technical Leaflet and poster are scheduled in 2016

D4 Notice Boards	Design and installation of 2 Notice Boards	Fully (100%)	Notice boards developed and installed
D5 Layman's report	Preparation of a Layman's Report	Fully (100%)	Document developed
D6 Film: virtual tour of the prototype	Elaboration of a Film (cirtual tour of the prototype)	Fully (100%)	Video developed and available
D7 Technical articles	Publication of 3 technical articles	Fully (100%)	Technical articles developed
D8 Press releases	Publication of 3 press releases	Fully (100%)	First press release published with more than 30 different impacts. Second and third press released in 2017 with numerous impacts
D9 Events	Organization of one major event	Fully (100%)	Major Lo2X event scheduled and developed in June 2017
D10 Presentation to the relevant authorities	Presentation to authorities	Fully (100%)	Project presented to relevant authoritie
D11 Presentation to stakeholders	Presentation to stakeholders	Fully (100%)	Project presented to relevant stakeholders
E1 General Management	General management. Elaboration of Management guidelines. Update of workplace in website. Call and coordination of meetings. Administration of funds. Project audits.	Fully (100%)	All General Management tasks have been developed as scheduled. No main problems have arosen. One Amendment to the Grant Agreement has been requested and accepted.
E2 Project management and monitoring the project progress	Elaboration of reporting guidelines. Monitoring of the project. Technical and Financial Reporting.	Fully (100%)	All General Management tasks have been developed as scheduled. No main problems have arosen.
E3 Networking activities	Networking activities with other Life+ projects.	Fully (100%)	Flowing communication with several projects maintained and meetings produced.

Results visibility

The results of a part of the actions carried out may be considered as visible, since the progress in the building up activities led to progressive changes on site, with more and more elements received, installed, etc.(the picture in Figure 16 shows a moment of this visible works) and also other regarding the prototype being used in the start-up (B3) and under operation (B4).

Also other results regarding other type of actions such as dissemination are also visible.

The visibility of the results has been extended from the initial one due to the increase in the size of the demonstrative plant. An smaller installation would have need not only less space but also less auxiliary services and thus, less site lay out adapttions, less administrative steps, less amounts of feed to be treated and managed, etc. This way, current LO2X demonstrative facility has involved more collaborators and suppliers, so that the visibitility of the project and its results has augmented. Also, as the demonstrative character of the plant has been reinforced to achieve sounder results, a real interest of the stakeholders has been detected in the interactions, meetings and visits.

This way, the visibility of the results is expected to continue active beyond the end of the LIFE Lo2X project itself. The consortium commitment to come to agreements for future steps and the interest about the initiative from several stakeholders points out this framework for the near future.

Amendment impact on results achieved

The new configuration of the Consortium approved by the Commission in first amendment was proved not only as necessary as one partner left the project but also as effective, since the contribution of the new partner URBASER satisfied the expectations and made interesting contributions to the progress of the project. In case the new Consortium structure would not have been agreed, the feasibility of the project would have been compromised and thus, the results obtained up to the date would not have been produced.

On the other hand, second amendment asking for an extension of 6 months has been crucial to approach experimental activities coping with circumstances associated to project development maintaining overall project scope, targets and budget. In case of not having this possibility, the scope and goals of the project would have been affected.

Effectiveness of the dissemination and major drawbacks

Dissemination actions made possible to receive contacts from diverse profiles: collaborators in other project, researchers, etc. No drawbacks were detected up to the date. Dissemination actions were revised, redesigned and rescheduled as well as a consequence of the development of the project and the requirement of fitting the technical actions to get the final goals.

5.4 Analysis of long-term benefits

1. Environmental benefits:

a) Direct/ quantitative environmental benefits:

The LIFE LO2X project deals on the demonstration of environmental and socio-economical benefits of the application the supercritical water oxidation technology as a synergic co-treatment of sewage sludge and wastes. The main issue tackled in this project is water quality through the links between wastewater treatment, sewage sludge management and pollution derived from sludge application (organics, nitrates and phosphorous) and the water energy-nexus. **The LIFE LO2X concept is addressed to converter WWTPs into resource factories.**

The project has involved the design, construction and operation of a prototype at demonstration scale. The prototype is prepared to treat up to 1 Tn dm/day of sewage sludge in combination with other wastes (co-oxidation) collected from the surrounding area of the Paterna WWTP (Valencia, Spain). Data to be collected from the experimental trials at this demonstrative scale are representative and useful to evaluate the industrial scaling of this technology.

The LIFE LO2X has aimed to reach a reduction in sludge management costs (investment plus operational cost per dry matter treated) in comparison with current scenario of treatment. Besides, conventional treatments for toxic and dangerous wastes are neither well established nor well controlled in current WWTPs, and the environmental pollution is transferred to soil, air or groundwater prior to be completely removed. The LIFE LO2X allows total oxidation of organic wastes such as pesticides and leachates other aqueous and liquors organic wastes.

The main benefits of LIFE LO2X are related with resource efficiency (P recovery), energy efficiency (positive energy balance), pollution reduction (N and organic substances), and waste and sludge reduction (disposal, treatment).

The following results were achieved during the experimental campaign of the LIFE Lo2x project:

- *99% elimination of orgnic matter*. The COD of SCWcO effluent is in average lower than 200 mgO2/L, reaching values even lower than 25 mgO_2/L.
- *100% elimination of pesticides.* Imazalil is degraded through SCWcO up to 350 mg/kg, four orders of magnitude higher than the concentration removed by anaerobic digestion.
- *100% elimination of pathogens. Escherichia coli*, *Clostridum perfringens* and *Salmonella spp.* are completely eliminated. SCWcO leads to complete sterilization.
- *>85% heavy metals are recaptured for safe handling.* Heavy metals are mainly detected in inorganic solid fraction of the SCWcO effluent.
- *Recovery of nutrients.* Mineralization of nitrogen and phosphorus facilitates the nutrient recovery in order to be used as building blocks of fertilizers. Nitrogen occurs in the liquid phase (NH_4~2 g/L) while phosphorus is present in the inorganic solid fraction of the SCWcO effluent (P_2O_5~25%).
- *No highly harmful gases are produced.* CO_2 is the main gas generated by SCWcO. Typical undesired gaseous products from the combustion processes as NOx and SOx are not produced.
- *98% reduction of sewage sludge leaving WWTP*. Total solid reduction higher than 90%. The inorganic solid fraction from SCWcO is a resource for phosphorous industry whereas wastes from anaerobic digestion may end up in the landfills.
- *Zero heat consumption.* The heat produced by the oxidation under supercritical conditions (highly exothermic reaction) makes pumping to be the only significant energy-consuming step (*i.e.*, 1 kWh/kg dm) through SCWcO.
- *>10% reduction in sludge treatment cost.* The gate fee thanks to co-substrate treatment by SCWcO allows reducing the cost of sludge treatment below the cost of anaerobic digestion.

b) Relevance for environmentally issues or policy areas:

Water quality remains an issue across Europe, with implications for public and environmental heath and biodiversity. Pollution (excess nutrients, pesticides, toxic substances, waste discharges, etc.) is still a **top priority** and a concern for all water users and the need to supply clean water in sufficient quantity for use at a reasonable cost remains a challenge EU wide. According to the **European Innovation Partnership (EIP) on water in 2020 Europe** must have safe, available and affordable water supply and wastewater treatment for all water in place, based on sustainable management of the water resources and most innovative, competitive and cost effective solutions.

On the other hand, **sludge management** has become one of the most critical issues for the wastewater industry worldwide, due to the very fast increase in sludge production resulting from increasing numbers of new wastewater treatment plants, more inhabitants connected to existing sewerage systems and upgrading of existing facilities to meet stricter discharge criteria. It must also be stressed how important it is for the competitiveness of Europe, that such problem can be solved with a permanent concern of all stakeholders (regulators included) to optimize solutions' cost-effectiveness. That does not mean lowering environmental or public health standards. It means proper risk identification and assessment, definition of best technologies and practices, and development of tools and technologies to keep costs as low as possible. The project's objectives fit the needs set in the baseline scenario resulting from the assessments on sewage sludge management carried out by the DG Environment of the European Commission in the process engaged for the revision of Directive 86/278/CEE, on application of sewage sludge in agriculture. The technology proposed might overcome some of the risks and uncertainties considered in such a survey due to the total oxidation nature of the process proposed.

LIFE LO2X is coherent with the **Roadmap to a Resource Efficient Europe** regarding the objective of **turning waste into a resource**. It is coherent with the priority "urban environment" as the project objectives are specially coherent with the priorities set by The European Water Technology Platform (WssTP) in the Strategic Research Agenda (2010) where "Sustainable water management inside and around large urban areas" is identified as a major European water problem. In relation to this issue among 5 key topics for the future of urban areas, topic 5 relates to "Sustainable Sludge management in Urban areas". It is also in line with "waste priority" regarding waste minimisation and the restrictions set by the Landfill Directive on sludge final disposal in the near future.

The main **European legislation in connection with the LIFE LO2X project** is:

- Directive 2000/60/EC, Water Framework Directive.
- Directive 86/278/CEE, application of sewage sludge in agriculture.
- Directive 91/271/EEC, concerning urban waste water treatment.
- Directive 91/676/CEE, water protection against nitrates pollution from agriculture.
- Directive 99/31/CE, landfill of waste.
- Directive 2006/12/CE, wastes.

2. Long-term benefits and sustainability:

It has been estimated the value that will be achieved in 10-year time horizont according to the data obtained along the LIFE LO2X project (Deliverable D.C.1.2) and two different future scenarios, which have been compared with the baseline.

- *BASELINE:* The technology to treat sewage sludge in the Paterna WWTP remains anaerobic digestion. The biological process will treat 20 Tn dm in 10 years.

- *AD+SCWcO MODULE:* Mixed sewage sludge generated in the Paterna WWTP will be treat by both technologies. Anaerobic digestion will treat 18 Tn dm of sewage sludge whereas a new SCWcO module will treat 2 Tn dm.

- *SCWcO PLANT:* A new plant of SCWcO will be built in the Paterna WWTP. This plant will be capatable to treat the enterity of sewage sluge generated by Paterna WWTP.

a) Long-term/ qualitative environmental benefits:

The project may be considered an adaptation measure for diffuse pollution source control as will reduce pollution of water bodies with nutrients causing eutrophication from sludge, raw/digested manure application in agriculture causing leaching of nitrates and phosphorous run off. It also contributes to reduce pollution from leachates and pesticides. The LIFE LO2X project considers the interlinked nature of water challenges, particularly, the water and energy nexus. The system proposed is energy producer unlike current sludge treatments.

A list of estimated long term benefits, that depend on the two scenarios, is shown as follows:

- Treatment of dangerous wastes such as drencher wastewater from 0.3 to 2.8 Hm^3.

- Reduction of nutrient: NH_4^+ from 18 to 193 Tn and P from 6 to 62 Tn.

- Reduction of COD from 409 to 4,472 Tn.

- Reduction of pesticides from 3 to 3 Tn.

- Reduction of pathogens from 226 to 282 ufc.

- Reduction of total solids from 35 to 378 Tn and subsequently, 226 to 282 lorries.

- Inertization of heavy metals from 213 to 2,342 Tn.

- Water recovery increased from 1.4 to 15 Hm^3.

- Low air emissions.

b) Long-term/ qualitative economic benefits:

At general level, the development of the technology proposed in LIFE+ LO2X with the participation of Valencian companies located in the area should help in promoting environmental services and technology with a broad market, so high qualified employment should be promoted in the near future.

More specifically, the SCWcO technology offers to the companies in charge of WWTP´s management, represented by IVEM in the LIFE+ Lo2x consortium, the following technical and economical advantages (figures estimated with a series of hypothesis from Lo2x results):

- Reduction of the economical costs of investment and operation for new and existing WWTP´s which have consider changing the current sludge management: from current WWTP to SCWcO-WWTP. Savings in running cost up to 625,000 € and in total cost up to 400,000 €, depending on the scenario.

- Treatment and valorisation in situ of a higher number of wastes: fat and oils from other WWTP units and from other wastes considered as substrate and co-substrate. Treatment of dangerous and toxic wastes (*e.g.*, drencher wastewater) from 0.3 to 2.8 Hm^3.

- Reduction of quantities of sludge to manage and their associated economical costs from 226 to 282 lorries.

- Nutrients recovery which could be put into the market as alternative to mineral fertilizers from 182 to close to 2,000 Tn of P feed stock.

- WWTP´s offers a treatment of complete mineralisation for hazardous pollutants.

c) Long-term/ qualitative social benefits:

The implementation actions of the project are in the city of Paterna (Metropolitan area of Valencia City, capital of the Valencian Region). The sludge generated in this plant will be the main input to the new system. Also, other wastes than sludge will be collected within the municipality of Paterna or from the surroundings (within the province of Valencia), linking economic growth and environmental technologies.

The economy of Paterna, in the last decades, has moved from being a town almost exclusively dedicated to agriculture into an important industrial and services center. This is the fate of most of the cities in the Metropolitan area of Valencia. Regarding the rest of the Valencian province intensive agriculture (mainly orange crops in the coastal areas) and food processing industry are still important. In this line, water stress in the region of Valencia is high. Water is a scarce resource but intensive agriculture and big agglomerations demands are high. Current socioeconomic scenario has lead to pollution of drinking water with nitrates and pesticides from intensive agriculture, food processing industries and high wastewater treatments plants to allow for tourism, (indeed population more than double during the summer season).

This technology should help in the way of such an objective in relation to public health and environmental problems of the Valencian Region.

Moreover, from 4 to 7 direct high qualificated employment may be generated depending on the scenario (additional indirect employpment may be derived).

d) Continuation of the project actions:

The demonstration character of the Lo2x project by itself is useful to promote the technology and to arouse interest in the continuation of the project actions related with technical aspects, in terms of more possible applications for wastes treatment and resource recovery. Indeed, the continuation of the technical project actions will be take into account the application of LO2X technology for other kinds of substrates, such as organic wastes from agri-food sectors not included in LIFE+ Lo2x, and hazardous materials from other chemical sectors such as

Pharmaceuticals and Personal Care Products (PCP). Moreover, specific research projects will be possible to address in order to obtain more in-deep details of yields, P recovery and energy balances, using wide variety of co-substrates and sludge from others WWTP´s of small, medium and large scale.

On the other hand, several actors, who are involved in the LIFE+ Lo2x project, will have an important role in the continuation of the project actions related with dissemination:

- Stakeholders:

As water is linked to so many sectors, a wide variety of stakeholders from many disciplines have been involved in the project: Public authorities, Water treatment RTDs, Platforms, Policy Makers, Industries, General public.

The involvement of **public authorities** such as **Valencian Public Entity for wastewater sanitation (EPSAR)** is essential to support the development and continuation of the project. The EPSAR is in charge of the regional sewers system management and they have direct responsibilities in providing the enabling environmental for innovation, set rules for procurements, and also they play an important role in the implementation of water policies. Implication of the EPSAR in the innovation process is key in order to boost the practical adoption of new processes and exchange information with policy makers.

- Consortium:

The LIFE+ Lo2x project is performed through a cross border collaborative project (Spanish and Irish). AINIA technological centre with twenty years of experience in supercritical fluid and environmental technologies, IMECAL specialist in equipment construction, URBASER (waste manager and sanitation engineering), IVEM responsible of the WWTP that will hold the prototype and SCFI Irish specialist in supercritical oxidation.

Finally, the dissemination activities: many activities as workshops, publications and press communications have been scheduled considering different target audiences bringing together a wide range of stakeholders on the EU and international levels. Also, these dissemination activities will be done along project. Also, the website www.lo2x.com is available as tool or way to consult information related with the evolution and results of the project.

3. Replicability, demonstration, transferability, cooperation:

The technology can later be easily replicated to other countries in Europe where the environmental problem tackled is common. As mentioned before, EU policies are oriented to abatement pollution in the best possible way: turning wastes into resources.

One of the most important strength of the project is their application and demonstration in the medium size Paterna WWTP. The size and technology of the reference is representative of an average recent installation so that results may be easily replicable in any location in Europe. This new SCWO sludge treatment may be applied to a large number of similar municipal waste treatment facilities, first of all in the regional area but rapidly all over Spain and other European regions. In addition to treatment of sludge from municipal sewage treatment, new developed technology plant might be further applied to other highly pollutant residues such as industrial sludge, high-oil-loaded sludge, cutting oils, etc. These options may make already potent market for this kind of plants even wider.

4. Best Practice lessons:

Running the SCWO pilot plant in a real context allows adjusting and contextualizing all the implementation phase to medium size Paterna WWTP. Also, this practice will allow obtaining economic and environmental performance indicators of the proposed system in parallel with such indicators regarding the current management rout (current at plant+external management) so that not only the feasibility of the SCWcO is demonstrated but also in which degree it excels current practice. This is a key question regarding the broad implementation of the system in the future as public bodies in charge of investments in new WWTP or retrofitting of old WWTP will need clear indicators in order to include this technology in substitution of current consolidated technologies.

5. Innovation and demonstrative value:

The scope of this project involves a new alternative based in a treatment that excels all the treatment steps carried out at a WWTP and the external treatments till final disposal as a whole and allows for the treatment of other organic wastes in the same infrastructure. The innovative nature of the LIFE LO2X project may be considered under different points of view:

Technological innovation: The technology background relies upon Supercritical Water Oxidation of organic material. This technology is still no available at commercial scale for the environmental application considered in this project. A prototype is being designed and constructed.

Innovative process: Process limitations already identified have been tackled by introducing the synergistic effect of co-oxidation of different selected wastes. Such wastes cannot be processed cost effectively separately but a proper mixing policy can do the work.

Innovative model: The system changes the concept of the wastewater treatment plant towards a resource recovery plant.

6. Long term indicators of the project success:

The LIFE LO2X project has defined in action C two types of indicators (deliverable D.C.1.1): Environmental and socio-economic indicators.

a) Environmental specific indicators:

The group of indicators included in the deliverable D.C.1.1 is considered as short term indicators, because they are directly linked with the expected results of the project in term of LO2X performance and their comparison with baseline. As mentioned before, a list of these indicators is included in deliverable D.C.1.1.

On the other hand, long term environmental indicators related with the LO2X project are:

- % of reduction of groundwater pollution as consequence of nitrates discharge on agricultural areas.

- % of utilisation as fertilisers of phosphate sales recovery from wastes considered in the project.

b) Socio-economic specific indicators:

This group of indicators is considered as both short and long term indicators. A list of these indicators is shown as follows:

1. Promotion of industrial diversification:

Short term indicator: Number of different providers for the LO2X prototype construction.

Long term indicator: Number of possible providers for the LO2X construction.

2. High qualified employments:

Short term indicators:

- Number of high qualified employment generated during the whole project.

- Number of high qualified employment generated according to the actions.

Long term indicator:

- Number of high qualified personal to work in the LO2X technology.

3. Reduction of public services, e.g. water sanitation:

Short term indicators:

- Cost of sewage sludge final disposal (baseline vs LO2X process).

- Total cost of water sanitation without returns of digested sludge dehydration.

- Cost of wastes treatment (baseline vs LO2X process).

Long term indicator:

- % of reduction costs by application of the LO2X technology.

4. Enhancement of productivity sectors:

Following indications from the EC in communication of Ref: Ares (2014)3721154 – 10/11/2014, concrete and measurable indicators in order to assess the “Enhancement of productivity sectors” has been defined, as follows:

Short term indicator:

- Number of companies from different productivity sectors interested to treat their wastes by co-oxidation with sewage sludge in LO2X technology (Feedback from ainia's associates; local companies;…).

- Cost saving (%) in the treatment of wastes from productivity sectors in comparison with current treatment or disposal.

Long term indicator:

- Number of water and waste management companies interested in LO2X technology (Feedback from contacts established with local-national-international authorities/companies; …).

5. Compliance legal environmental and safety requirements:

Short term indicator: Number of licenses accomplished.

6. Annexes

6.1 Technical annexes

6.1.1 - List of keywords and abbreviations used

P: Phosphorus

N: Nitrogen

COD: Chemical Oxygen Demand

EPSAR: water local authority

SCWO: supercritical water oxidation

SCWcO: supercritical water co-oxidation

DCP: Dissemination and Communication Plan

TM: Metric tonne

DM: Dry matter

EIP: European Innovation Partnership

CO: Project coordinator

SC: Steering Committee

TC: Technical Committee

PID: Piping and Instrumentation Diagram

PFD: Process flowsheet Diagram

HAZOP: Hazard Analysis and Operability

LCA: Life-cycle assessment

DOE: design of experiments

CIP: Clean in Place

WWTP: Wastewater Treatment Plants

WssTP European Water Technology Platform

PCB: Polychlorinated biphenyl

SCADA: Supervisory Control And Data Acquisition

6.1.2 - Technical reports and deliverables

Name of the deliverable	Submitted with
D. D.4. Film: virtual tour of the prototype.	Progress Report
D.B3.2: "Certification of the demonstrative plant (documents)"	Progress Report
D.B3.1: "Handbook of the demonstrative pilot plant": including the information of the general preventive and maintenance guidelines prepared.	Progress Report
D.E.3. Minutes from each meeting	Final Report
D.E.1. Consortium Agreement	Inception Report
D.E.2. Management guidelines	Inception Report
D.D.13. Report on networking activities	Final Report
D.C1.2: "Environmental and socioeconomic impact assessment report"	Final Report
D.C1.1: "List of specific indicators": specific indicators selected for the environmental and socioeconomic assessment of the project actions	Inception Report
D. A.1.2. "Basic Engineering project & Estimated program of the tasks for the construction of the plant"	Inception Report
D. A.1 Preparatory activities report: - "List of potential substances considered to be oxidized - "Data sheet of selected cosubstrates" - "Design of the preliminary tests"	Inception Report
D. B.2.2. "Demonstrative plant physically constructed (prototype)"	Progress Report
D. B.2.1. "Main units data sheets; special elements list; building plans for the assembly of the main units; document with main software instructions: control loops and alarms"	Mid-term Report
D. D.2. Project website and workplace	Inception Report
D.D.5. Other project materials: notice board, articles and press.	Final Report
D. D.3. Project leaflet	Inception Report
D. B.1. Detail engineering project with: Process Flow Diagram, List of equipments, List of streams, pipes and instrumentation, Data sheets: equipments, pipes, instruments and layout.	Mid-term Report
D. D.3. Layman's report	Final Report
D. B.4.2. "Summary of the results of the tests performed to assess the main SCWO variables and phosphorus recovery and conclusions of the corrosion assessment study and the mass and energy balances"	Final Report
D.B4.1: "Experimental design specifications to assess the SCWO process (document)"	Progress Report
D.E.5. Internal progress reports	Final Report