bericht

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AquaFUELs Roundtable – Conference Review

Conference review of the AquaFUELs Roundtable on 21st and 22nd of October 2010 in Brussels

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AquaFUELs Roundtable

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1 Conclusion

The AquaFUELs project intends to give an overview of research, assess if improved sustainability can be delivered through current research (lifecycle analysis) and identify the needs for further research. Additionally, AquaFUELs will structure relations between researchers, companies and regulators via the creation of the European Algae Biomass Association (EABA).

The AquaFUELs Roundtable presentations comprehensively reviewed all aspects of algae biofuels. Several contributions presented research work carried out at Universities and in companies, covering algae strain taxonomy, harvesting methods like membrane separation, and new reactor designs. Several testing facilities for algae cultivation systems already exist or are under construction in Israel, Italy, the Netherlands, Spain, Portugal and Czech Republic.

Business models proposed include the harvest of natural algal blooms, co-locating algae production with a cement factory, and the green desert project which allows low cost production of a range of biomass products at deserted lands in Africa.

All major reports and cost analyses outline that algae cultivation is currently too expensive for the production of only biodiesel, which is a low value product. Experts advise to use a multidisciplinary approach dealing with molecular, engineering, biology, upscaling, logistics, and sustainability issues. Some are in favour of microalgae biorefineries which should focus on the extraction of high-value components (cosmetics, food, chemistry, plastics) with energy as the co-product. The productivity of algae systems is limited physically to 24 g/m^2/day or 80 t/ha or 30-40 t of oil /ha under optimal climatic conditions. Today in real systems productivities of 11 g/m^2/d are reached.

The sustainability of algae biofuels production systems has not yet been proven, as no large-scale facilities exist. LCAs at this point of time are speculations only and should be based on pilot plant data from > 6 months of operation. The received data and LCA should be used for guiding research but not yet for policy advice. Within the EU27, algae production systems will need to prove 60 % of GHG reduction. In the 2012 update of RED default values, algae biofuel pathways will most likely not be included.

A discussion on GMO revealed that this approach holds both threats and opportunities: on the one hand, risks are high, as the genome comes out with the algae biomass; on

the other hand, GMO may provide major breakthroughs that could not be achieved with selective breeding.

All experts agreed that education and training in the field of algal biofuels is necessary.

The attendees of the AquaFUELs Roundtable agreed that this event was a great success and that they were looking forward to the transparency and structure which the project will add to the sector.

2 AquaFUELs Project

AquaFUELs intends to establish the state of the art on research, technological development and demonstration activities relevant to producing 2nd generation biofuels from non-food aquatic biomass, including algae. In order to understand the place of algae and aquatic biomass in the EU renewable energy sources portfolio, AquaFUELs will promote critical thinking and reasoning on the state of the art in this field.

The Roundtable was a milestone in the AquaFUELs project. The select panel of experts composing the Roundtable identified future research needs and potential industrial developments, with a careful eye to sustainability and social implications. The panel of experts invited to contribute to the presentations and following discussions of the Roundtable was composed of the leading experts in the field of algae biomass as well as from the biofuels community, while the chair was the Secretary-General of the European Biodiesel Board and Executive Director of the European Algae Biomass Association, Mr. Raffaello Garofalo. The outcome of the Roundtable was a realistic perspective on algae use for biofuels production – a necessary step towards future developments.

In addition to the scientific significance of gathering international experts to assess the state of the art of algae technologies for biofuels production, the objective of the Roundtable was to analyse the findings of the first half of the AquaFUELs project and to define the great orientations for the further activities until June 2011. Indeed, the state of the art identified during the first half of the project was instrumental in assessing the sustainability of algae-to-biofuels pathways and identifying the need for further scientific and industrial developments, which will constitute the second half of the project.

AquaFUELs gathers the Università degli Studi di Firenze, Diester Industrie International, Wageningen Universiteit, the Ben-Gurion University, the Almeria University, Roquette Frères, the Irish Seaweed Center, the University of Gent, Necton-Algafuel, the Imperial College and the Czech Institute of Microbiology ASCRe under the co-ordination of the European Biodiesel Board.

On 23rd – 27th of May 2011 the final conference of the AquaFUELs project will take place after a project duration of 18 months.

More information is available at the AquaFUELs website www.aquafuels.eu.

3 AquaFUELs Roundtable Presentations

Presentation of the AquaFUELs project and the Roundtable

Philippe SCHILD, European Commission, DG Research**:**

In the last 5 years there was a boom in algae. The commission wanted to fund algae projects already in 2007, but none of the proposals was positively evaluated.

The AquaFUELs project has 3 aspects: finding the state of play, research needs and structuring the area.

Mario R. TREDICI, University of Florence, President EABA**:**
Objectives of the AquaFUELs Roundtable/project

AquaFUELs intends to give an overview of research, assess if improved sustainability can be delivered through current research (lifecycle analysis) and identify the needs for further research. Additionally, AquaFUELs will structure relations between researchers, companies and regulators via the creation of the European Algae Biomass Association (EABA).

WP 1 deals with description of the state of the art and creates deliverables on taxonomy (D1.2), major stakeholders (D1.3), biology and biotechnology (D1.4), biofuel production processes (D1.5) and mapping (D1.6).

The milestone of WP 2 is the roundtable where information is gathered on main projects in Europe.

WP 3 deals with the issue of sustainability creating economic, environmental and societal evaluation of algae biofuels and production processes.

Raffaelo GAROFALO, European Biodiesel Board**:**
AquaFUELs findings:

The AquaFUELs project created a questionnaire on algae biofuels in Europe and worldwide: a WHO'S WHO and survey questionnaire. They received 120 answers from 600 questionnaires sent out. The responses were 90 % European answers and 10 % from outside Europe, mainly from the USA. 50 % of the respondents were from the field of research or academia, 25 % were from the industry. The purpose of the algae cultivation was 75 % for energy and 25 % for others like feed and food, aquaculture or

fine chemicals. The most frequently used algae strains were *Chlorella* and *Nannochloropsis*. 60 % of the respondents use photobioreactors for cultivation, 6 % open ponds and 33 % both systems.

The questionnaire is available on the AquaFUELs website (http://www.aquafuels.eu/).

State of the Art of algae biofuels production

Bert LEMMENS, VITO**:**

Water recycling and harvesting of algae via membrane separation

For cultivation of algae a lot of water is required, and for harvesting the algae a lot of water needs to be removed. For producing 50.000 t/yr algae in open ponds 11.400 m^3/h and in photobioreactors PBR 1.100 m^3/h water has to be removed. This water will contain algae and nutrients, thus it should be recycled. It also contains suspended solids, pathogens and inhibitors (metabolites). A closed or semi-closed water cycle is necessary.

VITO uses known technology from membrane bioreactor applications with 0,04 – 0,4 µm pore size. They have an integrated permeate channel 3-D structure on which the membrane is woven on top. A suspension flow of 20-30 l/m^2/h for *Nannochloropsis* is best. VITO proposes first low cost harvesting, afterwards membrane filtration. Membrane filtration should be also used for the effluent from the centrifuge. Membrane separation will effectively remove viable algae and suspended solids, some of the pathogens, but not the dissolved inhibitory substances. Submerged membranes can achieve 99,5 % efficiency in biomass harvesting.

The ALCHEMIS project is an abbreviation for “algae for chemicals production and emission abatement”. The project runs from 2010 until 2012 with a budget of 1 million EUR; in cooperation with GEA and Desmet Ballestra (oil processing). The goal of the project is to close the circle for the chemical sector by using waste gas streams and effluent to produce new renewable resources. The research topics treat upscaling of a novel photobioreactor, use of waste CO_2 and nutrients, water management, lowering harvesting costs, wet downstream processing and product development.

René WIJFFELS, Wageningen University**:**

Biofuels and biochemicals from microalgae

Algae cultivation is too expensive for the production of only biodiesel, which is a low value product. The costs of algal biomass are 10 €/kg DW on 1 ha scale. On 100 ha scale 4 €/kg DW are already achieved and 0,4 €/kg DW for algae biomass will be possible.

To reduce cost and optimize the process a ***multidisciplinary approach*** is necessary dealing with molecular, engineering, biology, upscaling, logistics, and sustainability issues.

The provided budget for algae research in Europe compared to USA is very low. Europe has little multidisciplinarity, is weak in biorefinery, life cycle analysis LCA, genetically modified organisms GMO,…. The US are better in GMO, LCA, draw their attention both on food and fuel, they perform strong in two stage raceway ponds, but they are poor in PBR and biorefinery is still weak.

What researchers should do in Europe is to look at PBR and ponds, become active in all disciplines, talk about possibilities instead of problems, develop a vision/roadmap, lobbying and team up with the industry.

At Wageningen University the WETSUS project is running, consisting of 7 PhD projects. 14 companies support or fund the project. WETSUS is dealing with PBR design, degassing, CO_2 transfer, biorefinery, harvesting, metabolic fluxes, scenario studies and others. Wageningen University is involved in small demo projects, wants to work on biorefinery issues such as mild cell disruption techniques, and fractionation of biomass with maintenance of functionality of proteins including an international graduate program.

The AlgaePARC project focuses on upscaling of various systems. It shall be an international independent centre of applied research, between basic research and applications. The parc facilities are under construction and a research program is funded for 2011-2015.

Robin SHIELDS, University of Swansea**:**

Energetic Algae project

The University of Swansea wants to start an energetic algae project with 19 partners with the aim of reducing CO_2 emissions in northwest Europe. The project proposal is still in review. Swansea University is also a partner in the European FP7 BioAlgaeSorb project. BioAlgaeSorb will focus on enabling European SMEs to remediate wastes, reduce greenhouse gas emissions and produce biofuels via microalgae cultivation.

In WP 1 of the energetic algae project a network of pilot scale algal culture facilities is created and best practices are shared. WP 2 wants to create a sustainable algae to energy market in north-western Europe. In WP 3 a knowledge based decision support tool will be developed.

Wolfgang TRUNK, European Commission, DG Health**:**

A new regulation is in application since 1st September 2010, it abolishes pre-market authorisation procedure for feed materials. Formerly the bio-protein regulation required this; now regulation 767 of 2009 (Regulation (EC) No 767/2009) is in application which regulates the placing on the market and the use of feed.

The catalogue of feed materials is very extensive and contains a chapter for algae and fermentation products. Industry might improve this catalogue through better descriptions of existing feed materials or through addition of new feed materials (now 600 feed materials are listed including algae products but not yet published). The catalogue adds to market transparency, but cannot improve the safety of products.

Addition to the catalogue of products from genetically modified algae strains might pose problems. The best is to cooperate already on the research level as to allow EC for insight on toxicological issues of these products.

Discussion:

Economic feasibility and costs:

Education and training in the field of algal biofuels is necessary. Academics and industry need to work together to improve education and training. Coordination of legislation, industry and researchers is substantial.

If waste water is used for algae production, then the product can not go into animal feed. The European legislation is very strict; some products cannot be sold there.

The EU has a huge deficit of proteins and feed, but algae biofuel producers should not rely too much on the protein market for the by-products, because that might be saturated soon. A major problem in Europe will not be the costs of algae production and conversion but finding suitable land areas for cultivation.

It's necessary to define the type of cost: is it for algae biomass, algae products or refined biofuels? Is harvesting or drying included? To reduce the costs microalgae and macroalgae can be mixed (macroalgae are on the market as a commodity). Macroalgae may be used as feedstock for ethanol fermentation. By usage of waste heat from CHPs a further reduction of algae production costs can be achieved.

García-Reina stated that costs for today's production of microalgae are 5 $/kg for *Spirulina* (30 t/ha/yr), 17 $/kg for *Dunaliella* (2 g/m^2/d), and the market price of macroalgae is around 1 €/kg. Predicted costs for microalgae are 1 €/kg or less than 0,5 €/kg without paying for CO_2 or nutrients. Predicted costs for macroalgae in the sea are 0,2 €/kg.

Coordination efforts:

Algae are already part of ETP Biofuels, EIBI already incorporates algal biomass. It is better to tie up with existing than to fragment the field and set up new organisations.

Algae LCA:

It is important to define the strain of algae for which the data is reliable and proven. For data on productivity not laboratory data should be used but pilot plant data from > 6 months of operation. The upscaling to commercial scale should be done in an optimistic way (assumption that the same productivity could be reached).

The received data and LCA should be used for guiding research but not yet for policy advice. A lot of LCAs are based on old data, but new data or technologies become available every 1-2 years.

Algae contain much protein and can replace high amounts of animal feed, thus they should be considered to have a land-use change in the other direction than usual.

In the AlgaeParc of Wageningen University it will be able to test new algae cultivation systems. In Israel it is already possible to test new reactors. The University of Florence spin-off company will also test systems. Testing facilities are also found at Almeria University in Spain, in Portugal and in Czech Republic.

Overall sustainability of algae biofuels

Raphael SLADE, Imperial College London**:**
Sustainability assessment

A literature review on algae LCA identified 7 key studies from Kadam, Lardon, Clarens, Jorquera, Sander & Murthy, Stephenson, Campbell (all 2009 or 2010 except for Kadam 2002). The productivity values have been called into question, normalised productivities range from 10-112 t/ha/yr.

The initial conclusions about algae LCA are that all algae LCA are speculative and rely on extrapolation. Data transparency is an important issue. LCA can only loosely guide policy until commercial processes are known.

Griet CASTELEYN, University of Gent**:**
Mapping

Task 1.9 of the AquaFUELs project deals with mapping available natural resources in artificial, marine and freshwater bodies. Mapping will cover both natural resources for

algae and other aquatic biomass, as well as land resources necessary to open ponds or photobioreactors for massive production of microalgae. Natural blooms, wastewater streams, polluted rivers and lakes will not be forgotten. The first part describes naturally occurring algal blooms as potentially interesting resource for the production of biofuels. The aim of the second part of this task is to develop an European map with potentially ideal locations for algae cultivation on large scale.

René WIJFFELS, Wageningen University**:**

Sustainable production of algal biofuels

Is it possible to replace all transport fuels in Europe (400 mio m^3 of lipids needed)? A surface area of Portugal would be needed and 40 times the amount of soy protein imported in Europe would be produced as by-product. In a biorefinery only a portion (15 %) of the profit would come from biofuels, more money comes from by-products. The AquaFUELs project works also on design scenarios to develop scenarios for production of energy carriers at very large scale.

Wijffels suggests to use GMOs and to use LCA to identify bottlenecks. Production in PBR could become cheaper than in ponds, probably submerged systems shall be used to receive a sustainable production of algal biofuels.

Ron VAN ERCK, European Commission, DG Energy**:**

EU legal requirements for algae sustainability

60 % GHG reduction is necessary for new installations after 2017 – these will apply for algae biofuels. Rules on chain of custody must respect mass balance approach.

8 voluntary schemes of member states have been received so far by the commission.

The question on default values for algae biofuels was answered in that way that algae will not be included in the first update 2012 of the directive.

Stefan LEU, Ben Gurion University**:**

Sustainability impacts of algae biofuels production

The issue of sustainability should have been tackled before any other research activities. There is a triangle of conflicts between water, food and energy. Algae are the only source that could cover the worldwide fuel demand entirely based on land areas.

A sustainability driven system design would consist of cultivation in lined open ponds and 5 % panels using seawater or waste water. A strain with high oil content would be used in a one-stage cultivation. Conversion would be carried out by hydrothermal

upgrading HTU, combustion of residues on site, combustion of biomass, waste or natural gas on site. The biological effluent would be treated for nutrient recovery and recycling. Nutrients can come from e.g. dairy farms, excess manure. Biorefinery concept together with biogas production is preferable where algae grow on effluent from biogas.

Discussion on sustainability:

While open ponds have been developed for low energy requirements for quite a while, PBR have been employed for production of high-value products, where development for low energy input was not an issue. Energy balance for PBR is negative, for open ponds it is positive. Probably a combination of small closed system for inoculation and large open system for production is needed.

LCAs at this point of time are speculations only, because no real data on algae production exists. LCAs should be done with pilot plant values.

Cultivation should be transferred towards industry sites, using waste water, waste heat and flue gas.

Biotechnology and technical challenges

Marco BROCKEN, EVODOS**:**

Low-cost algae biomass harvesting

Evodos is a young company, applying membrane technology of Pall and their own dewatering technology which is a centrifuge. Algae harvesting starts with membrane technology in a rather dilute system (optimum 4 % concentration) and a centrifuge is added (3.000 g) when the suspension has been concentrated. This technology is called Evodos SPT technology and discharges a paste where algae are still viable after this separation. The experience of Evodos leads to a calculated separation efficiency of 95 % at 12 m^3/h, but the technology needs to be validated with the specific algae strain. Costs on a large scale (5.500 m^3/h) are 172 €/t algae dry weight, with preconcentration the costs are 92,19 €/t. Energy consumption is 0,11 kWh/kg DW which means that only 2 % of the energy in the biomass is used for harvesting.

A cell disruption technology is under development to harvest and extract algae in one process step. First algae are cracked, then a 3-phase separator separates oil/lipids from water and biomass.

Alessandro FLAMMINI, FAO**:**

Algae-based biofuels: Application and Co-Products

Within the FAO the Aquatic Biofuels Working Group (ABWG) has been established. The scope of this group is to understand the state of the art, facilitate linkages between groups and disseminate knowledge.

The report "Algae-based biofuels: a review of challenges and opportunities for developing countries" shows that algae have a potential for developing countries, but not in short or medium term. Capital investment and technology capacity (economy of scale, foreign investments, engineering expertise) are required. The scope of ABWG was broadened to co-production of fuel, food and other valuable co-products to break through the barrier of economic viability (minimum cost of product 0,6-7 €/kg biomass – co-products for competitiveness), while at the same time producing a new protein source for human, livestock and fish consumption.

The report on "Algae-based biofuels - applications and Co-products" is finalised (2010). Integrated Food and Energy Systems (IFES) could help with a number of energy/environmental problems, but still require high investments. Market compatible products are fertilizers, inputs for the chemical industry, and alternative paper fibre sources. The products can be customized on local needs but viable algae-based IFES concepts are more complicated than agriculture-based.

Philippe WILLEMS, Orineo Original Renewables**:**

Algae product valorisation

The main statement of this presentation is that microalgae are far too valuable for energy purposes, the energy market price is too low to cover the potential production cost of microalgae and a microalgae biorefinery should focus on the extraction of high-value components (cosmetics, food, chemistry, plastics) with energy as the co-product.

A fractionated approach should be used where 40 % of the material has high value which pleases the investor and 50 % of the material is environmentally good.

The application should be developed following the market demand. Fractionation technologies should be used to produce different products.

Sofie VAN DEN HENDE, Ghent University**:**

PhD work: Carbon and nutrient scavenging from sewage and flue gas with MaB-flocs

Publications on algae greatly outnumber the industrial implementations. Microalgae for biofuel production are not yet economically viable because microalgal biomass is

expensive. Main costs are carbon, water and nutrients and harvesting. Flue gas is a cheap carbon source, sewage is a cheap water and nutrients source and bioflocculation is a cheap harvesting method,

MaB-flocs (micro-algae and bacteria) help with settling. In laboratory experiments PBR was used, but for large-scale open pond system would be used.

Natural settling was induced by local microalgae strains and activated sludge. The results were good productivity (0,05 – 0,19 g/l/d) combined with successful treatment of sewage and flue gas.

Guillermo GARCÍA-REINA, University of Las Palmas**:**

Green desert project

For a positive LCA nitrogen, phosphate, pumping and CO_2 have to be for free, this can be made possible through Integrated Aqua-AgroBiotech IAAB. With photovortex system (PBR) productivities of > 100 t/ha/a can be reached.

Locations in African deserts near the coast with an area of 20.000 km^2 exist which are below sea level. So pumping is for free, water is for free and light is for free. These areas are called shebka, this is what is left from a lake that has evaporated. The salt crust makes it very sunlight reflective. IAAB-module consists of PBR farm, animals for nutrients, seaweed raceway ponds, fish cultivation, sea cucumber cultivation, mangrove forests, *Dunaliella* and *Artemia* cultivation, marshland, birds and reptiles, halophytes and salt ponds in the end. Water from the sea is continually concentrated throughout the multipurpose biomass production system.

20.000 km^2 shebka areas have been identified. The international IAAB centre is located in Gran Canaria where first experiments for the green desert project are conducted.

Clayton JEFFRYES, Louvain University, Laboratory of Bioengineering (GEBI)**:**

Novel PBR-based approaches for improved productivities of algal cell cultures – the role of material science in algal cultivation

There are many configurations of PBR designs which can be optimized by decreasing volume, light dilution, improve mixing, improve mass transfer and control temperature. Material science can improve PBR by increasing material lifetime, eliminating cell adhesion, reducing accumulation of oxygen or water loss, cell separation or optimising material costs. It is necessary to involve industrial players like Exxon-Mobil and Dow Chemicals and other industry into PBR design. Technologies with new materials are developed by Proviron and Solix G4 (membrane material). Encapsulation materials can

be used or semi-enclosed cultivation can be carried out in bags rolled out on the ground.

Development of PBR from semi-permeable membrane, which would allow the oxygen to penetrate, would ease gas exchange.

Sammy BOUSSIBA, Ben-Gurion University**:**

Green Solutions to Global Problems

The working group on algae at Ben-Gurion University consists of 30 people, including students. Many papers are published by this group concerning research in algae parc with various algae cultivation systems.

The main factor limiting long term productivity in algal ponds is solar energy 100 %. Scattering and reflecting leads to 10 % loss, absorption spectrum leads 50 % loss, … Productivity is limited physically to 24 g/m^2/day or 80 t/ha or 30-40 t of oil /ha.

Today the production is low, in real systems productivities of 11 g/m^2/d are reached. A large PBR system is installed in Israel which is the place with the highest radiation of the world, thus cooling of the PBRs is necessary.

GIAVAP is a FP7 project on genetic improvement of algae for value added products. It has a budget of 5,7 mio EUR and was funded 2010. The scope of this project is to develop robust strains, understand ways to manipulate oil production rates and to identify the mechanisms involved in oil accumulation.

The key message is that algae biofuels need long-term R&D in all areas and even if successful, resource limitations will restrict the potential and aqua-biofuels can not replace cheap crude oil or cure global warming. Nevertheless algal biomass can become a valuable part of future energy supply.

Discussion:

Genetically modified organisms

Mistakes that have been made with GMOs before have to be avoided. GMOs for pharmaceuticals or medicines are accepted but what is about GMOs for biofuels? Novozymes sells GMO-made enzymes, but in this case the genome does not come out. In case of algae, the genome will come out with the biomass so we have to be careful not to make the mistakes that happened with agricultural crops, where genomes have spread. Biosecurity is a big issue concerning algae GMO.

GMO is an important technology to use, but the potential and the threat should not be overestimated. Another technology used could be selective breeding, as currently research is focussing on about 20 algae strains although there are millions out there.

GMO may provide major breakthroughs that could not be achieved with selective breeding. If *Haematococcus* (30 % lipid, 50 % carbohydrate) could be stopped producing carbohydrate, it could probably produce 60 % lipid. Probably GMO could place the lipid in the algae cells in places where it is easier to access, that would also be a major breakthrough.

How can we reach the price of oil?

The price of oil from microalgae is still far away from the price of crude oil. When the crude oil is gone, then price will not be the issue.

If we work on cheap cultivation of algal biomass, then any of these pathways can be supported; e.g. Aurora has stopped considering biofuels production, but the knowledge gained is helpful to produce algal biomass for other purposes.

Researchers on macroalgae and on microalgae are not very much communicating with each other, therefore they are reinventing instead of building on the knowledge of one another. In Europe there is only a small number of places to grow macroalgae (e.g. Norway), because they usually are not grown on land but off-shore. Macroalgae can be an interesting alternative for all types of biofuel except for biodiesel. PetroAlgae (USA) is now growing Lemna (they call it microcrop) in sewage water for carbohydrates, which is not an algae but another aquatic biomass.

Status of research in algae use for biofuels and future perspectives

Natascia BIONDI, University of Florence**:**

Taxonomy

The taxonomy is one of the deliverables of the AquaFUELs project. Due to the high complexity of algal taxonomy and evolutionary relationships, this document was conceived as an instrument to place the algae that have arisen an interest for biofuel production within the correct frame.

The species list is based on literature, results of the AquaFUELs questionnaire and discussion among partners. In the annex of the deliverable a list of culture collections already established is given.

Gabriel ACIÉN-FERNANDEZ, University of Almeria:
Cost analysis of microalgae production

For cost estimation a process flowchart is better than a block diagram, because it is very technology specific. Size and type of equipment, life time and taxes, consumables and utilities and manpower have to be considered for cost estimation.

Production cost is mainly a function of culture volume. At larger scale the production costs diminish mainly due to reduction in labour and cost of equipment. PBR constitutes the major costs of equipment. Costs can be reduced (PBR, CO_2, nutrients). Only the operation of microalgae cultures near their maximum theoretical values and the utilization of effluents (flue gases and wastewater) as raw materials will allow producing microalgae biomass competitive for biofuels market.

Liliana RODOLFI, Fotosyntetica & Microbiologica S.r.L.**:**
Current state of research

Annular columns PBR are only suitable for research, small scale production and inoculum production. With Green Wall Panel system and *Nannochloropsis* (60 % lipids) a productivity of 70 t/ha/yr could be reached. More than half of the energy produced in biomass must be invested into mixing and cooling in green wall panels. The cost of this PBR system is close to that of open ponds. The research is now on reducing the cost of mixing and cooling and maximising the volumetric productivity.

Attila WOOTSCH, MFKK Hungary**:**
Novel approach of funding algae related applied research for the benefit of SMEs

MFKK Invention and Research Centre is involved in multidisciplinary research projects. In algae business they are involved in biosensors and mechanical engineering. Now there is an FP7 call on capacities on the benefit of SMEs (FP7-SME-2011-BSG).

MFKK has an idea for a new type of bioreactor (innovative biofilm reactor design). The ALGADISK project proposal was prepared for the call. MFKK thinks economic analysis can be put into a software. MFKK would be the research and management partner.

Guido DE JONGH, CEN**:**

Standardisation: a tool to create a new market for new and innovative fuels

CEN (European Committee for Standardization) is not a part of the European Commission EC, but it is recognized by the European authorities as one of the three bodies for standardisation for the EU. European standards are legally voluntary. Diesel and petrol standards are frequently part of the legal documents in national legislation.

Standards are tools to create new markets, to build up confidence between producer and supplier and to define the quality of the product.

Is there a business case for algal biofuels? Political, economic, environmental and technical issues have to be considered. A CEN Workshop Agreement for algal fuels would help to create a new market for these fuels by having common specifications. Standardisation can be used to spread innovation and confidence in algae fuels.

Dina BACOVSKY, BIOENERGY 2020+**:**

IEA Task 39 report on algae biofuels

IEA Bioenergy Task 39 deals with commercializing liquid biofuels. A recent publication is a report on current status and potential for algae biofuels production. The report was elaborated by a team of authors from within or close to the task group: Al Darzins and Philip Pienkos of the National Renewable Energy Laboratory NREL, USA, and Les Edye, BioIndustry Partners, Australia. It assesses the technical and economic feasibility of liquid biofuels from algal biomass, and draws on an NREL report to the Congress of the USA and on techno-economic analyses by the authors.

The basic concept of algae biofuels including cultivation, harvesting, high lipid content in the cells, conversion to fatty acid methyl ester FAME, hydrogenation-derived renewable diesel HDRD or jet fuel is well known but still no algal biofuels industry exists. Current commercial production of algae biomass is around 9000 t/a either in open ponds, photobioreactors or fermenters, mainly for the production of high-value, low-volume food supplements and nutraceuticals. There are no low-cost options for algal harvesting, nor is the extraction of the algal oil really solved. The high water content not only in the cultivation system but also in the algal biomass itself poses problems to downstream processing. The economic analysis shows that currently algae biofuel production is not economically viable, but it is potentially viable.

Regarding the potential of algal biofuels to replace fossil transport fuels, the authors conclude the following: It is likely that a significant amount of research and a number of breakthroughs are needed to make algal biofuels a commercial reality. Assuming success in the first commercial venture and accelerated rates of adoption beyond 2015-2020, the potential contribution of algae biofuels to the global transport fuel demand would be 5 % of the biofuels supply by 2030.

Philippe MORAND, CNRS**:**

Macroalgae valorisation

Eutrophication is a problem e.g. at Brittany coast and in the Baltic sea. Algae blooms are often harvested and dumped inland, but then after decomposition the nutrient juice runs back to the sea and enables a continuous green tide.

Algal blooms should be harvested and either used for composting or biomethanation to reduce the nutrient flow back into the sea.

Nuno COELHO, AlgaFuel**:**

Algae for Energy and CO_2 sequestration

Algae projects have to be developed in steps. First thing to consider are constraints of local conditions.

AlgaFuel has a pilot facility at a cement factory. They use their flue gas without pretreatment. Remaining heat from the factory may be used for sterilisation, drying, but sometimes also cooling of the photobioreactors is required. One major problem of this co-siting is the fact that when the factory stops production, they do not have supply of flue gas for the algae.

Discussion:

Main technological aspects in biotechnology will be described for the main ca. 10 strains within the AquaFUELs project.

Algae do not really sequestrate CO_2, as its emission is only postponed when the algae are used later on.

In the discussion a few questions remained unanswered: What is small scale for aquafuel production in Africa? Are some values simply the extrapolation of laboratory experiments? We should be realistic when giving scenarios, and have to be very pragmatic – what can be feasible? Might there be climatic changes in desert area when building aquatic facilities?

4 Annex

AquaFUELs Roundtable Programme

AquaFUELs Roundtable Participants

EBB
European Biodiesel Board
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AQUAFUELS
ALGAE TOWARDS BIOFUELS

1043/AQU/10

19/10/2010

AQUAFUELS ROUNDTABLE

October 21st (14:00) to October 22nd (15:30), 2010, Crowne Plaza Europa Hotel, Brussels

PROGRAMME

Thursday, October 21st, 2010

14h00 Welcome and registration

14h15 **Presentation of the AquaFUELs project and the Roundtable**
Overall presentation of the AquaFUELs project
Raffaello Garofalo, European Biodiesel Board, Project Coordinator

Objectives of the Roundtable
Prof. Mario Tredici, University of Florence, Project Scientific Coordinator

Next steps: AquaFUELs coordination with production projects and establishment of EABA
Prof. Mario Tredici, University of Florence, Project Scientific Coordinator

14h45 **State of the Art of algae biofuels production**
AquaFUELs findings: biofuels production pathways, major stakeholders
Raffaello Garofalo, European Biodiesel Board, Project Coordinator

15h15 Experts Presentations
Bert Lemmens, VITO, ALCHEMIS project
René Wijffels, Wageningen University, Biofuels and Biochemicals from algae
Robin Shields, University of Swansea, Energetic Algae project

16h00 Discussions
What is the most sustainable production pathway?
How far are production pathways from commercial production?
Who are the major initiatives?
What are the next steps towards production and how to achieve them?

16h30 Coffee/tea break

2007 - 2013

16h45 **Overall sustainability of algae biofuels**
AquaFUELs findings: natural resources D1.6, existing sustainability assessments
Griet Casteleyn, University of Gent / Raphael Slade, Imperial College
Way forward on the sustainability assessment of algae biofuels
René Wijffels, University of Wageningen / Raphael Slade, Imperial College

17h15 Experts Presentations
Stefan Leu, Ben-Gurion University, Sustainability impacts of algae biofuels production
Ron Van Erck, European Commission, EU legal requirements for algae sustainability
Josche Muth, European Renewable Energy Council, Re-thinking 2050

18h00 Discussions
Will algae production release pressure on natural resources from fuel production?
What Greenhouse Gas Emissions reductions can algae biofuels really achieve?
Could algae be used to decarbonise conventional energy sources and produce renewable energy at the same time?
Will EU sustainability criteria support or hinder the development of algae?

19h00 **Cocktail at the Crowne Plaza Europa Hotel**
Rue de la Loi 107, Brussels *(The Crowne Plaza Europa Hotel is located in front of the European Commission Charlemagne building)*

20h00 **Gala dinner at the Crowne Plaza Europa Hotel**
"Smart" dress code

Friday, October 22nd, 2010

09h00 **Biotechnology and technical challenges**
Insights: biotechnology, technological and economic challenges & next steps
Sammy Boussiba, Ben-Gurion University / Nuno Coelho, Algafuel / René Wijffels, Wageningen University

09h15 Experts Presentations
Marco Broken, EVODOS, Low-Cost Algal Biomass Harvesting
Alessandro Flammini, FAO, Algae-based biofuels: applications and co-products
Philippe Willems, Orineo Original Renewables, Algae products valorisation
Sofie Van den Hende, Carbon and nutrient scavenging from sewage and flue gas with MaB-flocs
Guillermo Garcia-Reina, University of Las Palmas, Green Desert Project
Clayton Jeffryes, Novel photobioreactor-based approaches for improved productivities of algal cell cultures

11h15 Discussions
How to recover what algae have produced?
Producing algae for biofuels or using residues from other production processes?
What algae productivity needs to be achieved to reach economic viability?

11h45 Coffee/tea break

2007 - 2013

12h00	**Status of research in algae use for biofuels and future perspectives** AquaFUELs findings: active researchers, taxonomy, biology *Prof. Mario Tredici, Dr. Natascia Biondi, University of Florence*
12h30	Experts Presentations *Liliana Rodolfi, Fotosintetica & Microbiologia – current state of research* *F. Gabriel Acién-Fernandez – Costs analysis of microalgae production*
13h00	Lunch
14h00	*Dina Bacovsky, Bioenergy 2020+ GmbH, IEA Task 39 report on algae biofuels* *Guido de Jongh, CEN, Standardisation: a tool to create a new market for new and innovative fuels* *Attila Wootsch, Novel approach of funding algae related applied research for the benefit of SMEs* *Philippe Morand, Macro-algae valorisation*
14h45	Discussions On what areas should researchers focus? Are the right policies in place for the development of algae biofuels? With which important research initiatives should AquaFUELs coordinate in priority?

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AQUAFUELS
ALGAE TOWARDS BIOFUELS

Ref: 1028/AQU/10 20/10/2010

AquaFUELs Roundtable

October 21st- 22nd, 2010
Crowne Plaza Europa Hotel, Brussels

PARTICIPANTS

NAME	COMPANY	COUNTRY
1. Prof. Spiros AGATHOS	Louvain University	Belgium
2. Ms. Maria BARBOSA	WURFood & BioBased	The Netherland
3. Dr. Kateřina BIŠOVÁ	Czech Institute of Microbiology	Czech Republic
4. Mr. Jonas DAHL	Danish Technological Institute	Denmark
5. Dr. Maeve EDWARDS	Irish Seaweed Centre	Ireland
6. Mr. Cameron EDWARDS	VESTA Biofuels Brunsbüttel	Germany
7. Prof. Jose FERNANDEZ SEVILLA	University of Almeria	Spain
8. Dr. Imogen FOUBERT	K.U.Leuven University	Belgium
9. Dr. Gloria GAUPMANN	EBIO	Belgium
10. Dr. Sridharan GOVINDACHARY	Queen's University	Ireland
11. Prof. Patricia J.HARVEY	University of Greenwich	UK
12. Mr. Sven JACOBS	Howest	Belgium
13. Mr. Frédéric LAEUFFER	TOTAL	France
14. Mr. Remy MARCHAL	Institut Français du Pétrole	France
15. Mr. Riccardo MARCHETTI	Oxem S.p.a	Italy
16. Dr. Laura MARTINELLI	Studio Martinelli	Italy
17. Ms. Roberta MODOLO	Studio Martinelli	Italy
18. Mr. Benoit QUEGUINEUR	Irish Seaweed Centre	Ireland
19. Ms. Jessica RATCLIFF	Irish Seaweed Centre	Ireland
20. Mr. Jean-François ROUS	Diester Industrie	France
21. Ms. Briana SAPP	PANGEA	Belgium
22. Mr. Philippe SCHILD	European Commission (DR Research)	Belgium
23. Mr. Johannes SKARKA	Karlsruher Institute of Technology	Germany
24. Ms. Andrea SONNLEITNER	Bioenergy 2020	Austria
25. Mr. Julien TAIEB	FEFAC	Belgium
26. Prof. Laurenz THOMSEN	Jacobs University Bremen	Germany
27. Dr. Wolfgang TRUNK	European Commission (DG Health)	Belgium
28. Mr. Dries VANDAMME	K.U.Leuven University	Belgium
29. Mr. Peter VAN DEN DORPEL	AlgaeLink N.V.	The Netherlands
30. Mr. Jan VANHOUTTE	BEKO	Belgium

31. Dr.	Koen VANHOUTTE	Navicula	Belgium
32. Mr.	Ignacio VASQUEZ- L.	European Commission (DG Climate)	Belgium
33. Dr.	Milada VITOVÁ	Czech Institute of Microbiology	Czech Republic
34. Ms.	Annalisa VOLSE	PANGEA	Belgium
35. Dr.	Wim VYVERMAN	Ghent University	Belgium
36. Ms.	Annika WEISS	KIT	Germany
37. Dr.	Vilém ZACHLEDER	Czech Institute of Microbiology	Czech Republic

AquaFUELs Roundtable

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SPEAKERS

NAME		COMPANY	COUNTRY
38. Prof.	Gabriel ACIEN FERNANDEZ	Almeria University	Spain
39. Dr.	Dina BACOVSKY	Bioenergy 2020+ GmbH	Austria
40. Dr.	Natascia BIONDI	University of Florence	Italy
41. Prof.	Sammy BOUSSIBA	Ben - Gurion University	Israel
42. Mr.	Marco BROCKEN	Evodos	The Netherlands
43. Ms.	Griet CASTELEYN	Ghent University	Belgium
44. Mr.	Nuno COELHO	AlgaFuel	Portugal
45. Dr.	Guillermo GARCIA-B.REINA	University of Las Palmas Gan Canaria	Spain
46. Mr.	Guido DE JONGH	CEN	Belgium
47. Mr.	Alessandro FLAMMINI	FAO Aquatic Biofuels	Italy
48. Mr.	Clayton JEFFRYES	Louvain University	Belgium
49. Dr.	Bert LEMMENS	VITO	Belgium
50. Dr.	Stefan LEU	Ben - Gurion University	Israel
51. Mr.	Philippe MORAND	CNRS	France
52. Mr.	Josche MUTH	EREC	Belgium
53. Ms.	Liliana RODOLFI	Fotosintetica & Microbiologica S.r.l	Italy
54. Dr.	Robin SHIELDS	Swansea University	UK
55. Dr.	Raphael SLADE	Imperial College London	UK
56. Mr.	Mario R. TREDICI	University of Florence	Italy
57. Ms.	Sofie VAN DEN HENDE	Ghent University	Belgium
58. Mr.	Ron VAN ERCK	European Commission (DG Energy)	Belgium
59. Prof.	Rene WIJFFELS	Wageningen Universiteit	The Netherlands
60. Mr.	Philippe WILLEMS	Orineo BVBA	Belgium
61. Dr.	Attila WOOTSCH	MFKK Hungary	Hungary

AquaFUELs Roundtable

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EBB PARTICIPANTS

EBB STAFF

62.	Mr.	Raffaello GAROFALO	(EBB) Project Coordinator	Belgium
63.	Mr.	Angel A. ALBERDI	European Biodiesel Board	Belgium
64.	Mr.	Luca ANGELINO	European Biodiesel Board	Belgium
65.	Ms.	Elisa FAILLA	European Biodiesel Board	Belgium
66.	Ms.	Stephanie HO	European Biodiesel Board	Belgium
67.	Mr.	Pierre-Antoine VERNON	European Biodiesel Board	Belgium
68.	Mr.	Jean-Marie SERGOYNNE	European Biodiesel Board	Belgium