VELEUČILIŠTE
BALTAZAR
ZAPREŠIĆ

Ernest Vlačić

SOLEALGAE
AN EXAMPLE OF COLLABORATIVE PROJECT PROPOSAL SUBMISSION

Case Study Workbook

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Zaprešić, 2019.

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ERNEST VLAČIĆ

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Veleučilište *Baltazar Zaprešić*

Zaprešić, 2019.

Preface

The approach

Today courses in project management are taught on a range of degree programmes, most notably business and management studies. Students on such programmes may turn to a limited number of books and other literature that is covering the core subject, but the sheer length and density of these texts, and the inappropriateness of particular use often intimidate them. This workbook SOLEALGAE represents a real case example of collaborative project proposal submission to the Horizon2020 Fast Track Innovation (FTI) funding instrument, aiming to co-finance the technical innovation in firms.

The main objective in writing this Case study workbook has been to meet the needs of students, by providing practitioners real life case for all the relevant topics learned through their educational process.

I believe that this workbook achieves this while using a hand on writing style to present the complex project interesting and practitioners' accessible. The project proposal workbook SOLEALGAE emphasizes the relevance of structured project submission approach and represents itself a solid example and case to keep students interested, and engaged.

In summary

It is my personal intention is that the workbook should be:

- comprehensive yet concise
- rigorously structured
- business, strategically and project management relevant
- representing a real life example and case study
- written in an engaging style

In preparing the manuscript for this book I have worked closely together and benefited from a number of helpful comments made by colleague, Dr. Nicolas Walker, as well as many suggestions from different reviewers.

Ernest Vlacic

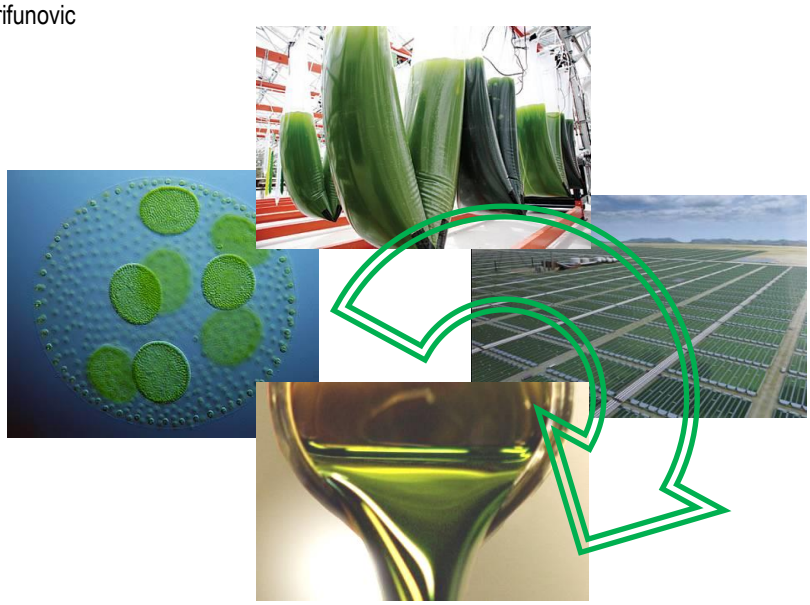
Horizon 2020: The Fast Track to Innovation (FTI) Instrument

Project acronym: *SOLEALGAE*

Project title: Hybrid Algae Cultivation System Based on Conditioned Environment with Efficient Light Collection and Distribution System

Beneficiary Number	Participant organisation name	Short name	Participant type	Country
1	**MICRODEAL Corporation Ltd.**	**MICRODEAL**	**SME**	**UK**
2	**ALGAEDIESEL Castilla la Mancha, S.L.**	**ALGAEDIESEL**	**SME**	**Spain**
3	**EMERGO d.o.o.**	**EMERGO**	**SME**	**Croatia**
4	**AlgaeTeam NV**	**ALGAETEAM**	**SME**	**NL**
5	**ScientX**	**SCIENTX**	**RTD**	**UK**
6 (coordinator)	**SCIMERGO Innovative Technology Centre**	**SCIMERGO**	**RTD**	**Croatia**
7	**Tecnologías Avanzadas**	**TEAV**	**RTD**	**Spain**
8	**GASOIL**	**GASOIL**	**OTHER**	**Slovenia**

Coordinating person: Nenad Trifunovic



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Terminology

Light Collector

An optical device which intercepts light and moves a proportion of it into some optical system for its subsequent use. Light might be concentrated by the collection (it achieves a light density exceeding the original intensity of the light source) or not.

Light Concentrator

An optical device which operates to achieve an increase in the intensity of light as compared to the original source. This light might be captured by a light collector or not. A converging lens is the simplest way to produce a light concentrator, but complex arrangements of reflectors and waveguides also perform this.

Luminescent Concentrator

A type of light collector which consists of a planar waveguide which incorporates fluorescent dyes either distributed in the material of the waveguide or in a thin film. The light absorbed and re-emitted by the fluorescent dyes is partially trapped within the waveguide and emerges, concentrated, at the edges.

Light Transmitter

An optical method of moving light from one place to another. The simplest such approach is a fibre optical cable but a variety of light guides or even free space optics can be used.

Light Distributor

A means of taking light from a controlled light source and spreading it though a volume of medium. It would normally consist of a combination of light transmission and light emission elements.

Abstract

This document is presenting an example of Horizon2020 industrial collaborative technology development project submission specifically targeting The Fast Track to Innovation (FTI).

The strategic overall objective of the presented case study project is to develop an optical light collection and distribution system that will significantly increase the productivity of existing open pond algae cultivation plant designs while maintaining low capital and operating costs and consequently reducing the overall costs per unit mass of algae oil produced.

Light intensity is a key parameter affecting algae growth. Depending on the algae species and cultivation environment maximum production rates are achieved with the light intensities between 30 W/m2 and 100 W/m2 - which is around 1/10 of the light intensity of direct sunlight. Furthermore algae are very efficient in absorbing the light that hits them and with fairly dense algae concentrations all light is absorbed in the thin top layer of the algae pond in the order of only few centimetres. These factors make open pond algae cultivation systems inefficient in their conversion of sunlight into algae oil mass.

Such comprehensive case will help students to understand and overcome the complexity of Horizon2020 submissions helping them to develop and submit their own proposals.

1. Excellence

Strategic overall objective of the project

Photo bioreactors are closed systems with controlled light distribution and algae environment. Existing prototypes of photo bioreactors show significant increases in productivity, but are very complex and expensive to build. High capital and operating costs increase overall costs per unit mass of algae oil produced in photo bioreactors over open ponds, even with these significant increases in productivity.

In order to achieve the objectives we are presenting innovative concept of hybrid open pond – photo bioreactor technology (HOBR in future text) that will exploit advantages of both algae cultivation technologies, low capital and operation costs of open ponds with the light distribution system of photo bioreactors for higher productivity, in a new hybrid algae cultivation technology.

Two technical approaches will be explored in a project:

- open pond with light distribution system and
- open pond / photo bioreactor hybrid system with light distribution and low cost closed algae environment system.

Open pond with light distribution system is a simpler concept that uses existing open pond design and introduces the novel low cost optical distribution system for increased productivity. Open pond / photo bioreactor hybrid system with light distribution and low cost closed algae environment system also includes low cost plastic tubes suspended in water connected to low shear mixing pumps in order to produce a fully closed system. This then addresses the additional issues of open ponds such as algae contamination and overgrowth.

The complete biofuels (ALGAEDIESEL) production cycle, in addition to algae cultivation, include: harvesting process, oil extraction process and oil to ALGAEDIESEL conversion process. Even though they are the part of complete production cycle, these processes are not in the scope of this project as this project concentrates on algae cultivation process as the key process that affects overall ALGAEDIESEL production costs.

Proposed technology will address the major obstacle for large scale algal oil biofuels production – higher production costs relative to other biofuels feedstock.

1.1. Objectives

Market drivers and potentials

In the coming decades the combination of falls in the production of conventional fossil fuels such as oil, the requirements to reduce carbon emissions due to climate change, and the increasing energy and food demands of a continually growing world population means that new, highly efficient means of generating fuel and food need to be developed. In addition, it is important that any new forms of biofuels are produced in ways that do not compete with agricultural food production in terms of land, water or other requirements.

The use of algae as a source of biofuels, biomass and food, looks extremely promising as they can be grown on scrub or desert land not capable of supporting conventional agriculture. Many algae can be grown in sea water and their potential levels of production per square metre exceed other methods of biofuel production (soy beans, sunflower, rapeseed, palm oil and others, see

Table 1) by many times. If algae production can cost effectively support biofuel production, it can also be cost effective for production of nutritional commodities.

All this implies that algae production should be an attractive option but for several reasons the total levels of production globally are miniscule and currently only serve to produce certain high margin nutritional or health products plus cosmetics. Further developments are required to lower the production costs of algae if they are to fulfil their potential.

The primary potential markets for algae products today include:

- Health food supplements (e.g. spirulina)
- High margin nutrients such as DHA (Omega-3 fatty acids)
- Aquaculture feeds

- Cosmetics
- Pigments and antioxidants
- biofuels production as future driving potential

The potential biofuels market today is driven by government mandates, but as energy prices increase, demand for biofuels may become more price-driven. Technological and regulatory developments, such as production of more fuel-efficient cars, hybrid cars or increased greenhouse gas emission reduction targets can also impact demand.

The global energy market consists of electricity and fuel sectors and carbon emission reduction is equally important in both areas. The electricity sector is around 33% of global energy and for this sector a range of increasingly viable CO_2-emission mitigation solutions are being pursued from renewable energy to carbon capture and sequestration. The fuels sector is larger (67% global energy) representing around 15.5 TW (489 EJ/year) in 2005 according to the Energy Information Administration, USA. Carbon emission mitigation in this sector is far less developed. The first generation biofuels systems, essentially fuels derived from agricultural products, have been disappointing due to serious economic and environmental limitations. In contrast, second generation lignocelluloses and microalgae biofuels have the potential to overcome these issues and develop into a clean fuels market which is predicted to expand US $500bn by 2050 [170], or more. The hope is that production costs can be brought down to a point that these fuels are cost competitive with oil, assuming increased oil prices and a possible carbon tax.

Project objectives

Overall technological aim

Overall technological aim of the proposed project is to develop optical light distribution system that will significantly increase productivity of existing open pond algae cultivation plant designs while maintaining low capital and operating costs and consequently reducing overall costs per unit mass of produced algae oil.

Light intensity distribution and wavelength conversion functions of optical light distribution system will lead to significant increase in productivity rate of algae cultivation. By introducing low cost light distribution system we aim to increase overall open pond productivity rate in the range of 80% to 120% and expect that overall increase in production costs will not exceed 25%. With these productivity and production costs targets we expect overall reduction of production costs per unit mass of algal oil to be in the range of 30% to 55% compared to existing open pond algae cultivation plant production costs.

Scientific objectives

Scientific objective of the proposed project is to develop optical light distribution system that will:

- Distribute light incident on the algae cultivation plant surface in a way that light reaches larger algae volumes with light intensity around optimal values (between 30 W/m^2 and 100 W/m^2) that yield to maximum productivity rates
- Provide light wavelength conversion from wavelengths that are poorly utilized to wavelengths that are efficiently utilized in algae growth

Two specific scientific objectives are identified in the project:

a. Development of the light collector for the collection of light in order to "feed" light distribution system. Light collector has to meet following specific goals:
    - The light incident on the surface below the light collector is reduced to between 1/10 and ¼ of the total incident light intensity
    - Light is harvested by the light collector and fed to an interface with the light distribution system with as high efficiency as possible

- Light which is only poorly used by blue-green algae is, if possible, converted into wavelengths with maximum photosynthetic activity
- Infra-red light is reflected away from the surface below the collector (and not fed into the light distribution system) in order to reduce the heat load on the algae cultivator

b. Development of light distributor that will conduct and distribute collected light to the algae to achieve more efficient light utilization. The light has to be conducted efficiently over some short distance and then released in a controlled manner over and extended volume such that the light intensity within an algae rich suspension will be illuminated as uniformly as possible over that volume.

Optical light distribution system, both light collector and light distributor, will be developed with the aim of making the system have as low capital and operating costs as possible. To achieve this goal, selected cost effective materials will be used and the system will be designed to be as simple as possible.

Technological objectives and achievement actions

Specific technological objectives of the proposed project are:

a. Design and development of algae cultivation plant (HOBR) based on existing open pond cultivation plant designs with introduction of optical light distribution system. Cultivation plant will be designed with the aim to best utilize light distribution system benefits to maximize production rate while keeping capital and operating costs as low as possible. Besides development and design of cultivation plant with introduction of light distribution system, guidelines will be given on best ways to incorporate light distribution system in existing open pond algae cultivation plants.
b. Design and development of algae cultivation environment conditioning system that will enable optimal environment parameters to maximize algae oil production rate. The system will provide measurement, monitoring and control functions. Algae cultivation and environment parameters that will be included in a system are:
    - algae concentration in suspension
    - temperatures in various points of algae cultivation plant
    - CO2 and O2 concentrations
    - nutrients concentration
    - pH factor of a suspension
c. Algae strain selection process that will determine algae strain (or strains) that can adapt and grow optimally at a large range of conditions in cultivation plant. Constant feedback between the design engineers and the algae biotechnologists will result in the lowest possible construction cost of the cultivation system, at a high biomass production rate, by finding the optimal algae strain to match the cheapest, most energy efficient design options. Besides design-related criteria, the economics will be analysed by looking at products that can be co-produced with algal oil, from the same algal biomass, and the sustainability will be analysed. This will result in a continuing feedback loop of improvement options.

1.2. Relation to the Work Programme

This innovation project answers directly to the Work Programme for “Innovation in SMEs” and will be submitted under EIC-FTI-2018-2020: Fast Track to Innovation (FTI) Stimulating the innovation potential of SMEs for sustainable and competitive agriculture, forestry and bio-based sectors. TEVINS is directly aligned to the call objective of a “HORIZON 2020 EIC-FTI-2018-2020: Fast Track to Innovation (FTI)” by providing innovative algae cultivating system, aiming to reduce cost of algae cultivation.

1.3. Concept and methodology

Current State of Art

Algae are today considered major potential feedstock for biofuel production. The main reason for such attention being directed towards algae for biofuel production is that algae have much higher oil production rate per unit area compared to other, land based, cultures like soybeans, sunflower, rapeseed, palm oil and others (see

Table 1).

Crop	Oil yield litres / ha year
Corn	170
Cotton	330
Soybean	450
Sunflower	960
Rapeseed	1.200
Oil palm	6.000
Algae (open pond production rate today)	11.200
Algae (potential production rate)	90.000

Table 1. Crop oil yields in litres per hectare and year (US National Renewable Energy Laboratory - The Potential for Biofuels from Algae, 2007)

The second important factor contributing to such an attitude is that algae can be cultivated in areas not suitable for agricultural production, that is, algae cultivation does not compete with food crops for arable land. Other factors in favour for algae are following: possess higher relative oil content, can be cultivated in saline or even wastewater and can utilize waste CO_2 streams.

Light intensity is the most important factor affecting oil production in algae. The algae growth increases with increasing light intensity until the light saturation point is reached in which algae reach their maximum growth potential. Increasing the light intensity beyond the saturation point leads to photo inhibition where damage of the light receptors occurs which leads to decrease of productivity. Furthermore, lipid or oil content in total algae mass severely falls during photo inhibition further reducing algae oil production. For optimal light intensities, algae can yield up to 80% of oil content while with normal sunlight light intensities (clear sky sunlight mostly between 200 – 800 W/m^2) oil content drops to 10 to 15%. Laboratory research results on light intensity impact on algae growth and oil content for the *Botryococcus Braunii* algae are shown on the

Figure **1** and

Figure **2**. Depending on the algae species and light-dark cycles (in open ponds they are normal sunlight day-night cycles) maximum oil production rates are achieved with the light intensities between 30 W/m^2 and 100 W/m^2.

Algae are very efficient in absorbing the light that hits them, even when they reach saturation point or enter into the photoinhibition state. For that reason, with fairly denser algae concentrations, all light is absorbed in the thin top layer of algae, which leads to saturation and photoinhibition of the top algae layer while algae in the lower layers are left completely in the dark.

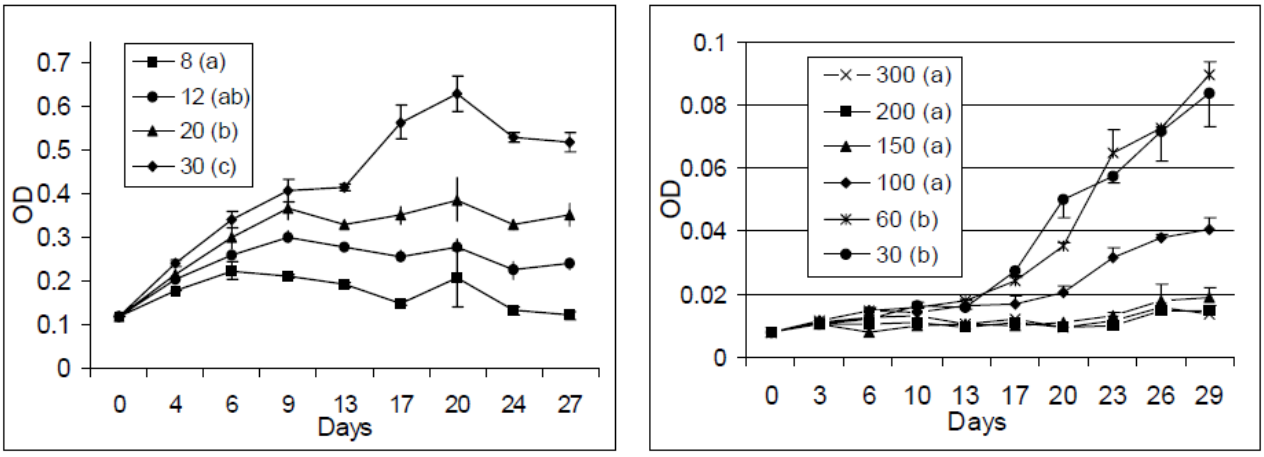

Figure 1. Algae growth for the Botryococcus Braunii algae in days (OD – optical density is proportional to algae density) for the low light intensities (left) and high light intensities (right) (light intensities in W/m²) [1]

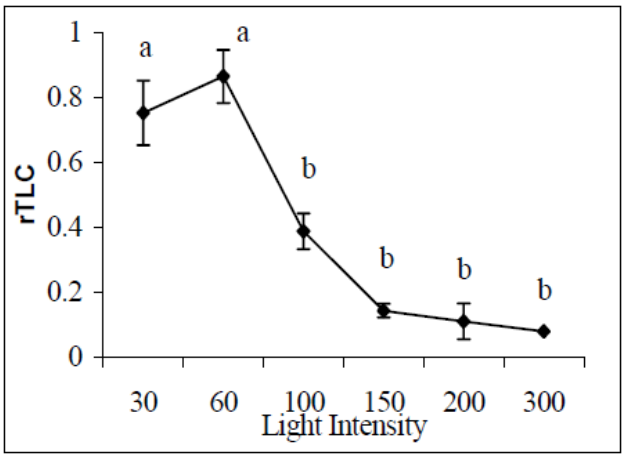

Figure 2. Dependency of Relative Total Lipid Content (rLTC) to Light Intensity (in W/m²) [1] for the Botryococcus Braunii algae

In addition to light intensity, several more factors have significant influence on oil production in algae.

Not all light incident on algae can be used in photosynthesis process in algae. The portion of solar spectrum with wavelengths between 400 nm and 700 nm, called Photosynthetically Active Radiation **(PAR), is used in photosynthesis process in algae. It is obvious from the fact that they are coloured rather than black that green plants and algae are not optimised to absorb light overall the full range of the visible light spectrum - their colour is due to their failure to absorb light in the middle of the visible light spectrum. Chlorophyll absorbs the best at the edges of the PAR range and not that well in the middle part of the range. Green algae absorption spectrum is shown in**

Figure 3.

[1] Australian Government – Rural Industries Research and Development Corporation, "Bio-Hydrocarbons from Algae – impacts of temperature, light and salinity on algae growth", Juan Qin

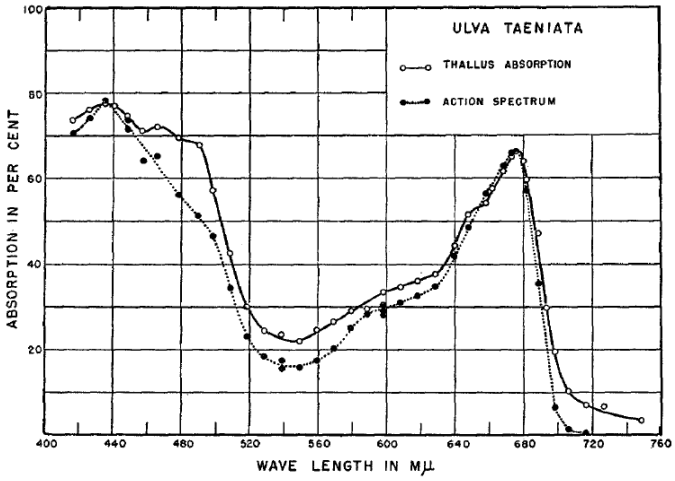

Figure 3. Green algae absorption spectrum (action spectrum, F.T.Haxo, L.R.Blinks, "Photosynthetic action spectra of marine algae", October 1949)

The temperature **of the algae suspension has a large affect on algae growth. Algae growth increases with the rising temperature during light part of the cycle, until optimal temperature is reached, after which it decreases. Optimal temperatures for the algae growth are mainly in the range of 20°C to 30°C. The temperature during the night part of the cycle can be kept 10°C to 15°C lower without negative effect on the oil production rate.**

During photosynthesis process CO_2 **is captured and** O_2 **is released. Low CO_2 concentrations and high O_2 concentrations in algae suspension can inhibit algae growth and oil production. It is therefore essential to ensure that CO_2 is fed to algae suspension and O_2 removed from algae suspension.**

Nutrients **are also necessary for algae growth. Nutrients that have to be added include nitrogen, phosphorus and silicon.**

Other factors often mentioned to affect algae growth are salinity and pH level**. Algae can, without affect on alga growth, be cultivated in low salinity water. Some algae species can even grow in high salinity water like sea water. Lower levels of pH have virtually no affect on algae growth and only excess levels of pH can significantly inhibit algae growth.**

Two major technologies are used today for algae cultivation:

- **open ponds**
- **photobioreactors**

All large-scale algae cultivation today relies on open pond plants**. Open pond algae cultivation plants are simple shallow (typically 0.2 to 0.3 m) ponds with algae suspended in water. Ponds are usually stirred (also called open raceways) as they have much higher productivity rate than unstirred ponds. Stirred ponds are designed as two parallel canals connected at the two ends. The algae suspension circulates the pond forced by stirring paddles. Open pond plants have low oil production rates compared to the theoretical possibilities but are simple in design and have relatively low capital and operational costs. Open pond have the lowest overall production costs per unit mass of produced oil and are still the only technology available today considered for large scale algae production. Reported algal oil yields in open ponds today reach levels around 10.000 litres per hectare and year.**

Figure 4. Open pond algae cultivation plants

Photobioreactors **are closed systems designed to maintain optimum algae growth parameters and utilize the most sunlight possible for algae oil production. There are many photobioreactor designs being proposed today but there are no large scale photobioreactor plants to date. Two basic principles in photobioreactor design are used for overcoming light intensity limitations: first uses dense algae concentration in concentrated solar light intensities with radial mixing of the algae culture and second uses light distribution technologies to distribute light to the algae with optimal intensities.**

The main advantage of photobioreactors is high oil production per unit area reaching maximum possible production rates. Further, they eliminate contamination with other species, reduce water evaporation and enable better control of production parameters. The main disadvantage of photobioreactors is high capital and maintenance costs. Even though photobioreactors have higher production rates than open pond plants, they still have higher total production costs per unit mass of produced oil and are still not considered for large-scale algae production.

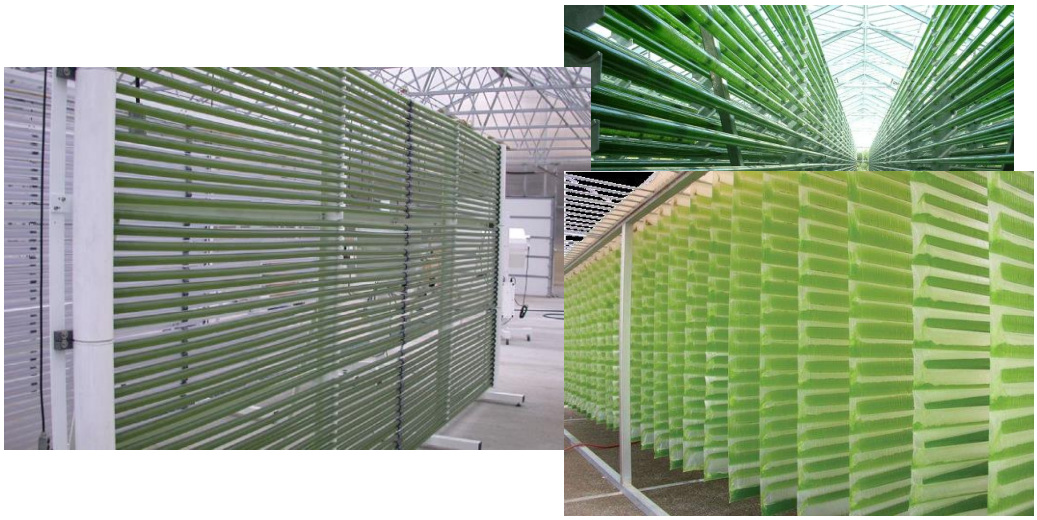

Figure 5. Photobioreactor plant designs

Algae cultivation is the first step in algae based biofuel (ALGAEDIESEL) production cycle. The processes that follow algae cultivation **are:**

- **harvesting process**

- **oil extraction process and**
- **conversion process.**

Harvesting process **include water draining and algae mass concentration. To achieve this there are few technical processes that can be used like using water draining tanks, mechanical presses, various drying processes like solar drying, flocculation, centrifugation and filtration. The cost of harvesting can be a significant part of overall ALGAEDIESEL production costs. The costs are lower with higher algae concentrations in algae suspension medium and with higher relative oil content in algae.**

Oil extraction process **extracts oil from the algae mass. Physical and chemical processes are used. Processes that are considered and used for oil extraction include: mechanical expulsion, solvent extraction, supercritical fluid extraction, enzymatic extraction, sonication and osmotic shock. The costs of this process are also high and can be made lower with higher relative oil content in algae.**

Conversion process **is the final step in which algae oil is converted into ALGAEDIESEL. ALGAEDIESEL is produced from a vegetable oil or animal fat feedstock in transesterification reaction between triglycerides esters (vegetable oil or animal fat) and alcohol (methanol) in presence of alkalis such as potassium hydroxide or sodium hydroxide as catalyst. Unlike raw algae oil, ALGAEDIESEL can be used in conventional diesel engines as a pure fuel, or blended with conventional diesel fuel. The ALGAEDIESEL that can be found in retail today is usually offered blended with conventional diesel fuel in ratios 1:5, 1:2 and 4:5 ALGAEDIESEL content in total volume, denoted respectively B20, B50 and B80.**

Even though they are the part of complete production cycle, these processes are not in the scope of this project. This project concentrates on algae cultivation process as the key process that affects overall ALGAEDIESEL production costs.

Technical Barriers of Current Technologies

Open pond algae cultivation plants **are the only technology considered today for large scale algae production. Even though algae production is the cheapest using open ponds technology, open ponds have a very low production rate compared to the theoretical production possibilities. Theoretical considerations estimate that algae oil production could reach as much as ten times more oil compared to the amounts today produced in open ponds.**

Several technical barriers are key factors that are limiting production to low rates in open ponds.

The most important factor is low light utilization**. Direct sunlight reaches algae pond surface with intensities around 10 times higher compared to optimal intensities for algae oil production. As algae are very efficient in absorbing light that hits them, light incident on pond surface reaches only a thin surface layer of only few centimetres, while algae in deeper layers are left completely in the dark. Not only that light does not reach a large part of algae in a pond, but the light is poorly utilized in algae that receive light. Due to high light intensity, algae in a top layer quickly reach saturation point and enter the stage where photoinhibition, that is, damage of the light receptors and decrease of productivity occurs. This leads to a low algae growth rates and low relative oil content.**

Therefore, to achieve optimal growth, algae growth systems need to reduce the direct illumination on an algae cell. Most systems, including open system, operate to perform this reduction using "temporal averaging" - a specific algae cell moves up and down in depth due to the mixing process and therefore experiences a range of light intensities between full intensity (when at the top of the water) and near zero intensity (when at the bottom of the water). This approach is necessarily suboptimal since some algae are being damaged by too intense light, some are operating near or below the saturation level (which is wasting light) and some are left completely in the dark.

The second major factor limiting the production rate is temperature of a pond that is hard to control **in optimal ranges. Generally, algae growth increases exponentially with rising temperature during the light part of the cycle until an optimum temperature is reached, after which algae growth decreases. Optimal temperatures**

during the light part of the cycle are in the range between 20°C and 30°C. Temperatures during dark parts of the cycle can be kept 10°C to 15°C below optimal temperatures without affecting algae growth. Depending on the location and season of the year temperatures in a pond can reach levels above and below optimal levels.

Third significant factor is susceptibility to contamination **by other species. This significantly limits the number of algae species that are adequate for cultivation in open ponds. Algae species that are adequate for cultivation in open pond plants have to be resistant to high ambient temperature swings and aggressive in limiting contamination with other species. However, these species are not the best in terms of growth rate and high relative oil content.**

Photobioreactor systems **were developed to overcome limiting factors of algae growth in open ponds. There are many photobioreactor designs being proposed today but there are no large scale photobioreactor plants to date.**

Two basic principles in photobioreactor design are used for overcoming light intensity limitations, first use dense algae concentration and concentrated solar light intensities with radial mixing of the algae culture and the second uses light distribution technologies to distribute light to the algae with optimal intensities.

Photobioreactors as closed systems enable closer control of algae cultivation parameters like temperature and nutrient concentration. Photobioreactors as closed systems eliminate potential contamination which enables cultivation of species with high growth rates and high relative oil content.

Intensive cultivation with dense algae concentrations in photobioreactors lead to overheating of the algae suspension and high O_2 and low concentrations. These parameters have to be controlled as both can lead to severe degradation of productivity. Photobioreactors thus have to have powerful systems for temperature control and intensive CO_2 / O_2 exchange to reach its productivity potential.

The main barrier in large scale algae production in photobioreactors is still large capital and operating costs **of photobioreactors. Photobioreactors today reach productivity rates that are around double the productivity rates of open pond plants, but the costs to build and operate photobioreactor plants increase even more making overall costs of production per unit mass of algae oil higher compared to open pond plants.**

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1.3.1. Overall strategy and general description

Implementation plan introduction

We, the SME proposers, aim to develop the scientific knowledge required for the implementation of the project over a period of 24 months. The consortium will than implement its plan for IRA (Innovation Related Activities) that will enable dissemination of the results of the project to the greater scientific and industrial community, initially at the EU and subsequently at a global level. Through the implementation of IRA, the consortium further aim to meet the societal and economic objectives of the project.

Research approach and methodology

The work programme is divided into eight Work packages: WPs as shown in the Perth and Gantt charts on the following pages. It is the objective of these work packages to research (WP1 and WP2) and develop (WP3, WP4 and WP5) the main innovations to be implemented. In brief, these consist of a novel light collecting and distribution system and novel concept of algae cultivation – hybrid open pond / photo bioreactor technology (HOBR). The developed technology will then be integrated into a product prototype, tested and validated (WP5).

1.4. Ambition

Optical light distribution system

Our solution for the barriers resulting in low productivity of open ponds and high production costs of photobioreactors is innovative concept of hybrid open pond – photo bioreactor technology. The main mean to achieve that goal is development of optical light distribution system. The main functions of light distribution system are:

- **to distribute light incident on the algae cultivation plant surface in a way that light reaches larger algae volumes with light intensity around optimal values (between 30 W/m2 and 100 W/m2)**
- **to provide light wavelength conversion from wavelengths that are poorly utilized to wavelengths that are efficiently utilized in algae growth**

Light distribution system is by function divided into two separate parts - light collector and light distributor.

Light collector **has a function to absorb incident light and transfer it to the light distributor with as high efficiency as possible. Specific development goals for light collector are:**

- **The light incident on the surface of the surface below the light collector is reduced to between 1/10 and ¼ of the total incident light intensity**
- **Light is harvested by the light collector and fed to an interface with the light distributor with as high efficiency as possible**
- **Light which is only poorly used by blue-green algae is, if possible, converted into wavelengths with maximum photosynthetic activity**
- **Infra-red light is reflected away from the surface below the collector (and not fed into the light distribution system) in order to reduce the heat load on the algae cultivator**

One approach will be taken and analysed in development of light collector:

a. **Luminescent concentrator collectors using a dye which emits at red peak of photosynthetic activity. An untracked luminescent concentrator will be mounted feeding light into a thin vertical waveguide. Uncollected light will pass through the luminescent concentrator (as well as some absorbed light re-mitted through the bottom of the collector). The concentrator will be coated with an IR reflecting mirror to control the heat load on the algae cultivator. Optimal shapes for the collector will be evaluated.**

Light distributor **has a function to distribute collected light to the algae suspension with optimum intensities. The light will be conducted efficiently over some short distance and then released in a controlled manner over an extended volume such that the light intensity within an algae rich suspension will be illuminated as uniformly as possible over that volume. The system will consist of waveguides and light outcoupling regions. Waveguiding will be performed a combination of total internal reflection in materials of higher refractive index than their surrounding (air or water) or reflection from a highly reflective surface. Light outcoupling will be performed by the inclusion of surface structures which outcouple light at differing efficiencies with these structures arranged so that light is released uniformly, using more efficient outcoupling in volumes where the light intensity within the guide is lower. The overall light emitting surface shapes will be chosen by evaluating a number of alternative solutions includes flat plates and cylindrical elements.**

The ability to fully clean the light distribution system of surface contamination by algae using simple, cheap and fast processes will be evaluated and surface treatments which improve the cleanliness or ease of cleaning of the structures will be evaluated and used where appropriate.

Prototypes of several alternative light distribution systems will be simulated, prototyped and evaluated, in both fully transparent and high algae occlusion volumes.

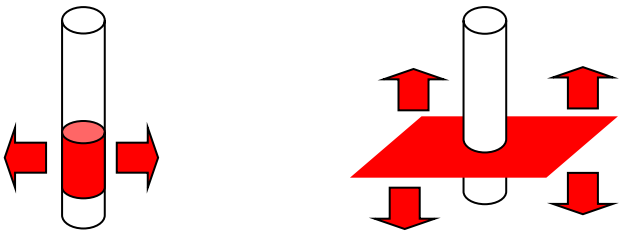


Figure 6. Illustration of light distribution principle, light pipes conduct light into the depths of the pond where light emitters illuminate algae in a controlled fashion

In 1976 Weber and Lamb proposed a new type of solar concentrator - Luminescent concentrators **which use fluorescent dyes and a planar waveguide to trap light (within the waveguide) and concentrate it to the ends of this waveguide. The light is absorbed by the dye and remitted at a longer wavelength. Part of the remitted light is trapped within the waveguide and emitted at its edges. The remainder is emitted up or down and exits the waveguide. The dye can be coated onto a thin film and the result is the same as being distributed through the bulk of the waveguide.**

Therefore the joint requirements of spatial light distribution and utilisation of spectral shift **can be used for algae growth using a waveguide with something like the following arrangement. A light absorption part either contains a fluorescent dye in the bulk or the waveguide or, preferably for manufacture, coated onto the surface of the waveguide (or on a film bonded on the surface of the waveguide). A light extraction section consists of microoptics textures of structures which are constructed in such a way that light is emitted uniformly over a this area. This uses diffractive, refractive or reflective structures to redirect light out of the waveguide, similar to methods used in the construction of edge illuminated waveguide plates for flat panel displays. In the light absorbing section not all the sunlight is absorbed, a certain amount simply travels straight through and in addition a proportion of the absorbed and re-emitted light does not waveguide but is emitted directly through the back face of the absorbing section (a similar proportion is re-emitted through the front face and therefore lost).**

The waveguide can be shaped into curves, though care must be taken to ensure that light is not lost out of the bent surface (for example by using mirror strips).

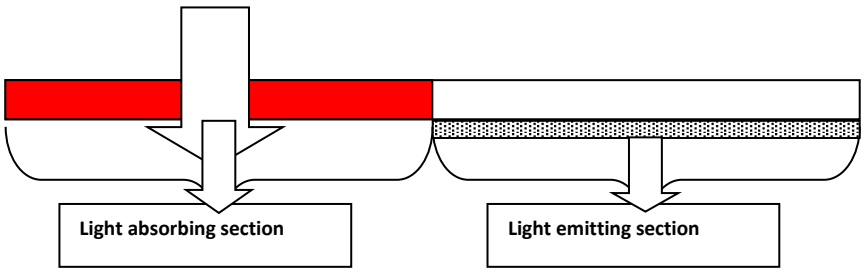


Figure 7. Illustration of light absorption and light emission sections of light distribution system

By choosing an appropriate fluorescent dye(s) which gives the correct absorption and red light emission (around 670nm) and which has long lifetime, a luminescent concentrator algae photobioreactor can be built.. A representational example of the approach is given here.

The light is absorbed by the dye and remitted. Part of the remitted light is trapped within the waveguide and emitted at its edges. The remainder is emitted up or down and exits the waveguide. The dye can be coated onto a thin film and the result is the same. Specific microoptical structures can be placed on the edges of part of the waveguide and these outcoupling structures enable light to be re-emitted from the waveguide. For use with

algae illumination, seeking to provide 10% sunlight intensity to the growing tubes, the overall system arrangement is given in the following figure.

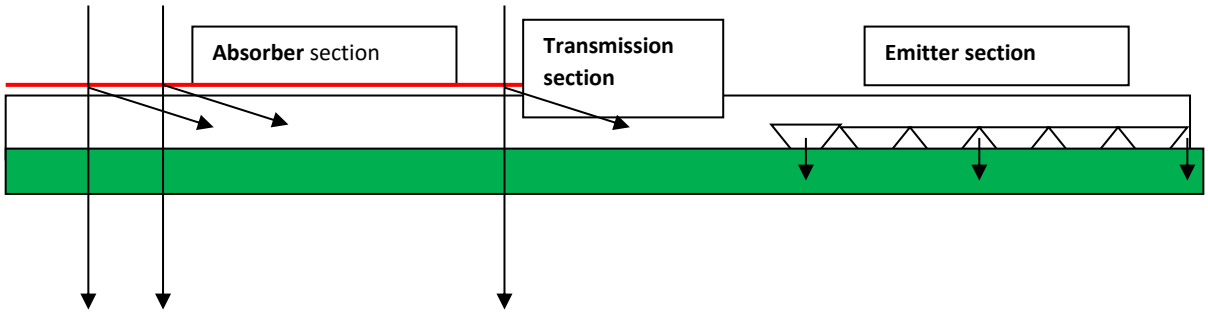


Figure 8. Overall arrangement of the light distribution system

Some light passes through the luminescent concentrator to illuminate algae below (by changing the density of the dye molecules in the coated section of the absorber this can be made to be 10%) whilst the remainder waveguides to the emitter section where it exits the waveguide to illuminate algae below that section. The microoptics of the emitter section can be tuned to ensure a uniform light emission over the length of this section (e.g. by reducing the outcoupling efficiency of the early part of this section and increasing the outcoupling efficiency of the late part).

Open Pond / Photobioreactor Hybrid Concept

Closed photobioreactors offer some significant advantages over open pond system in algae growth cultivation primarily due to the following issues:

- Growth rates are higher since the lighting, temperature, nutrient and gas (carbon dioxide) concentration can be closely controlled
- They prevent contamination of the growth medium with native algae which can be a serious problem particularly when growing a specialised algae (e.g. rare strain, genetically engineered etc)
- The primary problems with closed photobioreactors which open ponds avoid are:
- The cost is very significantly higher than open ponds
- There can be a problem with removal of oxygen resulting in higher than optimal dissolved oxygen levels

We therefore propose hybrid concept in which some of the befits of closed photobioreactors are brought in a form which is nearer to an open pond. This section discusses some potential approaches we aim to analyse:

a. Light redistribution approaches which are low cost and capable of being fitted to open ponds (and therefore support both open ponds and hybrid approaches). This is discussed in the optics section – essentially protruding light guides are fed surface light and redistribute it under the water to more evenly illuminate the entire bulk of the medium within a channel.
b. Low cost closed systems. The cost of acrylic, polycarbonate or glass tubes is prohibitively expensive. Therefore any method to enclose large volumes of growth medium must use the types of low cost plastic already employed in the agricultural industry, e.g. in strawberry growth tubes – polythene. A good example of a modified plastic suited to this application is Luminance THB. The plastic does not have the intrinsic strength to carry the algae filled water, so a suitable way to use this material would be to suspend tubes in a clear water medium. The problem of oxygen build up would need to be addressed, e.g. by using sections of the tube separated by mixing units where the oxygen is removed using low cost, but sealed, stations.
c. Sensors and monitoring will be deployed to manage the plant operations and ensure desired values of environment parameters.

Cultivation plant is a hybrid of tubular horizontal photobioreactor and open pond.

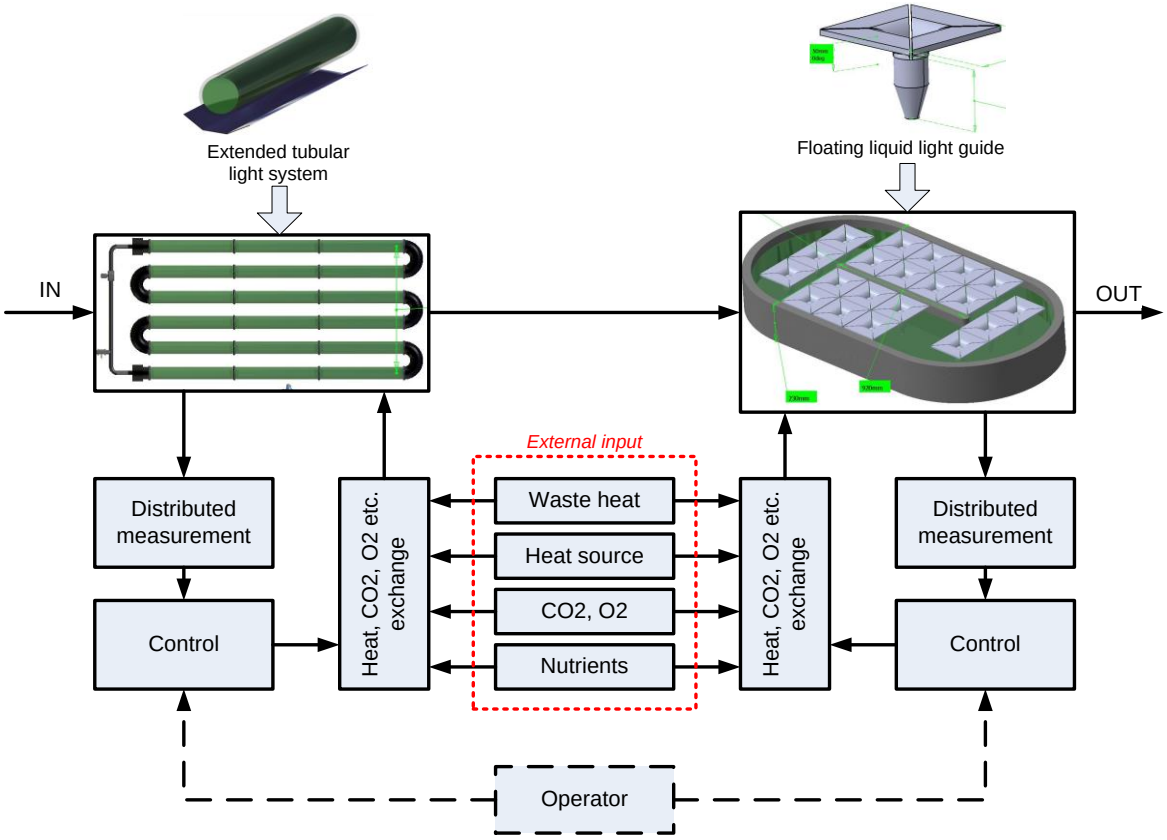


Figure 9. Cultivation plant conceptual design

The idea is to develop general design applicable for various types of tubular photobioreactors and ponds cultivation. This approach will give us opportunity to use the end product on photobioreactor, open pond and of course on hybrid cultivation plant. Other benefit is that we will be able to implement this system on various photobioreactors and open ponds that will enhance market potential.

However, the hybrid concept can be used not only for the equipment but for the whole cultivation strategy. The algae will be cultivated in two stages: firstly producing bio-mass in a photobioreactor, where the cultivation condition can be controlled for a better growth at higher concentration of nutrients and light, and secondly the biomass passes to an open pond with different conditions to favour biochemical algae composition such as increase lipids content.

In that sense, the Open pond and Tubular PBR are HBOR system and algae is grown first in tubular PBR and after that in Open pond.

The size of both can be determined by the difference in concentrations of each steps, but in general the volume of the bioreactor is 1/3 of the open pond. The higher concentration in the reactor, the lower size of it for the same biomass production and open pond size.

Depending of the final product ALGAEDIESEL or added value fatty acids, the conditioning system is different because for intensive cultivation (ALGAEDIESEL) water needs to be recycled, meaning more equipment and control.

Cultivation environment conditioning system

To achieve optimal algae growth in term of overall costs per unit mass of produced oil, number of parameters have to be measured and controlled. Algae cultivation environment conditioning system will ensure that all relevant algae cultivation parameters are controlled to be in the desired boundaries and measured and recorded

for later analysis SCADA control and data acquisition application will be used for plant control, supervision and data recording.

Cultivation parameters that are relevant in algae cultivation plant include:

- **monitoring of light levels in the algae suspension medium, in several predetermined locations**
- **algae density and relative oil content**
- **temperature in the algae suspension medium**
- **ambient temperature in the vicinity of algae pond**
- **algae medium water level**
- **oxygen and carbon dioxide concentrations**
- **nutrients concentration**
- **salinity and PH levels**

Algae cultivation conditioning system will be designed with the aim of minimizing costs while ensuring that the desired functions are fulfilled.

Levels of light intensity will be measured in algae suspension medium. This measurement will be compared to algae production rate to determine overall light utilization factor.

Algae density will be measured indirectly through optical density. As algae are very efficient in absorbing light, there is a straightforward relationship between light intensity that passes through some layer of algae suspension medium and algae density in that layer. Controlled light emitter and light intensity sensor will be placed so that algae suspension flows between them. Depending on the measured light intensity that reaches the sensor algae density will be calculated. The relationship between optical density and algae density for the selected algae species will be determined in laboratory.

Temperatures in the algae medium and ambient temperatures will be measured using low cost Pt100 sensors.

Algae medium water level will be measured and controlled. Water evaporation and algae harvesting will be lowering water levels in algae medium. Water exchange system will control water level in the algae cultivation medium.

Oxygen and carbon dioxide concentrations as well as nutrients concentrations, in algae medium will not be measured but only indirectly, trough algae growth rate, will be determined if the concentrations are adequate for algae growth. Oxygen and carbon dioxide exchange system will ensure sufficient exchange between algae medium and surrounding air. Optimal oxygen and carbon dioxide exchange rate and nutrients intake rates will be determined in laboratory and controlled according to laboratory predetermined patterns.

Salinity and PH levels will be periodically tested to ensure that they meet laboratory predetermined levels. All measurements will be converted to standard 4-20mA measurement signal and fed into PLC system and over network to SCADA application.

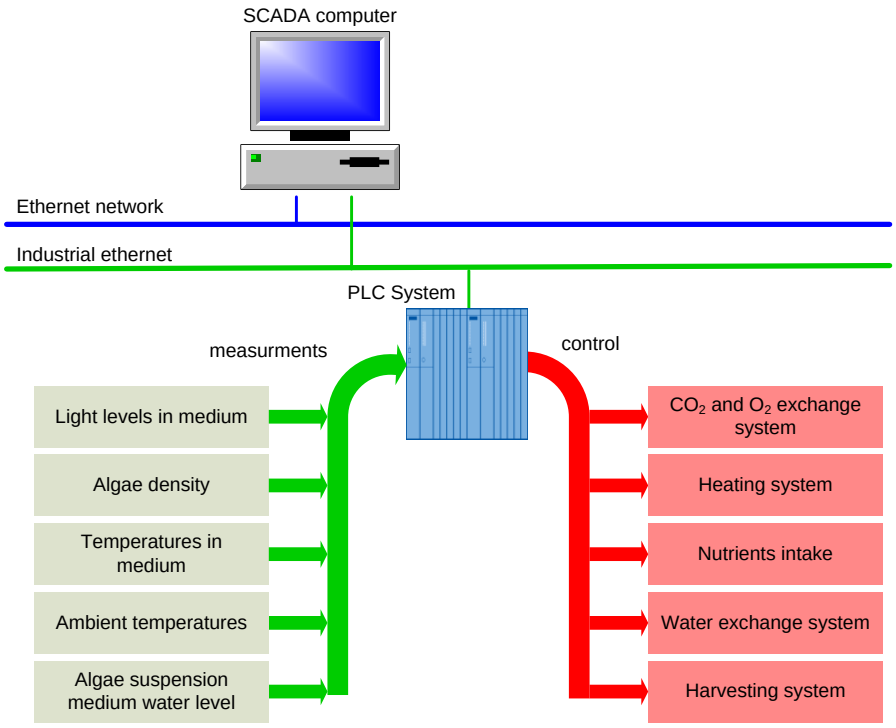


Figure 10. Functional diagram of cultivation environment conditioning system

Algae strain selection

Algae, as a group of organisms, have a very wide range of characteristics, in terms of shape and size, ability to produce oil and other products, growth speed, optimal salinity, temperature, light intensity, light wavelength, optimal pH, optimal nutrient concentration, optimal CO_2 concentration, optimal O_2 concentration, optimal flow speed, optimal density and many more characteristics. Furthermore, the products that a certain strain of algae produces, depends strongly on the cultivation conditions. Selecting the right strain of algae is therefore a highly complex process, and becomes even more complex considering that several 100.000 species of algae exist, of which have been studied in detail. Below a list of some of the most important selection criteria for the project is presented. The list will be updated and completed in the beginning phases of the project.

- Fast growing: **if a species is not fast growing, the effect of improved lighting conditions that SOLEALGAE offers is most likely less.**
- Optimal wavelength for photosynthesis: **Land plants primarily rely on chlorophyll (a and b) as the pigment to harvest light for photosynthesis, which results in 2 optimal wavelengths, while light in the middle of the spectrum (green) is partially wasted. Different algae families can produce high levels of different pigments that harvest light in this unused spectrum, or the outside of the spectrum, like near-infrared. The technology used in the project can convert an inefficiently used wavelength into a better used one. In coordination with the cheapest, most efficient options for new wavelengths, an algae strain can be selected that optimally benefits from this. Additionally, almost all of these pigments can be extracted and have a high market value.**
- Insensitive to high cell concentrations: **another unique feature of the technology developed in this project, is that the available sunlight is not only supplied from above, but also from other directions. Under normal conditions, fast growing algae will get so dense that light only penetrates centimetres (or less) into the water, no light is received at higher depths. This means that in regular open ponds the concentration is normally around 0.1g/l only, or at harvest, 99.99% is water that needs to be removed. Supplying the light from multiple directions allows higher cell densities, making harvesting cheaper and more efficient. Some algal species appear to prefer higher cell densities, other populations crash at a certain point.**
- Well known species: **The main objective of this project is to design a system that improves the lighting conditions in such a way that the biomass growth speed is significantly increased. This means it needs**

to be compared with the maximum growth speed under other conditions, so the most convincing results will be obtained by comparing a strain on which a lot of research has been performed, and the maximum growth speed is well known. Additionally, selecting a well-known strain means almost always that there is a market for that strain already, and that the optimal cultivation conditions are well known.

- Extreme condition: **In order to produce a low-cost cultivation system, a large part of it is open to the environment. This means that the selected strain has to compete with other algae that may grow faster at the given conditions, and algae-eating organisms. Therefore the only species that are currently successfully cultivated have a tolerance for an extreme condition that other organisms do not have. The most important examples are high salinity (e.g. *Dunaliella*), high pH (e.g. *Spirulina*) or high nitrogen (e.g. *Chlorella*). The selected strain must posses such a tolerance, else the cultivation will most likely be invaded by other species.**
- Salt water species: **Even though algae can potentially produce many times more oil than any land plant (see table 1), many 1000s of hectares will be needed to supply the EU with biofuel. If all that cultivation area would use fresh water, this would put too much pressure on the existing sources, especially since an open system is used, with high water losses due to evaporation. Fresh water systems could work in some specific locations, but from a sustainability point of view, using sea water would be preferred, so the algae strain must be salt water adapted.**
- Easily harvestable: **next to inefficient light utilisation, another major factor influencing the production cost of algae is the difficulty of separating these microorganisms from the water they grow in. Some species settle or float, are bigger than others or even from long wires. These and other characteristics would improve the overall economics**
- High oil content: **not every strain has high oil content, and strains that do, only produce this oil under very specific conditions. The best known trigger is Nitrogen starvation which will be considered in a project. Under the influence of extra light but no nitrogen, the algae yield solar energy but cannot produce protein, thus cannot grow multiply, therefore they produce oil instead, as an energy storage for when nitrogen is available again. The algae will be harvested before that happens. A strain that shows this behaviour needs to be selected**
- High co-product content: **it has become clear that even with the impressive cost reduction expected from the project, it still very difficult to produce algae oil at a price that can compete with fossil fuel. Fortunately, algae produce many more products then just oil, some with market values of many €1000s per kilo. The selected strain should produce a second product, to help reach economic feasibility.**
- Strength of cell wall: **the strength of the wall of algae cells varies very strongly between species. Weak cell walls are preferred because they are easier to break open to reach the valuable content of the cell, but if the cell wall is too weak, it will break when touching pumps, stirrers and reactor walls, and die. The ideal strain has a relatively weak wall, but survives cultivation**
- Attached growth: **many species of algae have the capability to attach to surfaces. If a strain is selected that can attach to the cultivation system wall, light will not pass into the reactor.**

2. Impact

Environmental analysis (PESTLE analysis)

The SOLEALGAE products are primarily initially aiming to cover the EU wide market, but on the other side it is a product with an undoubted global potential and have no regional limitations for penetration. To get to an understanding of the current environmental conditions that could influence the SOLEALGAE project success the appropriate environmental analysis was assessed by the simplified PESTLE framework, which is displayed in that follows.

SOLEALGAE Project, PESTLE analysis			
Factor	Impact	Trend	Supportive to the project
Political	**The impact of the environment somehow influences the project, mostly related to the political decisions on the legislation that regulates implementation of such plants.** **Some political influences on preferences with technology providers can be expected as well.**	**Clean energy is proving politically acceptable and the trend is to become ever more favourable to politics and politicians.**	
Economic	**The economic situation with regard to spiralling energy costs is definitively supportive to the project. CO2 certificates are offered to the producers of clean energy, what is an additional incentive for investors.**	**It expected that the price of energy will continue to increase rapidly.**	
Social	**Energy produced from proposed plant is clean, environmentally friendly and will create new jobs.**	**Trend on the social aspect is increasing, and it will become one of the focal points of interest in the future.**	
Technological	**Project is using State of Art technologies today. It is oriented towards future research and development of features in order to make it more efficient.**	**Development of the technology can help implementation of ever more efficient plant.**	
Legal	**We need to foresee and understand the potentially applicable legal requirements and ensure algae are legally and safely developed and the end-products (i.e., biofuels and co-products) comply with applicable consumption standards. Being a nascent industry, there are no existing standards for various aspects of algal biofuels production.**	**Public awareness of the legal issues relating to renewables is constantly increasing; this trend is expected to increase in the future.**	
Environmental	**The project is fully oriented towards the environment. Algae have a number of characteristics that allow for production concepts which are significantly more sustainable than their alternatives. These include The possibility of utilizing marginal, infertile land, salt water, waste streams as nutrient supply and combustion gas as CO2 source to generate a wide range of fuel and non-fuel products**	**With no doubt, the environmental aspect is strongly supporting the project.**	

Table 2. PESTLE analysis

The overall conclusion reached by the means of PESTLE analysis is that the current environment is that all six components strongly support the SOLEALGAE project. The level of support for each force could arguably be somewhat higher or lower; however, it never exits from the positive impact area. Overall, it is clean and renewable product that is economically feasible with great market potentials, environmentally friendly and with tangible social impact on the EU economy. However, the project attempts to emphasize strong improvements in technological and economic aspects.

2.1. Expected impacts

Although the need for dense energy carriers for the aviation industry and other uses is assured in the foreseeable future, there is currently lack of viable renewable alternatives to biofuels for that component of the transport sector. Algal biofuels have many advantageous characteristics that would lower impacts on environmental degradation in comparison to biofuel feedstock and in some cases improve the well-being of developing and developed communities.

Global Algae Market Opportunities

The global market for algal biomass is poised for explosive growth in the **next ten to fifteen years**. Algae is attracting increased investment and interest from biofuels, GASOILeum, and agribusiness industries. Europe and US can not grow enough corn, soy, or rapeseed to meet their biofuels targets. Fast growth in US and European ALGAEDIESEL markets from 2007-2009 has lead to increased biorefining capacity but a shortage of feedstocks. Long-term demand for biofuels in the US, EU and Asia will create **new opportunities** for algae and other non food- feedstocks to meet ambitious targets for ALGAEDIESEL, ethanol, and advanced biorefineries for biofuels and chems.

A new research report from Pike Research named 'Algae-Based Biofuels' indicates that the algae biofuel output will witness a tremendous growth in the **next two decades** resulting in the manufacture of over 61 million gallons of fuel per year with an estimated market value of $1.3 billion by 2020**.** The same research anticipates that, with 50% of all algae activity the United States is poised to ramp up production the earliest among world markets. Pilot- and demonstration-scale facilities are beginning to break ground across the country.

The European Union (EU) market, which is home to **about 30% of algae activity,** will be limited initially by the industry's focus on university research, and later by insufficient access to water, land, and nutrient sources. Latin America and Asia Pacific, which are home to fewer projects in operation today, are set to gain significant market share in the long run rate (CAGR) of 72%.

To date, most development is within the US with small peripheral markets in the European Union (EU) and Asia are expected to emerge through collaborations with companies based in that country, the report said. The US dominance is forecast to represent more than 80 per cent of the global market for open pond algae cultivation from 2010 to 2015, with the EU expected to gain a market share of 11% and Asia the remaining 7%.The report said through to 2015, cultivation technology sales are expected to hold most of the total algae biofuels production technologies market. Alongside this, the remaining market segments will be held by a combination of harvesting, extracting and fuels production facilities, with a total projected market value of more than 1.6bn in 2015.With a market size of about $271m for 2010, the report said this increase is significant and underscores that this is a quickly changing and evolving industry, expected to show an annual growth rate of almost 43 per cent.

Potential markets and estimated market share

The potential of the Algae market in the years to come is hard to predict due to number of uncertainties that are linked to this field (technology price and yields are among critical ones). To simplify our estimation for the market potentials we'll present the numbers only in the biofuels segment, while the other segments will be briefly presented in Table 5. So in order to estimate the total market potentials for the SOLEALGAE products we have to base our approach on different available data sources and relate it to the global needs and production of biofuels. Table 3. Biofuels Potentials in 2014 (billion gallons), FAO July 2010 presents the total biofuels prediction by the year of 2014.

Biofuels Potentials in 2014 (billion gallons), Assumption: One gallon of oil = $3	
Total Oil Consumption in 2014	1500
Total Projected Supply by Traditional Biofuels	41
Total Ethanol Production in 2014	26
Total ALGAEDIESEL Production in 2014	15
Share of Traditional Biofuels in Total Oil Consumption	2.73%
Projected Market Size for Traditional Biofuels	$ 123 billion

Table 3. Biofuels Potentials in 2014 (billion gallons), FAO July 2010

Due to the relatively new technology and markets we'll estimate our figures for the period of 15 years after the product will be launched. This will start in 1-2 years after the closure of this project.

For the sake of simplicity and with careful approach we'll use the forecast that was done by IEA in 2009, taking the 'Business as usual' figures from the figure

Figure 11 . IEA 2018, World Energy Outlook**. So based on the period 2015-2030, and values from the**

Figure 11 **we can present the estimated figures in the Table 4. Estimated Algae biofuels market. As for the Algae market estimation in the same table, it goes from modest 0,2% in the 2015 up to 12% in 2030, which is a bold guess for that year. However, the widely perception is that the share of Algae in biofuels will be significant in years around 2030, due to the fact that its market share can grow much faster than other biofuels.**

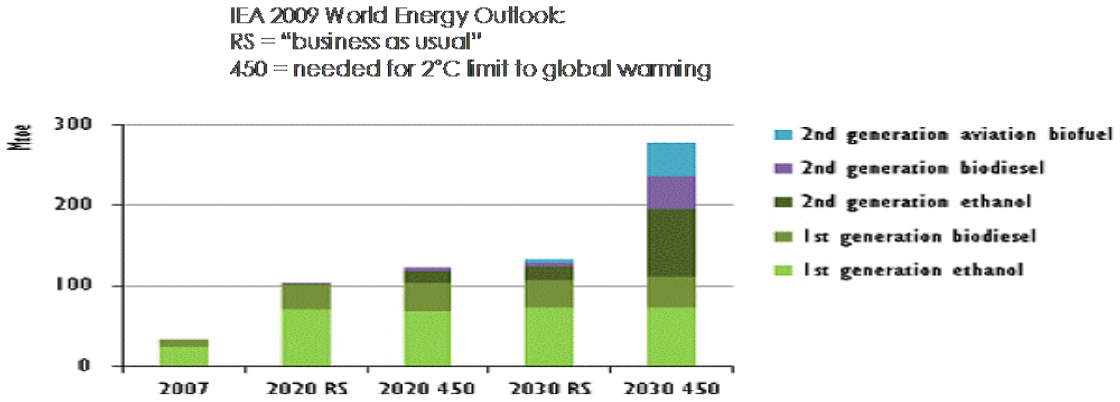


Figure 11 . IEA 2018, World Energy Outlook

year	2020	2023	2025	2030
Biofuel market in 2014 (in Billion Eur)	28,00 €	44,00 €	49,00 €	56,00 €
Algae biofuels share, estimated	0,2%	0,58%	3,00%	12,00%
Algae biofuels market (in Billion Eur)	0,06 €	0,26 €	1,47 €	6,72 €

Table 4. Estimated Algae biofuels market

Technology price estimation and validation

Energy is a low-value product. ("High" oil prices are tens of €cents per litre, algal biomass for health-foods and cosmetics can cost €1 000s per kilo.) This means that alga culture should be as cheap as possible in order to make conversion into energy carriers economically feasible. Current Algae market is more attractive for the pharmaceuticals, nutraceuticals and cosmetics, but in close future it is expected that biofuels production from algae will rapidly overcome other segments.

Applications	Price / Kg biomass	Market volume
Nutraceuticals (human consumption)	€ 100	€ 60 million
Nutraceuticals (animal and fish feed)	€ 5-20	€ 3-4 billion
Bulk chemicals	€ 1-5	> € 50 billion
Biofuels	< € 0.40	> € 1 trillion
Present market volume: € 1 billion Segment: biomass process > € 50 / kg biomass Objective: market segment < € 0.40 / kg biomass		

Table 5. Prices and volumes of markets where Algae can play a role, Wijffels, 2008

Current systems and HOBR upgrade

There are four existing systems for algae cultivation today and these are; open pounds, raceway production, photobioreactors and fermentators. Within the open systems, raceway ponds provide a much better yield than more extensive systems, while keeping capital investment generally low. In scientific literature, this system is sometimes mentioned as the only open system practicable for large-scale production (Carvalho *et al.*, 2006; Chisti, 2007).
Our target is to implement our technology (hybrid open pounds bioreactor - HOBR) in raceway algae production plants (RAPP), therefore all our calculations will be based on HOBR.

Table 6 is presenting the upgrading cost of the RAPP by HOBR and percentage of SOLEALGAE technology in it. Our technology value can be compared only with existing equipment, excluding the land, site preparation and construction, where estimations are made for the typical 5 hectares plant.

	Raceway Algae production plant	HOBR with SOLEALGAE Technology		% of SOLEALGAE in Equipment cost
Open pound construction, land and site preparation / 5ha	**110.000,00 €**	**19.900,00 €**		
Open pound construction, land and site preparation	**550.000,00 €**			
Equipment costs/ ha	**84.729,00 €**			
Equipment costs / 5ha	**423.645,00 €**	**391.975,00 €**		**93%**
Total / average 5ha pond size	973.645,00 €			
Annual Operational cost / ha	**14.500,00 €**			
Capital cost / 5 ha	**72.500,00 €**			
TOTAL	1.046.145,00 €	1.438.120,00 €		

Table 6. RAPP to HOBR upgrade price

With upgrading by SOLEALGAE technology, HOBR s will be able to produce increased yield as per table

Table 7. There we can see significant improvements in Yield (g/m2/day) at almost double, as well as twice increase in Algae lipid content. With this figures and the predicted price of 391kEUR (the cost is specified in the Table 8) in for the standard 5ha upgrade we can expect the return on investment for the SOLEALGAE technology in 6,3 years. The price of the oil is also estimated at 0,85 EUR/l in the period 2015-2030, calculated on value of 100 EUR/barrel, what we consider acceptable for the years to come.

	Raceway Algae production plant	Production increase factor HOBR with SOLEALGAE Technology	Payback period (years)
Yield (g/m2/day)	9,38	18	
Lipid	15%	30%	
Oil price/l, in the period 2015/2030, estimated 100EUR/barrel	0,85	0,85	
Production total / 5ha	21.946,79 €	84.230,77 €	
Difference with Solagen tech. and ROI		62.283,97 €	6,29

Table 7. RAPP to HOBR yields increase and payback period

To validate the SOLEALGAE price we have specified it for the typical standard unit of 5ha production facility. Price breakdown in major items is presented in Table 8. The highest value contributors to price are light collectors and light distributors due to the large quantity needed for covering the HOBR surface areas. The project results distribution will allow other SMEs to participate in the fair share of economic benefits through licensing of the light distributors/collectors.

	EUR 391.975,00	SME technology provider
Light Collectors	125.000,00	MICRODEAL
Light Distributors	160.000,00	MICRODEAL
Control part	10.500,00	EMERGO
Mechanical Part	39.000,00	ALGAEDIESEL
Piping and tubing	5.000,00	ALGAEDIESEL
Cleaning systems	15.000,00	ALGAEDIESEL
Bio items/components (CO2 injection, O2 extraction, algae)	15.000,00	ALGAETEAM
Maintenance, incremental per year	4.000,00	local
Engineering and design, other costs (max. 5%)	18.475,00	

		ALGAETEAM, ALGAEDIESEL

Table 8. Price breakdown of the SOLEALGAE technology for typical 5 ha plant

Sales Forecast

In order to estimate cumulative benefits of the SME partners we have to predict SOLEALGAE technology sales to market. Sales forecast will be done using the figures from previous tables and integrating them into the table **Error! Reference source not found.**.

	2020	2022	2025	2030
Estimated Algae biofuels market (in Billion €)	**0,06**	**0,26**	**1,47**	**6,72**
# HOBR 5ha needed for production of estimated Algae biofuels market	**665**	**3.030**	**17.452**	**79.781**
SOLEALGAE total market potential (in Billion Euro)	**1.303**	**5.938**	**34.204**	**156.360**
SOLEALGAE target	**1,00%**	**1,00%**	**0,70%**	**0,30%**
Price factor	**100,00%**	**90,00%**	**80,00%**	**65,00%**
SOLEALGAE number of units sold	**13**	**59**	**239**	**469**
SOLEALGAE total market in EUR @ base price of 391kEUR	5.107.449	20.947.835	75.079.494	119.514.297
			Total cumulative	220.649.075 €

Table 9. Sales forecast for SOLEALGAE products

Basis for the sales prediction is the Estimated Algae biofuels market in period of 2020 to 2030. Out of these values we can calculate numbers of typical 5ha HOBRs plants to be installed to satisfy those predictions. Although the numbers in the 2025 and 2030 appear high, in those years to come the average size of HOBRs in production could increase significantly, nevertheless we'll use the 5ha unit size for sales figures estimations.

Our targeted market share is rather limited and conservative. It ranges from the 1% at the begging, down to 0,3% of total market potential in the latter phase. Although the percentage is decreasing due to the emerging of new competition, our sales will grow organically because of the significant market growth. Due to the further advancements in the technology

and economies of scale we are expecting that the price will decrease in time, what is presented in the table and it is scaling down from 100% to 65% even less in 2030. That will give a boost in further HOBR installations and increase ROI on plants.

EU SME partners' economic benefit

Besides benefits that are associated with the final customers, it is for sure that the SOLEALGAE will bring substantial economic and non economic nature benefits to SME project partners for the 15 years period.

In order to keep the production volumes in line with the market needs, we'll have to extend SME's production capacities, particularly at the MICRODEAL and ALGAEDIESEL. It is also expected that the licensing of the technology to the remote worldwide installers and technology providers could take place in order to insure required quantities and ensure the added value from the after sales support. The partner SMEs will benefit economically additionally from this segment.

The SME's are expecting to share the total value of more than 220 MEUR in 15 years after product launch. The SME economic benefits are presented in Table 10. The estimation is based on the roughly agreed percentage of the partner supplying components or service.

	Benefit contribution	2015	2020	2025	2030	TOTAL
MSHARP	**43%**	**2.181.326 €**	**8.946.552 €**	**32.065.490 €**	**51.043.025 €**	94.236.392
EMERGO	**13%**	**647.560 €**	**2.655.922 €**	**9.519.136 €**	**15.152.910 €**	27.975.527
ALGAEDIESEL	**25%**	**1.279.517 €**	**5.247.848 €**	**18.808.900 €**	**29.940.698 €**	55.276.963
ALGAETEAM	**20%**	**999.045 €**	**4.097.514 €**	**14.685.968 €**	**23.377.664 €**	43.160.192
TOTAL	100%	5.107.449 €	20.947.835 €	75.079.494 €	119.514.297 €	220.649.075 €

Table 10. SMEs' benefit contribution

EU jobs safeguarding

One of the major non economic benefits that SOLEALGAE project will generate is the jobs safeguarding effect that could be roughly estimated and quantified for partners and other organizations in the supply chain (Table 11). We have estimated a rather conservative approach in the jobs estimation. New jobs at the HOBRs are not considered in the table. The extension of the production at the SMEs could generate even higher number of jobs then presented in the table.

	2015	2020	2025	2030	TOTAL	ACTIVITY-ROLE
EMERGO	**10**	**5**	**5**	**7**	27	**Advanced control and automation system provider, as well as other electro energetic systems.**
ALGAEDIESEL	**15**	**20**	**30**	**10**	75	**Will be integrator of the HOBR concepts, mechanical, construction parts of the design, after sales will be provided**
ALGAETEAM	**3**	**2**	**2**	**2**	9	**Will provide part of the plant design, algae strain selection services, biological HOBR operations know-how**
TOTAL	58	37	52	49	196	

Table 11. SMEs' new jobs and jobs safeguarding

Time to market and life cycle of the product

In order to place the SOLEALGAE plant to the market it needs to pass the development, testing and verification phases. It could be assumed that first full equipped and full operating plants is likely not be launched to the market before the end of the second year **of its development. Therefore assuming that the 2020 is the year of the development beginning, the first full featured product will enter the market somewhere in 2022/2, although commercial orders could and will be prepared in advance. Life cycle of the product is estimated at 20-30 years, due to the quality of components that will be installed, so it is the estimated exploitation period.**

2.2. Measures to maximise impact

EU SMEs and R&D partner's cross link

Complexity of product, technological demand and need for specific market niche globalization are justifying the needs for a combination of SME and RTD partners from different countries. To satisfy the initial pan-European demand for the specific product as SOLEALGAE is and later to supply it into global markets the necessity for creating a trans-national exploitation capability is unavoidable.
The necessity of creating a trans-national R&D, integration, manufacturing, validation capability at all points within the value chain are needed to develop and produce specific components of the SOLEALGAE.
The vehicle of success of this project is through technology, business partnerships, SME licensees and joint actions towards global LEs and European Trade Associations. The result of this project will be the creation of a trans-national delivery capability able to satisfy a significant proportion of the high demand member states. This will then be developed future to have the capability of supplying the remaining EU states and the rest of the world.
Clusters are spread across West Northern Europe to Southern and Eastern member states and even included one candidate country, Croatia.

Exploitation plan for use of foreground results, route to exploitation

In order to tackle the market with the challenging product as SOLEALGAE is partners produced the Exploitation Plan for the use of the foreground results which is defined in Table 12.

Years	Phase	Description
1	**Product development phase**	**During this period, research and innovation activities for developing single components for the SOLEALGAE will be completed. With these innovations, we will build a complete proof of concept prototype and will carry out an extensive testing programme during this phase to ensure that SOLEALGAE can operate efficiently at extreme conditions.** **During this period we will seek to establish a trademark and ensure that our innovations are fully protected.**
2-4	**Focused exploitation**	**Our Initial Exploitation phase will concentrate on establishing a market presence in EU and USA markets. Those markets have been selected as there are national regulations and price incentives to use renewable source for biofuels production. ALGAEDIESEL and ALGAETEAM that possess extended networks in the biofuels segment will be focused on the current Algae plants/ At the same time the SME members will target potential new plant producers in EU and worldwide.** **Some initial activities and moves to target Asian territories will be made in this phase as well.**
4-8	**EU market expansion**	**The main activity during this period will be to consolidate the market in the EU and USA, and predict training and equipment needs for first 3 years to penetrate key markets. We will target southern European countries primarily Spain, Portugal and Italy where more solar irradiation available. ALGAEDIESEL and EMERGO will lead the sales here. We will also expand into countries like Germany, France and UK which our extended partners representing.** **During this period, we expect demand to ramp up significantly as we build a portfolio of successful installations.** **As a result, we expect to license some aspects of production as well as approving new worldwide partners. Intense activities to target Asian territory will be made here in partnership with project partners.**
above 8-15	**Global market expansion**	**Once we have sufficient European and US penetration, we will be in a position to exploit the technology on the global market. There are four other potential countries Brazil, India, Australia and Canada identified where we can exploit SOLEALGAE application with the support of our partners.** **We will continue our global expansion in Chine. As such, we will monitor the market situation throughout the project and will collate our findings in the project's Exploitation Plan and make appropriate changes in exploitation strategy.**

Table 12. Exploitation plan for use of foreground results

2.2.1. Project results and IPR

The goals of the Project are two-fold. In the first case to provide each of the SME partners with technical developments which support their core activities in the fields they are engaged, and in the second part to assist in the development of an overall development which can be pursued by a cooperation between the partners. The following table indicates the specific interests of the SME partners and their links to the results from the Project

SME Partner	Specific Interest	Associated Result
MICRODEAL	**Optical systems including solar concentrators, both lens based and**	**R1: Novel concept of light collector for Algae cultivation**

	luminescent concentrators. Low cost waveguides. Coating technologies.	**R2: Novel concept of light distributors for Algae cultivation** **R3: Environment Control system for Algae cultivation**
Emergo	**Control systems, novel engineering solutions for renewable energy applications**	**R1: Novel concept of light collector for Algae cultivation** **R2: Novel concept of light distributors for Algae cultivation** **R4: HOBR integrated concept**
ALGAETEAM	**Development of algae photobioreactors, including sale of complete systems including growth systems, monitoring and control, cleaning. Systems for processing of algae biomass. Consultancy in selection of algae strains and use in aquaculture, nurtraculature and biofuels, including aircraft fuels**	**R3: Environment Control system for Algae cultivation** **R4: HOBR integrated concept**
ALGAEDIESEL	**Production of ALGAEDIESEL**	**R3: Environment Control system for Algae cultivation** **R4: HOBR integrated concept**

Consortium members are aware of the importance of protection of IPR and the project focus is on exploitation, not dissemination, where any dissemination that will be carried out, will only occur after the IPR, or knowledge created in the project has been protected by means of patents or other appropriate means.

The ownership of results has been agreed between the partners on the basis of their interests in the predominant results of the project as given in the following table.

The partnership has already developed an Exploitation Strategy for the management of knowledge, intellectual property and of its inter-relation with the various innovation-related activities planned.

This will also include the management of the activities to ensure that the results are adequately protected and that the dissemination is carried out without threatening the partners' ability to protect the knowledge.

Prior to the programme the conclusion of the innovation related activities, MICRODEAL will register the patent for the Luminescent Concentrator Collectors and another one for the Lens based Collectors. **Consortium has already confirmed with a patent attorney that the shield composition is patentable.**

The consortium partners have agreed that only the SMEs will own the IPR from the project **and that all RTD performers TEAV, SCIMERGO and SCIENTX are expressly prevented from owning any of the resulting IPR from the project. Any other results that may arise from the project will also be** owned by the SMEs.

Different types of Intellectual Property Rights (IPR) will be developed in this project. These include patents (collectors and distributors)**, conceptual design of production plant (both registered and unregistered), software and databases for the expert systems and advanced control system, and other secret know-how.**

The most valuable project results are:

- Novel concept of light collector for Algae cultivation
- Novel concept of light distributors for Algae cultivation
- Environment Control system for Algae cultivation
- HOBR integrated concept

Distribution of the IPR results among SMEs is displayed in Part A (A5 Project Results).

Background owned by the RTD performers or the SME partners which is or will be found necessary for the implementation of the project will be granted royalty free to all partners. For use purposes after the end of the project access to background will be granted royalty free in the most case, except for some prior patents of ALGAETEAM which will be provided on a fair and reasonable basis.

The SMEs will ensure the command on the IPR **through the CA that the licensing incomes from the direct sales to third parties will be regularly controlled. Access rights to the foreground and background will be fully provided to all partners in order to carry out the project.**

Background owned by the RTD partners for the SME partners which is necessary for the project to be undertaken will be granted royalty-free to all partners for the purposes of undertaking the project and subsequent R&D activities. After the end of the project, where required, RTD and SME partners will grant royalty to such necessary background as free access except in the case of patents owned by ALGAETEAM which will be provided on fair and reasonable conditions to other SME partners where they are required for commercial exploitation (since these patents form the basis of ALGAETEAM current commercial activities). The specific terms of the conditions for the other partners in the consortium to licence ALGAETEAM background IP will be agreed and included in deliverable D7.3 Interim Plan for the Use and Dissemination of the Knowledge. These terms will match or be better than any existing licence entered into by ALGAETEAM for this IP.

For Ip exploitation and development rights, the following table provides the background IP position as currently understood:

Background IP Holder	Description
MICRODEAL	**Filed patent: luminescent concentrators for algae growth**
MICRODEAL	**US 2011048411 (A1) - PRISMATIC LENS**
ALGAETEAM	**WO 2009051479 (A2) - PHOTOBIOREACTOR AND METHOD FOR THE PRODUCTION OF PHOTOTROPIC ORGANISMS**
ALGAETEAM	**WO 2009051478 (A2) - PHOTOBIOREACTOR WITH A CLEANING SYSTEM AND METHOD FOR CLEANING SUCH A REACTOR**

For IP exploitation and development rights, the following table provides an initial position on foreground exploitation:

Forground IP description	Exploitation Partners
Novel concept of light collector for Algae cultivation	**MICRODEAL, Emergo**
Novel concept of light distributors for Algae cultivation	**MICRODEAL, Emergo**
Environment Control system for Algae cultivation	**MICRODEAL, ALGAEDIESEL, ALGAETEAM**
HOBR integrated concept	**ALGAEDIESEL, Emergo, ALGAETEAM**

IPR will not be shared with the RTD performers. Therefore the SMEs will keep full ownership and reimburse at 100% the invoices for the RTD subcontracted to the RTD performers. RTD performers will be free to use the results for further research (that is non-commercial exploitation) if those results are not identified as confidential.

<u>International consortium benefits for the SMEs</u>
With the newly implemented technological SOLEALGAE solutions the project will provide, by creating higher levels of differentiation the partners will be able to overcome market obstacles in order to begin selling the

product to EU and global markets. The differentiation for the worldwide market will be gained through a suitable IPR strategy for the consortium, to be developed at the consortium meetings and laid out in the teaming agreement.

Since the products and systems to be developed within this project are of the global reach, the market approach will be ultimately global as well, and the worldwide distribution will be explored for the immediate market penetration phase.

Once entered on the market with proven functionality SOLEALGAE technology (components and the integrated novel plant design) will surely improve existing and stimulate new algae production plants. Selected project partners of different areas of influence and market opportunities will target in different exploitation phases different territorial areas. Thus the EU, Near East, Middle East and North African markets will predominantly be covered by organizations partners within the consortium (EMERGO, ALGAETEAM and ALGAEDIESEL). GASOIL as the non-SME partner will also contribute to the EU wide market penetration in areas of its influence. The later stage global market distribution will be planned initially with ALGAETEAM and other regional partners as required.

Second phase distribution strategy of the product on world market areas that are not yet directly covered by the project partners (South Africa, USA, Asia and other worldwide regions) will be developed and presented within the project span time. The provisory distribution for the product at the global level is presented on the Figure 13 . Global market coverage and european market coverage if presented on Figure 12.

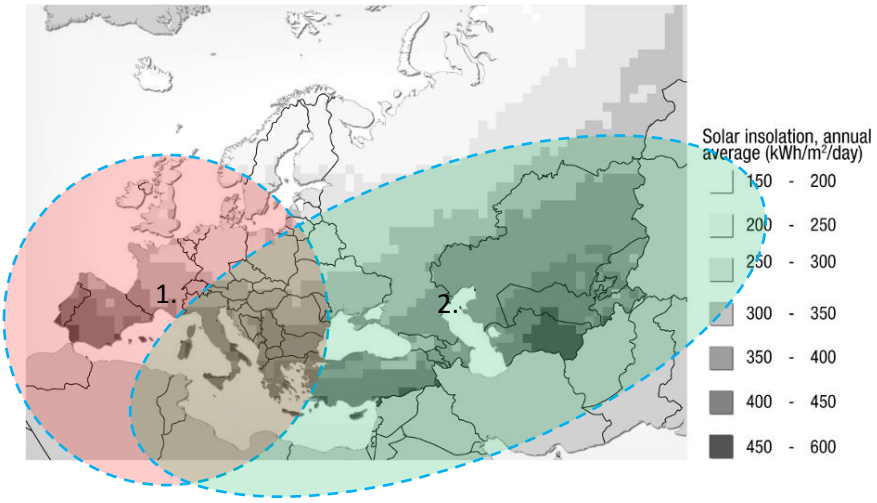


Figure 12 . European market coverage

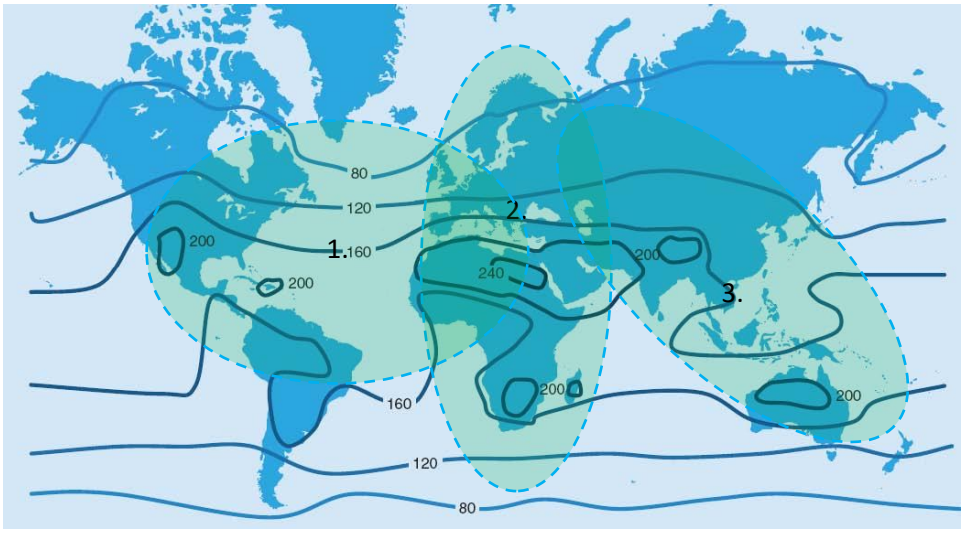


Figure 13 . Global market coverage[2]

Supply chain

Besides the three major RTD performers, the consortia will be extended with first class SME partners that are participating in the project, whether as suppliers, distributors or even end-users GASOIL d.d..
MICRODEAL (light collectors, distributors and Fresnel film supplier) will take care of light solar collectors and distributors production. Consortium will define a suitable replacement preferably among the partners and potentially with other non consortium partners. **ALGAEDIESEL** (integrator and dedicated supplier of the future algae plants) and **MICRODEAL** are representing fist class and cutting edge technology suppliers with whom we have established partner relationships. **EMERGO** will take care of the automation system and prototype components integration and the ALGAETEAM will provide all necessary knowledge and support for the biological and environmental conditions securing in order to produce the prototype algae Hybrid plant.
All the SME participants will assume the role of the distributors in their regional areas of influence and will use their business associates and networking to extend the exploitation reach.
In order to protect the concept and ensure delivery of the key components for the project, which are; light concentration solutions and distribution materials, controls systems components and SW package, system integration design and other plant components (CO_2 and O_2 treatment) a particular partnership and long term relationship with dedicated suppliers should be established.

All Project partners who haven't done so already will sign a non-disclosure agreement (NDR).

Commitment of the SMEs

The SMEs have already contributed to the production of this document and have demonstrated their commitment during the planning of the exploitation phase through their co-development of the consortium agreement. The SMEs have important role to play in the management and steering of the project, from the project conception through delivery and continuing to the dissemination phase. The SMEs are committed to cooperation with the RTD performers to contribute their expertise to ensure technical delivery and validate the system during the latter stage of the project. Furthermore they will ensure the innovation related activities successfully lead to exploitation of the results within the larger community of SMEs.
The SMEs will effectively contribute during the dissemination phase by supporting equipment to help during the various workshops, seminars, conferences and other dissemination activities to promote the results.

2.2.2 Dissemination and Use

[2] World map of algae biomass productivity (tons/ha/year) at 5% photosynthetic efficiency considering energy content of 20 MJ/kg dry biomass (Tredici 2010)

As we start to develop licensing and manufacturing agreements, the partners will be required to undertake technology transfer programmes, to train new licensees in the implementation of the manufacturing processes. These firms will be from areas of the Union and accession countries that we cannot service directly from either our national or existing supplier bases. Limited results will be made available for public dissemination after the conclusion of the project where possible links will be established with existing EU projects and relevant Coordination Actions.

The dissemination activities are closely linked with the local and international networking activities and future end-users involvement. At the same time, they will flexibly react to any opportunity that becomes available during the project runtime. The project web server, workshops and meetings as well as intense contacts with future end-users are the primary vehicles, but other media and mechanisms will be used as well, wherever feasible. The dissemination activities will be ongoing during the entire project duration. A dissemination plan **will be made and it will have to be adapted and updated several times.**

Trade Associations throughout Europe will be used to network the results and help demonstrate the technology to end users in a variety of industry sectors, as well as the placement of 'advertorials' and technical articles in industry journals. This will make the industry aware of the developments that are being carried out, and initiate market awareness of the potential of the technology. This combination will provide an ideal means of disseminating the process capability and widening the opportunities for its uptake.

In order to disseminated and maintain development activities visible to partners and the funding institutions, SOLEALGAE project will develop plans to ensure that the project results are presented in appropriate manner to the national and international stakeholders. At the start of the project local media in the various European countries will be contacted to explain the nature of the project and provide publicity and information, indicating the support of the European grant. The dissemination plan will primarily focus on our targeted profile of customers. Dissemination activities of R&D results are listed in the section 2 (WP6, Task 6.2) and consortium members have different roles in dissemination activities.

RTD performers can publish the results of the project only after obtaining the agreement of the SMEs. All partners, prior to any publication relating to the project, should give the Consortium 45 days' notice and, if there any objections, these should be communicated within 30 days of the notification.

The following sentence will be included in all publications and on the web site:

"The research leading to these results has received funding from the European Union's Seventh Framework programme managed by the REA **- Research Executive Agency http://ec.europe.eu/research/rea(FP7/2007-2013) under grant agreement 286013."**

There are no existing anticipated business agreements which may impose limitations on the subsequent exploitation or information or inventions generated as a result of the project.

Exhibitions and Conferences

Under the coordination of MICRODEAL partners will participate in two large exhibitions in Europe and one large exhibition in Turkey and Africa (venues and time will be decided when the prototype and-or other components will be ready for demonstration):

- **Exhibition: Günes Enerjisi 2020, Turkey**
- **Intersolar 2020, Munich, Germany**
- **Solar'10 "Putting Light to Work", Cairo, Egypt**
- **Soltec 2019, Hameln, Germany**

TEAV, SCIMERGO and SCIENTX as RTD performers will promote the project through R&D events and industry publications, among others following conferences will be attended where the project results will be presented:

- **Energethica 2021, Genoa, Italy**
- **Solar Industry Conference 2020, Madrid Spain**

Project WEB site

The SOLEALGAE project web server will be operational since the very beginning of the project, accessible under: http://www.SOLEALGAE.com. Major sections of the web server will include:

1. **Project administration (restricted access)**
2. **Project description. Consortium of partners**
3. **Technical documents and public Deliverables**
4. **Case Study descriptions, including links to**
    a. **PowerPoint presentations from the various project meetings**
    b. **Project partners WEB sites**
    d. **Image gallery**
5. **On-line prototype of web accessible models and data bases;**
6. **Links to project related relevant sites**
7. **The Discussion Forum (restricted access).**

Demonstration, final (live)

Live Dissemination **of results will be facilitated initially through pilot plant demonstration, which will be used to illustrate the benefits of the foreground technology. This facility will publicise the project's results to targeted potential customers and licensees while providing the prototype sampling capacity essential for end user and supplier commercialisation. It will be held on** ALGAETEAM's demonstration facility in Netherlands**. Another demo site will be on disposition, and this is potential** GASOIL's brand new demo site in Domzale (Slovenia), **which is located next to the experimental biofuels production site.**

The *final demonstration list* will be prepared in advance in order to ensure the efficient management of the event, and it will include elements as:

a. Equipment and materials:
    - functional SOLEALGAE plant
    - all necessary materials and equipment needed for the event (to be defined during the project development)
b. Methodology

Methodology for the event will be in line with Croatian (or Slovenian) and EU current regulations and events best practices for that kind of events. All precautionary measures to prevent eventual damages or injuries will be organized in order to control damage.

c. Participants (national and international)
    - project partners
    - trade associations
    - local community representatives
    - fire brigades representatives

- governmental decision makers
- end users, representatives from industry
- all SOLEALGAE project partners
- Media coverage (television, newspapers, magazines and journals)

Other dissemination means

- **Dispatching of SOLEALGAE brochures and videos to the Renewable Energy Agencies, customers, departments and other related organizations as well as governmental agencies in various countries**
- **Intense contacts with customers and end users on international worldwide level**
- **a live demonstration of the efficient el. Energy and heat production will take place in Croatia**
- **Obtain and analyse feedback from the targeted end users, summarise the dissemination results and lessons learned.**
- **Media coverage events will be organized in order to promote the product and the EU funded project as well (television, newspapers, magazines and journals)**
- **Short video on the project development and results will be produced**

The dissemination activities are closely linked with the local and international networking activities and future end-users involvement**. At the same time, they will flexibly react to any opportunity that becomes available during the project runtime. The project web server, workshops and meetings as well as intense contacts with future end-users are the primary vehicles, but other media and mechanisms will be used as well, wherever feasible.**

The dissemination activities will be ongoing during the entire project duration. Accordingly, the dissemination plan will have to be adapted and updated several times.

Project results are presented in Part A (A5)

3. Implementation

3.1 Work plan — Work packages, deliverables and milestones

In order to respond to all the mentioned challenges a **Consortium** of organizations (SMEs, RTDs and other organizations) will be set up. The organization that led the project until April 2013 was **MICRODEAL (UK)**, but was replaced by SCIMERGO (Croatia).

Lack of SMEs capabilities

Respecting the logic of this financial instrument, SME partners do not possess the required knowledge and R&D capabilities **to overcome the barriers described in this proposal.**

Hence, the SMEs are in need of outsourced R&D services to satisfy the need and develop the required technological solutions. For that purpose consortium SME members have selected three extraordinary organizations, TEAV **(Spain),** SCIMERGO **(Croatia) and** SCIENTX **(UK) that possess such knowledge and required R&D capabilities.**

SME partners have therefore recognized the need to move into a more knowledge intensive offering leading ultimately to a position protected with suitable IPR. For such a task the consortium partners have recognized EU wide based R&D institutions to help them develop the product that will be competitive at the worldwide level.

3.2. Management structure and procedures

For the purpose of this project coordination management activities one integrated work package, WP8 **is prepared that includes activities of the** 'Consortium Management' **and** 'Project Management'.

Consortium Management activities **are executed mostly by the Coordinator, SCIMERGO and for the purpose of theese activities. Project Management activities are performed by all participants at different effort levels.**

Several boards will be formed at the beginning of the project, however taking in consideration that each participant will engage one or maximum two persons in managing procedures of the project, this is defined due to the optimization and maximal reduction of related travels and other management costs.

Consortium management

Consortium management activity as a part of the WP8 work package is divided multiple tasks and the consortium leader MICRODEAL (Anthony Seymour) will be responsible for this WP, and only the coordinator is assigned to this WP. In accordance with the E.C.'s guidelines for Project Coordination the Coordinator (MICRODEAL) will be allocated only the contractual, legal and administrative aspects of the projects management, including:

- **collation of all deliverables and milestone reports;**
- **the overall legal, contractual, ethical, financial and administrative management of the consortium;**
- **preparing, updating and managing the consortium agreement between the participants;**
- **resolution of any administrative or contractual issues within the partnership and with the Commission**
- **organisation of Project Management and Exploitation Board meetings**
- **overseeing the promotion of gender equality in the project;**
- **collation of all the cost statements.**
- **ensuring prompt payments of financial contributions.**
- **Obtaining audit certificates by each of the participants, if needed**

- **Obtaining bank guarantees for SMEs (if applicable)**
- **Preparing for and facilitating audits by REA staff**
- **Coordinating payments and the distribution of money**
- **Coordination at consortium level of participant contractual obligations and collective responsibilities**

Anthony Seymour from MICRODEAL was the Coordinator *vis à vis* the Commission. He was replaced by Mr. Nenad Trifunovic from SCIMERGO. **Consortium has produced cost estimates for the person hours and external costs will need to expend to fulfil the role above within a project of this scale and it is included in project effort tables.**

Project management

Project management as a work package is divided in several subtasks and Dr. Petar Kostić **from** SCIMERGO **will be responsible for this WP in a role of** Technical Project Manager.

PM will include and provide the management of the technical progress between WPs and towards the objectives of the project and exchange of results and knowledge between the partners to enable cross-fertilisation of ideas and data flow needed to support concurrent tasks. More specifically, it includes tasks (in WP8) such as:

- **Review and management of overall project progress against scientific and technological objectives**
- **Reviews and management of impact on economic and societal issues**
- **Workflow scheduling and Work Plan change control procedure**
- **Communication between partners within the work package**
- **Provision of the minutes taken at these meetings**
- **Co-ordination of technical activities between partners within work packages**

Partner	PM and CM roles	PM and CM roles name
SCIMERGO	**Consortium Manager**	**Nemad Trifunovic**
ALGAETEAM	**Future Funding Manager**	**drs Mark van den Gall**
ALGAEDIESEL	**Validation Manager**	**Rodrigo Palma**
ALGAETEAM	**Dissemination and distribution**	**drs Mark van den Gall**
ALGAETEAM	**Exploitation Manager**	**drs Mark van den Gall**
SCIMERGO	**Technical Manager**	**Petar Kostić**

WP leader	WP leader Name	Organization
WP1	**David Smith**	**SCIENTX**
WP2	**DavidSmith**	**SCIENTX**
WP3	**Ernesto Fuentes**	**TEAV**
WP4	**Petar Kostić**	**SCIMERGO**
WP5	**Mark van den Gall**	**ALGAETEAM**
WP6	**Mark van den Gall**	**ALGAETEAM**
WP7	**Mark van den Gall**	**ALGAETEAM**
WP8	**Predrag Mikic**	**SCIMERGO**

Table 13. Project Management roles and WP leaders in the project

It is anticipated that Technical Meetings (within and between work packages) will be held at very regular intervals and not greater than 3 monthly. These meetings can be held by telephone or video conferencing.

The Exploitation Manager will be drs. Mark van den Gall (ALGAETEAM). Predrag Mikic **will be the Chair of the Steering Committee.**

The specific skills of the people managing each partner's contribution to the Steering Committee are described in the resources Table 18, in chapter 2.2. Here are described other project roles:

- ***Technical Manager*** **taking responsibility for identifying and solving technical problems across the partnership and work packages.**
- ***Exploitation Manager*** **taking responsibility for the IPR protection, market strategies and product development activities and other exploitation related tasks.**
- ***Dissemination and Visibility Manager*** **taking responsibility for the successful and widespread broadcasting of the results of the project whilst ensuring that the project IPR protection regime is not compromised.**
- ***Future Funding Manager,*** **responsible for quantifying the partnerships requirement for commercial funding from banks, venture capitalists, business angels and public sector investment sources for small firms WP leaders will not make part of the Steering Committee of the Project.**

WP leaders will not make part of the Steering Committee of the Project.

Technical Board **will be formed to manage all aspects of the project related to the R&D work, integration of the project and the validation. Technical board includes leaders of the individual work packages (Table 13. Project Management roles and WP leaders in the project) as well as project Coordinator and the Validation Manager. The coordinator of the technical board will be the technical manager of the project, Dr. Kostić (SCIMERGO). Regular meeting will be held each six months to evaluate the current state of the project and determine the proceedings.**

Exploitation Board **will be formed to prepare the exploitation of the product. Chairman of the exploitation board will be drs. Mark van den Gall (ALGAETEAM), in the role of the Exploitation Manager. As in the Technical Board, the Exploitation board will hold regular meetings every 6 months. This body will ensure that the SMEs will coordinate management and innovation related activities, particularly the absorption of the results and activities to promote best practices within the industry. Beside the Exploitation manager, other members of the Exploitation Board are Consortium Manager, Dissemination and Visibility Manager and Future Funding Manager.**

Handling of Technical Risk

The RTD performers have expertise in use of the Quality Function Deployment (QFD) risk management. These quality management skills will enable the consortium to identify and manage the risk associated to the overall implementation of the work plan at each stage of the project. In addition to overall management, the work plan has been broken down into distinct work packages in which associated risks will be identified independently and be minimized accordingly. Moreover each of the initial work packages can progress fairly independent of the others until the integration phase of the work programme.

Following the initial risk assessment performed during the development of this document an associated contingency planning element has been implemented within each work package such that problems can be fixed with the minimum disruption of the overall project flow. Estimation of risk ranging from highly speculative, high risk of failure to application of existing technology to different field with low risk of failure. Estimated risk is based on risk matrix below as a project evaluation helping tool. From the table results we can understand that

there are no particular high risk to the development of the new technology, however the consortia partners have to be aware that the risk is existing and have to be prepared with mitigation actions.

Risk	Likelihood (1-10)	Impact (1-10)	Risk Rating (1-100)	Mitigation Strategy	Effect on Project
Overall capital and operational cost increases exceeds production increases	**4**	**5**	**20**	**Central issue to be addressed within project. Focus will be on low cost, mass manufacture components, and core considerations of base material costs** **The cost effectiveness will be assessed throughout the project** **In this case further costs reduction will be considered with different materials and system design solutions**	**If the system is ultimately not cost effective then there project will not have been successful. Therefore this is critical to the basis of the project**
Illumination 'light transfer' efficiency is not sufficient to justify costs of illumination system	**3**	**8**	**15**	**Ray tracing and optical design, coupled with materials and optics measurements, will seek to understand in detail the likely performance of the system prior to building prototypes. An initial understanding that the light 'transfer' system has to 'release' at least 50% of the PAR removed** **The direct solar illumination (lens based collectors) will have a high efficiency at least for direct sunlight, and therefore ultimate solution may include some aspects of both systems. By taking this dual approach the chances of achieving a design abel to be low cost but efficient and operate under differing lighting conditions is improved.**	**Selection of approaches at early stage will have potential of providing sufficient performance. Multi-stage process gives results at many stages. need revirew and selection**
Biofoiling significantly impacts performance and cost effectiveness	**5**	**6**	**10**	**Biofoiling of active optical surfaces needs to be addressed from the start of the project and design undertaken which explicitly recognise the problem and deal with it. Where surfaces can be clad and protected they should be. Surfaces exposed to algae should be smooth and easily cleanable.**	**Only designs compatible with cleanable surfaces should be considered - evaluation of washing, may have additional costs of materials and maintenance**

Risk	Likelihood (1-10)	Impact (1-10)	Risk Rating (1-100)	Mitigation Strategy	Effect on Project
Algae cultivation prototype system doesn't work with the growth rates predicted during development and design phases	**3**	**6**	**18**	**Initial work will be undertaken to assess illumination and growth in small reactor vessels mimicking overall system to rapidly get understanding of key issues and potential for success** **Reason for low growth rate will be determined and action taken**	**The evaluation at several stages of growth expansion will give some indication of deviations. May require changes to some aspects of design**
Algae growth rate is shown to be limited by unforeseen factors in development and design phases	**1**	**8**	**8**	**Detailed assessment will be undertaken at start of project based on literature assessment and discussion with practitioners. Initial lab scale testing will seek to understand essential issues. Careful overview and analysis will be performed when scale up does not match expectations** **Unforeseen factors will be taken into account and actions taken to minimize the impact**	**Need to ensure that additional aspects of system can be addressed, e.g. within time and budget**
Seasonal and weather and **development within the project (e.g. completion of facilities and start of testing period) do not align well, preventing testing periods being conducted in the summer months**	**5**	**8**	**40**	**Strong efforts will be made to ensure that the completion of facilities and prototype elements leaves sufficient time for testing within the project and that this time is aligned with the summer months. This means that a September start is optimal for the project. However in this case, testing cannot easily be improved by a 6 month project extension.**	**In the worst possible case testing will be required to be carried out with a 1 year project extension but this will be avoided if at all possible by clear adherence to project timescales and ensuring all facilities are in place by spring 2013**

Table 14. Contingency plan table

Figure 14. Project Pert chart

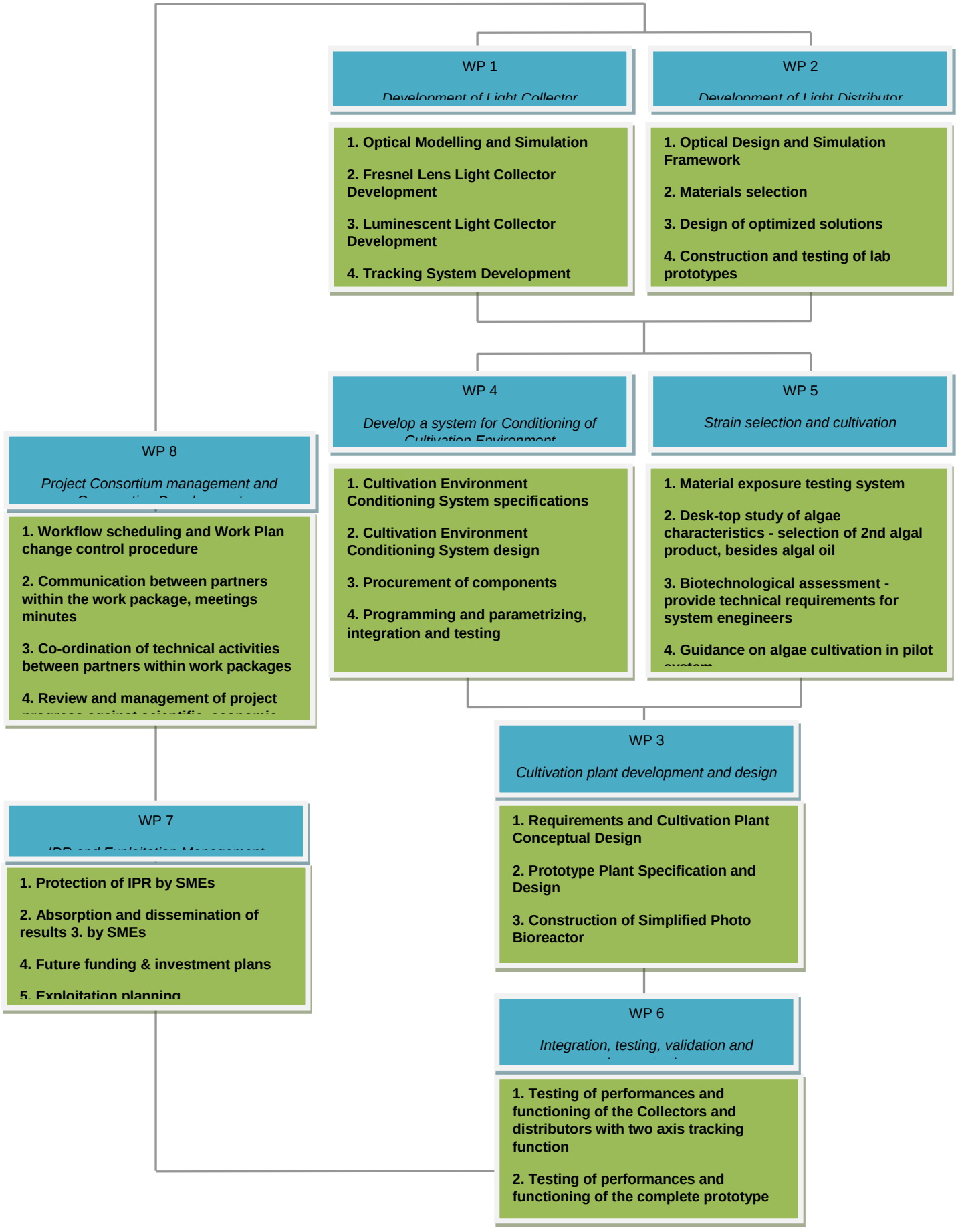
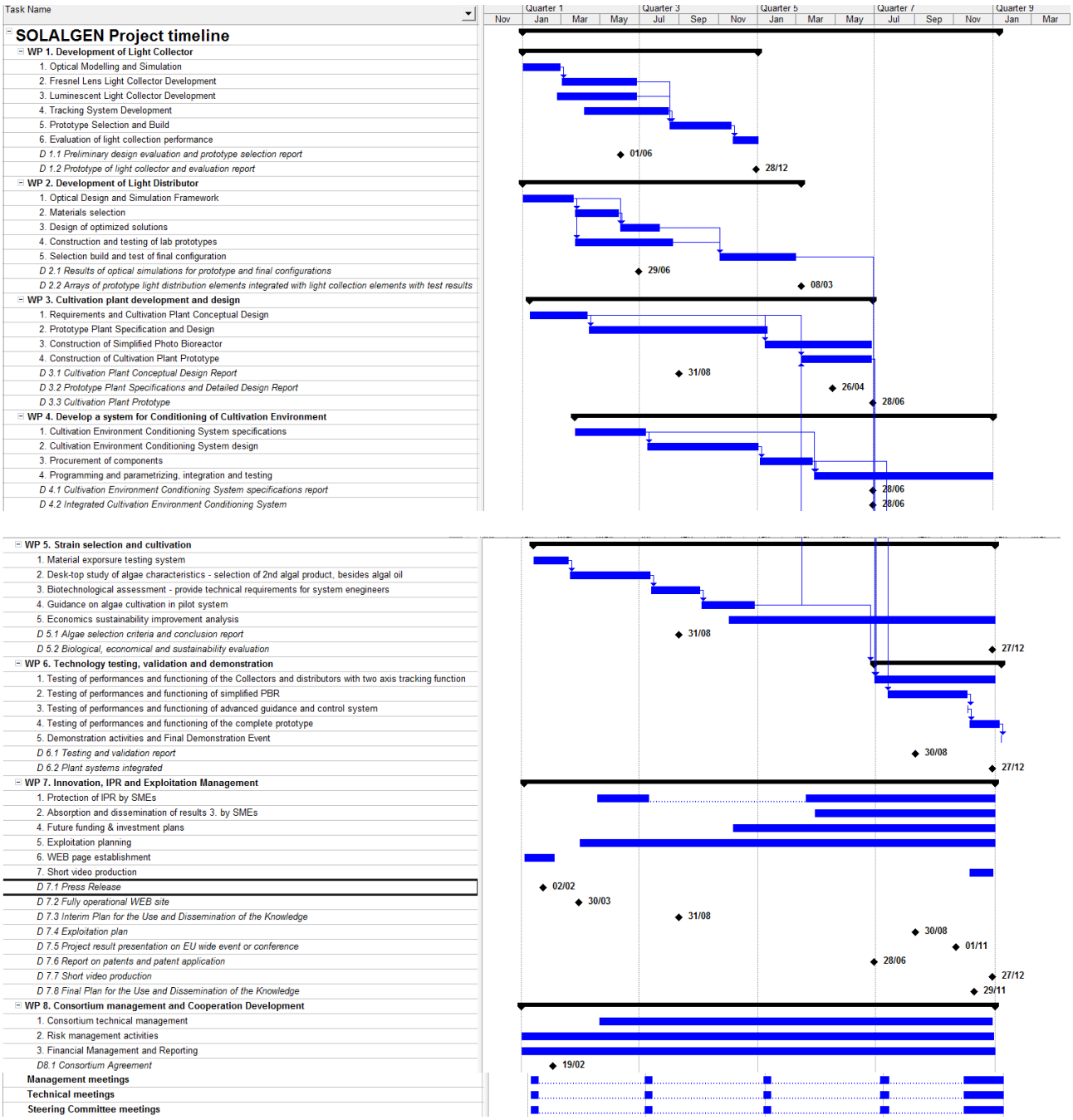


Figure 15. Project Gantt chart



WP contingency management

Each work package has been structured to include milestone control points associated with each major task at which the progress of the WP as a whole and its interrelationship with the other WPs can be assessed. The individual work packages 1-5 have also been constructed so that they are relatively autonomous and can progress without significant scientific or technical inputs into each other.

During each work package QFD will be used to assess progress and any variation in the risk to completion of that package. Any such variation will be countered by implementing contingency measures and these counter-measures are detailed for each of WPs where needed. In each case a Technical Board will meet to review the problem, identify experts from inside and if necessary, from outside of the consortium, that could provide a to fix the problem, draft an action and implement that plan to recover the rate of progress necessary to complete the WP. Work Package list and descriptions are provided within Workplan Tables, WT1 and WT3

Communication within the Steering Committee & with the Project Team

WP leaders will collate and circulate a monthly progress report containing contributions from each partner to identify whether task deliverables are being sufficiently progressed to schedule. This information is communicated upwards from the researchers to the Technical Manager via task leaders, dispersed across a number of member states, communicating with their WP leader and each other, on inter-related tasks.
Quarterly meetings of the Steering Committee (represented by the WP Leaders) will be carried out to review milestone progress and agree in detail the actions for the next period.
Besides the traditional communications media techniques such as workshops and brainstorming as well as exploiting technical media like e-mail, video conferencing, document exchanges and project websites etc. will be used for communication within the project.

Risk & Contingency Management

Work plan in WP8 includes specific task to manage potential risks for the project. There are some procedures we'll put in place to ensure that this risk is managed effectively:

- **our Technical Manager will also act as the project Risk Manager and will be responsible for advising the Steering Committee on contingency implementation**
- **we will maintain a risk log (details of expected risks) and each WP leader will maintain an issue log (events of note that have actually happened). It will be the job of the Risk Manager to cross-correlate these and spot any risk triggers**
- **at the end of each WP the Coordinator will update the risk log in light of the WP activities and, at each milestone, and if needed, the re-evaluation of the project risk will be made**

Project Quality management

The Coordinator and the Technical Manager will work together to produce a Project Quality Plan (PQP), **that will establish a method to ensure the quality of the project delivery is maintained and there's a transparency for all consortium members.**

The quality aspects of the technical proposal management will be tackled using two well-known quality management tools, FMEA[3] and QFD[4].

[3] **Failure Mode and Effects Analysis**
[4] **Quality Function Deployment**

Decision-making mechanisms & conflict resolution

Assignment of WP leaders with clear WP milestone deliverables is fundamental criteria for making decisions on the project relative to progress per partner per deliverable.

A collection of deliverables in WP are coinciding to form milestones and those specific milestones will be linked to the meetings of the Steering Committee. Major decisions during the project are structured around specific and named/described milestones.

Consortium will organize regular review meetings that will be run by the task leaders (reporting into WP leaders by e-mail or project web-site document download) with those individual researchers working on the task. These meetings will be coordinated to ensure that all deliverables are fully reported and properly formatted for the technical reports at milestone control points within the project, for input to the Steering Committee meetings.

The Steering Committee itself will meet at least every 3 months throughout the project. These meetings may be aligned with other meetings between the project partners (e.g. Reviews and technical meetings). In addition, any of the SME partners may request that an extraordinary Steering Committee meeting is scheduled. Meetings may be held by telephone or video conference.

Voting procedure for the Committee, with RTD Performers and the larger enterprise having no voting rights**, is established and agreed, as well as course of action in the case of disputes or impasse.** No decision in the consortium can be taken against the collective interest of the SME participants**.**

Each single SME participant has one vote**, therefore the voting in case of the conflict resolution needs will be brought by the majority of votes. In case the votes are equal, consideration can be taken of the RTD performers, again on a one vote per partner basis. If this still results in an impasse, the** Coordinator vote is decisive**. No veto option is available.**

Description of the Project Reporting Milestones

The project has 2 main reporting periods and review:

- **At the end of M9 – this will be undertaken approximately 75-80 days after the end of Rp1 (approximately M11) and will be held in Brussels**
- **At the project completion at M24 – this will be undertaken during the 60 days following the end of RP2 (therefore around m260 and will be held where the cultivation facilities are located, with a full demonstration of system operation**

The first reporting milestone will be associated with completion of the majority of the initial design elements of the project, and the delivery of the following reports:

D2.1	**Results of optical simulations for prototype and final configurations**
D3.1	**Cultivation Plant Conceptual Design Report**
D4.1	**Cultivation Environment Conditioning System specifications report**
D5.1	**Exposure testing design and manual**
D5.2	**Algae selection criteria and conclusion report**
D7.1	**Fully operational web site**

The second reporting period is associated with project completion, delivery of all deliverables and demonstration of the system operation.

3.3. Consortium as a whole

To successfully complete the project, the right consortium has to be set up. Created consortium is gathering members to fulfil different aspects of a value chain, from suppliers (ALGAEDIESEL and EMERGO), through distributors and algae market specialists (ALGAETEAM), system integrators (EMERGO and ALGAEDIESEL), and finally ends with RTD organizations that will do the most of the technological portion. The commitment is obtained from the Large Enterprises as well, primarily in the role of the end user – customer (GASOIL d.d.).

MICRODEAL, UK, SME, www.MICRODEAL.co.uk

Business area

MICRODEAL Corporation Limited (MCL) was established in the U.K. in April 1998, with the aim of developing a leading position in the provision of innovative, reliable and consistent light management technologies for flat panel displays. MICRODEAL products are mainly used to improve the performance of liquid crystal displays in direct view and under magnification as well as being used in front and rear projection display systems. They are also finding increased application in other industries from diagnostic devices through tailored light sources to security products. These technologies, which now form the basis of the MCL patent and product portfolio, were initially pioneered by Durand Technology Limited, and then developed by Nashua Corporation over a five-year period, before returning to form MICRODEAL Corporation Limited. MICRODEAL is an innovative developer of Light Management Technologies. We combine an understanding of end user applications in the displays, media, security and illumination industries with our capabilities in optical design and testing, UV-curable and self-organizing lacquers (resins), microprecision replication and optical film production.

MICRODEAL works with its clients in several different ways; Exclusive or non-exclusive licensing of patents, Supply of specific materials at a defined cost, Consultancy in optical design, optical solutions and optical testing

Research and development projects to develop or tailor materials with specific optical properties, Joint Ventures covering specific aspects of products or material development and commercialisation.

MICRODEAL is working with a range of global businesses to progress and enhance their systems and products.

ALGAEDIESEL, Spain, SME, www.ALGAEDIESELclm.com

Business area

ALGAEDIESEL is a company located about 80 km from Madrid. This new factory with state of the art technology is dedicated to industrial technology based on the transformation of used vegetable oils into biodegradable oils. That is because oils in their industrial process are chemically modified in their structure. ALGAEDIESEL Castilla La Mancha is located in a 20,000 square metre plot and has plans of staffing fifty people. The investment so far is over six million Euros. ALGAEDIESEL Castilla La Mancha has agreements and relationships with many local transport companies, public and private, for the

commercial use of ALGAEDIESEL. The recycling of used oil for its conversion into ecological fuel links to a significant reduction in waste. Against many first thoughts, used vegetable oil is a product that is still not biodegradable.

EMERGO, Croatia, SME, www.emergo.hr

Business area

Company located in Pula, is providing efficient and cost-effective Industrial Automation and Control Engineering Solutions to customers through latest technology. EMERGO has qualified electrical and control engineers having several years of experience in the design and development of electrical control panels. Understanding the market trends and energy needs in the future, EMERGO has focused on the Biofuels technologies, particularly into the ALGAEDIESEL and Biogas technologies several years ago. EMERGO possess resources to produce typical project design which includes; Fully Detailed Panel Layouts & general assembly, Wiring Schematics, Bill of Materials, Full Safety Schematics, PLC and DCS I/O Schematics, Marshalling, Termination & I/O Schedules. Besides the design department EMERGO possesses the start-up and commissioning department as well. In the recent years EMERGO has been working in numerous projects in renewables, particularly those related to the solar energy and light distribution as well as biofuels. EMERGO is moreover participating in national, regional, EU and FP7 projects as project partner.

ALGAETEAM, NV, Netherlands, SME, www.ALGAETEAM.com

Business area

ALGAETEAM started in 2007 with a prime objective of offering a robust, highly effective photobioreactor for the cultivation of algae. Extensive research over a number of years has proven that algae is a high-value commodity and extremely beneficial for use in a large number of markets, including the food (e.g. nutraceuticals, food additives), feed (e.g. aquaculture feed) and fuel industry. Algae farms offer great solutions for CO2 and waste water problems too.

In 2008 RIG investments joined as funding partners. This has allowed ALGAETEAM to extend its services and most importantly the research and Development department in order to maintain its leading position in this global market.

ALGAETEAM Nv is a Dutch Company that designs and manufactures algae growing equipment and cultivates algae for various global markets. AlgaLink is building a world-wide supply chain and partner network that is sustainable and delivers value to our global customers. Our operation covers algae production, equipment, consultancy, installation support and training.

ALGAETEAM strives to be a global leader in the algae business; we offer quality and value to our customers. We will provide products that are efficient and environmentally sound. We will be successful by perfecting our processes and learning to consistently exceed customer expectations.

SCIENTX, UK, RTD, www.SCIENTX.com

About the organization

SCIENTX is a organization specialising in the provision of the R&D services in field of optics, microfluidics, microchemistry, and nanotechnology. We provide R&D consultancy and administration as well as R&D project management. SCIENTX provides mentioned services to industrial organizations and

participates in large international research and development programmes. It has significant experience in Framework 5, 6 and 7 projects covering multiple thematic areas and instruments.

SCIENTX has significant R&D, technical and commercial experience including:

- **Commercial management of a large R+D facility**
- **Constructing collaborative research programmes and proposal writing**
- **Commercialising intellectual property developed from research**
- **Delivering commercial research on time and to budget**
- **Direct technical research experience in electronic engineering and instrument design, microengineering**

SCIMERGO Innovative Technologies Centre, Croatia, RTD, www.SCIMERGO.hr

About the organization

SCIMERGO is Croatian based R&D centre operating primarily in renewables, environmental engineering and processing technologies development for industry. It is offering R&D interdisciplinary and multidisciplinary services in control engineering and guidance systems, modelling and computation of complex mechanical and electrical systems.

SCIMERGO is oriented towards the research in the industrial environment, particularly in the SME (and large companies) sector. In the past years they have successfully participated in more than 20 large national, regional, European and World Bank collaborative R&D projects.

The organization has access to large number of researchers, scientists and engineers and is based centrally in the Croatian capital of Zagreb. It is surrounded by largest regional leading universities that are also located in Zagreb, where SCIMERGO implements its mission in cooperation with other scientists and institutions both from Croatia and abroad.

SCIMERGO is not an IPR holding or exploiting business and it is a non-profit, self owned private organization that does not seek to generate a profit for distribution to shareholders or owners but reinvest all profit in organizational development.

It possess a respectable team of engineers and scientists in mechanical, electrical, process technologies, biochemical, marine and other engineering fields. SCIMERGO has experience in naval technology, underwater systems and acoustic technology. The organization has on disposition numerous facilities (laboratories, process technologies testing facilities (cavitation, shock and vibrations, ultrasounds, noise etc.), fully operating towing tank for model testing, large conference, meeting and office space. The organization possesses specific expertise in using 3D modelling, numerical FEM and CFD modelling, and control simulation.

Tecnologías Avanzadas Inspiralia, TEAV, Spain RTD, www.TEAV.es

About the organization

TEAV is the main Research branch in South Europe of a transnational non for profit Institution (TEAV GROUP – www.teavgroup.com) committed to Innovation and Competitiveness of entrepreneurial customers. Sitting in Madrid and Rioja, TEAV provide companies with the necessary resources to develop leading edge solutions in materials science and microelectronics and the use of simulation and

advanced computational methods to model and design better product performance and more efficient processes. Our 60-years continued effort to create singular technologies for a broad range of industrial sectors from food industry and health to the energy and construction markets, has enabled us to offer our client companies access to more than 500 market-oriented scientists and engineers.

For this particular project, Dr. Ernesto Fuentes will lead the contribution of three team of researchers with sound experience on the development of Thermal diffusion, Structural analysis and simulation of complex systems with Computational Fluid Dynamics and Finite Element Analysis techniques, the design of electronic control systems and the design and synthesis of advanced materials for structural and functional applications. The successful management of the research team is backed by a track record of more than 200 collaborative research projects delivered at international scale.

GASOIL d.d., Slovenia, OTH, www.GASOIL.eu

Business area

GASOIL – the leading energy company in Slovenia, is the principal strategic supplier of oil and other energy products to the Slovenian market. Through an extensive distribution network of proprietary service stations, GASOIL provides drivers on Slovenia's roads and highways with a broad range of automotive goods and services and a wide selection of household and food products and other merchandise.

3.4. Resources to be committed

Integration and creation of the critical mass of resources

We have accurately estimated the levels of resource required to successfully deliver the project and also matched the resource of the consortium to the skills required. In order to calculate the overall effort required the Work Programme was constructed to deliver the project objectives. Consortia members have optimally mixed and combined the skills and resources available from the partners and RTO performers. In particular, the skills are integrated to form a coherent delivery capability and will ensure that the project objectives are met. A good balance between the intellectual and resource effort between the SMEs and RTD performers is proposed to ensure that the SMEs remain in control and thus represent the best interests of the wider SME community.

The consortium has selected the RTD performers due to their areas of expertise and complementary skills. The RTD performers have planned the proposed research based on their internal skills matrix and assigned the most appropriate people to each individual task.

Adequacy of the financial plan and budget estimation

During the project planning stage, each work package, task and sub-task was written in close consultation between SME proposers, and RTD performers. This consultation was to ensure that the maximum benefit was obtained from relevant specialist expertise knowledge to ensure the equipment, lead times, manpower, skills and cost has been accurately estimated, captured and understood by the entire consortium. This led to the creation at a pert diagram to show the project flow and the creation of a Gantt chart detailing the project timings and the inter-dependencies of the elements and work packages. As a result any project implications will be understood, accounted for and included within the project plan. The research work plan was generated by dividing and subdividing the work programs into a level of detail sufficient to enable finite tasks to be identified to which resource, lead times and cost will be assigned.

This enabled the consortium to determine the resources needed to complete the tasks including materials, consumables and travelling expenses. By applying the respective rates of the relevant partners, a figure for the project was derived. Comparing the effort required for each partner and size and resources of the partner, to the amount of work they were undertaking and outputs they were delivering, allowed an assessment of value for money to be made. The plan presented in this document is the sum total of these finite tasks and accurately represents the effort needed for successful delivery of developed product.

SME partners cost analysis

As previously discussed consortia have tried to match the critical skills needed for project with the most cost effective resource available to provide necessary competence for an optimum cost. The project costs have been calculated following an analysis of the quality of the competence being accessed verses the cost of it (value-for-money). Partners have evaluated and decided that all SME participants will use special transition flat rate cost model.

We noted that both, the overhead costs and the direct labour costs vary considerably across the partnership, relative to the country in which partners are based and also the business sector in which they operate. The calculation for the SMEs rates and the overhead costs is given in the table that follows.

Partner	Personnel Rate (euros per PM)	Cost Model	Organisation Type	Overhead Rate	Total Rate	Country
1	5500,00	Special Transition Flat Rate	SME	60,00%	8800,00	UK
2	4400,00	Special Transition Flat Rate	SME	60,00%	7040,00	Spain
3	3100,00	Special Transition Flat Rate	SME	60,00%	4960,00	Croatia
4	5800,00	Special Transition Flat Rate	SME	60,00%	9280,00	Netherlands
8	3900,00	Special Transition Flat Rate	OTH	20,00%	4680,00	Slovenia

Table 15. SMEs' rates calculation

RTD performers cost analysis

The analysis identified that different RTOs from different member and candidate states also vary in their salaries and overheads. Coordinator has consulted EARTO (The European Association of Research and Technology Organizations) to obtain a comparison between the cost rates put forward by selected RTO performers. In particular, to establish whether the rates they had requested were competitive and whether there were better value service providers available of equal quality. By comparison of this data appears that all proposed RTOs are good value for money for the work load they have to provide us.

Overhead rates also vary depending on the type of RTO organization involved. Part of the RTOs in the consortia is possessing large R&D infrastructures with extensive test equipment and facilities and, as such, their overhead rate is quite substantial (defined in table that follows).

RTD Partner	Partner Short Name	Personnel Rate (euros per PM)	Cost Model	Overhead Rate	Total Rate	Country
5	SCIENTX	5800,00	Special Transition Flat Rate	60,00%	9280,00	UK
6	SCIMERGO	3600,00	Real Indirect Costs	110,00%	7560,00	Croatia
7	TEAV	4935,00	Real Indirect Costs	170,00%	13324,50	Spain

Table 16. LE's and RTD organizations' rates calculation

Travel, consumables, protection of knowledge

Travel budgets have been compiled using quotes from budget airlines for attendance at meetings. Since most project meetings will be in Croatia and UK, the airfares to Zagreb and London are similar as per other cities in EU. Each partner travel budget is worked out on the basis of attendance at the project meetings, technology transfer meetings and dissemination events. It must be noted that the TEAV has a higher amount of travels and subsistence in these WPs. This is due to the need for some presence in Croatia and UK during the Algae Prototype build phase and validation work in WP4, WP5 and WP6.

Consumables budgets are allocated based on the material input required from each partner in the form of raw materials and consumable items. SCIMERGO, SCIENTX and TEAV applied for somewhat larger but still reasonable portions of consumables due to the prototype development needs.

Distribution of the grant between participants

The allocation of human resources per partner and per WP has been presented earlier in this document in Table 18. Coordinator has assessed each task to ensure the resource costs assigned to each partner reflects the value of deliverable or milestone they are responsible for delivering from that WP.

The majority of the RTD resources have been associated to the development of the WP that contains major risks (WP1, 2, 3 and partially 4). Most of deliverables, particularly those related to the critical risk in the project are supported by significant effort from RTO performers. The integrated and indicative breakdown of the offer from the RTD performers to the SME participants is presented in Part A (A4 RTD Performers).

Subcontracting

Not applicable for this project.

Equipment and Facilities

Below is the table with the durable equipment available at partners. None of the durable equipment will be purchased for the purpose of this project, and is therefore included in overheads of each partner.

Partner	Equipment and Facilities
MICRODEAL	Film production plants in UK, MICRODEAL has recently installed a new, state of the art, Precision Microstructure Coating Line at the Oxfordshire manufacturing unit. Optical components manufacturing facilities in Swindon. Large office and conference space.
ALGAEDIESEL	ALGAEDIESEL possess the firs Spanish Ecofuel plant, located in Toledo (Biodiésel CLM) has several years of experience and has gained recognized prestige. Its facilities have a production capacity of 50,000 tons/year of ALGAEDIESEL and comply with European regulations. Company possess large mechanical manufacturing and construction facilities.
EMERGO	Company possess all equipment needed for industrial automation and commissioning equipment (HW, SW and tools). It has industrial automation boards assembly facility in Zagreb. Company possess modern and large office and conference space.
ALGAETEAM	Company based in Netherlands, has extensive capabilities in the supply of Algae Cultures and the provision and support of algae photobioreactors of a range of scales..
TEAV	TEAV has expanded its capabilities and services to accommodate to the new techniques available on the CAD-CAE world. Rapid prototyping, development, engineering design, design optimization and failure analysis can be performed by using FEA (Finite Element Analysis) and CFD (Computer Fluid Dynamics) methods. This kind of tools offers the possibility to simulate and thus analyse and understand the physical behaviour of multiple systems providing a crucial support in the decision process involved in every successful design. Static, dynamic, modal, random vibration analyses are all available. Often these analyses are used to compare with strain gauge measurements during structural tests. Fatigue Life Prediction using S-N life methods combined with the finite element results can make predictive analysis of fatigue failures. Computational Fluid Dynamics (CFD) includes analysis of laminar or turbulent flow, isothermal or adiabatic and compressible or incompressible flow, noise generation and every data that could be post-processed from the velocity, pressure and temperature fields that define the state of a fluid. With the increasing social concerns about noise pollution, FEA will be also a useful tool to improve the vibro-acoustic design of engines, machines, vehicles, household appliances, etc. The simulations allow the calculation of resonance frequencies, natural modes of vibration, frequency response curves, noise propagation and radiation, effect of damping and much more.

SCIENTX	**Modern equipped laboratory facilities space in London (Twickenham) together with office and conference space. MICRODEAL operates from its own facilities but also works closely in collaboration with Centre for Renewable Energy Systems Technology (CREST) at Loughborough University and Brunel University in West London.**
SCIMERGO	**Laboratory facilities; control engineering and simulation laboratories which are relevant for this project, prototyping workshops, real time acquisition and simulation HIL software, process modelling and simulation software, CAD Mechanical laboratories with prototyping workshops are equipped for the complex prototypes constructions. Shock, vibrations and stress laboratories are available in the organization campus. SCIMERGO possess also large conferencing and showroom space, etc.** **Large SCIMERGOs laboratory spaces will be used for integration, testing and optimization of SOLEALGAE plant.**
GASOIL	**GASOIL is the largest energy company in Slovenia. It possess gas stations, More than** **410 service stations More than 3,500 employees in nine countries. More than 230,000 users or population equivalents to which we provide waste water treatment services.** **For this project GASOIL will put on disposition its laboratory space in Ljubljana and potential demo site in Domzale, next to the experimental biofuels production site.**

Table 17. Partners' equipment and facilities

Human resources – quality of the manpower

The table below shows the quality, level and type of the manpower allocated to the project, including in particular the expertise of key experts in respect to their task responsibilities.

Partner	Participant, Person and skills	WP
MICRODEAL *(01/12/2011 – 04/04/2013)*	Coordinator Antony **An employee of MICRODEAL since 2006, Anthony controls the accounts and finance functions and is skilled in project account co-ordination. In addition, he holds the post of Company Secretary and is responsible for the control and co ordination of quality management systems within the Company. Anthony has project managed a number of UK and EU programs including providing financial reporting. Anthony Seymour is an accountant with over 25 years experience in management accounting within manufacturing and retail sectors. Previous employment has included work for General Electric and Plessey.**	**WP1-WP8**
	Dr. Engineer Microdeal **obtained an MSc in Computer Science from University College London and then worked for four years as a clinical research fellow at the Biomedical Computing Unit of the Imperial Cancer Research Fund laboratories researching applications in computer vision and expert systems for medicine. He obtained a PhD in this area from Queen Mary's and Westfield College. He has extensive experience of optics and solar energy including concentrated photovoltacis and concentrated solar energy. Following this he worked in computing R&D consultancy at MTA and then at Central Research Laboratories (CRL), part of Scipher PLC, formerly the corporate research laboratories of Thorn EMI, conducting work in advanced computing including the use of neural networks in text and database mining including developing and delivering a major licensing deal with Fulcrum Technologies (later PCDocsFulcrum and then Hummingbird), where he worked for 2 years leading the software team that integrated the software. He returned to CRL, where following a period evaluating intellectual property he then ran for 3 years the Bio and Chemical Instrumentation group (BCIG), which developed advanced microsystems with an emphasis on microfluidics for chemistry and biology. During this time he founded, raised financing and developed the technology for a biomaterials startup – Spinox. He left to run the life sciences consultancy group at Scientific Generics. His recent work is focused on thorough research of the optics and light distribution in the Algae growing facilities, Solar thermal and Concentrated Solar Photovoltaic.** Engineer Microdeal 2 **worked for 19 years in the display industry, developing and patenting LCD, Polymer OLED and microdisplay technologies at Thorn EMI's Central Research Laboratories (That later became Scipher). This**	**WP1, 4, 5, 6**

involved transferring display technology to Japan, Korea and Taiwan, and managing the patent portfolio. As Technical Director of CRL Opto (a Scipher spin-out company), Paul gained experience of spinning out small businesses, and fund raising, along with delivering the technology. For the last 4 years he led a small team as Technical Director of Patterning Technologies, that successfully raised funds and delivered a production ready inkjet printing machine from scratch, that directly deposited electronic materials for the PCB industry. Patterning Technologies followed a business model of sub-contracting all but its core engineering, enabling it to deliver a cost effective solution that gained acceptance in the market. Paul joined MICRODEAL in January 2009 as Operations Director. Managing Engineer Microdeal 3 **is a director of MICRODEAL and is responsible for production engineering actives at the company. He has 10 years experience in the field of production engineering.** Engineer Microdeal 4 **studied at the University of Manchester, gaining BSc in Management Sciences. His career in marketing and brand management has taken him to Europe, Asia, Australasia and North America. David has considerable experience working with multinational organisations, including 10 years of international marketing with Diageo. Previous work has involved strategy development, brand management and promotions, innovation and new product development. He joined MICRODEAL in November 2007 as marketing and business development director.**	
ALGAEDIESEL **Manager AlgaeDiesel, Technical** Director. Industrial Engineer, 5 years of experience in the ALGAEDIESEL field and working for ALGAEDIESEL CLM's group of companies. He has valuable experience in biofuels production. His position as a technical director will significantly support the technical aspects of the project. Currently working for other national research projects for the improvement of the current ALGAEDIESEL technologies applied in ALGAEDIESEL CLM plants. **Engineer AlgaeDiesel,** Industrial Engineer, projects engineer, high experience on the ALGAEDIESEL sector (more than 5 years), he's leading some research current national projects for ALGAEDIESEL technologies.	**WP2, 3, 4, 5, 6**
EMERGO Manager AlgaeDiesel, is Technical Manager in EMERGO. He has **Diploma in Electrical Engineering He has** 20 years **previous experience in the control engineering, automation and manufacturing field, mainly in the project management and scheduling of projects related to the production of parts, sub-assemblies and components.** **He has projected and designed numerous industrial automation plants worldwide, and participated in their commissioning and start ups.** Engineer Emergo **His primary expertise is on the use of** algae in renewable energy **production and related business development. Recently, his second report on algae-based biofuels for the United Nations Food and Agricultural Organization (FAO) has been published, analysing options of co-producing bioenergy and other products from algae, including the effects on the economics, sustainability certification and applicability in developing countries. Besides topics relating to algae, he has worked on various projects involving different aspects of second and first generation biofuels, including sustainability, GHG balances and logistics. Recently he also developed an interview-based study on education-related barriers to renewable energy for the IEA, a large, multi-level database on greenhouse gas emissions and subsequent interactive graphical representation, performed several biofuel due diligences, worked on the analysis of the biomass potential of the European market and developed expertise in the automated/repeated gathering of internet-based data. Sjors holds an MSc degree in Environmental Sciences from Wageningen University, The Netherlands, with a specialization on Environmental Technology. He is native Dutch and is based in Porto, Portugal.**	**WP 3, 4, 5, 6**
ALGAETEAM Mark van Manager **(CEO). Mark gained extensive experience with GE Plastics and a number of other GE companies, with various senior management roles covering Europe, Middle and Eastern Europe and Asia. Mark has accumulated process operations, project, technology, sales, marketing and general management experience during his time at GE.** **In his capacity as CEO of ALGAETEAM N. V., Mark has contributed as speaker and panellist in many international conferences about Algae, Biomass, Bio-Fuel, Waster Water Treatment, Climate and Environmental topics. He has**	**WP4, 5, 6**

exclusive participations in report and studies on the same topics for the Club of Madrid, the Bellona Foundation and OECD.	
TEAV Dr. Ernesto Fuentes: (leading researcher, WP3 leader) **Project Manager. MSc in Mechanical Engineering and PhD in Metallurgy and Materials Science at Oviedo University. Relevant experience in following areas: Project Management aerospace industry, Machinery building technology, Mechanical and Structural Design, Degradation of Mechanical properties, Structural Integrity Assessment, Fracture Mechanics, Image Analysis, Numerical Methods, Statistics, Requirements Engineering, QA. Have worked since 1993 in following fields Applied and Academic R&D, Aerospace industry, Mining Industry, consultancy. The areas of application range Design of automotive transmission, Geophysics, pisciculture, Heat exchange, HIC & SCC degradation on API steels, etc** Pedro Gonzalez **has a degree in Mechanical Engineer with relevant experience in project management and industrial work environment. Has leaded FP7 research projects with a significant component of heat transfer and simulation.** Dr. Jose Dorlado, PhD **Master Degree in Physics (Optics and Structure of Matter) by the Universidad de Madrid and PhD at the Institute of Materials Science of Madrid (CSIC). With an overall** research record of 10 years**, he has worked in the area of particles scattering applied to materials engineering research, having been involved in the development and optimization of several neutron diffractometers at the Neutronforksninglaboratoriet (NFL, Sweden) and ISIS-Appleton Rutherford Laboratory, by means of simulation techniques. He is expert in the use of Finite Element Modelling, Monte Carlo Simulation techniques and other numeric methods for the analysis of complex systems. His combined expertise on optics and simulation suits the requirements for the delivery of the work assigned to TEAV.**	**WP2, 4, 5, 6**
Dr. Carlo Munez: **Research Engineer. He holds Industrial Engineering and BsC in Physics degrees and PhD in Mathematics. He is a senior R&D Engineer with more than 10 years experience in the mathematical modelling of physical problems, including mechanical, thermal, and more in depth acoustics and vibrations. His PhD was devoted to developing efficient numerical methods for the simulation of elastoacoustic systems. He held a postdoc position at the Institute of Sound and Vibration Research (University of Southampton, UK) for three years doing research on numerical methods for noise propagation in flows with applications to the aeronautical sector and was involved in two European Projects. Before joining TEAV he spent three years at the University of Vigo working as Research Fellow in numerical methods for acoustics and vibrations**	**WP2, 4, 5, 6**
Ing. Pedro Calle: **Research Engineer. He has MSc degrees in Physics and Mathematical Engineering and Applied Sciences by the University of Santiago de Compostela. His fields of expertise are focus on the numerical simulation. Strong background in engineer design covering wide range of environments related to CFD (Computational Fluids Dynamics) and FEA (Finite Element Analysis), with industrial experience on the Solar energy sector. He has work in many different projects, involving heat transfer, fluid dynamics, aerodynamic, HVAC, filtration and cooling systems as well mechanical issues like static analysis, impact simulations, fatigue predictions, fluid-structure and mechanical-thermal coupling. The main area of application of his research has been renewable energies (particularly solar) and environment.**	**WP2, 4, 5, 6**
SCIENTX David Peter (WP1 leader) **has a BSc in Chemistry, Physics & Computing. He also has significant technical expertise in microengineering, nanotechnology and microfluidics. He was previously Operations Manager for a large group within a major research organisation. David is an experienced project manager with many years experience of commercial R&D including industrial, national and international collaborative programmes as well as FP5 and FP6 projects. His recent work is focused on thorough research of the optics and light distribution in the Algae growing facilities, Solar thermal and Concentrated Solar Photovoltaic.** Martin Fox **has an HNC in Applied Physics and Electronics. He has significant expertise in design work, including CAD, in micro and macrofabrication of advanced systems and devices and in electronics and control systems. In recent years he has been involved in the design and fabrication of microfluidic devices and fluid delivery systems.**	**WP 1, 4, 5, 6**

This has been by using a combination of AutoCAD and Excaliber CAM software to drive a Datron CAT3D-M6 micro mill. Either the components being milled into a polymer or machinable ceramic with precision parts having structure down to 0.1mm and tolerances to ±0.005mm, also the design and assemble of precision components and integration into a working prototype instrument.	
SCIMERGO Predrag Martic, MScEE, MScME, (Coordinator) **Mechanical engineer graduated on University of Mechanical Engineering and Naval Architecture University of Zagreb and finished postgraduate study at Faculty of Electrical engineering and Computing University of Zagreb and obtain Master degree in Electrical engineering. He has more than 15 years of working experience. His professional career trace from position of junior researcher, leading researcher to R&D program leader position and was mainly related to energy system optimization, guidance and control area. He was involved in more than ten power plant guidance and control system development, design and commissioning projects and led dozen complex measurements of energy systems. He possesses extended field experience in the international industrial business environments especially EU R&D projects.** **His scientific and professional intense interest is field of renewable energy sources (biofuels and solar), particularly ORC cycles and power generation from solar and waste heat thermal sources. Predrag possesses specific expertise in CFD modelling, and control simulation.**	**WP3, 4, 5, 6**
Tomislav Bublic, MScEE, **he holds Electrical Engineering degree in Power Engineering and Masters degree in Control Engineering from the Faculty of Electrical Engineering and Computing Zagreb. He also holds a Diploma Study in Management from the Faculty of Electrical Engineering and Computing Zagreb. He has 9 years of experience in project planning, design and control commissioning and data acquisition systems in hydropower plant systems and ship systems. In the last 2 years he has been intensively involved in machine vision and pattern recognition application project for fire fighting vehicle. His professional interests are control systems and image analysis and pattern recognition algorithms. In the recent years Mr. Bublic has worked on control engineering for the biofuels and biogas plants in Croatia and abroad.**	**WP3, 4, 5, 6**
Dr. Petar Kostić, PhD EE (Technical Project Manager) **has more than 30 years experience in the control engineering and advance guidance systems, particularly in the vehicles guidance, navigation and dynamic positioning. His past research activities are intensively related to the simulation of dynamic system and prototyping of complex simulators (flight, vehicle, etc.). In his work he's been using intensively the HIL systems. He is also visiting professor at the University of the Mechanical Engineering in Zagreb, and his areas of the recent research work are in the practical implementation of the advanced guidance systems in renewables and energy supply systems, particularly solar and waste heat from industrial sources. Dr. Kostić possesses valuable experience in working with large and multinational multidisciplinary teams in the country and abroad.**	**WP3, 4, 5, 6**
Damir Petar Pribenic, **MScME, Damir has graduated at the Faculty of mechanical engineering in Zagreb. He has been involved more than 10 years as a researcher in complex national and international research projects. Damir possesses proven experience in researching, designing and development thermodynamics systems, especially thermal installations and equipment (HVAC). Damir has been developing and calculating electrical vehicle dynamics for the electromotive vehicles. His recent research is oriented towards the modelling of the thermal processes in renewable, and computing and modelling of electric vehicles and hybrid systems. Damir possesses specific expertise in using 3D modelling, numerical FEM and CFD modelling.**	**WP3, 4, 5, 6**

GASOIL d.d. Dr. Janka Prešern **holds a PhD and MSc in Chemistry with working experience of more** than 15 years**. Since March 1992 she is employed in GASOIL d.d., Ljubljana – Laboratory GASOIL (chemical testing laboratory operating in the field of GASOILeum products (liquid fuels, lubricants, fuel and lubricant additives, waste oils, GASOILeum solvents and some chemical products) testing for the needs of the mother company (internal customer) and external customers on the market). She worked as a Senior analyst in Laboratory GASOIL and as a Testing manager in Laboratory GASOIL** **As a member of the laboratory's managerial team she was involved in decision making regarding future R&D work, work organization, investments, costs, personnel and others.** **Recently Janka operates as manager responsible for Technical Development Quality and safety department. The department take care for safety management – total safety and environmental management, fire safety, occupational safety and security. TQM and technical development is also the core business of the department. There are 40 staff members.** Mojca Rukeš, MScChE, **holds a master degree from University of Ljubljana, Faculty for Science and Technology, Department for Chemistry and Chemical Technology on her Master Thesis: "Influence of heteroatoms on reactivity of ketones". She has worked in biofuels industries for more** than 20 years **as scientist, manager and director. Currently she works for GASOIL and her mean projects: Introduction of European Chemical law in GASOIL's Business, Innovations methodology, Methodology of project leading, Collaboration on different development projects as bio fuels, lighting pollution, isolative materials, cleaning agents.**	**WP 4, 5, 6**

Table 18. Partners' human resources

Integration and creation of the critical mass of resources

We have accurately estimated the levels of resource required to successfully deliver the project and also matched the resource of the consortium to the skills required. In order to calculate the overall effort required the Work Programme was constructed to deliver the project objectives. The required man months of effort were then calculated for each technical work package. The consortium management value reaches a reasonable 7,4% of the project value. There is a difference between the consortium management and the technical management activities. The technical management activities are included in the individual tasks, whereas the overall consortium management is listed separately. Consortia members have optimally mixed and combined the skills and resources available from the partners and RTO performers. In particular, the skills are integrated to form a coherent delivery capability and will ensure that the project objectives are met. A good balance between the intellectual and resource effort between the SMEs and RTD performers is proposed to ensure that the SMEs remain in control **and thus represent the best interests of the wider SME community.**

The following table shows the overall budget for the project:

SOLALGEN

Budget Table of Estimated Eligible Costs

PARTNERS				RTD ACTIVITIES										DEMONSTRATION ACTIVITIES							
Participant No.		Country	Cost Model	Number of Person Months	Personnel Costs	Travel & Subs	Consumables	Other Costs	Protection of Knowledge	TOTAL DIRECT COSTS -	Indirect Costs - Overhead	RTD Subcontract	Subcontract	Total Estimated Eligible Costs	Number of Person Months	Personnel Costs	Travel & Subs	Other	Indirect Costs - Overhead	RTD Subcontract	Subcontract	TOTAL Estimated Eligible Cost
1		UK	Special Transition Flat Rate	5,00	27500	2000	0	0	0	29500	17700	336367	0	383567	3,00	16500	0	0	9900	19106	0	45506
2		Spain	Special Transition Flat Rate	3,00	13200	1000	0	0	0	14200	8520	163102	0	185822	1,50	6600	0	0	3960	9264	0	19824
3		Croatia	Special Transition Flat Rate	7,00	21700	1000	0	0	0	22700	13620	179582	0	215902	1,50	4650	0	0	2790	10201	0	17641
4		Netherlands	Special Transition Flat Rate	8,00	46400	1000	0	0	0	47400	28440	310852	0	386692	1,50	8700	0	0	5220	17857	0	31577
8		Intl	Special Transition Flat Rate	1,00	3900	1000	0	0	0	4900	980	0	0	5880	0,00	0	0	0	0	0	0	0
				24,00	112700	6000	0	0	0	118700	69260	989902	0	1177862	7,50	36450	0	0	21870	56228	0	114548

For Information - RTD Performers Efforts Identified Above as Subcontracting to the SME-AG and SME Partners

5		UK	Real Indirect Costs	20,80	137280	4000	47000	0	0	188280	82368	0	0	270648	2,00	13200	0	0	7920		0	21120
6		Croatia	Real Indirect Costs	46,00	165600	4000	63000	0	0	232600	162160	0	0	414760	2,00	7200	0	0	7920		0	15120
7		Spain	Real Indirect Costs	19,70	97220	4000	38000	0	0	139220	165274	0	0	304494	1,50	7403	0	0	12585		0	19988
TOTAL				86,50	400100	12000	148000	0	0	560100	429802	0	0	989902	5,50	27803	0	0	28425	0	0	56228

PARTNERS				MANAGEMENT ACTIVITIES							OTHER ACTIVITIES							TOTALS	
Participant No.	Participant Short Name	Country	Cost Model	Number of Person Months	Personnel Costs	Travel & Subs	Other	Indirect Costs - Overhead	Subcontract - Including AUDIT CERT	TOTAL Estimated Eligible Cost Incl. Subcon	Number of Person Months	Personnel Costs	Travel & Subs	Other	Indirect Costs - Overhead	Subcontract	TOTAL Estimated Eligible Cost Incl. Subcon Audit Cert	TOTAL Number of Person Months Including those of the RTD Performers	TOTAL Estimated Eligible Cost for Whole Project
1		UK	Special Transition Flat Rate	5,00	27500	2000	0	17700	0	47200	2,00	11000	0	0	6600	0	17600	15,00	493873
2		Spain	Special Transition Flat Rate	1,50	6600	1500	0	4860	0	12960	1,50	6600	0	0	3960	0	10560	7,50	229166
3		Croatia	Special Transition Flat Rate	1,50	4650	1500	0	3690	0	9840	2,00	6200	0	0	3720	0	9920	12,00	253302
4		Netherlands	Special Transition Flat Rate	1,50	8700	1500	0	6120	0	16320	1,50	8700	0	0	5220	0	13920	12,50	448509
8		Intl	Special Transition Flat Rate	1,00	3900	2000	0	1180	0	7080	1,00	3900	0	0	780	0	4680	3,00	17640
5		UK	Real Indirect Costs	0,50	3300	500	0	1980	0	5780	1,50	9900	0	0	5940	0	15840	24,80	21620
6		Croatia	Real Indirect Costs	0,50	1800	500	0	1980	0	4280	1,00	3600	0	0	3960	0	7560	49,50	11840
7		Spain	Real Indirect Costs	0,50	2468	500	0	4196	0	7164	0,50	2468	0	0	4196	0	6664	22,20	13828
TOTAL				12,00	58918	10000	0	41706	0	110624	11,00	52368	0	0	34376	0	86744	146,50	1489778

Table 19. Project budget

The consortium has selected the RTD performers due to their areas of expertise and complementary skills. The RTD performers have planned the proposed research based on their internal skills matrix and assigned the most appropriate people to each individual tasked. Indicative breakdown of project RTD expenses from the RTD performers to the SME participants is presented in Part A (A4 RTD Performers).

4. Members of the consortium

MICRODEAL, UK, SME, www.MICRODEAL.co.uk

Role in the project

In this project MICRODEAL participated in the SOLEALGAE RTD phase mainly as optical solutions components (collectors and distributors) supplier. **MICRODEAL also acted as a project Coordinating organization where Mr. Anthony Seymour was the coordinating person. The company proactively participated and supported the RTD activities in part of the research in its area of expertise (WP1). Using their internal capacities and networking MICRODEAL participated in creation of the marketing strategies for the consortium technology sales. MCL left the project in April 2013.**

Benefits expected

MICRODEAL aimed at developing a Light Collector-Distributor product unique on the market, with a high value added value that could be marketable at the worldwide level and becoming its supplier and licenser were applicable. MCL also gained ownership share in other technologies, particularly of the prototype that would be developed throughout this project.

Company Size

The company had 11 employees and an approximate turnover of 1.2m euros.

Expected exploitation results: **mainly partial ownership and licensing of project results table (Part A, A5 Project Results).**

ALGAEDIESEL, Spain, SME, www.ALGAEDIESELclm.com

Role in the project

In this project ALGAEDIESEL is expecting to participate as the plant integrator and future product producers and installer. ALGAEDIESEL is interested in the conceptual design of the HOBR plant. When the cultivation technology proves itself efficient and functional, ALGAEDIESEL will, beside the potential prototype plant in Croatia-Slovenia built its own plant in Toledo Spain in order to master the technology. Besides, ALGAEDIESEL is interested to provide and produce mechanical and structural components for the algae production plants. For this project Mr. Rodrigo Palma will manage all activities that are related to ALGAEDIESEL, and he'll also manage a part of the Consortia technology validation activities in the role of the Validation Manager.

Benefits expected

ALGAEDIESEL expect that the project will produce a fully functional prototype marketable at the global market level. The company is moreover expecting to take over the concept for the future HOBR production and exploitation. We anticipate revenues of more than 55 million of EUR in next fifteen years in collectors and distributors sales. We do also expect a growth in employees due to the organization

expansion needed to match the predicted production. Extra economic benefits are expected from the technology licensing to the remote worldwide locations and customers.

Company Size

The company has 9 employees and has an approximate turnover of 1.1m euros.

Expected exploitation results: **mainly licensing of partners' products is expected from the project results table (Part A, A5 Project Results).**

EMERGO, Croatia, SME, www.emergo.hr

Role in the project

In this project EMERGO is expecting to participate in the SOLEALGAE integration phase as the Control Systems provider**, where the plant automation and environment and cultivations algae control have to be implemented. EMERGO will also take care of implementation and integration of the prototype plant. In certain cases EMERGO will ,together with ALGAETEAM and ALGAEDIESEL, agree on the distribution of the product and its integration in their respective areas. EMERGO will provide its personnel in the Control engineering development phase in WP2 and WP3. WP5 and WP6 are packages where EMERGO will participate intensively due to their integration and validation nature.**

Benefits expected

EMERGO is expecting to take over the control engineering part from SCIMERGO for consequent projects in the future. Becoming a part of the supply chain in the SOLEALGAE project is another benefit that EMERGO is expecting from this project. We anticipate revenues of more than 27 millions of EUR in next fifteen years where we'll use our partners as suppliers and product distributors, as well as potential licence owners. We do also expect a growth in employees due to the organization expansion needed to match the predicted production.

Company Size

The company has 12 employees and has an approximate turnover of 1m euros.

Expected exploitation results: **mainly licensing of partners products is expected from the project results table (Part A, A5 Project Results).**

ALGAETEAM, NV, Netherlands, SME, www.ALGAETEAM.com

Role in the project

ALGAETEAM will provide knowledge and consultancy on algae strain selection and algae cultivation and growth. It will interact to ensure that its experience in algae photobioreactors is enhanced within the objectives of the project. It will assist in the development of the algae cultivation facilities.

Benefits expected

Further development of ALGAETEAMs R&D in algae cultivation and provision of cost effective algae growth products.

Expected exploitation results: **Licensing of partners products is expected from the project results table (Part A, A5 Project Results).**

SCIENTX, UK, RTD, www.SCIENTX.com

Role in the project

SCIENTX will be responsible for the enhancement of scientific knowledge and development of the film patterns in WP1 together with MICRODEAL. With its waste experience in managing R&D projects SCIENTX will support the technical project management of the project, and be direct additional support to Tech Manager.

Benefits expected

As RTD performer SCIENTX expects that it will be reimbursed at the 100% of its eligible costs for undertaking the tasks assigned to it by SMEs. It will have absolutely no ownership of the resulting IPR, which will be owned by SMEs.

Company Size

The company has 4 full time employees (plus outside consultants) and has an approximate turnover of 300k euros.

Expected exploitation results: **No exploitation results are expected for SCIENTX as an RTD organization.**

SCIMERGO Innovative Technologies Centre, Croatia, RTD, www.SCIMERGO.hr

Role in the project

SCIMERGO will be the lead R&D performer in two Work Packages (3 and 4) and will actively contribute the project through the rest of the project, particularly in product integration phase, as well as in the phase of testing and product verification.

Furthermore SCIMERGO will allocate its senior project manager Dr. Petar Kostić to the role of Technical Project Manager. In this role he'll be able to coordinate complex R&D activities that are foreseen within this project, based on the experience from othe FP7, national, and regional projects.

Following the withdrawal of MICRODEAL in April 2019, SCIMERGO took over the role of project coordinator.

Benefits expected

SCIMERGO expects to be reimbursed 100% of its eligible costs for undertaking the tasks assigned to it by SMEs. It will have absolutely no ownership of the resulting IPR, which will be owned by the SMEs.

Expected exploitation results: **No exploitation results are expected for SCIMERGO as an RTD organization.**

Tecnologías Avanzadas Inspiralia, TEAV, Spain RTD, www.TEAV.es

Role in the project

TEAV will be the third RTD performer in this project and work on the WP2 and integration and validation WPs. It will actively contribute the project through the rest of the product development phase, particularly in product integration phase, as well as in the phase of testing and product verification.

Furthermore TEAV will allocate its senior project manager Dr. Ernesto Fuentes to the role of the TEAV Technical Project Manager and WP3 leader. In this role he will be able to coordinate complex R&D activities that are foreseen within this project.

Benefits expected

TEAV expects that it will be reimbursed at the 100% of its eligible costs for undertaking the tasks assigned to it by SMEs. It will have absolutely no ownership of the resulting IPR, which will be owned by SMEs.

Company Size

The company has 593 employees and has an approximate turnover of 53m euros.

Expected exploitation results: **No exploitation results are expected for TEAV as an RTD organization.**

GASOIL d.d., Slovenia, OTH, www.GASOIL.eu

Role in the project

GASOIL is expected to participate in the project as the potential end user or customer of project results. GASOIL will offer numerous technical, commercial, environmental and logistical information related to its facilities and the energy business in order to drive and focus the consortia partners on the current market conditions and specifics of the algae cultivation in order to focus their R&D activities and prototype. We consider the role of the LE (large enterprise) and its presence in the project as crucial, due to the presence of the credible potential customer and end user that will be able and willing to use the final product (algae oil) into their portfolio, or help in further development and/or funding if the technology demonstrate itself proven.

Benefits expected

We expect to participate as a partner in the research and development process of a series of product (light collectors, distributors, focused control system) and a prototype (HOBR plant) with a higher value added that could be marketable at the worldwide level. GASOIL will put on disposition its demonstration site close to Ljubljana for testing and final event purposes. GASOIL do expect to format a supply chain with our partners that will be able to supply us with latest SOA products and components for SOLEALGAE product. GASOIL believes that this project could give a significant boost in creating more efficient technology in the algae production segment.

Company Size

The company has 663 employees and has an approximate turnover of 2m euros.

Expected exploitation results: **No exploitation results or particular project related IPR are expected for GASOIL being in the role of the LE (OTHER) organization.**

5. Ethics

There are no gender issues for special consideration involved with SOLEALGAE project. However, in accordance with EC Directives (COM 96) and general policy project will incorporate the principles of the gender mainstreaming in all aspects of this project. Throughout SOLEALGAE, consortium members will strive to promote gender equality and avoid any activities that may cause gender inequality.

We will ensure that all genders have equal opportunities to work in various parts of the project whilst understanding the different situational needs of men and women. Project partners will maintain an

overriding policy of reducing inequality between men and women. Furthermore, consortia partners will also be promoting the active participation of women as scientists through appropriate representation in the consortium and leading elements of work packages.

Overview final of status of the project

Description of Work has been amended in the course of the project as a consequence of the withdrawal of the coordinator, MICRODEAL Corporation Ltd, due to liquidation, which occurred on 4/4/2013. The new coordinator is SCIMERGO Innovative Technology Centre.