CIP Eco-innovation

First application and market replication projects

Call Identifier: CIP-EIP-Eco-Innovation-2012

Final Report

EcoPonics

Contract ECO/12/332783

Covering the reporting period from

18/07/2013 to 17/07/2016

Reporting Date

18/08/2016

Project coordinator: Dr. Ragnheidur Thorarinsdottir

Project website: http://aquaponics.is/ecoponics/

European Commission | Executive Agency for Small and Medium-sized Enterprises

1 Achievements of the action

1.1 General progress - Summarise the achievements, deviations, important problems and difficulties met during the whole duration of the action.

The project has run well and the project consortium has had a good collaboration spirit from start. The three SMEs, Breen in Spain, IGFF in Denmark and Svinna in Iceland have developed, designed and implemented their aquaponics systems towards zero waste commercial production. The work has included water quality control, maintenance and cleaning of the systems, analysing alternative protein sources for feed, co-production of crayfish in the system and the synergy effect of adding edutainment and experience tourism to the business plan.

Breen has built a new aquaponics hatchery in Tknika that started operation in 2014. The production system has been designed so it can also serve for future development and further optimization of the production and it includes a show-room for visitors. The production area of the pilot plant in Hondarribia has been increased from 500 m^2 to a commercial viable business of 6,000 m^2. The main production is tilapia in the RAS part and in the hydroponics the main focus is on lettuces, tomatoes, strawberries and herbs (basil, rosemary, oregano and parsley).

IGFF has designed new 2,000 m^2 commercial decoupled aquaponics units based on best available technologies from RAS and hydroponic. The production system will be constructed in collaboration with the greenhouse producer EuropaFrugt and the technology provider AkvaGroup. The model is based on IGFF´s modern industrial based aquaponic test system with mobile plant tables covering the fish tanks utilizing ‘economies of space’, and the horticultural production in pots with soil hence accepted for organic certification. The scientific based modelling on the IGFF aquaponic production system has documented energy savings of 21%, and CO_2 contributions from fish boosting plant production with 14% compared to conventional greenhouse production.

Svinna has built and operated aquaponics pilot units since January 2014, first within the capital area and later in collaboration with the greenhouse farmers Akur in South Iceland and Laugarmyri in North Iceland. The test systems have been run with tilapia, Australian crayfish and several types of leafy greens and fruity plants. Svinna has joined university students, researchers and specialists from horticulture, aquaculture and tourism to develop the business idea towards joining circular sustainable production, edutainment and experience tourism. The future plan includes further enlargement of the production systems to a viable size and building a training and visiting centre.

The project has been presented widely towards the industries, R&D environment and governmental institutions. The aquaponics network has been strengthened substantially through active participation in international collaboration networks and presentations of EcoPonics at conferences, seminars, in journals and public media. The Association of Commercial Aquaponics Companies has been established with a growing number of interesting start-ups in the sector.

1.2 Results achieved as compared to what was planned in the project proposal – *Compare in a few lines the activities planned (based on Annex I of the grant agreement and the previous progress reports) to the progress made, work package by work package; purchase of equipment; identify partners involved, including their roles; describe major* *subcontractors, stakeholders, etc. involved. Also assess in the table below the deliverables listed in Annex I of the grant agreement for the whole duration of the action. If any, state and discuss which targeted results could not be achieved and the reasons therefore. You can argue under point 1.3.*

WP1: Project management

The project had a good start and has been running well. The consortium works well as a team and EcoPonics has been well presented. The communication within the consortium has mainly been through e-mail and skype and internal project information and documents were stored and distributed via the project dropbox.

Six physical meetings have taken place, the first in September 2013 visiting aquaponics entreprenurs in Norway. The second meeting was held in Iceland in combination with an aquaponics seminar in Iceland on March 25th 2014. The third meeting was held in May 2014 in San Sebastian in Spain in connection with an international congress on vocational education, competitiveness and employment held by the Basque government. The fourth meeting was held in San Sebastian in relation to the Aquaculture Europe 2014 congress in October 2014 including presentations of the project results in the special aquaponics session at the conference, at Breen´s business stand and during several visits of stakeholders and other interested groups to Breen and Tknika. The fifth meeting was held in Grimstad Norway in November 2014 where the main results of EcoPonics were presented at the aquaponics seminar held by Bioforsk. The sixth EcoPonics meeting was held in Copenhagen Denmark on March 16th 2015 back to back with an aquaponics seminar on March 17th. The project manager visited Breen in July 2015 and IGFF in January 2016. Furthermore, part of the group has met on aquaponics meetings within the European Science Foundation (ESF) and the COST Action on aquaponics.

The progress report (D1.1) was delivered June 12th 2014 and the interim report (D1.2) was delivered March 12th 2015.

WP2: Upscaling and optimization of BREEN Technology

The main tasks of WP2 include an optimal design of the commercial plant, taking into account optimal harvesting at least once a week all-year round, driven by the market need. Focus is on environmentally friendly production and full use of all resources. The key to this is a healthy and balanced polyculture system. Thus, the feed is 100% based on sustainable ingredients, no synthetic fertilizers are used for the plant production and no effluent water or waste leave the production.

During the EcoPonics project a new hatchery and aquaponics units have been designed and constructed at Tknika. The new units were ready in the beginning of 2014 and have been running since with automatization controlling the water quality, investigations on available fish feed formula and alternative protein sources, monitoring parameters for mass and energy balances and optimizing fish:plant ratio. Calculations on environmental indicators and LCA assessment has been carried out based on the results. IGFF has provided knowledge to economic and cost-benefits analysis and Svinna has provided support to risk analysis.

The reproduction of tilapia is synchronized in an incubator system, see Fig. 1. The fish are capable of reproducing every 15-20 days during the year.

Figure 1: Incubator system for tilapia breeding

During the second half of the project Breen´s aquaponics pilot unit has been scaled up to a commercial viable business of approximately 6,000 m^2 production area, see Fig. 2. The design is based on the earlier pilot units and all necessary surveillance systems have been included. This is the first commercial scale aquaponics farm in Europe. ´

Figure 2. NER-BREEN 6,000 m^2 Commercial Aquaponics in Hondarribia, Basque country

The main equipment bought and the main suppliers are the following:

- Construcciones Iñadi, Construcciones Suña Eraiketak, DisetecMar:
    - Fish tanks
    - Hatchery fish tanks
    - Mechanical filtering system
    - Water and thermal management system for production
    - Aeration system of the water
    - Aquaponics tanks design and CAM (Computer-aided manufacturing)
    - Installation of RAS and heat (recirculating aquaculture system)
    - Pumps and pipes
- PcComponentes, Ebi T. Electrotecnicos:
    - Computers and components for the control and computering system
- Coralleida:
    - Profilux control system
- Construcciones Iñadi, Logislur, Ebi T.Electrotecnicos:
    - Greenhouse infrastructure
- Disetec Mar:
    - Sand filters

The main subcontractors are the following:

- Construcciones Iñadi, Estudio K, DisetecMar, Itsasnatura, Coralleida, Azti Tecnalia.

Tknika is the main collaboration partner of Breen. It is a centre promoted by the Basque Department of Education, Universities & Research. It is under the direct auspices of the Sub-Department of Vocational Training & Lifelong Learning. Innovation is at the core of Tknika in its ongoing efforts to place Basque Vocational Training at the European forefront. Tknika provides their installations and buildings to develop Breens aquaponics. They offer good space for the production units, as well as the laboratory and the hatchery. Emphasis is on sustainable energy use such as biomass heating and solar energy.

D2.1 was delivered by Breen June 12^{th} 2014 and was resubmitted with the interim report together with D2.2 and D2.3. D2.4 and D2.5 are delivered with the final report.

WP3: Smart Eco System management and urban food production

A 60 m^2 modern industrial based aquaponic test plant for potential upscaling was established by IGFF in August 2014, see Fig. 3. The test plant is placed in a greenhouse facility designed for research and innovation, owned by Copenhagen University and managed by the Danish

Research and Innovation Center: AgroTech Ltd. In December 2014 the test plant was up and running in full operation, and commencing sale trials of various herbs taking place every two weeks for optimizing operational management. Three types of fish are on trial: red tilapia for sale as a whole fish, silver tilapia for filleting, and pike perch for whole fish sale. A consumer study has been commenced with an urban food network in Copenhagen having 1,500 members on preferences for fish delivery at the demand side.

Figure 3. IGFF Aquaponic test plant

In June 2014 meetings between IGFF and the Danish Agriculture & Food Council (DAFC) / Organic Division started on the prospects of obtaining an organic certification within aquaponics. Since the IGFF urban production system grows its plants in soil it has been confirmed, there are no problems in getting the horticultural products certified organic. The challenge is the fish production, which at present collides with the EU rules for organic fish production. DAFC discussed with its organic industry members in February 2015 if there should be a political initiative to push for changes in the EU organic rules so aquaponics can be certified as an organic production system.

IGFF and AgroTech have developed a scientific model for analysing energy and CO_2 consumption in aquaponics and the first estimations have been made. A conference paper with the results was completed in October 2014, documenting energy savings of 21%, and CO_2 from the fish contributing to a 14% higher growth yield in the plants, compared to a conventional horticultural production with the same technological specificities. The IGFF/Agrotech model and its physical measurements on energy and CO_2 in a 1,000 m^2 modern industrial aquaponic production system as a baseline, are being made into a scientific paper with a complete ‘Contribution margin accounting’ comprising both the variable cost savings on CO_2 and energy as well as the fixed cost savings in the IGFF production design.

The aquaculture production system has been designed and provided by the aquaculture company AkvaGroup Ltd in close collaboration with IGFF. Together with IGFF a new mobile legging system was developed so the plant tables could stay mobile above the fish tanks. Plant tables are used in more than 50% in Danish horticulture. Likewise, AkvaGroup Ltd supplied the piping and electronic operational system connecting their aquaculture equipment with the horticulture production, hence managing the whole aquaponic production in an optimal way. Profilux has supplied the electronic surveillance system for both alarm as well as data monitoring for scientific trials once the aquaponic system is in a biological steady state. Negotiations with DTU-aqua has commenced for using the 60 m^2 test plant to MSc and/or PhD students interested in making trails on RAS-systems. Negotiations will also commence with Copenhagen University on the prospects of using the test plant for MSc and/or PhD students working within industrial horticulture.

Breen has provided know-how about technology development and the implementation of the surveillance system from Profilux and Svinna has been involved in discussions about policies, regulations and organic standard requirements affecting aquaponics.

IGFF has in its efforts to promote aquaponics and urban food production established a cooperation with the wholesale company Europafrugt, who already has a supply chain of 500,000 herbs per year from its own greenhouse placed in the suburb of Copenhagen in Ballerup municipality. IGFF and Europafrugt Ltd are to form a new common company establishing an aquaponics production under 2,000 m^2 greenhouse producing 450,000 organic herbs and 25 tons of pike perch per year. Product suppliers will be a continuation of the cooperation with Akvagroup on the design and installation of the aquaculture part, and greenhouse production system will be supplied by ‘Danish Greenhouse Suppliers’ (DGS). The production system will be based on trials from the test plant on decoupled aquaponics, and a continuation of producing herbs in soil. Production in soil and moving tables is already practised by Europafrugt, hence making an organic certification possible. However, plant production will in the new system take place on a ‘moving gutter system’ using moveable NFT pipes. The positive experiences on ‘economies of space’ will be continued in a new and more efficient form, where all the germination and seedlings will be produced 2 meters above the large outgrower fish tanks. This has improved a reduction of the ecological footprint concerning space of 25%.

D3.1 was delivered by IGFF June 12th 2014 and was resubmitted with the interim report together with D3.2. D3.3 – D3.8 are delivered with the final report.

WP4: Renewable energy for food production with geothermal aquaponics

Svinna in collaboration with partners and university students have built and run aquaponics pilot units in Reykjavik and at two greenhouse farms, Akur in South Iceland, see Fig. 4 and Laugarmyri in North Iceland, see Fig. 5. Based on the results from the pilot units a large scale aquaponics production system has been designed and a business plan constructed that includes expansion of the production units, education, training and experience tourism.

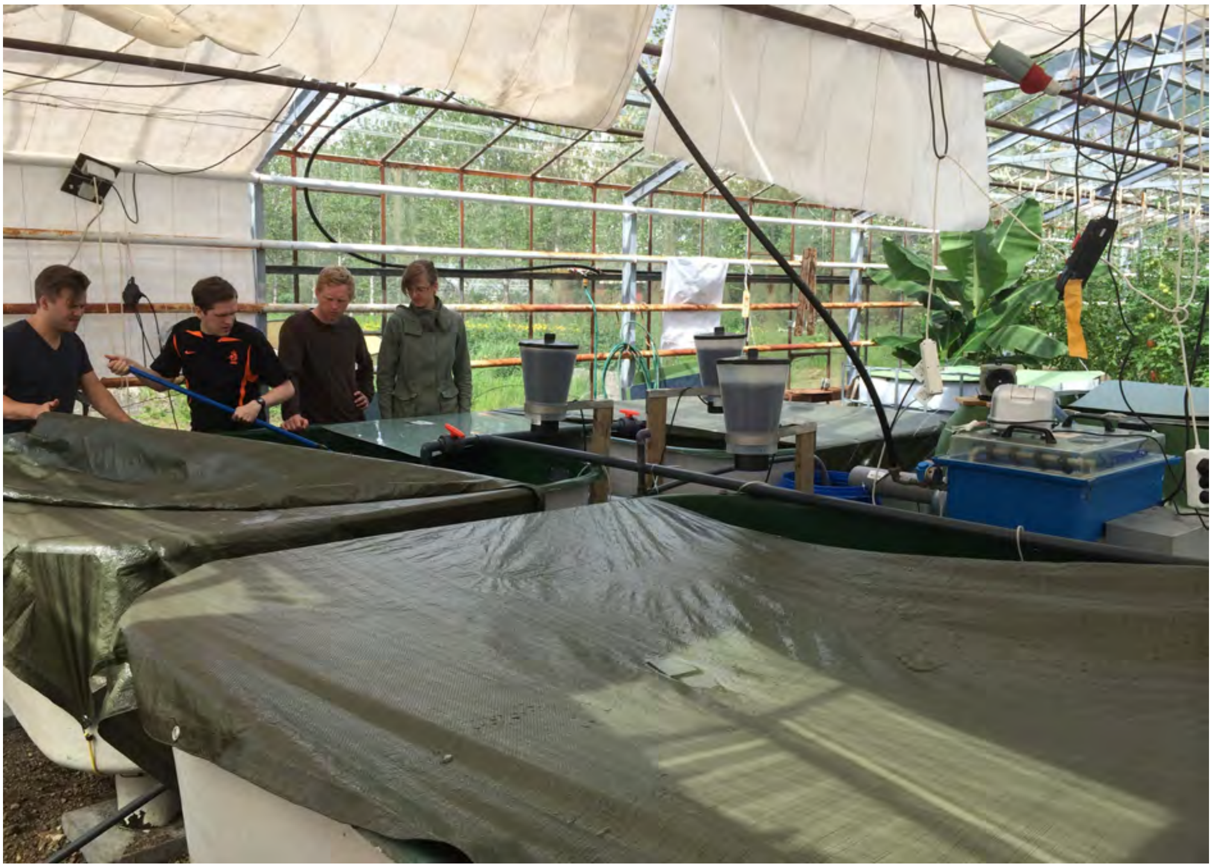

Figure 4. Aquaponics system in Akur

Figure 5. Laugarmyri aquaponics system

The project has joined skills and knowledge from the different fields of aquaponics, such as keeping the environmental parameters stable, choosing suitable plants, breeding tilapia, improving the efficiency in the overall system and marketing issues including regulations and certification criteria. Tilapia was imported from Fishgen UK and the survival and growth has been good. A wide range of different plant species have been tested, both fruity plants as cucumber, tomato, pepper, strawberries, okra and aubergine and leafy greens such as salad, basil, mint, dill and coriander. It has been concluded that tilapia and leafy greens suit best for environmental and economic benefits. The feed conversion ratio has been found approximately 1 and the mass balance of herbs:fish in a mature system is found to be at least 4.

A surveillance system from Oxyguard has been set up for online monitoring and controlling temperature, pH, dissolved oxygen (DO) and carbon dioxide (CO_2). Other parameters, electrical conductivity (EC), total dissolved solids (TDS), iron (Fe), potassium (K), calcium (Ca), magnesium (Mg), ammonia, nitrite, nitrate and phosphorus are measured less frequently as needed.

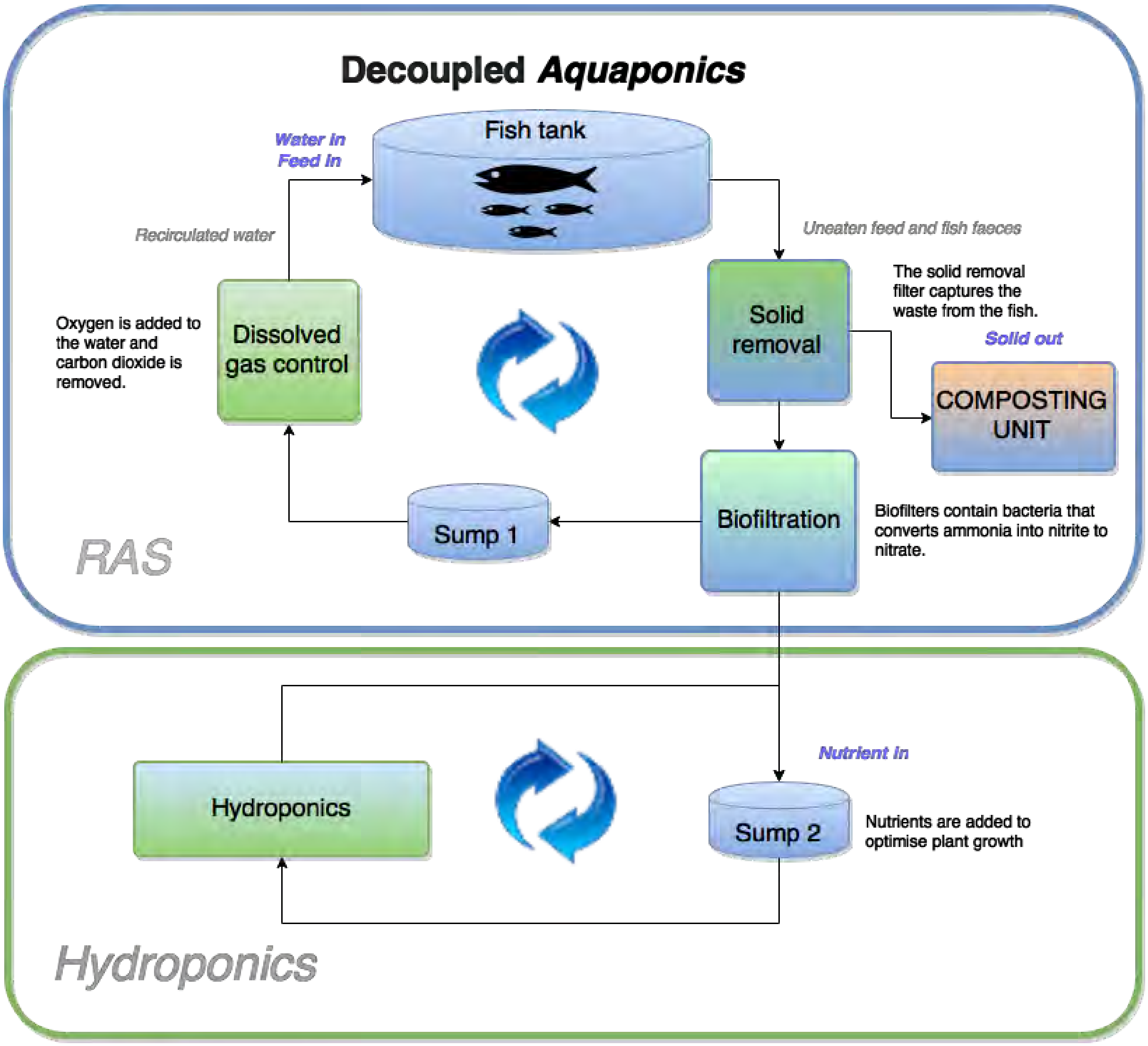

Figure 6. Decoupled aquaponics system

One of the main findings from the project is the development towards decoupled aquaponics for commercial production systems, see Fig. 6. The aquaponics technology is developing in several European countries as the interest from the R&D environment as well as the industries is increasing. In simple aquaponics setups there is a trade-off between the optimum environment for the fish and for the plants, respectively, as e.g. the optimum environment for tilapa is at higher temperature and pH than the optimum conditions for the salad and herbs. This is solved in the decoupled systems securing optimum conditions for both the plants and the fish. Also decoupled systems open up for cold water species such as rainbow trout and Arctic charr. Based on the results from EcoPonics it is concluded that the future development of large scale aquaponics production systems will be based on decoupled systems relying on the latest development within Recirculation Aquaculture Systems (RAS). IGFF has established collaboration with AkvaGroup in Denmark one of the main suppliers of modern RAS systems to develop this further. Thus, the results from the decoupled system at IGFF in WP3 has been taken into account for the future development of large production units by Svinna. However, such systems have a much higher capital cost.

Certification and marketing issues related to aquaponics and organic production have been discussed with certification specialists and organic farmers. Furthermore, the project has been presented to other businesses and associations both in aquaculture and horticulture, to research partners, several municipalities in Iceland, governmental bodies, the geothermal cluster and ocean cluster collaborations, the United Nations University Geothermal and Fisheries Training Programmes situated in Iceland and FAO.

A risk analysis has been carried out pointing out the main risks in an integrated aquaponics production system and how these can be minimized. The results show that monitoring and controlling the crucial environmental parameters is essential to maintain a healthy and stable system. The main risk parameters are shown in Table 1.

The equipment cost in WP4 is less than planned, as the pilot units were based on a simple design and used equipment (tanks, drum filter, hydroponics) could be bought from aquaculture and horticulture companies in Iceland. More students and researchers from the university took part in the work coming from different departments, engineering, biology, aquaculture, horticulture, computer science and art/design. This provided a very enthusiastic and innovative environment that will be built on for future collaboration. In spite of these changes the deliverables have been met and the next steps towards commercialisation looks promising. A request for budget transfer from Svinna to the university was submitted to EASME in June.

Breen has provided know-how on technology and implementation of surveillance system and IGFF has been involved in the discussions about future design of decoupled aquaponics systems and the marketing aspects. UoI has provided assistance on the technological and design issues, the pilot units setup, operation and surveillance and mass balance calculations. The Agricultural University of Iceland and Laugarmyri have provided advice on choosing plants and knowledge and skills about the optimum environmental parameters for the plant part. The aquaculture specialists at Fishgen, Haukamyri and Menja have provided advice on the breeding of tilapia and design and building of the aquaculture part of the aquaponics systems, Fiskar provided breeding facilities for the tilapia, LandingAquaculture has provided assistance on filtering systems and Adego provided monitoring and control services and renovation of used fish tanks.

D4.1 was delivered by Svinna June 12th 2014 and was resubmitted with the interim report together with D4.2 and D4.3. D4.4, D4.5 and D4.6 are delivered together with the final report.

Table 1: Risk analysis for aquaponics

Risk	**Probability**	**Severeness**	**Contingency plan**
Fish disease	Low	Medium	Strict management procedures, dividing production systems into units, controlling and keeping a healthy environment and cleaning tanks between stocking
Plant pest	Low	Medium	Strict management procedures, organic defences
Power failure and/or failure of temperature control	Low	High	Online monitoring and automatic control with alarm system
Oxygen level too low	Low	High	Monitoring and control
Failure of pH control	Low	High	Monitoring and control
Sodium levels too high	Low	Medium	Monitoring and control
Failure of EC control	Low	Medium	Monitoring and control
Contamination of water	Low	Medium	Monitoring and control
Marketing failure	Low	High	Keeping good quality, fulfil official requirements, and inform consumers about the production processes
Extreme weather conditions, earthquakes, volcanic eruption	Very low	High	Initiate emergency plan minimizing losses

WP5: Exploitation and Business Plan

In WP5 the focus has been on aquaponics business replication based on results from EcoPonics. All partners have been active in presenting their systems to conventional horticulture and aquaculture businesses and it has been obvious how the interest in aquaponics is growing in the industries. All partners have been actively participating in the COST Aquaponics Hub starting up in 2014 expanding the aquaponics network within Europe and worldwide. Based on this network a European aquaponics business cluster collaboration has been established, *Association of Commercial Aquaponics Companies (ACAC).*

The aquaponics modules and other results from EcoPonics have been presented at the Aquaculture Europe conferences, aquaponics seminars and training programmes and through articles and published guidelines. The results have also been presented directly to potential industry partners. Based on this Breen has started collaboration with the company NER and has within the project period built the first commercial size aquaponics company in Europe. Breen has also started up a strong vocational training programme within aquaponics in collaboration with Tknika. The commercial affiliate Chinampa of IGFF is establishing a new common company with Europafrugt Ltd for joint collaboration on the 2,000 m^2 decoupled aquaponics plant in Denmark. Production will be 450,000 organic herbs and 25 tons of pike perch per year. Svinna has started the expansion of the pilot units in Iceland to a viable business and built a strong network of business and research partners. Svinna and HI have held a few training seminars with participants from both the aquaculture and horticulture sectors, hobbyists and researchers from several disciplines.

The group has actively presented the results to governments and municipalities and have put together strategy advice for local sustainable food production based on the results from EcoPonics.

With the show cases built in Denmark and Iceland and the commercial aquaponics established in Spain within EcoPonics the market barriers for aquaponics have been lowered. The group has actively shown how two different production systems can be integrated into one in spite of the complexity towards management skills, biology and other essential knowledge.

Deliverables D5.1-D5.6 are delivered together with the final report.

WP6: Dissemination Activities

EcoPonics and the project results have been presented widely, locally and internationally, both at congresses and seminars and in public media, including radio and newspapers. Also the aquaponics sites in all three countries have received many visitors. Moreover, the project has been presented towards government, municipalities, aquaculture and horticulture businesses. Also, the project consortium has broadened its global aquaponics network by active participation in international aquaponics networks. A project website has been designed and operated, http://aquaponics.is/ecoponics, where public information and news about the project and its progress is presented.

A logo for the project was designed and furthermore, corporate logos for the new installation by BREEN and for Svinna, respectively have been designed for improved marketing of their aquaponics.

The three SMEs have designed, built and operated aquaponics units in the respective countries and built a strong aquaponics network through participation in vocational training networks, ESF meetings, the COST-Action FA1305 - *The EU Aquaponics Hub - Realising Sustainable Integrated Fish and Vegetable Production for the EU,* the established Association of Commercial Aquaponics Companies (ACAC) and by local seminars, meetings and training programmes in the respective countries joining people with interest in the field of aquaponics.

The main presentations in public media, handout materials, seminars/conferences and industry journals (D6.8) are listed in annex C and on the EcoPonics website. All deliverables with public dissemination level (PU) are uploaded on the website http//aquaponics.is/ecoponics for public download.

D6.1, D6.6, D6.7 and D.6.8 were delivered with the progress report in June 2014 and D6.1 and D6.8 were updated and included in the annexes of the interim report. D6.2 was delivered with the Aquaponics Guidelines submitted in November 2015 for an internal EASME event under the participation of high-level people of the European Commission (26/11/2015) and 6.3 was delivered with participation by Eider de la Cruz from Breen in the 18th forum on Eco-Innovation May 20-21 2015 in Barcelona and the project coordinator will participate in the EASME event ECO-I Forum in Tallin October 26-28 2016 with a presentation. D6.4 is submitted with this final report and D6.1 and D6.8 have been updated and are included in Annexes. D6.5 is to be sent 2 years after project ends.

Del. N° [1]	**Deliverable name** [1]	**Type**[1]	**WP N°** [1]	**Delivery date from Annex I** [1]	**Delivered (yes/no) and status (draft/final)**	**Submission with report²**	**Forecasted delivery date**	**Comments on progress**
D6.1	Project information updates	Project information sheet	6	M1	yes – updated regularly	PR1 and IR	12/6/2014 and 12/3/2015	According to plan
D6.7	Project dropbox	Internal website	6	M1	yes – updated regularly	PR1	12/6/2014	According to plan
D6.6	Project Website	Website	6	M6	yes – updated regularly	PR1	12/6/2014	According to plan
D6.8	Presentations in public media, handout materials, seminars/conferences	Presentations	6	Regularly	Yes / see list in Annex C	PR1 and IR	12/6/2014 and 12/3/2015	According to plan

	and industry journals							
D2.1	Report on technical advancement and difficulties met	Report	2	M8	yes - final	PR1 and IR	12/6/2014 and 12/3/2015	According to plan
D3.1	Report on technical advancement and difficulties met	Report	3	M8	yes - final	PR1 and IR	12/6/2014 and 12/3/2015	According to plan
D4.1	Report on technical advancement and difficulties met	Report	4	M8	yes - final	PR1 and IR	12/6/2014 and 12/3/2015	According to plan
D1.1	Progress report	Report	1	M10	yes - final	PR1	12/6/2014	According to plan
D4.2	Starting up production – report on design	Report	4	M10	yes - final	IR	12/3/2015	According to plan
D2.2	Report on environmental parameters	Report	2	M14	yes - final	IR	12/3/2015	According to plan
D2.3	Report on design and risk analysis	Report	2	M18	yes - final	IR	12/3/2015	According to plan
D3.2	Starting up production – report on design	Report	3	M18	yes - final	IR	12/3/2015	According to plan
D4.3	Fresh vegetables for local markets	Vegetables	4	M18	yes - final	IR	12/3/2015	According to plan
D1.2	Interim report	Report	1	M19	yes - final	IR	12/3/2015	According to plan
D2.4	Report on mass and energy balances, environmental indicators and optimized fish:plant production ratio	Report	2	M20	yes - final	FR	18/8/2016	According to plan
D2.5	Report on LCA, economic analysis and cost-benefits analysis	Report	2	M24	yes - final	FR	18/8/2016	According to plan
D3.3	Report on the possibilities of urban aquaponics in European countries and how different policies and regulations can affect the adoption of the technology	Report	3	M24	yes - final	FR	18/8/2016	According to plan

D4.4	Fresh sustainable and high quality white fish	Fish	4	M24	yes - final	FR	18/8/2016	According to plan
D5.1	European aquaponics business cluster collaboration formally established	Network	5	M24	yes - final	FR	18/8/2016	According to plan
D5.2	Report on solutions to market barriers	Report	5	M24	yes - final	FR	18/8/2016	According to plan
D3.4	Marketing of local sustainable food products (fish and greens)	Products	3	M28	yes - final	FR	18/8/2016	According to plan
D3.5	Report on dynamic climate control I	Report	3	M29	yes - final	FR	18/8/2016	According to plan
D3.6	Report on dynamic climate control II	Report	3	M29	yes - final	FR	18/8/2016	According to plan
D3.7	Report on economies of space	Report	3	M29	yes - final	FR	18/8/2016	According to plan
D3.8	Design for installation of second urban commercial aquaponics	Report	3	M36	yes - final	FR	18/8/2016	According to plan
D4.5	Specific recommendation for choice of plants and fish for aquaponics systems	Report	4	M36	yes - final	FR	18/8/2016	According to plan
D4.6	Operational procedures to minimize environmental impact and secure economic continuous operation	Report	4	M36	yes - final	FR	18/8/2016	According to plan
D5.3	Business plan for business replication based on aquaponics modules	Business plan	5	M36	yes - final	FR	18/8/2016	According to plan
D5.4	Exploitation and replication plan to enhance integrated eco-innovation towards conventional horticulture and aquaculture industries in the EU	Report	5	M36	yes - final	FR	18/8/2016	According to plan

D5.5	Strategy advice for governments and municipalities for local sustainable food production	Report	5	M36	yes - final	FR	18/8/2016	According to plan
D5.6	Presentation of products to distributors	Report	5	M36	yes - final	FR	18/8/2016	According to plan
D6.2	Inputs to additional common information material related to eco-innovation actions (pre-defined)	Input to posters, articles for newsletters, visuals, interviews	6	Upon request	yes - final	FR	November 2015	According to request
D6.3	Project presentations (pre-defined)	ppt, presentations, participation in events	6	Upon request	yes - final	FR	May 2015 and October 2016	According to request
D6.4	Layman´s report	Brochure	6	M36	yes - final	FR	18/8/2016	According to plan
D1.3	Final report	Report	1	M36	yes - final	FR	18/8/2016	According to plan

1.3 Deviations, problems and corrective actions taken in the whole project period – *If any, review the nature and the reason for deviations incurred during the action and the strategies chosen to get back on track.*

WP3: Some disagreements came up in Denmark on sharing costs and risks between IGFF and Ballerup municipality. The problem was solved as Copenhagen municipality offered collaboration related to Urban Demo farms, green roofs and job creation. However, despite Copenhagen municipality paying for all the costs on engineering and static analysis of five potential buildings of four-five storey high none of them were able to carry an aquaponics production on the roof. The cost of building support measures exceeded the budget from Copenhagen municipality of 340,000 euro. A one storey building was found during the second term of 2015, making a support scheme feasible. Unfortunately in 2016 it was decided to sell the property, tear the building down and build a new high rise building. Hence an urban roof top based aquaponics farm was simply not possible during the project period, but parallel efforts to establish a peri-urban farm became much more successful.

WP4: It was difficult to manage the first steps of aquaponics development far from Reykjavik where the university students and others involved in the project live. This was solved by putting up aquaponics systems in Reykjavik for the development process with simple movable setups and monitoring systems while building up skills and knowledge about aquaponics. During 2015 pilot units were developed in collaboration with two greenhouse farmers. The staff costs at the University became higher. The equipment costs at Svinna became lower than planned and therefore a budget transfer from Svinna to the University of Iceland was requested.

1.4 Progress regarding performance indicators – *Assess performance indicators listed in Annex I of the Grant Agreement against impacts of the action achieved. Please update the excel table of the Annex II attached to the Grant Agreement.*

The units built are closed-loop zero waste systems and all nutrients are fully used. No CO_2 is added to the plant system and no waste-water is taken out from the system. The heating is based on direct use of renewable energy and waste heat. In Denmark district heating is used. No synthetic fertilizers are used, other than calcium carbonate and hydroxides for pH control and to add necessary Ca and K for the plants. Furthermore Fe-chelate is added to provide necessary iron to the plants. The first energy and mass balance calculations have been carried out showing the production ratio (kg) between plant and fish up to 4:1 and the feed conversion ratio down to appr. 1.0.

The excel table with performance indicators based on the technology remains unchanged.

IGFF has estimated the progress regarding the environmental performance indicators in collaboration with Agrotech in Denmark. From the IGFF & AgroTech modelling on the symbiotic effects in the IGFF aquaponic system the following reductions on CO_2 emissions and energy based on the synergy effect from the fish were measured per m^2 greenhouse/ year:

- CO_2 from fish: 2.54 kg CO_2
- Energy reduction for heating due to fish tanks operating as heating buffers: 0.22 GJ

If the energy supply is based on natural gas, the CO_2 emission would be 57.2 kg/ GJ.

The savings in CO_2 from heating the greenhouse in an aquaponic system would then be: 57.2 kg/GJ X 0.22 GJ/ m^2 = 12.6 kg CO_2/ m^2/ year

Total reductions in CO_2 emissions would be: 12.6 kg CO_2 + 2.54 kg CO_2= 15.14 kg CO_2/ m^2 greenhouse/ year

Reduction in water usage in the aquaponic system is estimated to be 4.5 m^3 compared to a modern RAS system (Recirculating Aquaculture System), and 49.5 m^3 if compared to an open pond.

Table 2 shows the environmental indicators in the IGFF & AgroTech modelling on the symbiotic effects in the IGFF aquaponic system and their absolute impact.

Table 2: Environmental indicators in IGFF aquaponic system

Objective	**Indicators**	**Absolute impact**
Improved environmental performance **(REDUCTIONS)**	CO_2	15.2 kg CO_2/ m^2 greenhouse/year
Better use of natural resources	Water	0.5 m^3/ kg fish produced
	Energy	0.86 GJ/ m^2 greenhouse/ year
	CO_2 (from fish to plants)	14% higher yields or 6 kg yield increase/ m^2/ year

2 Evaluation of results - *The final report must provide an assessment of each of the points indicated below, on the basis of detailed and where possible quantified analysis. Please remember that you will also be asked to complete a questionnaire on economic and environmental impacts two years after the project has finished.*

2.1 Results regarding market uptake and exploitation – *remember that Eco-Innovation aims to multiply the impacts of the projects' solutions and mobilise a wide market uptake, reaching a critical mass during the project and in the short to medium term. Describe here your results.*

The consortium has been very active in presenting the business idea to aquaculture, horticulture and organic farmers as well as to municipalities, public administration and the general public. Also the consortium members are actively participating in European networks on aquaponics and have established the Association of Commercial Aquaponics Companies (ACAC). Furthermore, the project has been well presented internationally e.g. at the Aquaculture Europe conferences in San Sebastian, Spain, October 2014, in Rotterdam in October 2015, at Leonardo seminars and at COST and ESF meetings during the project period.

The interest for aquaponics is growing both from the research area and from horticulture and aquaculture related businesses. Many hobbyists and researchers have built small scale systems but the Breen system in Hondarribia is the first commercial size aquaponics in Europe and very few have built pilot systems at the size of those constructed by the group in the three countries. Thus, the commercial system in Spain and the pilot aquaponics in Denmark and Iceland are good show cases on how two different industries can be combined in a circular production system. Thus they provide a new dimension to the aquaponics development.

The group has together with international partners published a booklet, Aquaponics Guidelines, summarising all larger scale aquaponics pilot units developed in Europe. The booklet has been published open source on the internet and has been downloaded more than two thousand times. The downloading is from countries all over the world and the interest obviously shows the growing interest for this emerging technology.

Breen has taken off with the first commercial aquaponics farm in Europe and IGFF and Svinna are close behind with their business plans ready and partners for the scaling up of their pilot units to commercial size. The three companies closely collaborates with other businesses in the sector and it is believed that the market uptake and exploitation will be rapid during the next 5-10 years. IGFF and Svinna are both establishing decoupled auaponics systems, which will allow for a full optimization and production output level registered in both the aqua- and horticulture section when operating as commercial specialized single units. Once the aquaponics farms of IGFF and Svinna stands as solid 'proofs-of-concepts' decoupled aquaponics could reach an important market niche position as organic farm sector has in Europe.

2.2 Environmental benefits

– *Direct/quantitative environmental benefits (e.g. reductions of waste, emissions, energy, resource savings, etc.); comparison with the status quo ante.*

The symbiotic effects from aquaponics have been modelled to reduce CO_2 emissions by 21%, energy consumption by 21%, water consumption lowered by a factor of 10 compared to modern RAS, and a factor 100 compared to open pond systems. Likewise, the ecological footprint on space consumption has been a reduction of 25%, when production focuses on using common space for both plant and fish production.

– *Relevance for environmentally significant issues or policy areas, consistency with important environmental principles, relevance to the EU legislative framework (directives, policy development, etc.) and EU sector strategies.*

The results of this programme contribute to the following EU Directives, Policies, Roadmaps, Actions and Frameworks:

Circular Economy Strategy: The circular economy strategy aims at closing the loop of product lifecycles through water recycling and re-use. Aquaponics recycles nutrients, minimizes waste, reduces water use, reduces CO_2 output and reduces energy use.

Water Framework Directive: The Directive includes clauses on water re-use - which is what aquaponics does, the water is circulated in the system. This links in with the EU Circular Energy Strategy. Also, aquaponics reduces nitrogen and phosphorous pollution of water due to circulation of the water and uptake of by plants - this reduces **eutrophication** due in surface waters and coastal waters.

Renewable Energy Directive: The Directive promotes the production and use of energy from renewable sources. The Ecoponics project brought about reduction in energy use, and developed strategies for the use of geothermal energy in Iceland in aquaponics.

EU Policy on the Urban Environment: Aquaponics contributes to integrated strategies for sustainable urban development and the set of criteria the Commission should develop by 2020 to assess the environmental performance of cities, taking into account economic, social and territorial impacts, as well as that by 2050 all Europeans are living well, within the limits of the planet.

EU Climate Action: Aquaponics allows for production of both fish and vegetables in the urban environment, hence reducing CO_2 emissions and therefore aids in the achieving the EU targets both for 2020 and 2030.

EU Reference Framework for Sustainable Cities: Aquaponics food production with cities provides a viable solution for local food production for sustainable and climate friendly cities.

Common Agriculture Policy: Aquaponics reduces stress on soil due to vegetable production being undertaken in wastewater from fish, and no soil is involved in the production. Hence Aquaponics contributes to soil protection.

2.3 Economic benefits - *cost-effectiveness compared to other solutions, long-term cost savings and/or business opportunities with proposed solution, etc.*

The long-term cost savings from aquaponics are obtained via lower variable costs on resource inputs and gains from the symbiotic effects. The more these natural resource inputs will be ‘valued’ - either by various charges on CO_2 emissions, water consumption or economic support for implementing resource saving technologies - the faster the long term savings will be returned as well as create a growth in new sustainable industries. However, the lower variable costs obtained in aquaponics through various symbiotic effects are counter matched with higher capital investments placed as fixed costs. The gains in variable cost can only outnumber the fixed costs, if aquaponics are organized as a small unit with high labour input compared to capital input, or being a larger commercial operation with economies of scale gains made from the capital input.

2.4 Measures taken to ensure the autonomous economic viability of the business programme established in the project, beyond project lifetime and therefore after the EASME financial support has ended. Residual threats and barriers should be explicitly addressed.

All three companies have made necessary network building with actors within the aqua- and horticulture industries as well as public entities supporting the aim of establishing commercial aquaponics production systems. Likewise, all three companies are proceeding in establishing commercial units based on the valuable trials and experiences made during the project period. Residual threats and barriers could be related to changes in markets and expected product prices, financial backdrops if partners drop out, delays in various types of permits (environmental, food safety, organic certificate etc)

3 Other issues (max 1 page) - *If any, indicate other issues*

N/A

4 Overview on hours spent (template downloadable from our website http://ec.europa.eu/environment/eco-innovation/managing-projects/contract-finance/index_en.htm)

Project Hours (Partner / Workpackage)

Project Number and Acronym	**ECO/12/332783/S12.656985 EcoPonics**
Reporting period (M1 to MX)	**M1-M36**
Deliverable (PR, IR, etc)	**FR**

Total Project Hours	34.360,0
Total Spent Project Hours	40.502,5

Hours x Partners	WP1		WP2		WP3		WP4		WP5		WP6		Total	
	Annex 1	Spent	Annex 1	Spent	Annex 1	Spent	Annex 1	Spent	Annex 1	Spent	Annex 1	Spent	Annex 1	Spent
Partner 1 (Svinna)	1.200,0	1.520,0	200,0	188,0	200,0	172,0	6.700,0	5.892,5	500,0	502,0	300,0	452,0	9.100	8.726,5
Partner 2 (Breen)	300,0	300,0	13.780,0	16.734,0	200,0	206,0	200,0	194,0	1.230,0	5.566,0	150,0	165,0	15.860	23.165
Partner 3 (IGFF)	300,0	232,0	200,0	110,0	6.800,0	3.725,0	100,0	76,0	500,0	210,0	200,0	220,0	8.100	4.573
Partner 4 (HI)	300,0	380,0					800,0	3.178,0			200,0	480,0	1.300	4.038
	2.100	2.432	14.180	17.032	7.200	4.103	7.800	9.340,5	2.230	6.278	850	1.317		

% Project Hours (Partners / Workpackage)						
	WP1	WP2	WP3	WP4	WP5	WP6
Partner 1 (Svinna)	126,7%	94,0%	86,0%	87,9%	100,4%	150,7%
Partner 2 (Breen)	100,0%	121,4%	103,0%	97,0%	452,5%	110,0%
Partner 3 (IGFF)	77,3%	55,0%	54,8%	76,0%	42,0%	110,0%
Partner 4 (HI)	126,7%			397,3%		240,0%
	115,8%	120,1%	57,0%	119,8%	281,5%	154,9%

5 Financial report

The final report has to be submitted by the coordinator in one consolidated package with the financial report and with a cover letter in which the coordinator requests the payment of the balance. For details on the payment of the balance please consult your grant agreement Article I.5.3, together with Annex III. Up-to-date guidance on financial issues such as general financial guidelines, financial report or timesheets to report the time worked on the project, is available on our website http://ec.europa.eu/environment/eco-innovation/managing-projects/contract-finance/index_en.htm

Annex A – An updated version of the publishable project information sheet

Project Information Sheet

EcoFood from Aquaponics (EcoPonics)

Programme area:	CIP Eco-Innovation, First Application and market replication projects
Coordinator:	Dr. Ragnheidur Thorarinsdottir Svinna-verkfrædi ehf. (SVINNA), Iceland E-mail: svinna@svinna.is Tel: +354 8964830
Partners:	Breen Breeded in Green SL (BREEN), Spain Paul Rye Kledal – Institute of Global Food and Farming (IGFF), Denmark Haskoli Islands (HI), Iceland
Website:	www.aquaponics.is/ecoponics/
Benefits (max. 150 characters incl. space):	EcoPonics provides commercial Aquaponics - an environmentally friendly food production method that will be marketed for replication in Europe
Keywords:	Aquaponics, Sustainability, Food
Sector:	Green Business
Type of solution	Sustainable products, technology development, new service
Duration:	18/07/2013 – 17/01/2016
Budget:	€ 1,723,028 (EU contribution: 49.97%)
Contract number:	ECO/12/332783 SI2.656985

Summary

EcoPonics joins three innovation companies from Denmark, Iceland and Spain, respectively, collaborating with the University of Iceland with the aim to implement commercial and competitive Aquaponics production systems in all three participating countries. Aquaponics is a combination of the words aquaculture and hydroponics, and the eco-innovative technology behind is similarly a combination of the two normally specialized production systems, producing fish and plants in one production loop. The wastewater from the fish is used as resources in the horticultural production where plants take up the nutrients and hence cleanse the water before being returned to the fish, eliminating traditional use of fertilizers and minimizing use of water and energy. Thus, Aquaponics is a resource efficient and environmentally friendly food production system optimizing use of resources.

The EcoPonics partners will work towards dissemination and replication of the Aquaponics technique in Europe providing new high skilled jobs and sustainable high value food products.

Expected and/or achieved results

New and smarter Eco-innovative Life cycle technology solutions driven by European SME´s generating commercial based industrial showcases

Integrating modern food production with EU transition policies advocating for climate resilient and CO_2 neutral cities

New possibilities for direct use of renewable energy in industry

New sustainable food products locally produced in Europe

Waste products made into valuables

Annex B – Copy of the deliverables during the reporting period

- Presentations in public media, handout material, seminars/conferences and industry journals (D6.8) – listed on the project website http://aquaponics.is/ecoponics/?page_id=215 and in Annex C
- Report on mass and energy balances, environmental indicators and optimized fish:plant production ratio (D2.4)
- Report on LCA, economic analysis and cost-benefits analysis (D2.5)
- Report on the possibilities of urban aquaponics in European countries and how different policies and regulations can affect the adoption of the technology (D3.3)
- Fresh sustainable and high quality white fish (D4.4)
- European aquaponics business cluster collaboration formally established (5.1)
- Report on solutions to market barriers (D5.2)
- Marketing of local sustainable food products (fish and greens) (D3.4)
- Report on dynamic climate control I-II (D3.5 and D3.6)
- Report on economies of space (D3.7)
- Design for installation of second urban commercial aquaponics (D3.8)
- Aquaponics Guidelines including Specific recommendation for choice of plants and fish for aquaponics systems (D4.5) and Operational procedures to minimize environmental impact and secure economic continuous operation (D4.6)
- Business plan for business replication based on aquaponics modules (D5.3)
- Exploitation and replication plan to enhance integrated eco-innovation towards conventional horticulture and aquaculture industries in the EU (D5.4)
- Strategy advice for governments and municipalities for local sustainable food production (D5.5)
- Presentation of products to distributors (D5.6)
- Inputs to additional common information material related to eco-innovation actions (pre-defined) (D6.2)
- Project presentations (pre-defined) (D6.3)
- Layman´s report (D6.4)

Annex C – D6.8 Presentations in public media, handout material, seminars/conferences and industry journals

Below are the main EcoPonics presentations during the period 18.07.2013 – 17.07.2016 listed. Further information can be found on the EcoPonics project website - http://aquaponics.is/ecoponics/?page_id=215

- Interview in the local newspaper in Grimstad Norway, October 1st 2013
- Kledal, Paul Rye, Morgendagens By-landbrug [The Urban farms of Tomorrow], Grøn Hverdag no. 4/2013, pp. 16-18, 2013
- Kledal, P.R., Presentation at: 'Dyrk, Høst, Spis', [Grow, Harvest, Eat] Conference on Urban Farming and the edible city, Copenhagen October 6th
- Thorarinsdottir, R.I., Aquaponics based on geothermal energy, 2nd NordicRAS in Aalborg, Denmark, October 9-11 2013
- Thorarinsdottir, R.I., Direct use of Geothermal Energy for new businesses, presentation at the University of Iceland, November 22nd 2013
- Kledal, P.R., Presentation on 'Aquaponics & Urban farming', Seminar at SLU University Alnarp Community, Sweden December 11th 2013
- Interview in Casos de Exito, BREEN, innovación en cultivos acuícolas, December 16th 2013 - http://work.noticiasdegipuzkoa.com/2013/12/breen-innovacion-en-cultivos-acuicolas/
- Presentation at Iceland Ocean Cluster January 17th 2014 – guests included politicians and civil cervants from municipalities, representatives from public media and the minister of industries and innovation in Iceland
- Kledal, P.R., Lecture on: '500 years of Urban farming in Denmark', Grøn Hverdag, Copenhagen January 21st 2014
- Morgunbladid (Icelandic newspaper) – January 23th 2014 - http://www.mbl.is/greinasafn/innskraning/?redirect=%2Fgreinasafn%2Fgrein%2F1494923%2F%3Ft%3D939238291&page_name=article&grein_id=1494923
- Tímarit Haskola Islands / University of Iceland Magazine, February 2014
- Radio Interview in Bylgjan – I bitid, March 4th 2014 - http://vefutvarp.visir.is/upptokur?itemid=25090
- Interview in Utvegsbladid, March 4th 2014 - http://utvegsbladid.is/sameldi-i-husi-sjavarklasans/
- Visit of the President of Iceland, Olafur Ragnar Grimsson, to Iceland Ocean Cluster March 11th 2014
- Radio interview on RUV – Ras 1, Sjonmal - http://www.ruv.is/mannlif/naeringin-flyst-fra-fiskum-til-plantna, March 24th 2014

- Presentations at the Aquaponics seminar at the ecovillage Solheimar in South Iceland on March 25th 2014
- Interview at Natturan March 28th 2014 - http://natturan.is/samfelagid/efni/12580/
- Presentation at the Municipality of Reykjavik March 28th 2014
- Interview in the local newspaper "El Diario Vasco", about Breen and this project, April 16th 2014
- Presentation at the Municipality of Seltjarnarnes in Iceland, April 22nd 2014
- Presentation for representatives from Austurbru in East Iceland, April 28th 2014
- Presentation at the Municipality of Kopavogur in Iceland, May 20th 2014
- Design of Breens aquaponics development at Tknika, June 30th 2014, https://www.youtube.com/watch?v=rApbKaWB8Ug
- Article in Frettabladid (Icelandic newspaper), July 2nd 2014
- Article in Morgunbladid (Icelandic newspaper), July 16th 2014
- Article in Frettabladid (Icelandic newspaper), July 22nd 2014
- Article in Kopavogsbladid (Icelandic newpaper), September 8th 2014
- Presentations at the Aquaponics meeting at Tknika Basque October 2014
- Gutzmann, E. and Kledal, P.R., Aquaponics and the prospects of large scale commercial production. presented at Aquaculture Europe 14, San Sebastian, Spain, October 14-17, 2014
- Körner, O., Gutzman E. and Kledal, P.R., Modelling the symbiotic effects in aquaponics, presented at Aquaculture Europe 14, San Sebastian, Spain, October 14-17, 2014
- Thorarinsdottir, R., Implementing commercial aquaponics in Europe, first results from the EcoInnovation Project EcoPonics. presented at Aquaculture Europe 14, San Sebastian, Spain, October 14-17, 2014
- Information at Breens stand at Aquaculture Europe 14, San Sebastian, Spain, October 14-17, 2014
- Breen presented at the Television Program Sustraia November 25th 2014, see https://www.youtube.com/watch?v=UeoFlk46VWU
- Presentations at the Aquaponics seminar at Bioforsk in Grimstad Norway,November 29th 2014

- Goddek, S., Delaide B., Mankasingh U., Ragnarsdottir, K.V., Jijakli, H. and Thorarinsdottir, R., Challenges of Sustainable and Commercial Aquaponics, Sustainability 2015, 7, 4199-4224; doi:10.3390/su7044199

- Thorarinsdottir R.I. (Ed.) Aquaponics Guidelines, University of Iceland, August 2015, ISBN: 978-9935-9283-1-3

- Sustaeta, F. (Ed.) Aquaponics Practical Guide, Tknika, August 2015

- Interview with Isak Mar Johannesson and Ragnheidur Thorarinsdottir about EcoPonics by Dominique Plédel Jónsson published in the Icelandic journal Gestgjafinn, www.gestgjafinn.is

- Thorarinsdottir, R.I., Kotzen, B., Milliken, S., Kopina, M. and Pantanella E., Analytical innovation system framework analysis on commercial aquaponics development in Europe, Aquaculture Europe 15, October 20-23 2015, Rotterdam, Netherlands

- Thorarinsdottir, R.I., Aquaponics. Presentation at Mengi, Reykjavik, January 16th 2016

- Thorarinsdottir, R.I., Aquaponics development in Iceland. Presented at the International conference Aquaponics – Research matters on March 22nd 2016 in Ljublana, Slovenia

- Interview with Ragnheidur Thorarinsdottir by Dagny Gisladottir about EcoPonics by published in April 2016 in the Icelandic journal I bodi natturunnar, www.ibn.is

- Thorarinsdottir, R.I. Aquaponics development in Europe and aquaponics in Iceland. Presentation at Holar University College, May 20th 2016

- Milicic, V., Thorarinsdottir, R.I., Skar, S.L.G. and Hancic, M.T., Consumer acceptance of aquaponics products. Accepted for Aquculture Europe 16, September 20-23 2016, Edinburgh, UK

- Kledal, P.R. and Thorarinsdottir, R.I. Aquaponics: A commercial niche for sustainable modern aquaculture. Book chapter submitted to Springer June 2016

This publication has been produced with the assistance of the European Union. The contents of this publication are the sole responsibility of Svinna, Breen, IGFF and HI and can in no way be taken to reflect the views of the European Union.

Co-funded by the Eco-innovation
Initiative of the European Union