PROJECT FINAL REPORT

BioEnergy Sustaining the Future 2 (BESTF2)

Grant Agreement number: 618046

Project acronym: BESTF2

Project title: BioEnergy Sustaining the Future 2: Joint Strategic Planning and Programming to Enable the Implementation of Bioenergy Demonstrations

Funding Scheme: ERANET Plus

Period covered: 1 December 2013 to 31 May 2019 (66 months)

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1. Final publishable summary report

1.1 Executive Summary

The BESTF2 ERA-NET Plus built on the results of and lessons learnt from the BESTF ERA-NET Plus. BESTF2 used the network established in BESTF bringing together a number of national and transnational organisations with an interest in promoting the greater use of bioenergy. Its aim was to kick-start large scale investment in close-to-market implementation of bioenergy, thereby helping to achieve the key objectives of the European Industrial Bioenergy Initiative (EIBI) Implementation Plan and the Strategic Energy Technology (SET) Plan. In so doing BESTF2 successfully achieved all the objectives specified in the Energy 2013.10.1.1 ERA-NET Plus call topic.

BESTF2 addressed the need for integrated action across Europe to promote the development of bioenergy demonstrators across a number of technologies by coordinating research and development projects and providing a financial mechanism to support projects that are close to commercialisation.

The overarching objectives of BESTF2 were to enable commercial availability of advanced bioenergy at a large scale by 2020 and strengthen EU technology leadership for renewable transport fuels. These were to be achieved by the implementation of a joint programme for bioenergy demonstration projects to help Europe progress towards achieving its 2016 and 2020 targets. It used the leverage of public-private partnerships to manage the risks and share the financing of close to market bioenergy projects with the launch of a single joint transnational collaborative funding call with EU top-up funding to support projects. The call enabled the funding of two transnational demonstration size projects which achieved significant cost reduction results thus enhancing the cost effectiveness of the technology and contributed to commercialisation in the sector.

The BioWaMet project demonstrated the feasibility of the Anaerobic Membrane Bioreactor (AnMBR) as an innovative technology to achieve sustainable wastewater treatment (WWT), with specific focus on maximising the production of bioenergy. This new approach transforms wastewater into renewable energy and simultaneously produces a water resource of high quality that can be safely reused, recovering valuable nutrients during the process. Two demo-scale AnMBR wastewater treatment plants were successfully built and operated in Spain by Aqualia. The first AnMBR demonstration was operated in an office building (Nigrán) treating black water. The second demonstration site enabled the retrofit of an old system based on septic tanks in Bitem (Tortosa) into an advanced AnMBR, the first large scale application worldwide of this technology for the treatment and reuse of urban wastewater.

The CoryFee project's aim was to reduce production costs of cellulosic ethanol by combining partner technologies. An efficient pre-treatment and enzymatic hydrolysis process, in combination with strategies for (partially) continued fermentation of hydrolyzed biomass, were refined, up scaled and successfully demonstrated in the Biorefinery Demo Plant (BDP) in Örnsköldsvik, Sweden. The project showed that the process is technically feasible (at 10,000 litre fermentation scale) and with a positive business case for commercial 2G ethanol projects. The partners have formed a strong consortium that has the competencies, personnel and equipment to provide promise of a low risk transfer to commercialisation.

BESTF2 fused joint strategic planning and programming between the Member States that subscribed to enable the implementation of transnational bioenergy demonstration projects. Without the ERANET Plus action this would have been very difficult to achieve. Its outputs also influence those Member States that were not directly involved in the project, helping to bring greater alignment between their bioenergy initiatives and those of the Consortium.

1.2 A summary description of project context and objectives

1.2.1 Summary of the Project Context

This BESTF2 ERANET Plus brought together a number of national and transnational initiatives in the field of bioenergy. These included research, development, demonstration and financial instruments, driven by both public and private participants. By integrating these actions, risk was minimised and confidence provided to private investors in support of bringing bioenergy closer to market and in Europe.

This project's aim was to kick-start large scale investment in close-to-market implementation of bioenergy thereby helping to achieve the key objectives of the European Industrial Bioenergy Initiative (EIBI) Implementation Plan which foresees that; "*Bioenergy will play a key role in the EU long term energy strategy for all applications and especially the transport sector, contributing up to 14% of the EU energy mix and up to 10% of energy demand in transport in 2020*". This project has also contributed to the wider strategic European requirements: to increase the security of energy supply and to increase the sustainability of energy supply.

BESTF2 implemented a single collaborative funding call, which supported projects focused on the generation of bioenergy: energy generated directly or indirectly from sustainable biomass. These projects were based on prior high quality research undertaken at a European, national or industrial level that required a final "non-economic step to demonstrate the performance and reliability of all critical steps in a value chain so that the first commercial unit can be designed and performance guaranteed from the outcome of the demo unit".

New renewable energy sources (RES) are required to supplement the reduced availability of easy-to access fossil supplies, and to help mitigate their impact on climate change. The development of indigenous European bioenergy supplies is critical to both ensure the security of energy supply and to reduce greenhouse gas (GHG) emissions.

Bioenergy is generated from biomass. Biomass is derived from different sources of organic matter; it can be used for heating, electricity production and for transport. Biomass use can significantly reduce GHG emissions as the CO_2 emitted when it is burnt is counterbalanced by the amount absorbed when the feedstock biomass was grown. However the net GHG savings are heavily dependent on the cultivation and fuel production process used. Other RES, such as wind and solar, are inherently intermittent in supply; bioenergy can be used on demand and in a variety of different applications.

The EIBI, now integrated into the European Technology and Innovation Platform Bioenergy (ETIP Bioenergy), aimed to boost the contribution of sustainable bioenergy to the 2020 climate and energy objectives. The EIBI Implementation Plan identified seven bioenergy value chains selected to reflect diversity of feedstock options, processing options, different national bioenergy markets, and bioenergy outputs (table 1).

Table 1 European Industrial Bioenergy Initiative's seven value chains

Thermochemical Pathways
1: Synthetic liquid fuels and/or hydrocarbons (e.g. gasoline, naphtha, kerosene or diesel fuel) and blending components through gasification.
2: Bio-methane and other bio-synthetic gaseous fuels through gasification.
3: High efficiency heat & power generation through thermochemical conversion (propose limit e.g.: η_{el} > 45%)
4: Intermediate bioenergy carriers through techniques such as pyrolysis and torrefaction

Biochemical Pathways
5: Ethanol and higher alcohols through chemical and biological processes
6: Hydrocarbons (e.g. diesel and jet fuel) through biological and/or chemical synthesis from biomass containing carbohydrates
7: Bioenergy carriers produced by micro-organisms (algae, bacteria) from CO_2 and sunlight

Within each of these "generic" value chains, different paths based on different biomass feedstocks (including fossil co-processing), conversion technologies and/or energy products are possible, leading to a wide range of options. Selecting the most relevant options cannot be achieved at a generic level, outside a specific context of locally available feedstocks and targeted end products serving clearly identified markets requesting them. Sustainable biomass feedstocks could include those made of lignocellulose, agricultural residues and biological waste materials.

BESTF2 has helped to mitigate the technological and commercial risks in realising these value chains through a public-private partnership approach. A prerequisite for public funding support for projects stimulated by this BESTF2 action was real, auditable financial support from the commercial sector. The public funding provided the private financial sector with confidence in their long-term investments into building commercial-scale operations.

1.2.2 Overarching objectives

BESTF2 ERA-NET Plus promoted joint strategic planning and programming for the implementation of Bioenergy demonstration projects, in accordance with the priorities set out in the EIBI SET-Plan. In the preparation of the objectives, consideration was given to the links between the EIBI, the ERA-NET Plus and the BESTF2 Joint call. Thus the EIBI drove the ERANET Plus ambitions, which in turn drove the BESTF2 call. The respective goals, purposes and specific objectives and their interrelationships as shown below:

These EIBI goals, purpose and specific objectives, provided the framework for the ERA-NET Plus action:

European Industrial Bioenergy Initiative

GOALS:

- Demonstration of supporting projects and/or reference plants for innovative bioenergy value chains with large market potential, based on significantly advanced feedstocks and technological options;
- Secured financing for subsequent commercial large scale deployment, and for gaining social acceptance, because demonstration of the sustainable and reliable performance of these innovative technologies over the complete value chain is critical;

PURPOSE:

- To boost the contribution of sustainable bioenergy to EU 2020 climate and energy objectives;

SPECIFIC OBJECTIVES:

- To enable commercial availability of advanced bioenergy at large scale by 2020, aiming at production costs allowing competitiveness with fossil fuels at the prevailing economic and regulatory market conditions, and advanced biofuels (sustainable biofuels with a broader material base and/or better end product properties than the biofuels currently on the market) covering up to 4% of EU transport. energy needs by 2020;
- To strengthen EU technology leadership for renewable transport fuels, serving the fastest growing area of transport fuels in the world.

ERANET Plus BESTF 2 action

GOALS:

- To promote joint strategic planning and programming for the implementation of Bioenergy demonstration projects;
- To further the demonstration of enhanced bioenergy technologies for a range of demonstrator and flagship plants, that will help Europe to make progress towards achieving its 2016 and 2020 energy targets;
- To exploit the synergies available through pooling Member States knowledge, resources and expertise, thereby creating added value to Europe.

PURPOSE:

- To support part of the implementation plan of the SET-Plan European Industrial Bioenergy Initiative (EIBI) linked to demonstration projects;
- To strengthen the cooperation and coordination of national and regional R&D programmes in the area of Bioenergy driving towards 2020 and indeed 2050 goals and targets.

SPECIFIC OBJECTIVES:

- To implement a single collaborative funding call that will support projects focused on the generation of bioenergy;
- To maintain and enhance coherence and networking between national bioenergy programmes across the EU;
- To further the demonstration of enhanced bioenergy technologies via demonstrator and flagship plants;
- To disseminate knowledge gained from the programme and individual projects across the EU.

1.2.3 Specific Objectives

The project directly addressed the goals of the Energy 2013.10.1.1 ERA-NET Plus call by implementing a joint programme for bioenergy demonstration projects to demonstrate enhanced bioenergy technologies to help Europe progress towards achieving its 2016 and 2020 targets. It leveraged public-private partnerships to manage the risks and share the financing of close to market bioenergy projects.

The key objectives of BESTF2 initiative were:

1. To implement a single collaborative funding call to support projects focused on the generation of bioenergy (WP2).
2. To maintain and enhance coherence and networking between national bioenergy programmes across the EU (WP4).
3. To further the demonstration of enhanced bioenergy technologies in order to help develop robust project plans for a range of demonstrator and flagship plants, that will help Europe to make progress towards achieving its 2016 and 2020 energy targets (WP3).
4. To disseminate knowledge gained from the programme and individual projects across the EU (WP4).

Projects to be funded under BESTF2 must address innovative technologies and processes, or novel integration of known technologies and processes to be established at the appropriate scale for first-of-its- kind demonstration. At least one "section" of the value chain or the integration of "sections" of the considered value chains should not have been deployed at demonstration / commercial scale before. The funding of such projects will focus exclusively on the innovative elements, including their possible integration into existing facilities, the process operation for the time and volumes that are necessary to integrate the novel part, and the assessment and optimisation of the complete integrated process.

BESTF 2 will complement existing financial measures available to industry and support projects that have progressed to high technology readiness levels (TRLs) but still require a level of public and private financial support to enable their industrial implementation.

It will support projects at TRL 6-8 but is particularly interested in projects between “proof of concept” and income generation, commonly known as the “valley of death”. Crossing this valley often requires public and private investment to generate sufficient acceptance of a technologies ability to be commercially viable. It is recognised that the seven value chains are at different stages of technological maturity.

1.3 A description of the main Scientific and Technological results

This section includes the launch and implementation of the BESTF2 ERANET Plus with information on the Scientific and Technological results of the transnational projects funded by the ERANET.

1.3.1 Call launch and Implementation

The BESTF2 ERANET Plus joint call was launched on 11th December 2013, and closed to applications on 12th February 2014. The evaluation followed a two-stage process as follows:

Stage 1 - national/regional evaluation – each funding agency reviewed the applicants from its country to check that the applicant complied with the appropriate national funding agency rules eg. the applicant is an incorporated entity. Thirty eight (38) projects were submitted to stage 1 and of these thirteen (13) were invited to submit a proposal for stage 2 evaluation.

Stage 2 – independent expert panel review – experts were appointed with relevant expertise to evaluate proposals. Each proposal was evaluated by at least three experts using evaluation criteria provided by the consortium. The evaluation criteria were published in the call documents. Twelve (12) of the thirteen (13) projects initially invited to submit to stage 2 were submitted to the expert panel for evaluation. Six of the projects submitted did not reach the quality threshold in one or more evaluation criteria and were rejected. The combined national and EC funding was sufficient to ensure that the remaining transnational projects were selected for funding. Of the six selected for funding one project Hymethane withdrew, so five projects entered grant negotiation with national funding authorities. Table 1 below shows the details of the funded projects.

Table 1

Action	Project Acronym	Countries	Company	Completion date
BESTF2	BioWaterMethanisation	Spain	Aqualia	2018
		The Netherlands	Delft University	
		United Kingdom	University of Southampton	
	CoryFee	Denmark	Terranol	2018
		Sweden	SEKEB E-Technology	
			SP Technical Research Institiue of Sweden	
	MSWBH	United Kingdom	Wilson Steam Storage	CLOSED 2018
			University of York	
			University of Nottingham	
		The Netherlands	Wageningen Food and Biobased Research	
		Norway	Artech Automation AS	
	NPTLCT	United Kingdom	WSP CEL	CLOSED 2016
			Aston University	
		Ireland	Nova Pangaea	
		Latvia	Latvian State Institute of Wood Chemistry	
		Germany	Karlsruhe Institute of Technology	
			Franhofer Institute for Applied Polymer Reseearch	
		Spain	CTAEX / TROIL	
		Netherlands	NNRGY	
	W2Bu	Spain	Abengoa Bioenergia Nuevas Tecnologias	CLOSED 2016
			Abengoa Research SL	
		United Kingdom	Green Biologics	
		Switzerland	E4Tech Sarl	

Of the five funded projects, both BioWatermethanisation (project cost €1.92M) and CoryFee (project cost €3.92M) completed their objectives in 2018. MSWBH having carried out much preliminary work had to close in 2018 as a result of withdrawal of third party private investment. Projects NTPLCT and W2Bu both closed early without completing their objectives.

Total project costs and grant funding are detailed in Table 2 below:

Table 2

Project Acronym	Total Project Costs €	Grant requested €	EC contribution €
BioWaMet	1,921,271	699,565	230,856
CoryFee	3,927,500	2,562,900	845,757
MSWBH	3,321,124	2,379,583	785,262
Totals	**9,169,895**	**5,642,048**	**1,861,876**

1.3.2 The Monitoring Process

The European Industrial Bioenergy Initiative (EIBI) sets out a comprehensive list of key performance indicators (KPIs) for RD&I projects. This aligns with the *Monitoring and Review Framework* of the SET plan.

The BESTF projects were monitored against a key subset of these KPI's (see below) in order to meet national reporting requirements of the national agencies funding the call

KPI 1: ***Price before taxes of bioenergy products in 2020 per value chain at point of sale to customer***

- Synthetic liquid fuels by gasification: < €80/MWh
- Biomethane: <= price of natural gas and other synthetic gaseous fuels by gasification dependent upon product, for example: Dimethyl Ether <€60/MWh; compressed H_2<€80/MWh; CO <€30/MWh
- High efficiency heat and power by thermochemical conversion: < €75/MWh_e; <€35/MWh_{th}
- Intermediate bioenergy carriers: <€30/MWh, competitive with Heavy Fuel Oil, but depends on actual product
- Ethanol and higher alcohols from ligno-cellulosic biomass by biological processes: <€80/MWh (equivalent to <€0.50/litre)
- Hydrocarbons by biological processes and/or chemical synthesis: < €80/MWh
- Bioenergy carriers by micro-organisms (algae) from CO_2 and sunlight: < €70/MWh for lipids (to be competitive with vegetable oils and animal fats).

KPI 2: ***GHG savings compared to fossil equivalents***

GHG savings monitored in accordance with the Renewables Directive with the following targets:

- Biofuels and bio-liquids: to be at least 60% saving.

- Other bioenergy products: whilst not defined in the Renewables Directive, in the absence of specific targets, the EC has indicated the use of the 60% target.
- Other energy products: reference data based on the JRC Well-to-Wheels study

KPI 3: ***Total bioenergy produced by EIBI projects (TWh/year)***

Targets to be:

- ***2016***: 25% of 2020 target as an intermediate stage between 2012 to 2020 reflecting maturity of first phase of demonstration projects.
- ***2020***: 35TWh total energy from EIBI projects contributing to the 20% renewables target; 17.5TWh of the 10% biofuels target for transportation will be reached by advanced biofuels

It was recognized that the projects supported by BESTF2 ended before 2020 and therefore would probably not necessarily achieve the targets within their project lifetime. However, projects were expected to show how (eg. via a roadmap) they would support the achievement of these KPI values by 2020. The two funded transnational projects did make progress in achieving the relevant KPIs.

1.3.3 Project results in detail

1.3.3.1 BioWaMet

Project Summary:

This project demonstrated the feasibility of the Anaerobic Membrane Bioreactor (AnMBR) as an innovative technology to achieve sustainable wastewater treatment (WWT), with specific focus on maximising the production of bioenergy during the process. This new approach aims to transform wastewater into renewable energy and simultaneously, to produce a water resource of high quality that can be safely reused, recovering valuable nutrients during the process.

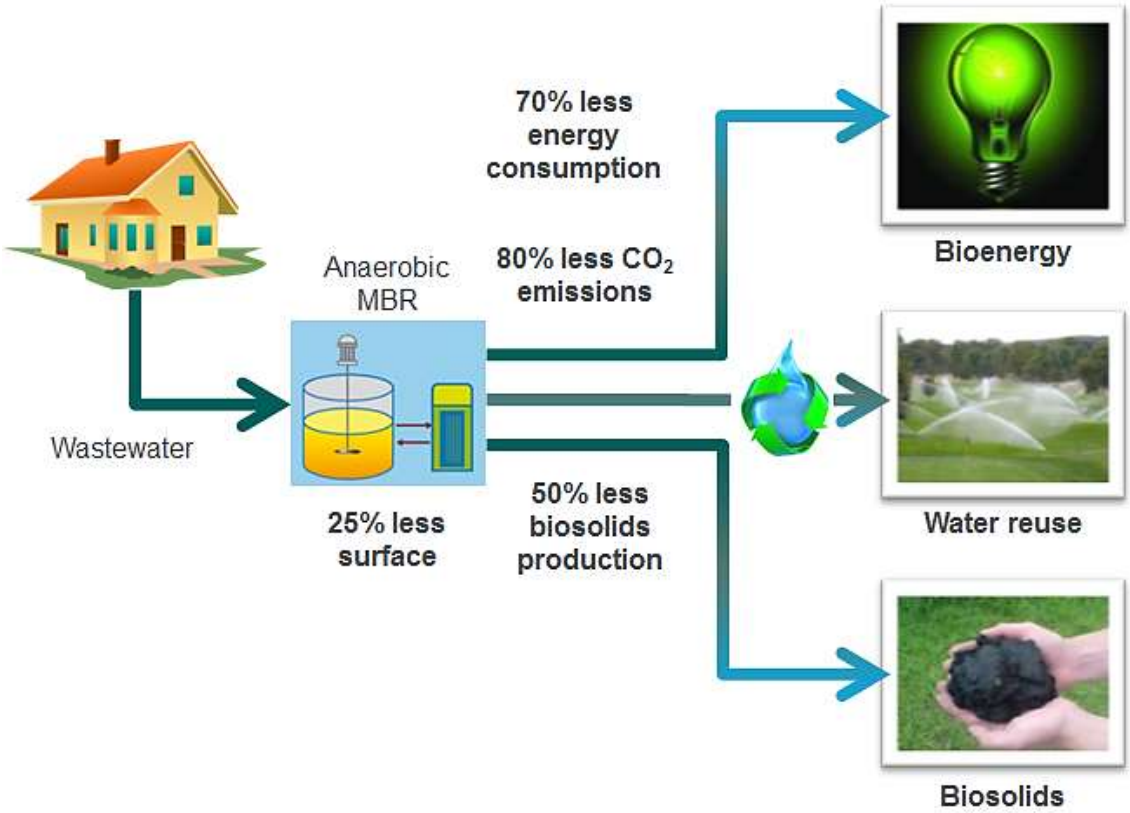
AnMBR technology is the synergy between anaerobic treatment and membrane ultrafiltration (UF) within a high-performance single step. The anaerobic process transforms the organic matter contained in wastewater into a biogas stream mostly composed of CH_4 and CO_2. Bioenergy as heat and electricity can be harvested from this biogas. Simultaneously, membrane UF completely retains the microorganisms within the anaerobic reactor allowing disinfection and a perfect control of sludge retention time. Moreover, low growth rate of anaerobic bacteria coupled to longer sludge retention time reduces sludge production, resulting in lower residue disposal burden, and substantially less emissions.

Wastewater treatment in anaerobic systems coupled to UF membranes allows:

- Energy recovery thanks to efficiency (since no aeration is needed) as well as biogas production, saving, at least, 70% of energy consumption. This brings a dramatic reduction of the carbon footprint by 80% compared with conventional sewage treatment.
- Water recovery with suitable characteristics for agricultural reuse, since nutrients have not been degraded in the process.
- Less produced sludge, which reduces sludge management costs.

See Figure 1 below for a visual representation of the benefits of this system.

Figure 1



Different scenarios were considered, from municipal to diverse Industrial wastewaters, with different operational constraints.

Details of the project

The AnMBR system was demonstrated at two sites in Spain:

- Business Park of Porto do Molle (Nigrán, Pontevedra): In the main office building, 2 m^3/d of black water was collected in a segregated pipe from a WC and being treated in an AnMBR. The process was started in March 2018.
- Bitem WWTP (Tortosa, Tarragona): Three septic tanks were been retrofitted into an AnMBR to achieve the treatment of 18 m^3/d of urban wastewater. In spring 2018 the first commissioning tasks were completed.

The two AnMBR systems are currently being optimized to maximize their performance and efficiency. The main features of the installations are as follows:

	Bitem WWTP	Nigrán Office Building
Capacity treatment	18 m^3/d	3 m^3/d
MBR configuration	Submerged/Hollow Fiber	Submerged/Flat Sheet
UF membrane area / pore size	61 m^2 / 0,02 µm	6,25 m^2 / 0,1 µm
AnMBR Volume	23 m^3	3 m^3

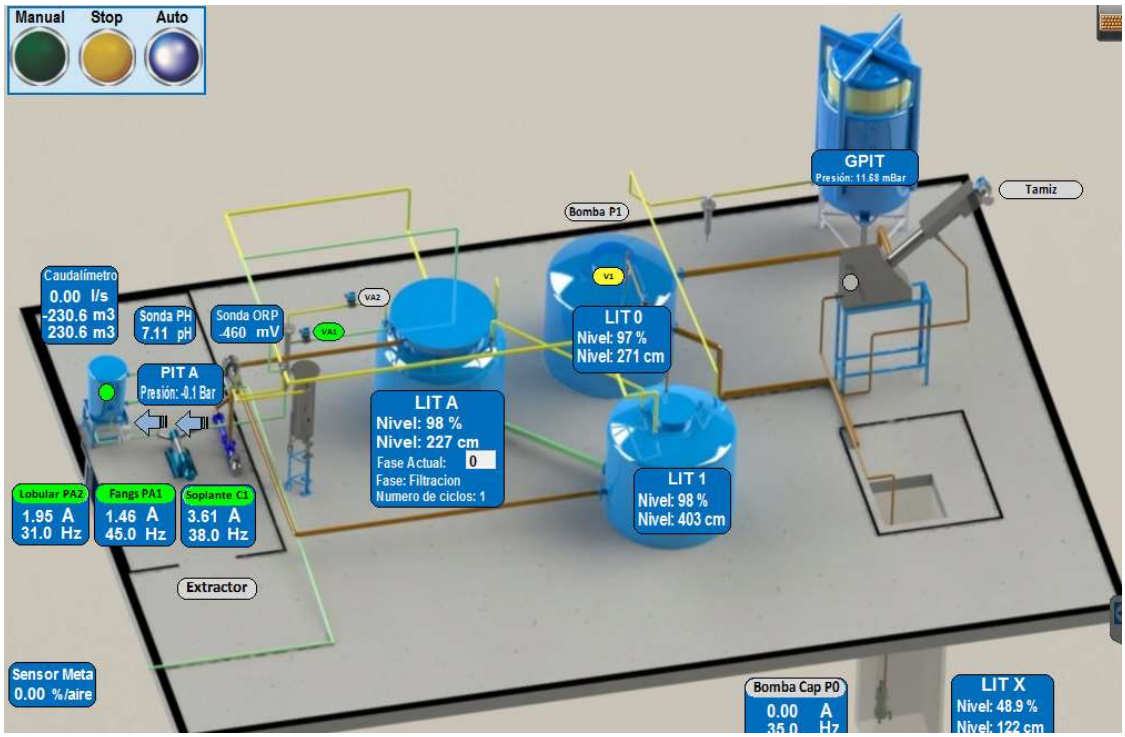


Figure 2 - Schematic overview of the AnMBR installed in Bitem WWTP. LIT-0 = Equalization Tank. LIT-1 = Anaerobic Reactor. LIT-A = Membrane Tank.

The results obtained are promising:

- Start-up strategy has been successful, since no acidification of the reactors has been observed.
- Chemical oxygen demand removal is above 80%, achieving the local discharge requirements (<125 mg COD·L^{-1}) for the treated wastewater.
- 20ºC-Standardised membrane permeability is above 90 L·m^{-2}·bar^{-1}·h^{-1}.

- After ultrafiltration, the water is disinfected (since no cells can pass through the membranes) and is further reused for irrigation purposes, a good example of water reclamation and the circular economy.
- Methane content in biogas up to 80% (the biogas becomes a source of renewable energy).

The Delft filtration characterization module (DFC) was modified and adapted to enable the online measurement of the anaerobic biomass filterability in an AnMBR (DFC was originally used for aerobic systems). A mathematical model to study the effect of flux enhancer on the biological activity of anaerobic biomass was developed, calibrated and validated. Appropriate flux enhancers were selected and tested at pilot scale AnMBR. A control strategy based on online filterability measurements and with the addition of flux enhancer was developed.

(A)

(B)

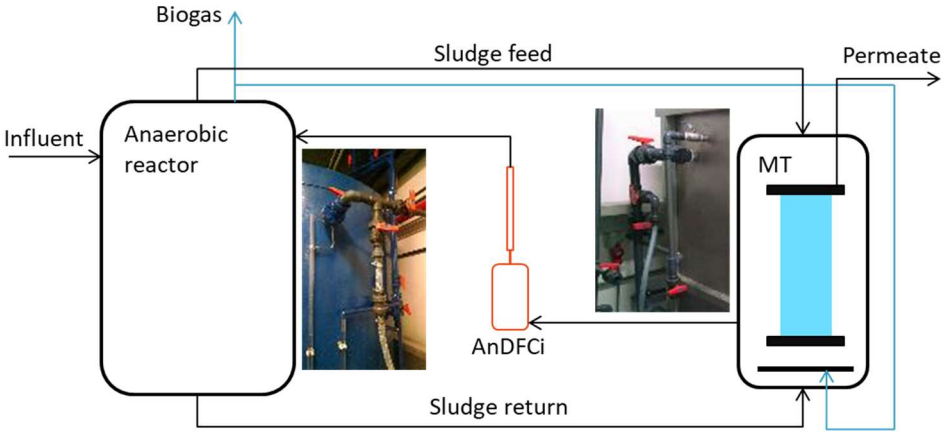


Figure 3 - Anaerobic DFC installation connected online to the pilot AnMBR from Aqualia (A) and connection scheme (B). Pilot located at the Business Park of Porto do Molle office building, Nigrán, Pontevedra, Spain.

In order to achieve fouling reduction the modification of an ultrasonically activates stream (UAS) was tested. A UAS system has been proven effective at removing biofouling on a variety of substrates and has been shown that it does not damage substrates as traditional ultrasonic cleaning does. Despite lack of evidence of cleaning in the live system, ex-situ tests on membrane samples did show significant flux recovery relative a water rinse or mechanical cleaning. As an alternative, particle scouring systems were tested. This uses suspended objects to 'bump' against the membrane surface, removing the large-scale fouling layer and has the advantage that the existing AnMBR mixing system can provide the energy for the anti-fouling process. The experimental work adopted two approaches, using sponge and soft gel particles. Promising results were obtained and further research is ongoing.

Issues and how they were overcome

There were project management/consortium issue as well as technical problems to overcome.

The original project timetable was delayed as a result of the coordinator's decision to build and operate two demo-scale plants instead of one, which increased the AnMBR applications. In particular the permits from the municipal and regional authorities for retrofitting Bitem WWTP took longer than expected.

The construction of the first pilot AnMBR plant in Nigrán (ES) was delayed. As a consequence the experimental trials with the DFC installation could not be started as planned. In order to speed up the construction of the pilot TU Delft provided extra technical support to the project partner in charge of the construction. The experimental trials of the DFC installation were started in February 2017 at an alternative location operated by the coordinator at a municipal sewage pilot in Alcázar de San Juan, Spain. Following this trial the equipment was transferred to the original planned location in Nigrán, where the tests started in March 2018, and measurements were carried out until December 2018. Due to the delay reulsting from the location change of the pilot plant the end of the project was extended to 30 September 2018, which enabled TU Delft to complete its measurements.

Fairfield Control Systems Ltd left the consortium at the very beginning of the project as a result of new strategic objectives of the new owner of the business. A replacement partner was identified, unfortunately, due to the necessary due diligence required by the UK funding agency, approval for the inclusion of this replacement partner in the consortium was allowed in the last month of the project and therefore none of the joint work associated with the partner was able to take place.

A significant portion of the research effort on the ultrasonic part of the project was spent in an attempt to reduce the power consumption of the ultrasonic cleaning system to a level both feasible for a lab-scale study and plausible for operation at pilot-scale. When the ultrasound arrays were finally optimized so that in in-situ tests could proceed in live lab-scale bioreactors, no improvement in membrane fouling reduction could be detected by running the reactors with the ultrasonic field turned on. However, ex-situ studies have shown that fouling was effectively removed by ultrasound. Therefore, it was concluded that something was preventing cleaning within the in-situ systems, either, the digestate or the gas present in the digestate introducing significant loss to the ultrasound thus preventing cleaning.

Therefore optimization of in-situ cleaning was abandoned and experimental work concentrated on the recovery of flux from fouled membranes in an ex-situ process.

Added value and the future

The Bitem WWTP is the first urban wastewater treatment plant based on AnMBR technology and represents a real breakthrough for the commercial readiness and maturity of AnMBR technology.

Previous experience with AnMBR technology has shown promising results:

- Modelling and simulation helped to design the installation, as well as the optimal operation conditions. The resilience of the system when faced with hydraulic or organic overloads has been proven.
- Past prototype tests with real urban wastewater demonstrated the technical viability of the process and the installation. Membrane fluxes higher than 20 LMH have been obtained, as well as good biogas quality (methane content higher than 70%) and optimal process performances (COD reduction higher than 90%).
- An economic comparison has demonstrated the profitability of AnMBR in comparison with conventional treatment. CAPEX of AnMBR is comparable to conventional treatment costs based on activated sludge, although OPEX is below. OPEX savings allow a Return of Investment lower than 3 years, which means that AnMBR is a competitive technology. Moreover, BioWaMet has shown the potential of AnMBR as a real option for retrofitting old septic tanks, by improving the water treatment globally and obtaining the above benefits.

The project enabled an increase in the TRL of AnMBRs applied to urban wastewater treatment to 8-9 overcoming the funding “valley of death”. The project placed Aqualia as leader of the AnMBR technological application. This new technological application demonstrated its potential to be extended and replicated across Europe. It also demonstrated successful retrofitting of outdated existing WWTP, especially where irrigation water is needed since nutrients are not removed and pathogen free reuse water is produced.

Aqualia is contacting potential customers for AnMBR implementation and replication. The project’s example of the first successful demonstration scale application gives considerable confidence to potential clients/investors.

Aqualia is building on the outcomes of this project by using the results from the AnMBR application in Nigran for the H2020 RUN4LIFE project where the recovery of nutrients from black water is one of the main objectives.

The academic partners have shown that further research and development at demonstration scale is needed in order to increase the competitiveness of AnMBR.

TU Delft’s research is being continued by a PHD researcher, with a focus on the development and testing of the control strategy based on online filterability measurements and the addition of flux enhancer. Several journal and conference papers have been published and are underway.

The ultrasound systems tested by the University of Southampton did not show great promise for commercialization for in-situ cleaning of submerged membranes in a suspended biomass bioreactor. The principle of ultrasound cleaning of membrane surfaces was proven and there may also be potential applications in other membrane systems which have much more dilute and smaller-scale contaminants (e.g. reverse and forward osmosis). The laboratory scale results on soft particle membrane scrubbing were particularly promising and ripe for scale-up.

1.3.3.2 CoryFee

Project summary

The aim of the project was to reduce production costs of cellulosic ethanol by combining the partners respective technologies. An efficient pre-treatment and enzymatic hydrolysis process, developed by SEKAB E-Technology AB, in combination with strategies for (partially) continued fermentation of hydrolyzed biomass, using yeast strains developed by Terranol A/S, have been further refined, upscaled and successfully demonstrated in the Biorefinery Demo Plant (BDP) in Örnsköldsvik, Sweden, managed by Sweden's technical research institute (RISE) and operated by SEKAB. The results at 10,000 litre scale were in accordance with results obtained at two litre laboratory scale. The objectives concerning robust online feed control, improved operating economics and reduced fermentation needs, have been achieved and demonstrated for the overall process; there is a significantly improved yeast economy and the necessary fermentation tank volume for finished production from given biomass quantity per time is also considerably reduced.

Details of the project

Proprietary technologies for an efficient pre-treatment and enzymatic hydrolysis process, developed by SEKAB, in combination with strategies for continued or partially continued fermentation of hydrolyzed biomass, using yeast strains developed by Terranol, have been further refined, upscaled and successfully demonstrated in the Biorefinery Demo Plant (BDP).

The overall objective of the project was to reduce production cost of cellulosic ethanol. In a 2G ethanol production the amount of enzymes, yeast and energy drives up the operational expenses (OPEX) per produced unit. As more unit operations are needed in order to process cellulosic biomass into ethanol compared with a 1G process, a higher initial capital expenditure (CAPEX) is also needed. To ensure a wide deployment of 2G bioethanol production in market conditions, there is a need for further reduction of the overall production costs.

Development of pentose fermenting yeast was an important accomplishment as this increased obtainable yields by up to 50%. This was due to the additional conversion of pentoses which constituting 20-40 % of the hydrolysed sugars. However, the release of various inhibiting substances during harsh pre-treatment of the cellulosic materials makes the fermentation step more challenging than in a 1G process. Increasing the yeast amount in the initial fermentation step may partially circumvent this challenge but this increases the OPEX of 2G ethanol production. An additional problem is substantial amounts of weak acids, such as acetic and benzoic acid, released

during pre-treatment, which slow down the fermentation, causing a need for higher fermentation tank capacity, higher yeast addition, or an extra process unit for pH shift.

Terranol and SEKAB E-Technology have collaborated for a number of years and this project was therefore a natural next step to address these issues. SEKAB E-Technology has a complete pre-treatment and hydrolysis process, CelluAPP™, that releases only limited amounts of inhibiting substances in general and of weak acids in particular. Terranol has a xylose fermenting yeast, which is capable of simultaneous fermentation of hexoses and pentoses. These Swedish and Danish technologies are of the highest international class and coupled with the demonstration facility Biorefinery Demo Plant (BDP) in Sweden (run by RISE and managed by SEKAB) have complemented each other perfectly in this project.

In total six milestones were identified and all of them were met:

(1) The initial aim was to use the BDP to test the flow rates of the CoRyFee fermentation system, review the functionality needed and install any necessary updates and upgrades to fermentor functionality and piping/pumping.

(2) The results lead to the use of parallel-connected secondary tanks (in contrast to serial connection) in a continuous fermentation process integrated into the production scheme.

(3) Based on laboratory experiments it was decided that a refractive index (RI) instrument was the best option for online glucose measurement (due to its robustness and accuracy) and this was installed in the BDP.

(4) A yeast propagation procedure in which very little sugar is lost as undesirable products and with a very high yeast biomass concentration was developed at laboratory scale and successfully transferred to the BDP.

(5) The CoRyFee concept was rigorously tested at laboratory scale and subsequent verification trials in the BDP show comparable results in terms of yields, productivities and sugar utilization for both fermentation scales.

(6) Trials in the BDP were carried out mainly using wheat straw and aspen hydrolysates and the economic benefits of the CoRyFee concept were demonstrated in both instances.

In conclusion, the results at 10,000 litre scale were in accordance with results obtained at two litre laboratory scale. The objectives concerning robust online feed control, improved operating economics and reduced fermentation needs, have been achieved and demonstrated for the overall process.

There is a significantly improved yeast economy as the amount of yeast needed per produced unit of ethanol has been reduced by at least 80%. The necessary volume of fermentation tank for finished production for a given biomass quantity per time is also considerably reduced, amounting to a 50% reduction in size.

Issues and how they were overcome

The project was started on 1 January 2015 and has since been granted two extensions. Both SEKAB and Terranol have been affected by loss of employee resources in the form of sick leave and termination of employment. These factors combined with an unexpected high occupancy of the BDP influenced the planning and implementation of activities. Major tasks would have been difficult to perform and report on before the planned end of the project if extensions had not been granted. These unforeseen challenges were, however, met and the project reached its targets.

Added value and the future

A novel fermentation control program effecting real time feed control based on online measurement of the RI was developed, and the method and the process have been the subject of a joint European patent application filed by Terranol and SEKAB with the title "Process and System for Microbial Fermentation".

The parties share the rights and have entered into a preliminary joint intellectual property and patent application ownership agreement and begun discussions how to agree on commercial terms and conditions of joint worldwide commercialization of the patented technology. First attempts to commercialize the developed concept have begun with a Scandinavian energy company, who is planning a 2G bioethanol factory to be operational in 2021. Marketing of the CoRyFee concept directed to potential customers has thus already been initiated and the search for further potential customers is ongoing, without limiting the use of this fermentation concept for 2G bioethanol production.

The main conclusion of the project is that the CoRyFee process is technically feasible as proved in 10,000 litre fermentation scale and that a positive business case for commercial 2G ethanol projects can be established. The partners have formed a strong consortium that has the competencies, personnel and equipment, which provides promise of a low risk transfer to commercial scale.

1.3.3.3 MSWBH

Project Summary

This project's aim was to demonstrate the economically-viable production of butanol, hydrogen fuels and other chemicals from autoclave-pretreated municipal solid waste (MSW), Grape Marc and Brewery Waste by hydrolysis and fermentation. It was planned to develop a new demonstration scale plant that could potentially treat 1.5 tonnes of MSW a day, and provide the expertise and data necessary for a full assessment of a commercial scale process. The demonstration plant would use established technologies for hydrolysis, fermentation, and separation of chemicals. The products were to be removed from the fermentation broth by gas stripping followed by decantation and distillation. In addition, the hydrogen gas produced during the fermentation would be purified using pressure swing adsorption technology.

Following design and manufacture of the autoclave plant, optimization of enzymatic hydrolysis, fermentation parameters were to be fed into the design of the fermentation plant and the ancillaries

for product recovery. At the end of the project continuous trials in a commercial scenario were planned.

Progress to project close

University of York (UoY) established a site for the Demonstrator plant and waste pretreatment and hydrolysis work was undertaken using a 50kg capacity pilot scale plant.

Design work for the Demonstrator scale plant was undertaken and a draft layout was defined allowing more detailed design work to commence.

The small scale pretreatment, hydrolysis and fermentation of the three types of waste continued throughout 2017 to optimise conditions to trial at larger scale. This work involved Wilson Steam Storage (WSS), University of Nottingham and Wageningen Food and Bio based Research (WFBR) with support from the University of York.

WSS began procurement of autoclave equipment for the demonstration scale facilities, following design work to specify the overall layout of the facilities. The detailed specification and procurement of the hydrolyser, fermentor and chemical recovery equipment followed in the second half of 2017 based upon findings from the work at small scale.

Life cycle assessment of the process, at pilot and demonstration scale, ran in parallel throughout 2017.

In anticipation of the likely complexity of deconstruction of waste during autoclave processing, several temperature and time profiles were mapped out to look at the best process pre-treatment for release of polysaccharides without creating inhibitor chemicals. A broad band of conditions, particularly temperatures between 140-180°C gave flexibility in pre-treatment conditions.

With regard to hydrolysis of polysaccharides there were no perceived issues during pilot hydrolysis other than the rapid decrease in viscosity during the process which will need to be considered in a full scale plant. Small particles of other debris (glass, plastic etc) will influence choice of pump and heat exchanger for transferring the hydrolysate to the fermentation process.

Using c. acetobutylicum it was noted that halving the sugar concentration produced much more ABE (close to control ideal) which needs to be repeated. The use of inhibitor chemicals during fermentation needs to be explored further as indications were that, in the unwashed samples, their presence may be having an effect. Initial fermentation trials need to be repeated to confirm the ABE yield when the solids are halved.

Issues contributing to project close

The project had an initial start date of September 2015 with a work plan of 36 months.

During grant negotiations the consortium lost an engineering partner (IDE S.A. from Spain) and the partner who was to host the demonstration scale facility (SUON Limited from the UK). These were

replaced by Artech Automation AS (a Norwegian company) and the University of York (UK) respectively.

The project consortium was therefore made up of Wilson Steam Storage (WSS), University of Nottingham (UoN), University of York (UoY), Stichting Wageningen Research, Wageningen Food & Biobased Research (WFBR) and Artech Automation AS (Artech).

The time taken to find replacement partners was considerable resulting in a project start date of 1st April 2016 with an end date of 31st August 2018 with a reduced work plan. It was recognized that the project needed the 36 months work plan originally envisaged. A project time extension would only be possible if the BESTF2 action was extended beyond its initial time period of 60 months, ending on 30th November 2018. Therefore the BESTF2 Coordinator requested a time extension to the BESTF2 action which was granted by the Commission and was extended to 31st May 2019.

Unfortunately, the third party private investment funds needed to build the demonstration facility were not paid to the project. This lack of finance lead to the closure of the project as no capital purchases could be made to enable the building of the demonstration plant.

The UK funding agency, Innovate UK, gave the consortium until 6th July 2018 to show firm evidence of investment which unfortunately, though promised, didn't materialise.

1.3.3.4 NPTLCT

Project Summary

The project aimed to demonstrate the pre-commercial scale-up of the Lignocellulosic Conversion Technology (LCT) developed by Nova Pangaea Technologies Ltd (NPT), and to confirm its potential for profitable operation at commercial scale, without subsidy, so that at the conclusion of the project, agreements for the first commercial scale implementations of the technology could be put in place. Designed from the outset as a continuous, staged, complete, physical and thermochemical fractionation and conversion process, capable of extracting all valuable fractions from biomass cells, LCT is a highly efficient process that converts waste and non-food biomass to sugars and on to fuels, along with valuable by-product chemicals (which reduce the effective cost of the fuels). A 100tph LCT is expected to cost €141m and earn €40m p.a. EBITDA – a first step towards replacing fossil fuels.

Progress to project close

The project started on the 1st September 2015. The period between the grant award and project kick-off afforded the opportunity to simplify the design engineering activities but more importantly to de-risk the performance of the technology. The NPT technology team reviewed each stage of the process and identified key equipment suppliers with the optimal technology, ensuring an approach that works closely with specific equipment suppliers to support the development of their proven process systems. Much of the initial work involved selection of the best suppliers, meeting with

them and carrying out tests at their facilities. It was planned to build a specialist test rig in Latvia to underpin the design of the final pyrolysis phase.

NNRGY and CTAEX both made early progress with their feedstock characterisation activities. KIT carried out design support and testing activities on microwave and PEF treatments resulting in early recommendations.

Aston University carried out focused literature review and modelling of mass and energy balance for the fast steam pyrolysis stage.

Issues contributing to project close

WSPCEL (UK coordinator) requested a pause to project activity in April 2016. UK national authorities, DECC (BEIS) and Innovate UK, worked with WSPCEL over several months to try to address a range of issues as follows:

- The operational framework in the BESTF2 proposal, whereby NPT staff were seconded to WSPCEL was not workable for WSPCEL and NPT (the UK investor) once the project started. Innovate UK agreed in principle to establish NPT (UK) as a project partner in its own right. During the normal due diligence checks it became clear that WSPCEL and NPT had not fully appreciated the Innovate UK project financial requirements - specifically in relation to capital usage and retention (and thereby the impact on cash flow), as well as compliance with actual labour costs.
- There was a need to confirm the project scope with BESTF2 stakeholders given proposed changes to the proposal and to ensure clear demarcation with the associated UK publicly funded "ABDC" project. In a project meeting with UK national funding authorities concern was raised regarding the possible scale-up of the final stage of the process and the need for the BESTF Management Group to confirm that the project remained in scope if this occurred.
- There were concerns about the nature of the European collaboration. The project suffered from a number of partner changes following the evaluation, specifically the loss of the Irish partner, one of the German partners and one UK partner and the addition of another UK partner (Aston University). It was also decided that NPT (the UK investor) would fund the second German partner, in addition to funding the Latvian and Dutch partners. The Spanish partner (CTAEX/TROIL) remained funded by its national funding authority. The breakdown of funding from national authorities was 93% UK, 7% Spain and in relation to the work carried out, by value, only 15.6% was to be conducted outside the UK.

The Coordinator submitted a request for early termination of the project in June 2016 and a formal closure letter was received in August 2016.

1.3.3.5 W2Bu

Project Summary

The project aim was to demonstrate, at pre-commercial scale, cost competitive process technology to produce biobutanol from municipal solid waste (MSW) that provides significant reductions in GHG

emissions compared with first generation biofuel. MSW is one of the most attractive feedstocks for advanced biofuel production in Europe both from the perspective of costs and sustainability.

The project was to develop a tailored solution to produce glucose syrup from MSW fibre, utilising a proprietary technology currently used for the pre-treatment and fermentation of agricultural residues into ethanol. It was to produce and optimise a tailored enzyme cocktail for the production of glucose syrup at lab and pilot scale. The enzyme production process would also be optimised to demonstrate cost-effective process technology.

An advanced and proprietary fermentation process for butanol was to be applied to the pre-treated MSW at both bench and pre-commercial pilot scale, with the aim of demonstrating butanol yields comparable to those achieved using pure sugars and a three-fold increase in butanol productivity over conventional batch fermentation.

The techno/economic feasibility of blending the butanol to produce advanced biofuels (high octane ethanol and low flash point biodiesel) was to be investigated.

Progress to project close

Green Biologics (UK), carried out physical and chemical analysis of a dewatered MSW sample, provided from an external supplier. Design of Experiments (DoE) software was used to plan the experiments for optimising feedstock hydrolysis, evaluating a range of enzymes and enzyme cocktails in raw and homogenised feedstock. The experimental design was executed as planned and a final report is available.

The key finding was that 30-45% sugars (dry weight basis) were released from the pre-sorted and autoclaved MSW sample. Homogenisation offered little improvement in sugar release compared to using the raw feedstock and they identified the enzyme cocktail that provided the greatest degree of hydrolysis.

Issues contributing to project close

The Spanish companies, Abengoa Research and Abengoa Bioenergia, (one of which was the coordinator), had to withdraw from the project due to the financial situation of the Abengoa Group.

The remaining members of the consortium proposed an alternative consortium arrangement to replace the Spanish partner. However, the BESTF Management Group felt that replacement of the coordinator was a change that was too fundamental to the proposal to be agreed and so the project was closed.

1.4 The potential impact (including the socio-economic impact and the wider societal implications of the project so far) and the main dissemination activities and exploitation of results

1.4.1 Impact - socio-economic impact

1.4.1.1 BESTF2 ERA-NET Plus Impact Assessment

BESTF2 built on the results of and lessons learnt from the BESTF ERA-NET Plus. BESTF2 used the network established in BESTF and fused joint strategic planning and programming between the Member States that subscribed to enable the implementation of bioenergy demonstrations. Its outputs also influence those Member States that were not directly involved in the project, helping to bring greater alignment between their bioenergy initiatives and those of the Consortium.

The ERANET Plus action, not only facilitated the cooperation and coordination of Member States, but enabled the availability of significant funding, by combining both Member States and EC funds, in order to boost the demonstration of large Bioenergy projects and facilitate commercialization.

The funded transnational projects exemplified this achievement by realizing two demonstration size projects both with significant cost reduction results which further progressed commercialization in the sector. Project BioWaMet established two AnMBR demonstration sites, one of which retrofitted an old system based on septic tanks being the first of a kind commercial scale application of this technology. Both demonstrations for the treatment and reuse of urban wastewater have given considerable confidence to potential clients/investors. Project CoryFee demonstrated at the commercial scale of 10,000 litres fermentation that the process is technically feasible and that a positive business case for commercial 2G ethanol was established.

In addition to the funding of demonstration projects, the resultant cooperation between funding agency partners lead to the consortium members implementing further calls (without EC top up) in the BioEnergy sector which have lead to the funding of further projects. These calls fund lower TRL projects and contribute to greater knowledge and learning in the sector.

In summary the ERA-NET Plus programme achieved the following benefits:

- the leverage of funding from the EC and Member States provides a great enabler for projects to pursue the development of their innovations, which may otherwise not have taken place;
- open discussions about priority innovation areas for bioenergy, and how to address these through the BESTF programme;
- the link with the European SET Plan research and policy agenda gives the possibility of influencing the research and policy agenda;
- the co-funding approach creates unique opportunities for Member States to support more ambitious projects;
- the programme offers access to and links with a wide prestigious European network in the field of bioenergy technologies;
- collaboration between R&D and industry on a bilateral/multilateral level is supported;
- benefits from collaboration and learning from experiences of other countries;

- higher TRL levels will be achieved in the projects supported through the BESTF programme, which has helped drive technological advancements in the wider industry. This must be coupled with meeting the specific commercial drivers required for technologies to be deployed at a larger scale.

It should be noted that there was a significant reduction in projects submitted to stage 1 (38) and those selected to be evaluated at stage 2 (13). This is a reflection of the variety and complexity of national funding agency funding requirements. In order to maximize projects selected for stage 2 evaluation funding agencies taking part in future ERANETs should endeavor to keep stage 1 evaluation as simple as possible whilst adhering to national requirements.

A total of 12 projects were evaluated at stage 2 of which six were of sufficient quality to be considered for funding. The combined level of EC/MS funding was sufficient to enable all projects over the threshold to be offered funding. The lack of proposals of sufficient quality meant that there was no reserve list. In order to help promote the level of proposal quality future call for proposals could include sub topics focusing on two or three value chains rather than one general call. This may promote submission from specialist entities and thus encourage a larger number of proposals of a higher quality.

The lack of a reserve list meant that the funders were not able to offer funding to alternative projects after the initially selected projects did not proceed. A reserve list would have ensured maximization of available funds.

1.4.1.2 Transnational Projects Impact assessment

BioWaMet

The wastewater treatment sector is experiencing a process of change, from an approach where the centralised facilities are called Waste Water Treatment Plants (WWTP) to an ecocentric approach, where the wastewater is considered a physical vector containing resources to be recovered in a sustainable way. This approach means facilities are renamed as “Water Resource Recovery Facilities”. The Anaerobic Membrane Bioreactor (AnMBR) is a technology that represents a potential tool to achieve this new approach. It allows the capture of biogas as well the production of safe recycled water rich in nutrients produced by a process with much lower energy requirements than conventional treatment systems.

In order for this technique to work at low temperature with the associated potential benefits, development of energy-efficient systems to reduce the parasitic energy demands of operation are needed. One of the major energy-consuming processes associated with this technology is keeping the membranes clean so that they can operate at high rates and without fear of blockage. This happens due to the deposition of bio solids on the surface of the membrane as the treated water is filtered through, leading to a condition known as fouling.

BioWaMet via the water utility partner Aqualia, has enabled the first urban wastewater treatment plant based solely on AnMBR being built and successfully operated in Bitem (Spain). The result of the AnMBR technology proved to be competitive in economic and technical terms and is ready to penetrate the WWTP market. Importantly the project also enabled the demonstration of an innovative second AnMBR in Nigran (Spain) being used for the treatment and separation of black water. The results of this second demonstration were as positive and the first AnMBR site in Bitem.

BioWaMet also enabled the development of an installation that quantified sludge fouling potential, crucial for effective control of the sludge thus improving the potential of the AnMBR technology. The Delft filtration characterization module (DFC) installation proved to be a promising tool to develop a control strategy to optimize the performance of AnMBRs. A knowledge-based control strategy was proposed using the online filterability measurements as an input to control the sludge filterability by flux enhancer dosing. The control strategy contributed to the optimization of the membrane filtration process allowing it to stabilize and enhance the operational flux.

The projects results from the use of ultrasound to clean the bioreactor membrane showed that it was an effective method of cleaning the membrane surface, however, due to the high cost of the required ultrasonic power this could not be practically implemented for continuous operation in a submerged membrane bioreactor. The second cleaning method looked at the use of soft surface particles in hydraulic motion over the membrane surface to scour the biofilm deposited. This particle scouring strategy showed promise for further development and use in anaerobic membrane bioreactors in which the membrane is in direct contact with the biomass.

CoryFee

The project developed a yeast fermentation process for commercial production of cellulosic ethanol in which production costs are reduced. The project partners developed a cost efficient 2G ethanol fermentation process based on a flexible production strategy. The new process control method which enabled control of the feed stream allowed a semi continuous or continuous fermentation process.

A new yeast propagation procedure which allows far greater carbon source utilization of yeast biomass developed at laboratory scale was successfully transferred to the Bio Refinery Demo Plant (BDP). A significantly improved yeast economy was demonstrated as the required yeast amount per produced unit of ethanol was reduced by at least 80%. The necessary fermentation tank volume for finished production from a given biomass quantity per time was also considerably reduced, resulting in a 50 % reduction in size.

A case for CAPEX reduction was achieved as a result of the implementation of process changes. The CoryFee concept was demonstrated in BDP performance trials where an investment reduction of around 50% was achieved when compared to conventional yeast fermentation processes. The laboratory scale results were shown to be transferable to near industrial scale, and the OPEX cost savings were primarily as a result of the significantly lower yeast requirements.

The refractive index (RI) instrument was successfully trialled in the laboratory then installed and tested in the BDP where it was found to be highly suitable for process control. It is of utmost importance that accurate and stable output data can be obtained in order to accurately control the fermentation process. The “sweet spot” of the fermentation process was thoroughly tested at laboratory scale and verified in the BDP during large-scale fermentation trials. The results from the near industrial scale trials closely resemble those achieved in the laboratory and proved that the “sweet spot” could be controlled at large scale.

The project developed a novel fermentation control program effecting real time feed control based on online measurements of the refractive index, and this method and process is the subject of a joint European patent application filed by Terranol and SEKAB.

1.4.2 Dissemination activities and exploitation of results

1.4.2.1 Dissemination objectives

The final objective of BESTF2 was to promote dissemination and exploitation of the ERA-Net Plus BESTF2 project and the projects it supported. This included to:

- present the ERA-Net Plus BESTF2 project to relevant national and transnational policy makers, industry, the Research and Development base and the investment and financial communities.
- highlight the interaction of the "BESTF2" project with the EIBI, the EC SET plan and other relevant initiatives.
- report on and work with all actors to deliver and facilitate learning and development on outputs and value delivered from the BESTF2 project portfolio and the processes employed in the BESTF2 ERANET Plus project

1.4.2.2 Fundamental Project outcomes

The preceeding BioEnergy ERANET BESTF ran in tandem with this ERANET and one further Bioenergy ERANET was formed being BESTF3 (ERANET Cofund). It was decided by the Management Group that the most efficient and effective method of dissemination would be to align all BESTF dissemination activities. This has worked well enabling the dissemination of the BESTF projects as a whole to stakeholder groups.

1.4.2.3 Dissemination of BESTF model

The lessons and experiences of the BESTF and BESTF2 networks have been utilized in the subsequent BioEnergy ERANETs and BESTF3. The BESTF network also led to the formation of a separate ERANET BioEnergy network which has aligned with the BESTF programmes and has launched a succession of calls (without EC funding).

1.4.2.4 Dissemination highlights

Presentations at industry conferences and seminars

On 14th June 2017 BESTF and ERA-Net Bioenergy organised a joint seminar, together with ETIP Bioenergy entitled "Bioenergy – from research to market deployment in a European context". The seminar addressed the market deployment challenge and discussed how to bridge the gap between research, demonstration projects and industry.

The workshop was organised as a side event at the European Biomass Conference (EUBCE) in Stockholm and attracted about 50 stakeholders from research, industry and governmental organisations.

The morning session focussed on the results and main highlights of the BESTF projects. The BESTF2 projects BioWaMet, CoryFee and MSWBH along with the BESTF projects BioSNG and BioProGReSS were presented in this session. This was followed by a selection of the ERA-NET Bioenergy projects covering a broad spectrum of Technology Readiness Levels (TRL). The project coordinators gave presentations which were followed by a lively discussion with all the speakers.

During the afternoon session BESTF and ERA-Net Bioenergy joined forces with the European Technology and Innovation Platform Bioenergy (ETIP Bioenergy), the European Energy Research Alliance (EERA) Bioenergy Joint Programme, and the European Technology and Innovation Platform Renewable Heating and Cooling (ETIP RHC) to host an interactive session focussing on how to strengthen the market uptake of advanced biofuels and bioenergy under the new Strategic Energy Technology Plan (SET-Plan) Key Action 8 (Renewable fuels and bioenergy). A key conclusion was the influence of wider commercial factors, for example availability of finance often linked to investor confidence, or the cost of other forms of energy, which impact on decisions to implement commercial scale plants.

This was an ideal opportunity to join forces and showcase and promote the results so far of both BESTF and ERA-net Bioenergy to a diverse group of stakeholders including those from research, industry and government.

A presentation was given by Kees Kwant of RVO during the ETIP Bioenergy workshop entitled "Bioenergy towards 2030" on 16th May 2018 at the EUBCE 2018 in Copenhagen. The title of the presentation was: "BESTF/ERA-Net Bioenergy Joint Research and Development Projects- status and vision towards 2030" see: http://etipbioenergy.eu/bioenergy-towards-2030-etip-bioenergy-eubce-2018.

Newsletters

BESTF and ERA-NET Bioenergy have published three joint Newsletters, December 2016, October 2017 and October 2018

News from both networks was included and disseminated to the bioenergy community. A brochure entitled "Bioenergy from research to Market Deployment" was published in June 2017 to promote the results of the BESTF and BESTF2 projects so far with links to ERA-NET Bioenergy.

http://eranetbestf.eu/wp-content/uploads/2017/08/Brochure-Bioenergy-from-Research-to-Market-Deployment-in-a-European-Context-v2-web.pdf

1.4.2.5 List of dissemination activities

Table 3 below itemises the major dissemination activities which have taken place during the period of the BESTF and BESTF2 projects.

Activity	Country	Date	Stakeholder	Outcome
Report	Sweden	2012	Swedish Government	Informing the Swedish government of participation in the scheme and benefits
Tekes internet, launch event, seminars	Finland	Oct-Dec 2012	Industry and academia	Advertising the opportunity for funding
Early Market Engagement document	UK	Nov-12	Industry and academia	Document issued in UK to prepare industry for upcoming call
Webinar	UK	Dec-12	Companies	Providing orientation to companies regarding their project ideas and how to proceed
Briefing	UK	Jan-13	UK Energy Ministers	Informing UK Ministers of the scheme
BESTF information meeting	Sweden	Jan-13	Swedish industry	Informing industry of scheme and providing guidance on application and eligibility
SWEA website updates	Sweden	Jan-13	Swedish bioenergy stakeholders	Dissemination of opportunity to Swedish industry
Press release	Germany	Jan-13	German industry and bioenergy stakeholders	Informing of call launch
BESTF Presentation to EIBI team	N/A	27-Feb-13	EIBI	Update on BESTF progress
Press article in Euro Heat and Power	Germany	Mar-13	German bioenergy stakeholders	
BESTF Presentation – SET plan conference	N/A	08-May-13	EU Industry, academia and funding agencies	Update on BESTF scheme and outcomes
Attendance and presentation at ERANET SMARTGrids team meeting	N/A	12-Jun-13	EU funding agencies, ERANET community	Share best practice and lessons learned from implementing ERANET plus BESTF
Representation on panel at EIBI conference	N/A	26-Jun-13	Industry, academia and funding agencies	Answer queries on ERANET plus scheme
BESTF Presentation to EIBI team	N/A	27-Jun-13	EIBI	Update on BESTF progress
Article in ERALEARN newsletter	N/A	Sep-13	EU ERANET community	Information regarding the ERANET plus mechanism
BESTF Presentation to EIBI team	N/A	05-Nov-13	EIBI	Update on BESTF progress
Briefing	UK	Feb-14	UK Energy Ministers	Informing UK Ministers of successful projects
Activity	Country	Date	Stakeholder	Outcome

BESTF internet, Tekes internet	Finland	Mar-14	Industry and academia	Dissemination of outcomes of BESTF1, including benefits of participation in scheme for industry partners
Information meeting	Sweden	Mar-14	Swedish bioenergy stakeholders	Dissemination of results of BESTF1 and publicising future opportunities
Poster presentation – European Bioenergy Conference	N/A	26-Jun-14	All bioenergy stakeholders	Present ERANET plus best practice and results to date
Annual Report	Finland	2014	Finnish Ministry	Informing Ministry of participation and output of the scheme
Annual Report	Sweden	2014	Swedish Ministry	Informing Government of the results of the evaluation
European Bioenergy Conference	Netherlands	Jun-16	All bioenergy stakeholders	BioSNG and BioProGress presented in a parallel event
Briefing	UK	Jun-16	UK Energy Ministers	Informing UK Ministers of results of projects
BESTF Newsletter	N/A	Dec-16	All bioenergy stakeholders	Update on BESTF progress
Joint seminar with ETIP Bioenergy	Sweden	Jun-17	All bioenergy stakeholders	Seminar addressing market deployment challenges
Event brochure	N/A	Jun-17	All bioenergy stakeholders	Promoting the results of BESTF projects
Presentation	Denmark	May-18	All bioenergy stakeholders	Promoting the results of BESTF projects and the future plans
BESTF Newsletter	N/A	Nov-17	All bioenergy stakeholders	Update on BESTF progress
BESTF Newsletter	N/A	Nov-18	All bioenergy stakeholders	Update on BESTF progress

1.5 The address of the project public website as well as relevant contact details.

BESTF ERANET http://www.eranetbestf.eu

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2.1 Use and dissemination of foreground

Section A (public)

Project BioWaterMethanisation

TEMPLATE A1: LIST OF SCIENTIFIC (PEER REVIEWED) PUBLICATIONS, STARTING WITH THE MOST IMPORTANT ONES										
NO.	Title	Main author	Title of the periodical or the series	Number, date or frequency	Publisher	Place of publication	Year of publication	Relevant pages	Permanent identifiers (if available)	Is/Will open access provided to this publication?
1	*Identification of the Methanogenesis Inhibition Mechanism Using Comparative Analysis of Mathematical Models*	*M. Odriozola*	*Frontiers in Bioengineering and Biotechnology*	*No 7, May 2019*	*Frontiers Media S.A.*	Switzerland	2019	*pp. 1 - 16*	doi: 10.3389/fbioe.2019.00093	yes

Project CoryFee

TEMPLATE A1: LIST OF SCIENTIFIC (PEER REVIEWED) PUBLICATIONS, STARTING WITH THE MOST IMPORTANT ONES										
NO.	Title	Main author	Title of the periodical or the series	Number, date or frequency	Publisher	Place of publication	Year of publication	Relevant pages	Permanent identifiers (if available)	Is/Will open access provided to this publication?
1	*Optimising fermentation*	*Birgitte Rønnow*	*Biofuels International*	*Issue 3, volume 13*	*Woodcote Media Ltd.*	*UK*	*2019*	*32*		yes
2	*Injecting new life into cellulosic ethanol production*	*J.D.Knudsen*	*Biotechnology for Biofuels*	*In preparation*	*Springer*					yes

Project BioWaterMethanisation

TEMPLATE A2: LIST OF DISSEMINATION ACTIVITIES								
NO.	Type of activities	Main leader	Title	Date/ Period	Place	Type of audience	Size of audience	Countries addressed
1	*Flyers*	*FCC Aqualia*	*AnMBR: Anaerobic systems for the transformation of organic matter into methane bio-methane production from urban organic matter*	*21 September 2016*	*Online (https://www.aqualia.com/es/i-d/calidad) / paper*	*Scientific Community, Industry, Civil Society*	*1000*	*All*
2	*Flyers*	*FCC*	*AnMBR: Anaerobic systems for the*	*21*	*Online*	*Scientific Community,*	*1000*	Spain, Latin-America

		Aqualia	transformation of organic matter into methane bio-methane production from urban organic matter (in Spanish in the original)	September 2016	(https://www.aqualia.com/es/i-d/calidad) / paper	Industry, Civil Society		
3	Web (iagua.es)	FCC Aqualia	Emérita Jimenez: "If a water is treated properly, it becomes a source of resources" (in Spanish in the original)	3 October 2016	https://www.iagua.es/noticias/aqualia/16/10/03/emerita-jimenez-si-agua-se-trata-adecuadamente-se-convierte-fuente	Scientific Community, Industry, Civil Society	572	Spain, Latin-America
4	Other (youtube.com)	FCC Aqualia	Emérita Jimenez: "If a water is treated properly, it becomes a source of resources" (in Spanish in the original)	3 October 2016	Online (youtube.com)	Scientific Community, Industry, Civil Society	405	Spain, Latin-America
5	Articles published in the popular press	FCC Aqualia	Wastewater cleaning and reclamation, challenges for a sustainable future (in Spanish in the original)	22 March 2017	Tarragona (Spain)	Civil Society	92.000	Spain
6	Workshops	FCC Aqualia	Water management and circular economy	November 22th 2017	Zaragoza (Spain)	Policy makers, Scientific Community (higher education, Research)	100	Spain
7	Workshops	FCC Aqualia	Technical Course "Wastewater treatment in small villages in Aragon (Spain)",	May 22th-23th 2018	Zaragoza (Spain)	Industry, Policy makers, Scientific Community (higher education, Research)	100	Spain
8	Conferences	FCC Aqualia	LIFE MEMORY & BESTF2 BIOWAMET PROJECTS: Three AnMBR applications within urban waste waters in Atlantic, Mediterranean and continental climates. (in Spanish in the original)	28 May 2019	Barcelona (Spain)	Scientific Community	25	Spain
9	Conferences	FCC Aqualia	AnMBR: Evaluation of three membranes and three substrates.	23-27 June 2019	Delft (Netherlands)	Scientific Community	400	All
10	Conferences	FCC Aqualia	LIFE MEMORY & BESTF2 BIOWAMET PROJECTS: Three AnMBR applications within urban waste waters in Atlantic, Mediterranean and continental	12-15 November 2019 (upcoming event)	Madrid (Spain)	Scientific Community	100	Spain

			climates.					
11	Conference	TUD	European Conference on Nanotechnologies	26 February 2010				
12	Conference	TUD	12th IWA Specialized Conference on Instrumentation, Control and Automation	11-14 June 2017	Québec City, Québec, Canada	Scientific Community (higher education, Research), Industry		World wide
13	Conference	TUD	5th IWA Young Water Professionals Benelux Conference	5-7 July 2017	Ghent, Belgium	Scientific Community (higher education, Research)		The Netherlands, Belgium and Luxemburg
14	Conference	TUD	15th IWA World Congress on Anaerobic Digestion,	17-20 October 2017	Beijing, China	Scientific Community (higher education, Research)		World wide
15	Conference	TUD	12th IWA Latin American Workshop and Symposium on Anaerobic Digestion	21-24 October 2018	Medellin, Colombia	Scientific Community (higher education, Research)		Mainly Latin-American and Spain
16	Conference	TUD	16th IWA World Congress on Anaerobic Digestion	23-27 June 2019	Delft, the Netherlands	Scientific Community (higher education, Research)		World wide
17	Web	Soton	Post on BioWaMet project and collaboration with an Erasmus+ student from Universidad Autónoma de Madrid, describing design and construction of a test rig with accompanying brief video clip https://www.facebook.com/environmental.lab.university.of.southampton/posts/846347488859710	06-dic-18	Facebook	Scientific Community (higher education, Research	180+	International
18	Web	Soton	Social media post https://www.facebook.com/environmental.lab.university.of.southampton/posts/1087397181421405	04-dic-18	Facebook	Scientific Community (higher education, Research	180+	International
19	Presentation	Soton	BORRG meeting	14-nov-18	Soton	Scientific Community (higher education, Research	~20	International
20	Web	Soton	Post on R2B (EP/P032826/1) and BioWaMet (BB/M025691/1) presentations at Biogas Science 2018	09-oct-18	Facebook	Scientific Community (higher education, Research	650+	International

			https://www.facebook.com/environmental.lab.university.of.southampton/posts/979945998833191					
21	*Conference*	*Soton*	*Poster presentation by Dr Craig Dolder on project results at Biogas Science 2018*	*17-19 Sept 2018*	*Turin*	*Scientific Community (higher education, Research), Industry*	*50+*	*International*
22	*Web*	*Soton*	*Social media post on work on acoustic membrane cleaning carried out as part of BEST F2 BioWaMet and NUCE Newton Link projects. https://www.facebook.com/environmental.lab.university.of.southampton/posts/889015874592871*	*28-feb-18*	*Facebook*	*Scientific Community (higher education, Research*	*150+*	*International*
23	*Presentation*	*Soton*	*Presentations by Javier Escobar Ortiz on work carried out during Erasmus+ placements in conjunction with BioWaMet under the supervision of PDRA Dr Craig Dolder*	*29-nov-17*	*Soton*	*Scientific Community (higher education, Research*	*~30*	*International*
24	*Web*	*Soton*	*Post on a series of events involving Newton Link and BioWaMet https://www.facebook.com/environmental.lab.university.of.southampton/posts/842543949240064*	*28-nov-17*	*Facebook*	*Scientific Community (higher education, Research*	*1000+*	*International*
25	*Presentation*	*Soton*	*Presentation by Dr Craig Dolder on results of acoustic cleaning trials in BioWaMet, to Bioenergy and Organic Resources Research Group (BORRG, www.bioenergy.soton.ac.uk) plus guests and external visitors*	*11-oct-17*	*Soton*	*Scientific Community (higher education, Research*	*~25*	*International*
26	*Web*	*Soton*	*Update on activities in Newton Link, covering BioWaMet project https://www.facebook.com/environmental.lab.university.of.southampton/posts/801276116700181*	*29-ago-17*	*Facebook*	*Scientific Community (higher education, Research*	*550+*	*International*
27	*Presentation*	*Soton*	*Presentation by Dr Craig Dolder on development of acoustic cleaning system in BIOWAMET, to Bioenergy*	*21-jun-17*	*Soton*	*Scientific Community (higher education, Research*	*~25*	*International*

			and Organic Resources Research Group (BORRG, www.bioenergy.soton.ac.uk) plus guests and external visitors. Also formed part of Newton Institutional Link activities with participants from NUCE, Hanoi. Led to an increased awareness of and interest in these methods					
28	*Web*	*Soton*	*Post on ERA-Net Stockholm conference https://www.facebook.com/environmental.lab.university.of.southampton/posts/765653606929099*	*20-jun-17*	*Facebook*	*Scientific Community (higher education, Research*	*450+*	*International*
	Presentation	*Soton*	*Presentation on BioWaMet (BB/M025691/1) at ERA-Net conference*	*14-jun-17*	*Stockholm*	*Scientific Community (higher education, Research*	*~80*	*International*
29	*web*		*Information and video clip on AnMBR cleaning concepts by Dr Craig Dolder.*	*11-ene-17*	*Facebook*	*Scientific Community (higher education, Research*	*1100+*	*International*
30	*Presentation*	*Soton*	*Presentation by Dr Craig Dolder on using microcontrollers for automation, control and data acquisition in acoustic membrane cleaning; to Bioenergy and Organic Resources Research Group plus guests and external visitors*	*07-dic-16*	*Soton*	*Scientific Community (higher education, Research*	*~25*	*International*
31	*Presentation*	*Soton*	*Presentation by Dr Craig Dolder at visit to Southampton by Newton Institutional Link partners from National University of Civil Engineering in Hanoi, Vietnam*	*29-sep-16*	*Soton*	*Scientific Community (higher education, Research*	*~30*	*International*
32	*Presentation*	*Soton*	*Presentations by Prof Charles Banks and Dr Sonia Heaven to staff, students and invited industry participants in a seminar at the National University of Civil Engineering (NUCE) in Hanoi,*	*22-ago-16*	*Hanoi*	*Scientific Community (higher education, Research*	*~80*	*International*

			Vietnam. Work on BioWaMet highlighted in seminar and in subsequent meetings with industry and local organisations during a one-week visit.					
33	*Presentation*	*Soton*	*Presentation by Dr Craig Dolder on acoustic membrane cleaning techniques, to BBSRC ADnet Early Career Researchers conference. Presentation won the best-in-session. award. Information posted on Bioenergy group Facebook page viewed by over 200 people - see post 65 on 14 July 2016.*	*04-jul-16*	*Soton*	*Scientific Community (higher education, Research*	*~50*	*International*
34	*Web*	*Soton*	*Additional dissemination of workshop on in situ cleaning of membranes in AnMBR in Southampton, supported by BBSRC's ADNet.*	*28-jun-16*	*Facebook*	*Scientific Community (higher education, Research), Industry*	*700+*	*International*
35	*Workshop*	*Soton*	*Specialist workshop on cleaning anaerobic membrane bioreactors with guest talk by Prof Jaeho Bae from Korea http://anaerobicdigestionnet.com/memclean%2016.htm*	*20-jun-16*	*Soton*	*Scientific Community (higher education, Research), Industry*	*~15*	*International*
36	*Presentation*	*Soton*	*Presentation by Dr Craig Dolder to Bioenergy and Organic Resources Research Group at Southampton on using Starstream technology developed by ISVR for membrane cleaning.*	*06-jun-16*	*Soton*	*Scientific Community (higher education, Research*	*~25*	*International*
37	*Web*	*Soton*	*Post on University of Southampton Environmental Lab Facebook page about anaerobic membrane bioreactors mentions BioWaMet https://www.facebook.com/watch/?v=493401844154278*	*13-nov-15*	*Facebook*	*Scientific Community (higher education, Research*	*100+*	*International*
38	*Web*	*Soton*	*Post on Southampton Environmental Lab Facebook page about anaerobic*	*23-oct-15*	*Facebook*	*Scientific Community (higher education,*	*500+*	*International*

			membrane bioreactor workshop in TU Delft, mentioning BioWaMet https://www.facebook.com/environmental.lab.university.of.southampton/photos/a.449850248509438/488175778010218			*Research*		
39	*Web*	*Soton*	*Project webpage on Bioenergy and Organic Resources Research Group website http://www.bioenergy.soton.ac.uk/projects/BESTF2%20150921.pdf*	*21-sep-15*	*Web*	*Scientific Community (higher education, Research), Industry*	*n/a*	*International*
40	*Workshop*	*Aqualia*	*Workshop and brainstorming session on different designs for Anaerobic Membrane bioreactors and implications for pilot-scale design and operation with participants from Spain, UK, Netherlands*	*07-jun-15*	*Washington DC*	*Scientific Community (higher education, Research), Industry*	*~10*	*International*
41	*Web (Twitter)*	*Aqualia*	*Presenting 3 @aqualia AnMBR experiences in #AD16 conference. @RUN4LIFE_H2020, @LifeMethamorph and Biowamet projects. Thank you team!*	*26-jun-19*	*Web*	*Scientific Community (higher education, Research), Industry*	*n/a*	*International*

Project CoryFee

TEMPLATE A2: LIST OF DISSEMINATION ACTIVITIES								
NO.	Type of activities	Main leader	Title	Date/Period	Place	Type of audience	Size of audience	Countries addressed
1	*Seminar*	*B.Rønnow*	*Bioenergy – from Research to Market Deployment in a European Context*	*14 June 2017*	*Stockholm, Sweden*	*Selected members from bioenergy sector*	*30-40*	*EU*
2	*Conference*	*J.D.Knudsen*	*Reducing the fermentation costs for lignocellulosic ethanol production bu closing the gap between fed-batch and continuous fermentation*	*1 May 2018*	*Florida, USA*	*Scientific community, Industry*	*30-50*	*EU and North America*
3	*Conference*	*J.D.Knudsen*	*Injecting new life into cellulosic ethanol production*	*11 June 2019*	*Indiana, USA*	*Scientific community, Industry*	*30-50*	*EU and North America*
4	*Press release*	*Terranol A/ & SEKAB E-technology AB*	*Cooperation –Production Efficiency 2Gen Ethanol*	*6 May 2015*	*http://www.sekab.com/about-us/cooperation-partners/collaboration-2gen-ethanol/*			

5	*BESTF3 Final forum Conference*	*B.Rønnow*	*TBD*	*21 November 2019*	*Brussels, Belgium*	*Selected members from bioenergy sector*	

Project MSWBH

TEMPLATE A2: LIST OF DISSEMINATION ACTIVITIES								
NO.	Type of activities	Main leader	Title	Date/Period	Place	Type of audience	Size of audience	Countries addressed
1	*Conference*	*Bio-Renewables Development Centre, University of York*	*EUCB Conference*	*June 2017*	*Stockholm*	*University and Industry researchers working on bio-energy.*	*+100*	Pan European

Section B (relevant for project CoryFee only)

Part B1

TEMPLATE B1: LIST OF APPLICATIONS FOR PATENTS, TRADEMARKS, REGISTERED DESIGNS, ETC.					
Type of IP Rights	Confidential Click on YES/NO	Foreseen embargo date dd/mm/yyyy	Application reference(s) (e.g. EP123456)	Subject or title of application	Applicant (s) (as on the application)
Patent application	No		PCT/EP2019/060706	Process and system for microbial fermentation	SEKAB E-technology AB & Terranol A/S

Part B2

Type of Exploitable Foreground	Description of exploitable foreground	Confidential Click on YES/NO	Foreseen embargo date dd/mm/yyyy	Exploitable product(s) or measure(s)	Sector(s) of application	Timetable, commercial or any other use	Patents or other IPR exploitation (licences)	Owner & Other Beneficiary(s) involved
Commercial exploitation of R&D results	*Process and system for microbial fermentation*	*No*		*Fermentation system*	*1.Fermentation industry 2. Ethanol production*	*2019*	*A patent application has been submitted*	*SEKAB E-Technology AB and Terranol A/S*

The purpose was to reduce production costs of cellulosic ethanol by combining respective technologies of the partners. An efficient pre-treatment and enzymatic hydrolysis process, developed by SEKAB E-Technology AB, in combination with strategies for (partially) continued fermentation of hydrolyzed biomass, using yeast strains developed by Terranol A/S, have been further refined, upscaled and successfully demonstrated in the Biorefinery Demo Plant (BDP) in Örnsköldsvik, Sweden, managed by RISE and operated by SEKAB.

The results in 10.000L scale are in accordance with results obtained in 2L laboratory scale. The objectives concerning robust online feed control, improved operating economics and reduced investments costs have been achieved and demonstrated for the overall process; there is a significantly improved yeast economy and the necessary fermentation tank volume for finished production from given biomass quantity per time is also considerably reduced.

The method and process have been the subject of a joint patent application filed by Terranol and SEKAB with the title “Process and System for Microbial Fermentation”.

The technology verified in the project is directly targeted to bioethanol plant construction or modernization projects, and thus impacts the needs of the fuel bioethanol market. It has the potential to become the primary technology used in this market, therefore representing a sizeable business opportunity.

The partners have formed a strong consortium that has the competencies, personnel and equipment, which provides promise of a low risk transfer to commercial scale. First attempts to commercialize the developed concept has begun with an existing 2G bioethanol producer as well as a Scandinavian energy company, of which the latter is planning a 2G 60 000 m^3 bioethanol factory to be operational in 2021. Marketing of the CoRyFee concept directed to potential customers has thus already been initiated and search for further potential customers is ongoing, without limiting the use of this fermentation concept for 2G bioethanol production.

3.1 Report on societal implications

Project BioWaterMethanisation

A General Information *(completed automatically when **Grant Agreement number** is entered.*

Grant Agreement Number:	IDI-20150204
Title of Project:	BIO-WATER-METHANISATION
Name and Title of Coordinator:	FCC AQUALIA, S.A.

B Ethics

1. Did your project undergo an Ethics Review (and/or Screening)? • If Yes: have you described the progress of compliance with the relevant Ethics Review/Screening Requirements in the frame of the periodic/final project reports? Special Reminder: the progress of compliance with the Ethics Review/Screening Requirements should be described in the Period/Final Project Reports under the Section 3.2.2 *'Work Progress and Achievements'*	***No***
2. Please indicate whether your project involved any of the following issues (tick box) :	***YES***
RESEARCH ON HUMANS	
• Did the project involve children?	NO
• Did the project involve patients?	NO
• Did the project involve persons not able to give consent?	NO
• Did the project involve adult healthy volunteers?	NO
• Did the project involve Human genetic material?	NO
• Did the project involve Human biological samples?	NO
• Did the project involve Human data collection?	NO
RESEARCH ON HUMAN EMBRYO/FOETUS	
• Did the project involve Human Embryos?	NO
• Did the project involve Human Foetal Tissue / Cells?	NO
• Did the project involve Human Embryonic Stem Cells (hESCs)?	NO
• Did the project on human Embryonic Stem Cells involve cells in culture?	NO
• Did the project on human Embryonic Stem Cells involve the derivation of cells from Embryos?	NO
PRIVACY	
• Did the project involve processing of genetic information or personal data (eg. health, sexual lifestyle, ethnicity, political opinion, religious or philosophical conviction)?	NO
• Did the project involve tracking the location or observation of people?	NO
RESEARCH ON ANIMALS	
• Did the project involve research on animals?	NO
• Were those animals transgenic small laboratory animals?	NO
• Were those animals transgenic farm animals?	NO
• Were those animals cloned farm animals?	NO
• Were those animals non-human primates?	NO
RESEARCH INVOLVING DEVELOPING COUNTRIES	

• Did the project involve the use of local resources (genetic, animal, plant etc)?	NO
• Was the project of benefit to local community (capacity building, access to healthcare, education etc)?	NO
DUAL USE	
• Research having direct military use	NO
• Research having the potential for terrorist abuse	NO

C Workforce Statistics

3. Workforce statistics for the project: Please indicate in the table below the number of people who worked on the project (on a headcount basis).

Type of Position	Number of Women	Number of Men
Scientific Coordinator	0	3
Work package leaders	2	5
Experienced researchers (i.e. PhD holders)	1	1
PhD Students	1	2
Other	12	13

4. How many additional researchers (in companies and universities) were recruited specifically for this project?	**4**
Of which, indicate the number of men:	1

D Gender Aspects

5. Did you carry out specific Gender Equality Actions under the project?

- ○ Yes
- ⦿ No

6. Which of the following actions did you carry out and how effective were they?

	Not at all effective				Very effective
❑ Design and implement an equal opportunity policy	○	○	○	○	○
❑ Set targets to achieve a gender balance in the workforce	○	○	○	○	○
❑ Organise conferences and workshops on gender	○	○	○	○	○
❑ Actions to improve work-life balance	○	○	○	○	○

○ Other: None

7. Was there a gender dimension associated with the research content – i.e. wherever people were the focus of the research as, for example, consumers, users, patients or in trials, was the issue of gender considered and addressed?

- ○ Yes- please specify
- ⦿ No

E Synergies with Science Education

8. Did your project involve working with students and/or school pupils (e.g. open days, participation in science festivals and events, prizes/competitions or joint projects)?

- ⦿ Yes- please specify: "EU in my region" programm. Road trip. http://run4life-project.eu/2018/06/28/road-trip-project-atlantic-route-visited-vigo-demosite/
- ○ No

9. Did the project generate any science education material (e.g. kits, websites, explanatory booklets, DVDs)?

- ○ Yes- please specify
- ⦿ No

F Interdisciplinarity

10. Which disciplines (see list below) are involved in your project?

- ⦿ Main discipline[1]: 2.3. Other engineering sciences
- ⦿ Associated discipline[1]: 1.5 Biological sciences
- ○ Associated discipline[1]:

G Engaging with Civil society and policy makers

11a Did your project engage with societal actors beyond the research community? *(if 'No', go to Question 14)*

- ○ Yes
- ⦿ No

11b If yes, did you engage with citizens (citizens' panels / juries) or organised civil society (NGOs, patients' groups etc.)?

- ⦿ No
- ○ Yes- in determining what research should be performed
- ○ Yes - in implementing the research

[1] Insert number from list below (Frascati Manual).

○ Yes, in communicating /disseminating / using the results of the project		
11c In doing so, did your project involve actors whose role is mainly to organise the dialogue with citizens and organised civil society (e.g. professional mediator; communication company, science museums)?	○ ⦿	Yes No

12. Did you engage with government / public bodies or policy makers (including international organisations)

- ○ No
- ○ Yes- in framing the research agenda
- ⦿ Yes - in implementing the research agenda
- ○ Yes, in communicating /disseminating / using the results of the project

13a Will the project generate outputs (expertise or scientific advice) which could be used by policy makers?

- ○ Yes – as a **primary** objective (please indicate areas below- multiple answers possible)
- ⦿ Yes – as a **secondary** objective (please indicate areas below - multiple answer possible)
- ○ No

13b If Yes, in which fields?

Agriculture Audiovisual and Media Budget Competition Consumers Culture Customs Development Economic and Monetary Affairs Education, Training, Youth Employment and Social Affairs		Energy Enlargement Enterprise **Environment** External Relations External Trade Fisheries and Maritime Affairs Food Safety Foreign and Security Policy Fraud Humanitarian aid		Human rights Information Society Institutional affairs Internal Market Justice, freedom and security Public Health Regional Policy **Research and Innovation** Space Taxation Transport	

13c If Yes, at which level?

- ⦿ Local / regional levels
- ○ National level
- ○ European level
- ○ International level

H Use and dissemination

14. How many Articles were published/accepted for publication in peer-reviewed journals?	**1**
To how many of these is open access[2] provided?	**1**
How many of these are published in open access journals?	**0**
How many of these are published in open repositories?	**0**
To how many of these is open access not provided?	**0**
Please check all applicable reasons for not providing open access:	
❑ publisher's licensing agreement would not permit publishing in a repository ❑ no suitable repository available ❑ no suitable open access journal available ❑ no funds available to publish in an open access journal ❑ lack of time and resources ❑ lack of information on open access ❑ other[3]: ……	

15. How many new patent applications ('priority filings') have been made? *("Technologically unique": multiple applications for the same invention in different jurisdictions should be counted as just one application of grant).*		**0**
16. Indicate how many of the following Intellectual Property Rights were applied for (give number in each box).	Trademark	**0**
	Registered design	**0**
	Other	**0**
17. How many spin-off companies were created / are planned as a direct result of the project?		**0**
Indicate the approximate number of additional jobs in these companies:		**0**

18. Please indicate whether your project has a potential impact on employment, in comparison with the situation before your project:

❑	Increase in employment, or	❑	In small & medium-sized enterprises
☒	Safeguard employment, or	❑	In large companies
❑	Decrease in employment,	☒	None of the above / not relevant to the project
❑	Difficult to estimate / not possible to quantify		

[2] Open Access is defined as free of charge access for anyone via Internet.
[3] For instance: classification for security project.

19. For your project partnership please estimate the employment effect resulting directly from your participation in Full Time Equivalent (*FTE = one person working fulltime for a year*) jobs:	*Indicate figure:*
Difficult to estimate / not possible to quantify	☒

I Media and Communication to the general public

20. As part of the project, were any of the beneficiaries professionals in communication or media relations?

○ Yes ⦿ No

21. As part of the project, have any beneficiaries received professional media / communication training / advice to improve communication with the general public?

○ Yes ⦿ No

22 Which of the following have been used to communicate information about your project to the general public, or have resulted from your project?

☒	Press Release	☒	Coverage in specialist press
❑	Media briefing	❑	Coverage in general (non-specialist) press
❑	TV coverage / report	❑	Coverage in national press
❑	Radio coverage / report	❑	Coverage in international press
❑	Brochures /posters / flyers	☒	Website for the general public / internet
❑	DVD /Film /Multimedia	☒	Event targeting general public (festival, conference, exhibition, science café)

23 In which languages are the information products for the general public produced?

☒	Language of the coordinator	☒	English
☒	Other language(s)		

Project CoryFee

A General Information *(completed automatically when **Grant Agreement number** is entered.*

Grant Agreement Number:	CoRyFee
Title of Project:	Cost Reduction in Yeast Fermentation for Commercial Production of Cellulosic Ethanol
Name and Title of Coordinator:	Birgitte Rønnow, CEO

B Ethics

1. Did your project undergo an Ethics Review (and/or Screening)? • If Yes: have you described the progress of compliance with the relevant Ethics Review/Screening Requirements in the frame of the periodic/final project reports? Special Reminder: the progress of compliance with the Ethics Review/Screening Requirements should be described in the Period/Final Project Reports under the Section 3.2.2 *'Work Progress and Achievements'*	***No***
2. Please indicate whether your project involved any of the following issues (tick box) :	***YES***
RESEARCH ON HUMANS	
• Did the project involve children?	No
• Did the project involve patients?	No
• Did the project involve persons not able to give consent?	No
• Did the project involve adult healthy volunteers?	No
• Did the project involve Human genetic material?	No
• Did the project involve Human biological samples?	No
• Did the project involve Human data collection?	No
RESEARCH ON HUMAN EMBRYO/FOETUS	
• Did the project involve Human Embryos?	No
• Did the project involve Human Foetal Tissue / Cells?	No
• Did the project involve Human Embryonic Stem Cells (hESCs)?	No
• Did the project on human Embryonic Stem Cells involve cells in culture?	No
• Did the project on human Embryonic Stem Cells involve the derivation of cells from Embryos?	No
PRIVACY	
• Did the project involve processing of genetic information or personal data (eg. health, sexual lifestyle, ethnicity, political opinion, religious or philosophical conviction)?	No
• Did the project involve tracking the location or observation of people?	No
RESEARCH ON ANIMALS	
• Did the project involve research on animals?	No
• Were those animals transgenic small laboratory animals?	No
• Were those animals transgenic farm animals?	No
• Were those animals cloned farm animals?	No
• Were those animals non-human primates?	No
RESEARCH INVOLVING DEVELOPING COUNTRIES	
• Did the project involve the use of local resources (genetic, animal, plant etc)?	No
• Was the project of benefit to local community (capacity building, access to healthcare, education	No

etc)?	
DUAL USE	
• Research having direct military use	No
• Research having the potential for terrorist abuse	No

C Workforce Statistics

3. Workforce statistics for the project: Please indicate in the table below the number of people who worked on the project (on a headcount basis).

Type of Position	Number of Women	Number of Men
Scientific Coordinator	1	
Work package leaders	1	3
Experienced researchers (i.e. PhD holders)	1	4
PhD Students		
Other		

4. How many additional researchers (in companies and universities) were recruited specifically for this project?	**0**
Of which, indicate the number of men:	

D Gender Aspects

5. Did you carry out specific Gender Equality Actions under the project?	○ Yes X No	

6. Which of the following actions did you carry out and how effective were they?

	Not at all effective				Very effective
❑ Design and implement an equal opportunity policy	○	○	○	○	○
❑ Set targets to achieve a gender balance in the workforce	○	○	○	○	○
❑ Organise conferences and workshops on gender	○	○	○	○	○
❑ Actions to improve work-life balance	○	○	○	○	○

○ Other:

7. Was there a gender dimension associated with the research content – i.e. wherever people were the focus of the research as, for example, consumers, users, patients or in trials, was the issue of gender considered and addressed?

○ Yes- please specify

X No

E Synergies with Science Education

8. Did your project involve working with students and/or school pupils (e.g. open days, participation in science festivals and events, prizes/competitions or joint projects)?

○ Yes- please specify

X No

9. Did the project generate any science education material (e.g. kits, websites, explanatory booklets, DVDs)?

○ Yes- please specify

X No

F Interdisciplinarity

10. Which disciplines (see list below) are involved in your project?

○ Main discipline[4]: 1

○ Associated discipline[1]: 1.5 | ○ Associated discipline[1]:

G Engaging with Civil society and policy makers

11a Did your project engage with societal actors beyond the research community? *(if 'No', go to Question 14)*	○ Yes X No	

[4] Insert number from list below (Frascati Manual).

11b If yes, did you engage with citizens (citizens' panels / juries) or organised civil society (NGOs, patients' groups etc.)?

X No

○ Yes- in determining what research should be performed
○ Yes - in implementing the research
○ Yes, in communicating /disseminating / using the results of the project

11c In doing so, did your project involve actors whose role is mainly to organise the dialogue with citizens and organised civil society (e.g. professional mediator; communication company, science museums)?	○ ○	Yes No

12. Did you engage with government / public bodies or policy makers (including international organisations)

x No

○ Yes- in framing the research agenda
○ Yes - in implementing the research agenda
○ Yes, in communicating /disseminating / using the results of the project

13a Will the project generate outputs (expertise or scientific advice) which could be used by policy makers?

X Yes – as a **primary** objective (please indicate areas below- multiple answers possible)

○ Yes – as a **secondary** objective (please indicate areas below - multiple answer possible)
○ No

13b If Yes, in which fields?

Agriculture Audiovisual and Media Budget Competition Consumers Culture Customs Development Economic and Monetary Affairs Education, Training, Youth Employment and Social Affairs		Energy Enlargement Enterprise Environment External Relations External Trade Fisheries and Maritime Affairs Food Safety Foreign and Security Policy Fraud Humanitarian aid	x	Human rights Information Society Institutional affairs Internal Market Justice, freedom and security Public Health Regional Policy Research and Innovation Space Taxation Transport	x

13c If Yes, at which level?

- ○ Local / regional levels
- ○ National level
- ○ European level
- x International level

H Use and dissemination

14. How many Articles were published/accepted for publication in peer-reviewed journals?	**0**
To how many of these is open access[5] provided?	
How many of these are published in open access journals?	
How many of these are published in open repositories?	
To how many of these is open access not provided?	
Please check all applicable reasons for not providing open access:	
❑ publisher's licensing agreement would not permit publishing in a repository ❑ no suitable repository available ❑ no suitable open access journal available ❑ no funds available to publish in an open access journal ❑ lack of time and resources ❑ lack of information on open access ❑ other[6]: ……	

15. How many new patent applications ('priority filings') have been made? *("Technologically unique": multiple applications for the same invention in different jurisdictions should be counted as just one application of grant).*		**1**
16. Indicate how many of the following Intellectual Property Rights were applied for (give number in each box).	Trademark	
	Registered design	
	Other	**1**
17. How many spin-off companies were created / are planned as a direct result of the project?		**0**
Indicate the approximate number of additional jobs in these companies:		

18. Please indicate whether your project has a potential impact on employment, in comparison with the situation before your project:

X	Increase in employment, or	❑	In small & medium-sized enterprises
❑	Safeguard employment, or	❑	In large companies
❑	Decrease in employment,	❑	None of the above / not relevant to the project
❑	Difficult to estimate / not possible to quantify		

[5] Open Access is defined as free of charge access for anyone via Internet.
[6] For instance: classification for security project.

19. For your project partnership please estimate the employment effect resulting directly from your participation in Full Time Equivalent (*FTE = one person working fulltime for a year*) jobs:	*Indicate figure:*
Difficult to estimate / not possible to quantify	x

I Media and Communication to the general public

20. As part of the project, were any of the beneficiaries professionals in communication or media relations?

○ Yes X No

21. As part of the project, have any beneficiaries received professional media / communication training / advice to improve communication with the general public?

○ Yes X No

22 Which of the following have been used to communicate information about your project to the general public, or have resulted from your project?

X	Press Release	x	Coverage in specialist press
❑	Media briefing	❑	Coverage in general (non-specialist) press
❑	TV coverage / report	❑	Coverage in national press
❑	Radio coverage / report	❑	Coverage in international press
X	Brochures /posters / flyers	❑	Website for the general public / internet
❑	DVD /Film /Multimedia	X	Event targeting general public (festival, conference, exhibition, science café)

23 In which languages are the information products for the general public produced?

❑	Language of the coordinator	X	English
❑	Other language(s)		

Project MSWBH

A General Information *(completed automatically when **Grant Agreement number** is entered.*

Grant Agreement Number:	620103
Title of Project:	MSWBH
Name and Title of Coordinator:	Peter Metcalf, R&D Director, Wilson Bio-Chemical Ltd

B Ethics

1. Did your project undergo an Ethics Review (and/or Screening)? • If Yes: have you described the progress of compliance with the relevant Ethics Review/Screening Requirements in the frame of the periodic/final project reports? Special Reminder: the progress of compliance with the Ethics Review/Screening Requirements should be described in the Period/Final Project Reports under the Section 3.2.2 *'Work Progress and Achievements'*	***NO***
2. Please indicate whether your project involved any of the following issues (tick box) :	
RESEARCH ON HUMANS	
• Did the project involve children?	No
• Did the project involve patients?	No
• Did the project involve persons not able to give consent?	No
• Did the project involve adult healthy volunteers?	No
• Did the project involve Human genetic material?	No
• Did the project involve Human biological samples?	No
• Did the project involve Human data collection?	No
RESEARCH ON HUMAN EMBRYO/FOETUS	
• Did the project involve Human Embryos?	No
• Did the project involve Human Foetal Tissue / Cells?	No
• Did the project involve Human Embryonic Stem Cells (hESCs)?	No
• Did the project on human Embryonic Stem Cells involve cells in culture?	No
• Did the project on human Embryonic Stem Cells involve the derivation of cells from Embryos?	No
PRIVACY	
• Did the project involve processing of genetic information or personal data (eg. health, sexual lifestyle, ethnicity, political opinion, religious or philosophical conviction)?	No
• Did the project involve tracking the location or observation of people?	No
RESEARCH ON ANIMALS	
• Did the project involve research on animals?	No
• Were those animals transgenic small laboratory animals?	No
• Were those animals transgenic farm animals?	No
• Were those animals cloned farm animals?	No
• Were those animals non-human primates?	No
RESEARCH INVOLVING DEVELOPING COUNTRIES	
• Did the project involve the use of local resources (genetic, animal, plant etc)?	**No**
• Was the project of benefit to local community (capacity building, access to healthcare, education etc)?	**No**
DUAL USE	

• Research having direct military use	No
• Research having the potential for terrorist abuse	No

C Workforce Statistics

3. Workforce statistics for the project: Please indicate in the table below the number of people who worked on the project (on a headcount basis).

Type of Position	Number of Women	Number of Men
Scientific Coordinator	1	3
Work package leaders	1	5
Experienced researchers (i.e. PhD holders)	3	4
PhD Students		
Other		

4. How many additional researchers (in companies and universities) were recruited specifically for this project?	**2**
Of which, indicate the number of men:	1

D Gender Aspects

5. Did you carry out specific Gender Equality Actions under the project?	X	No

6. Which of the following actions did you carry out and how effective were they?

	Not at all effective				Very effective
❑ Design and implement an equal opportunity policy	○	○	○	○	○
❑ Set targets to achieve a gender balance in the workforce	○	○	○	○	○
❑ Organise conferences and workshops on gender	○	○	○	○	○
❑ Actions to improve work-life balance	○	○	○	○	○

○ Other:

7. Was there a gender dimension associated with the research content – i.e. wherever people were the focus of the research as, for example, consumers, users, patients or in trials, was the issue of gender considered and addressed?

X No

E Synergies with Science Education

8. Did your project involve working with students and/or school pupils (e.g. open days, participation in science festivals and events, prizes/competitions or joint projects)?

X No

9. Did the project generate any science education material (e.g. kits, websites, explanatory booklets, DVDs)?

X No

F Interdisciplinarity

10. Which disciplines (see list below) are involved in your project?

1.5 Main discipline[7]:

2.3 Associated discipline[1]: | 5.4 Associated discipline[1]:

G Engaging with Civil society and policy makers

11a Did your project engage with societal actors beyond the research community? *(if 'No', go to Question 14)*	X	No

11b If yes, did you engage with citizens (citizens' panels / juries) or organised civil society (NGOs, patients' groups etc.)?

○ No

○ Yes- in determining what research should be performed

○ Yes - in implementing the research

[7] Insert number from list below (Frascati Manual).

○ Yes, in communicating /disseminating / using the results of the project		
11c In doing so, did your project involve actors whose role is mainly to organise the dialogue with citizens and organised civil society (e.g. professional mediator; communication company, science museums)?	○ ○	Yes No

12. Did you engage with government / public bodies or policy makers (including international organisations)

- ○ No
- ○ Yes- in framing the research agenda
- ○ Yes - in implementing the research agenda
- ○ Yes, in communicating /disseminating / using the results of the project

13a Will the project generate outputs (expertise or scientific advice) which could be used by policy makers?

- ○ Yes – as a **primary** objective (please indicate areas below- multiple answers possible)
- ○ Yes – as a **secondary** objective (please indicate areas below - multiple answer possible)
- ○ No

13b If Yes, in which fields?

Agriculture Audiovisual and Media Budget Competition Consumers Culture Customs Development Economic and Monetary Affairs Education, Training, Youth Employment and Social Affairs		Energy Enlargement Enterprise Environment External Relations External Trade Fisheries and Maritime Affairs Food Safety Foreign and Security Policy Fraud Humanitarian aid		Human rights Information Society Institutional affairs Internal Market Justice, freedom and security Public Health Regional Policy Research and Innovation Space Taxation Transport	

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- ○ Local / regional levels
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- ○ International level

H Use and dissemination

14. How many Articles were published/accepted for publication in peer-reviewed journals?	**1**
To how many of these is open access[8] provided?	**1**
How many of these are published in open access journals?	**1 (Green Open Access)**
How many of these are published in open repositories?	**1**
To how many of these is open access not provided?	
Please check all applicable reasons for not providing open access:	
❑ publisher's licensing agreement would not permit publishing in a repository ❑ no suitable repository available ❑ no suitable open access journal available ❑ no funds available to publish in an open access journal ❑ lack of time and resources ❑ lack of information on open access ❑ other[9]: ……	

15. How many new patent applications ('priority filings') have been made? *("Technologically unique": multiple applications for the same invention in different jurisdictions should be counted as just one application of grant).*		**0**
16. Indicate how many of the following Intellectual Property Rights were applied for (give number in each box).	Trademark	**0**
	Registered design	**0**
	Other	**0**
17. How many spin-off companies were created / are planned as a direct result of the project?		**0**
Indicate the approximate number of additional jobs in these companies:		

18. Please indicate whether your project has a potential impact on employment, in comparison with the situation before your project:

X	Increase in employment, or	X	In small & medium-sized enterprises
❑	Safeguard employment, or	X	In large companies
❑	Decrease in employment,	❑	None of the above / not relevant to the project
x	Difficult to estimate / not possible to quantify		

[8] Open Access is defined as free of charge access for anyone via Internet.
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19. For your project partnership please estimate the employment effect resulting directly from your participation in Full Time Equivalent (*FTE = one person working fulltime for a year*) jobs:	*Indicate figure:*
	o
Difficult to estimate / not possible to quantify	X

I Media and Communication to the general public

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X No

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23 In which languages are the information products for the general public produced?

❑	Language of the coordinator	❑	English
❑	Other language(s)		

***Question F-10*:** Classification of Scientific Disciplines according to the Frascati Manual 2002 (Proposed Standard Practice for Surveys on Research and Experimental Development, OECD 2002):

FIELDS OF SCIENCE AND TECHNOLOGY

1. NATURAL SCIENCES

1.1 Mathematics and computer sciences [mathematics and other allied fields: computer sciences and other allied subjects (software development only; hardware development should be classified in the engineering fields)]

1.2 Physical sciences (astronomy and space sciences, physics and other allied subjects)

1.3 Chemical sciences (chemistry, other allied subjects)

1.4 Earth and related environmental sciences (geology, geophysics, mineralogy, physical geography and other geosciences, meteorology and other atmospheric sciences including climatic research, oceanography, vulcanology, palaeoecology, other allied sciences)

1.5 Biological sciences (biology, botany, bacteriology, microbiology, zoology, entomology, genetics, biochemistry, biophysics, other allied sciences, excluding clinical and veterinary sciences)

2 ENGINEERING AND TECHNOLOGY

2.1 Civil engineering (architecture engineering, building science and engineering, construction engineering, municipal and structural engineering and other allied subjects)
2.2 Electrical engineering, electronics [electrical engineering, electronics, communication engineering and systems, computer engineering (hardware only) and other allied subjects]
2.3. Other engineering sciences (such as chemical, aeronautical and space, mechanical, metallurgical and materials engineering, and their specialised subdivisions; forest products; applied sciences such as geodesy, industrial chemistry, etc.; the science and technology of food production; specialised technologies of interdisciplinary fields, e.g. systems analysis, metallurgy, mining, textile technology and other applied subjects)

3. MEDICAL SCIENCES
3.1 Basic medicine (anatomy, cytology, physiology, genetics, pharmacy, pharmacology, toxicology, immunology and immunohaematology, clinical chemistry, clinical microbiology, pathology)
3.2 Clinical medicine (anaesthesiology, paediatrics, obstetrics and gynaecology, internal medicine, surgery, dentistry, neurology, psychiatry, radiology, therapeutics, otorhinolaryngology, ophthalmology)
3.3 Health sciences (public health services, social medicine, hygiene, nursing, epidemiology)

4. AGRICULTURAL SCIENCES
4.1 Agriculture, forestry, fisheries and allied sciences (agronomy, animal husbandry, fisheries, forestry, horticulture, other allied subjects)
4.2 Veterinary medicine

5. SOCIAL SCIENCES
5.1 Psychology
5.2 Economics
5.3 Educational sciences (education and training and other allied subjects)
5.4 Other social sciences [anthropology (social and cultural) and ethnology, demography, geography (human, economic and social), town and country planning, management, law, linguistics, political sciences, sociology, organisation and methods, miscellaneous social sciences and interdisciplinary , methodological and historical S1T activities relating to subjects in this group. Physical anthropology, physical geography and psychophysiology should normally be classified with the natural sciences].

6. HUMANITIES
6.1 History (history, prehistory and history, together with auxiliary historical disciplines such as archaeology, numismatics, palaeography, genealogy, etc.)
6.2 Languages and literature (ancient and modern)
6.3 Other humanities [philosophy (including the history of science and technology) arts, history of art, art criticism, painting, sculpture, musicology, dramatic art excluding artistic "research" of any kind, religion, theology, other fields and subjects pertaining to the humanities, methodological, historical and other S1T activities relating to the subjects in this group]