AQUASEF

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AQUASEF TECHNICAL REPORT

"ENVIRONMENTAL IMPROVEMENT IN AQUACULTURE ACTIVITIES THROUGH THE DEVELOPMENT OF ECO-EFFICIENT TECHNOLOGIES"

www.aquasef.com

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AQUASEF

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1 PROJECT
GENERAL OVERVIEW

ABOUT AQUASEF

The **"Environmental improvement in aquaculture activities through the development of eco-efficient technologies (AQUASEF)"** project aims at demonstrating, promoting and disseminating innovative, efficient and low-emission technologies and best practices to implement in the aquaculture sector in the European Union. The project addresses measures reducing both the installation energy dependency and the oxygen dependency of tanks supply, as well as effluents treatment techniques and CO2 fixation (via the cultivation of micro-algae), reducing the impact in the environment.

Briefly, this project intends to reduce the carbon print generated and to improve the effluent water quality through the implementation of clean and innovative technologies, improving the global methods for environmental sustainability in the salt water fishes and molluscs growing process.

For this purpose, a series of prototypes have been designed, produced and installed in an aquaculture site (Esteros de Canela S.A.) in order to prove the efficiency and profitability of these. Below, the technical features of these prototypes are introduced, as well as the improvements and energy savings implying their installation.

2

TECHNICAL SPECIFICATIONS OF THE DESIGNED PROTOTYPES

2.1.

Diffuser for fries´ tanks by MicroBTech (D&BTech)

2.2.

Fan device for ponds via O2BTech (D&BTech)

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Open tank for micro-algae cultivation (D&BTech)

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2.1
DIFFUSER FOR FRIES´ TANKS BY MICROBTECH (D&BTech)

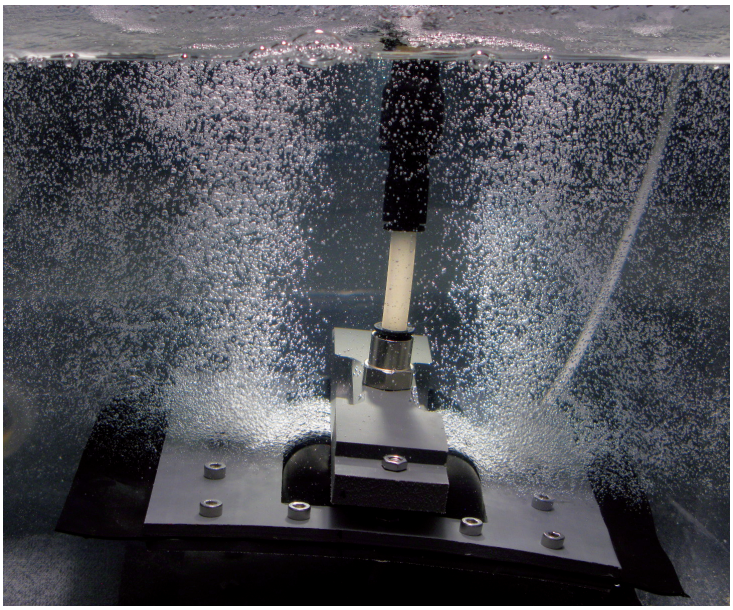

Figure 1. Cross-flow diffuser for generation of micro bubbles (Source: D&BTech)

Description:

Device generating micro air inside fries´ tanks.

Technical features:

The diffuser allows to reduce the amount of oxygen lost when not dissolved in the water. The key being the bubble size, smaller than that usually set in these devices. Thus, bubbles get almost completely dissolved when going up within the fries´ tanks (nurseries), representing high costs savings.

The device designed is able to create varying bubbles sizes (between 100 and 2000 micron) depending on the liquid

and gas flows. The liquid used as a driving fluid may come from an external source or recirculated from the fries´ tank itself. The necessary pressure in the gas line to achieve the mentioned flows is within the range between 100 mbar to 1 bar in relation to the diffuser release pressure. On the other hand, the gas supply pressure shall not exceed, in any case, the amount of pressure at the diffuser´s output point plus 1.2 bar, representing the maximal operational limit of gas pressure.

Costs comparison:

Nursery
Alevin tanks

Current diffuser: porous hose	
Cost per tank	10 €
Maintenance per tank (monthly)	14 € (20 minutes weekly)
Duration (months)	6
Number of tanks in use (average)	25
kg of O_2 nursery	15.800 (1,7 M fishes/year)
O_2 total cost	2.841 € (0,179 €/kg O2)
Yearly cost oxygen + diffusers	7.541 €
Diffuser developed: MicroBTech	
Cost per tank	150 €
Maintenance per tank (monthly)	0€
Duration (months)	72 (6 years)
Number of tanks in use (average)	25
kg of O_2 nursery	15.800 (1,7 M fishes/year)
O_2 total cost	2.841 € (0,179 €/kg O2)
O_2 saving due to better transfer	50%
Yearly cost oxygen + diffusers	2.045 €

Figure 2. Cost comparison (equipment/maintenance/O2 consumption) with the currently most common pre-fattening fan (Source: D&BTech)

2.2
FAN DEVICE FOR PONDS VIA O2BTECH
(D&BTech)

Description:

Fan device for fishes fattening tanks.

Technical features:

This allows a better nutrients mixing presenting an improved quality in the cultivation method. The equipment consists in 12 diffusers with a supply capacity of 15-50 l/min each. A bubble size around 1 mm has been selected, as this makes the equipment more energy efficient. The average air flow supplied is 24 cubic metre/h. Operational pressures are low. Pressure at the gas line is within the range between 100 mbar in relation to the diffuser release pressure and as for the water, it is sufficient with the pressure of a 10 mbar water column. During the lab tests, the following averages were obtained out of the diffusers: SAE: 7.6 kg/kWh O_2 / SOTR: 25.6 kg/h O_2.

The system developed allows to achieve, even at the time with more oxygen demands, the optimal oxygen concentration via the sole supply of air micro bubbles, preventing almost completely additional oxygen supply. The diffuser requires an air supply coming from a ventilation unit and a water flow obtained through a little pump submerged in the tank itself (cross flow system). The water connexion may be made from a distant point in relation to the diffuser, in a way allowing to recirculate the tank water and the oxygen enriched water mix, which is produced in the device.

Figure 3. Device out of the water (left) and supplying only air (right) (Source: D&BTech)

Costs comparison:

Fattening
Outdoor ponds (raceways)

Current diffuser: agitador Force-7	
Cost per tank (2 units)	1.300 €
Maintenance per tank (yearly)	120 € (tightness seal/sacrificial anode)
Duration (years)	3
Number of tanks in use (average)	12
kg of O_2 at the fattening stage	176.000 (684,5 TM fishes/year)
O_2 total cost	31.645 € (0,179 €/kg O_2)
Yearly cost oxygen + diffusers/agitators	38.285 €
Diffuser developed: O_2BTech	
Cost per tank (2 units)	3.600 €
Maintenance per tank (yearly)	30 € (inner cleaning by pressure jet)
Duration (years)	10
Number of tanks in use (average)	12
kg of O_2 at the fattening stage	176.000 (684,5 TM fishes/year)
O_2 total cost	31.645 € (0,179 €/kg O_2)
O2 saving due to better transfer	100%
Yearly cost oxygen + diffusers/agitators	4.680 €

Figure 4. Cost comparison (equipment/maintenance/O2 consumption) with the currently most common fattening fan (Source: D&BTech)

2.3

OPEN TANK FOR MICRO-ALGAE CULTIVATION

(D&BTech)

Description:

Hydrodynamic tank dug on the ground for mass micro-algae cultivation. Conceived for an efficient energy use and minimisation of maintenance efforts.

Technical features:

The central wall has been designed by means of fluid-mechanic simulation techniques. The objective is to reduce load losses to save energy in the agitation process and locate two collection areas for solid wastes so that it can be removed by a pump. The driving system designed to keep the algae moving so that they evenly receive solar energy also implies a reduction in the energy consumption. The traditional "paddle-wheels" have been replaced by a low revolutions helix system in order not to damage the algae. The pressure in the gas line supply to achieve the mentioned flows ranges between 100 mbar and 1 bar in relation to the diffuser release pressure. The gas supply pressure shall not shall not exceed, in any case, the amount of pressure at the diffuser´s output point plus 1.2 bar, representing the maximal operational limit of gas pressure. This system allows to fix CO_2 coming from combustion gases in a boiler used to heat the water.

Each tank working 24 hours/365 days is estimated to fix 15,3 Mt of CO_2.

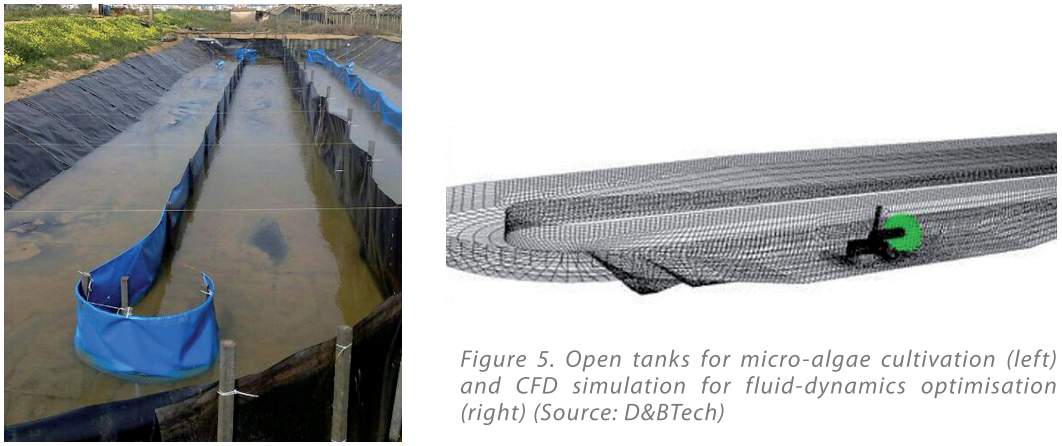

Figure 5. Open tanks for micro-algae cultivation (left) and CFD simulation for fluid-dynamics optimisation (right) (Source: D&BTech)

Costs comparison:

Outdoors micro-algae cultivation tank (raceway)

Current systems	
Surface of each one of the tanks in sqm	200
Estimated energy consumption (W/sqm)	0,55
Number of tanks in use	2
Energy yearly cost (24 h/day, 365 days)	165,7 €

Tank developed for the AQUASEF project	
Surface of each one of the tanks in sqm	200
Estimated energy consumption (W/sqm)	0,3
Number of tanks in use	2
Energy yearly cost (24 h/day, 365 days)	90,4 €
Difference/year	75,3 €

Figure 6. Costs comparison between the current tanks and those designed. (Source: D&BTech)

2.4
THERMAL SOLAR INSTALLATION FOR TEMPERATURE CONTROL OF AQUACULTURE CULTIVATION TANKS (Inoma Renovables S.L.)

Description: Installation based in low-cost and high-performance thermal solar captators.

Technical features:

Innovative application of commercial equipements already existing in the market. Nevertheless, the installation has been specifically conceived to supply thermal energy to the aquaculture cultivation tanks, matching the particular needs of the aquaculture site, reducing the use of fossile fuels for their temperature control. The designed installation is totally detachable and it can be scaled depending on volumes and flows to be preheated. The technology used is based on the use of low-cost and high-performance captators for the necessary temperature range, resulting in an innovative, simple, cheap application of the technology, preventing the issue of high temperatures reached in traditional solar thermal installations.

By this 33 sqm surface installation for capture, we achieve more than 17% of the energy needs to control the temperature of two 20,000-litre tanks (40,000 litres in total).

Figure 7. Thermal solar installation for temperature control of pools (Source: Inoma Renovables S.L.)

2.5

RENEWABLE ENERGY SYSTEMS FOR AUTO-CONSUMPTION IN AQUACULTURE SITES (Inoma Renovables S.L.)

Description: Installation based on photovoltaic modules and a mini wind power air generator.

Technical features:

The energy systems designed can be easily escaled depending on the aquaculture site needs. Through the auto-consumption of the clean energy generated out of photovoltaic and mini wind power technology, twe reneweable resources are being exploited (the sun and the wind). Thanks to these systems, both the electrical energy consumption in ponds and pollutant gas emissions are reduced, so that the savings achieved allow the amortization of the installation. Moreover, the installations will be fitted with a climate station allowing to monitor different environmental patterns affecting the energy production.

This installation showing 30 kW of photovolaic power and 5.5 kW of air generator power achieves a yearly electrical energy production higher than 45,000 kWh.

Figure 8. Renewable energy systems (Source: Inoma Renovables S.L.)

2.6
PLUG&PLAY PHOTOVOLTAIC SYSTEMS
(Inoma Renovables S.L.)

Description: Independent system based on photovoltaic sun energy.

Technical features:

These systems have been designed for isolated energy appilcations in locations with a hign corrosion, such as marine aquaculture sites, therefore, they improve these installations reliability. The equipment is the result of an innovative application of products by INOMA RENOVABLES, and provides a solution, through photovoltaic technology, for the remote supply of electricity in areas where this supply is distant or poorly reliable. They have been designed for different powers and autorun periods.

Figure 9. Plug&Play photovoltaic systems (Source: Inoma Renovables S.L.)

2.7

ELECTROLYSER FOR OBTAINING OXYGEN AND HYDROGEN OUT OF WATER (ARIEMA)

Description: Electrolyser equipment for oxygen and hydrogen exploitation.

Technical features:

The electrolyser designed is a 5 kW alkaline equipment, particularly conceived to be able to use both gases, oxygen and hydrogen, and counts on a sensoring and automation level not seen in current market devices. The electrolysis is usually made to obtain hydrogen, a high value added gas as an energy vector, venting the oxygen away in the air. Inland aquaculture installations allow both gases may be used, the oxygen for cultivation tanks oxygenation and the hydrogen for heat, movement or electricity generation.

The electrolysis devices developed by ARIEMA foster the aquaculture activity sustainability, as they are fitted with an easy inter-connexion to 100% renewable sources, being their waste water steam, generating zero emissions.

Figure 10. Electrolyser for obtaining oxygen and hydrogen out of water (Source: ARIEMA)

2.8
HYDROGEN STORAGE TANKS
(ARIEMA)

Description: Storage system consisting in an under pressure tank and three tanks for metallic hydrides for hydrogen storage.

Technical features:

One of the benefits of the electrolysis system is to allow energy storage by means of hydrogen, to be used for different purposes, including an energy "back up" system in case electricity supply is interrupted, which in remote locations where inland aquaculture installations are usually located, may be critical, and also very usual. This is why two devices for generated hydrogen storage have been designed; a 15 Nm^3 under pressure tank and three tanks for metallic hydrides (500 NL each).

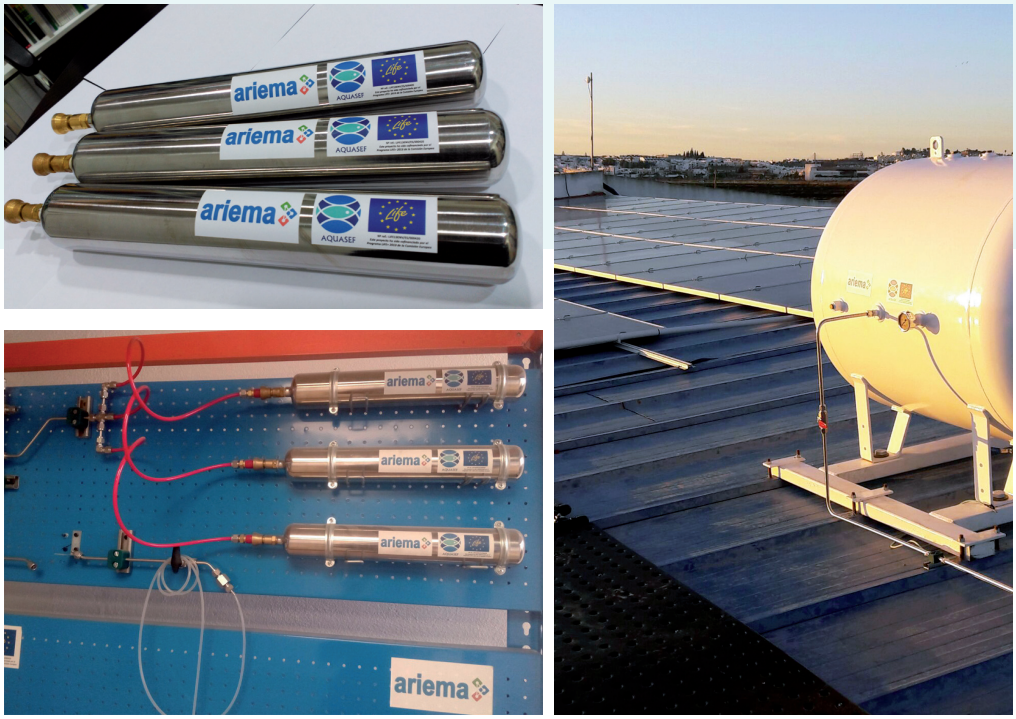

Figure 11. Tanks for hydrogen storage (Source: ARIEMA)

2.9
COMBUSTION ENGINE AND FUEL CELL
(ARIEMA)

Description: Equipment for using hydrogen generated by the electrolyser, consisting in a hydrogen combustion engine and a fuel cell.

Technical features:

In order to use the hydrogen generated by electrolysis, two demonstration devices have been designed: a hydrogen combustion engine and a fuel cell. The internal combustion engine is used to recover the hydrogen surplus, transformed into electric power and heat, which may be used by the site. The 1.5 kW fuel cell is used for back-up electricity generation in case of a supply interruption in the aquaculture installation. Thanks to 5 kW of electrolysis and the introduction of hydrogen in a fuel cell, a power of 15,878 kWh/year is obtained, an energy generated on 100% renewable basis.

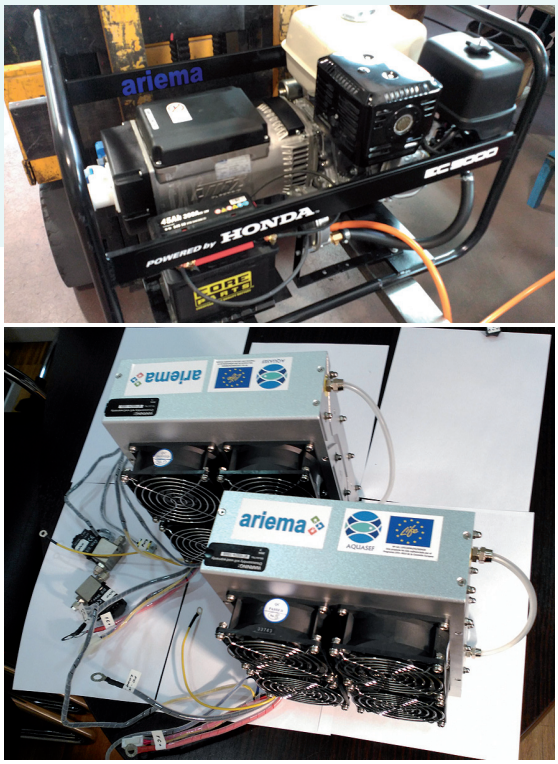

Figure 12. Combustion engine (up) and fuel cell (down) (Source: ARIEMA)


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Dña. Aurora de Blas
Dña. Maribel Rodriguez
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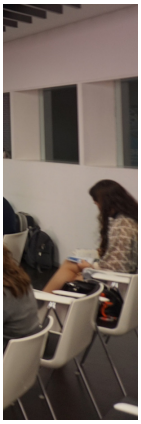

3.

RESULTS REPLICABILITY

One of the main goals of the LIFE AQUASEF project consists in assuring the replicability of the results achieved within the project. In order to so, the **Technology Centre for Aquaculture of Andalusia (CTAQUA)** Foundation, in charge of the communication and dissemination actions and **Esteros de Canela**, as the company validating the developed technologies within the project have assured, during the whole project, a suitable dissemination of all the partial results achieved when developing the innovative technologies shown in this report. And all of this for replicability of the actions set out by this project to be realistic in the whole of the aquaculture sector both at national and international level.

Among the actions carried out to assure a suitable dissemination of the projects results, some may be highlighted: development of the website project **www.aquasef.com**, creation of three strong social networks profiles such as Twitter and Facebook, holding workshops and networking meetings with industry companies, researchers and representatives from public administrations linked to the aquaculture industry, press notes release at national and international level, holding breakfast for the press and attendanc

The execution of these actions allowed to reach more than **300,000** potential beneficiaries of the project results, thanks to the appearance on TV programmes, radio interviews, publication of different articles in specialising magazines, advertising posters at international conferences and performing five lectures at specialising conferences and trade fairs.

4. CONCLUSIONS

The **efficient and low energy consumption venting systems** developed by D&BTech in the framework of this AQUASEF project, as well as the MicroBTech diffusers or the O2BTech, allow an optimal exploitation of air bubbles generated in those, mixing all the nutrients of the cultivation milieu, improving its quality for fish growth. The **tanks conceived for micro-algae cultivation** allow to valorise wastes and emissions, as micro-algae fix CO2 coming from combustion gases of the boiler used to heat the water and provide supplementary nutrients for fish and mollusc cultivation.

Although **thermal solar, photovoltaic and wind systems** provided by INOMA RENOVABLES already existed on the market, its use and customisation for aquaculture sites is innovative, reducing the dependency on fossil fuels and implying important energy savings. The **Plug&Play system** (with different powers and self-functioning features) allows electricity supply in faraway areas, where this supply is far or poorly reliable, providing a new electricity supply option for those installations located in remote areas in which the current options are related with no sustainable sources (gasoil generators).

On the other hand, the electrolysis technologies validated by ARIEMA offer an **interesting option for oxygen self-production** in situ, necessary in many cases for the cultivation tanks and the use of **hydrogen as a "back up" system for potential electricity supply interruptions, which these installations are used to experiment**, providing an emergency electricity supply system for the most critical equipment at the site. The combination of these technologies with renewable energies, apart from transforming the aquaculture industry into a zero emissions sector, allows to carry out this activity in faraway locations where network connexion and gas supply may be difficult.

This an aspect of a great interest for the **aquaculture industry, especially for aquaculture sites located in places far from city nodes**, where the number of gas companies supplying oxygen is significantly reduced and supply costs are high due to the complexity of transporting oxygen by trucks in cryogenic tanks to faraway areas. Production of oxygen on site is more flexible in almost every installation and implementing water electrolysis technologies offers an added value due to the hydrogen supply to be used as an energy vector or fuel to generate electricity, heat or movement for necessary inputs at the aquaculture sites.

Out of the dissemination actions within the project, some conclusions may be drawn: there is a high interest on the aquaculture companies side, both at national and international level, for implementing innovative methods allowing to increase sustainability of the activities carried out. Therefore, the implementation of new eco-efficient technologies as those developed in the AQUASEF project are regarded as very interesting for their application in other companies in the industry.

Given all that, we may state that the AQUASEF project opens a new range of opportunities for aquaculture planning, focused on the use of clean, efficient and innovative technologies.

5.
ABOUT AQUASEF PARTNERS

ARIEMA

ARIEMA Energía y Medioambiente S.L. is a **"Spinoff technology-based company"** of the National Institute for Aerospace Technology (INTA) born in 2002. It is integrated by scientists and researchers focused on energy and R&D&I management since 1990. Some of the company objectives are:

• To promote Research and Development (R&D) initiatives by improving R&D project management and coordinating efforts through Technology Platforms.

• To promote clean and renewable energy technologies such as hydrogen and fuel cells.

• To participate in the technical develpment and training in key technologies focused on energy efficient (especially hydrogen) as well as more environmentally friendly.

The experience of its professionals has allowed ARIEMA to be consolidated as a Spanish independent leading company for initiatives regarding hydrogen and fuel cells, with outstanding experience in energy efficiency and R&D&I management in all sectors involved. More information: www.ariema.com

INOMA RENOVABLES

INOMA RENOVABLES, S.L. It is a company which belongs to GRUPO IGFOTON, a group of engineering companies with high technological specialization.

Our vision is a more sustainable world with a responsible industrial activity, through the use of clean energetic resources, the execution of industrial installation more respectful with the enviroment, and the application of new energetic technologies for local development.

INOMA RENOVABLES, is a company of engineering highly specialized in solar energy, with a commitment to the innovation and development of new designs and products, joining lastest progress in equipment and methods of calculation which allows both the architectural integration and energy efficiency.

INOMA RENOVABLES makes electric, energetic and industrial engineering projects, including technical management and legalization. Provides energetic services, giving solutions for saving energy by the reduction of energetic cost in companies or public institution, improving the organizations and making them more sustainable and efficient through newest advanced technologies, which produces real savings for the investment. More information: www.grupoigfoton.es

DROPS & BUBBLES

Drops & Bubbles Tecnología SL (D&BTech) is a spin-off SME from the Department of Fluid Mechanics and Aerospace Engineering, University of Seville. It was founded in 2010 by Prof. Javier Dávila , PhD who actually is the company's technical manager. The two main business lines are:

• Development and marketing of high efficiency diffusers for gas transfer in fluids with application in fields such as aquaculture, chemical and food industries, biotechnology, wastewater treatment, etc.

• CFD (Computational Fluid Dynamics) Consultancy for private/public organizations where numerical simulation helps to improve design/performance of elements/ processes where fluids in movement are involved

The company is located in Seville and besides its headquarters in Palomares del Río, uses the facilities (laboratory and workshop) of the School of Engineering in La Cartuja. More information: www.dbtech.es

ANDALUSIAN AQUACULTURE TECHNOLOGY CENTRE - CTAQUA

The Andalusian Aquaculture Technology Centre was founded in 2007 as a private non profit organization. 80% of its members are aquaculture farmers, feed companies and other industry related enterprises; Universities are also members of CTAQUA as well as regional governmental institutions.

CTAQUA focuses on fostering competitive innovation between companies, addressing the business needs of the aquaculture and seafood sectors, as well as the development of research applied to the different technical and production processes. At their facilites located in El Puerto de Santa María (Spain), CTAQUA works on projects and activities with strategic collaborators on a regional, national and European level.

The Center facilities allow for the development of projects in the test units (nutrition, diversification, mollusc, crustacean, phytoplankton and zooplankton rooms), workshops (transformation room and engineering rooms), laboratories equipped with the latest technology (microbiology, physicochemical, materials and food technology labs) technical offices, and conference rooms. More information: www.ctaqua.es

ESTEROS DE CANELA

The company was founded in 1992 and is located in Ayamonte (Huelva), in the surroundings of the estuary of the Guadiana river. From this date on, they are consecrated to the fattening of different species of fishes, molluscs and crustaceans in their own aquaculture premises.

Their production has been consolidated through the years, from 20 tonnes for the first years up to nearly 400 tonnes nowadays. This growth allowed the company to bet on innovation, investing in new equipment leading them to provide differentiated and high quality products. The company boasts a new 5,000 m2 commercial site, where today they carry out the processing and commercialisation of their own production including other product lines coming both from aquaculture and the extractive fishery industry.

Esteros de Canela is the supplier to companies such as Fripozo, Carrefour or Pingo Doze and markets their products under the brand Pescado de Estero. More information: www.esterosdecanela.com

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"Environmental improvement in aquaculture activities through the development of eco-efficient technologies (AQUASEF)"

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25 YEARS
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