

Energetic and Environmental Impacts Related to Transport and Assembling Processes in A Biogas Production Plant from Marine Macroalgae (FP7 Project BioWALK4Biofuels)

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Abstract - GHG emissions, eutrophication and energy dependence are problems that the EU has to face in the near future.

The BioWALK4Biofuels project aims to find a common response to these challenges, taking advantage of spontaneous biological processes: the growth of algae and anaerobic digestion of biomass.

This project is being built thanks to European funding under the 7th Framework Programme.

To evaluate the results obtained, a first LCA study was carried out that, as regards the data on infrastructure and on the assembly of the plant, refers to data supplied by manufacturers, while the study of algal growth was made on the basis of a model of cultivation that takes account of the aspects that most affect this key process among all the ones that cooperate in the whole plant.

The electricity and heat produced through a co-generator fueled by biogas produced from algal biomass, according to this study, are responsible for GHG emissions reduced by 52% compared to traditional technologies.

The biogas produced during the 4 years of the project allows the substitution of 85 tonnes of oil equivalent (toe).

Keywords - LCA, macroalgae, marine biomass BioWALK4Biofuels, biogas.

I. INTRODUCTION

The idea that led to the creation of the B4B project stems from several considerations:

1. Europe imports 60% of its energy needs from abroad. This situation is unsustainable and a solution that enables to get away as far as possible from energy exporters must be sought.

2. Our targets for reducing emissions of greenhouse gases identified by the Kyoto Protocol require a further reduction of GHG emissions in many European countries.

3. The phenomenon of eutrophication of water affects many coastal areas of the continent, as well as internal courses and ponds. This phenomenon caused by the discharge of nitrogen compounds in sea causes primarily a high growth of aquatic

plants. When they die and decompose the subsequent absorption of oxygen causes the death of all life forms in the stretch of water affected.

4. The macro-algae are plants that, even under normal conditions, have a very high photosynthetic efficiency, approximately twice that of terrestrial plants

(energetic crops) traditionally used for the production of 1st generation biofuels.

5. On the other hand, it has been observed in several studies that such an injection of carbon dioxide in the cultivation medium of algae can increase the rate of daily growth DGR, allowing production to be three times larger in some species than in standard conditions of cultivation

Policy-makers in making appropriate and urgent choices in terms of energy must take into account all these aspects, while the role of research should be that of proposing alternatives to choose from, providing at the same time an assessment of the value of the proposed solution.

The BioWALK4Biofuels project proposes a multidisciplinary approach to these issues, transforming the negative aspects listed above into benefits.

Four tanks with a total area of 5000 m² will be installed in a stretch of sea in the industrial port of Augusta. A boiler, a few meters away, serves an industrial plant and emits, at present, about 500 tons per year of carbon dioxide that will be instead directed into the tanks to stimulate algal growth.

Finally, to support and stimulate furthermore the synthesis of new biomass through photosynthesis, the injection of nitrogen compounds will be provided in an algae growth medium to recreate the conditions of eutrophication, which will cause a further increase in production.

The biomass thus obtained will be sent in an innovative anaerobic digester, able to convert almost all biomass into biogas.

In this way, from the limited space available, we will try to get a quantity of biofuel comparable to those obtained from terrestrial plants only from areas several times larger. This

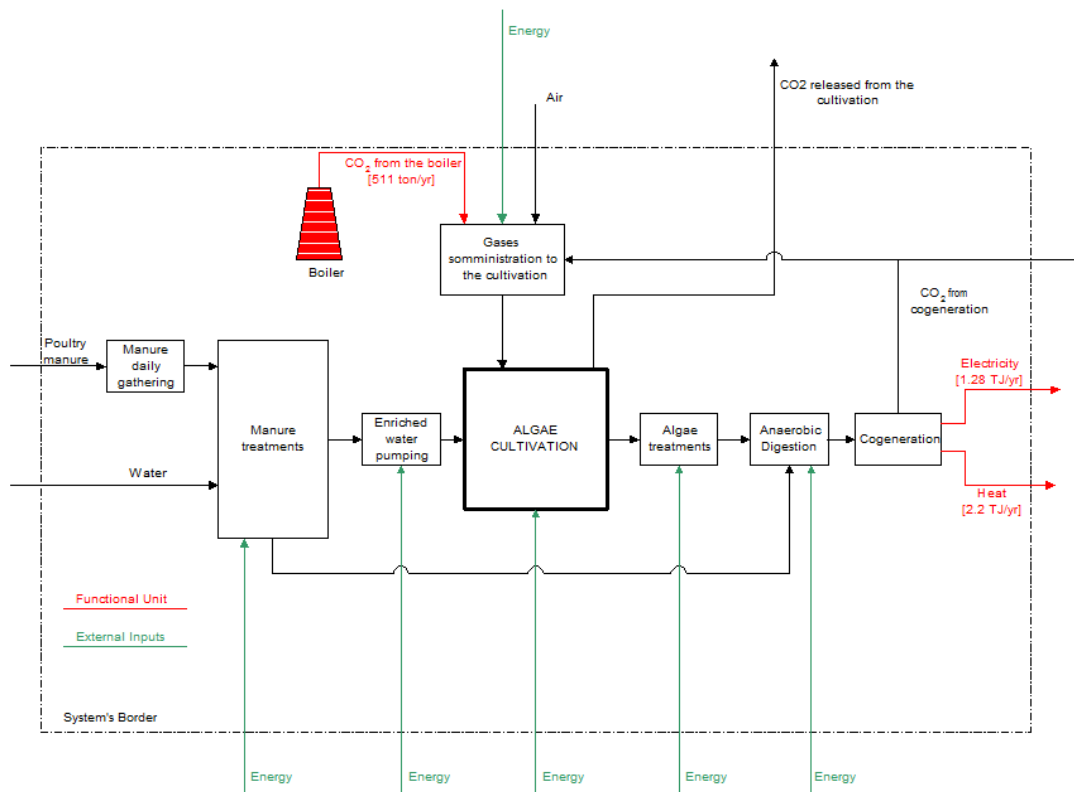


FIG.1. BLOCK DIAGRAM OF THE BIOWALK4BIOFUELS PLANT [1].

reduction will have a beneficial impact on energy, environmental and social issues.

First of all, the limited extension of cultivation will mean that farm machinery will not be required to move and the harvested biomass will not need to be transported from one place to another. The movement of water, necessary to avoid mutual shading and thermal stratification, will be designed in such a way that biomass is transported to the section of harvest and collection.

Secondly, an intensive cultivation allows for greater efficiency in the absorption of CO₂ and nitrogen compounds.

Finally, no land surface will be taken away from agriculture and thus food production.

The objective evaluation on the values and benefits provided by the installation B4B will take into account environmental impacts both local and immediate, delayed in time and space as well. The instrument that can best accomplish this task is the Life Cycle Assessment (LCA), the more so because of the variety of issues related to the project.

Therefore this study seeks to provide an initial predictive assessment on what may be the energetic and environmental performances reached from the manufacturing of biogas from anaerobic digestion of algal biomass produced by intensive cultivation of macro algae.

II. STUDY OBJECTIVES

This study aims to assess the GHG emissions due to construction of the plant and processes that contribute,

together with the cultivation, to the production of biogas from anaerobic digestion of marine biomass.

The calculated emissions over the lifecycle of the plant B4B will be compared with the alternative represented by the current situation.

This will give the opportunity to quantify the benefits gained through the adoption of the process tested.

III. FUNCTIONAL UNIT

The system function is the production of electricity and heat, and the processing and absorption of carbon dioxide contained in exhaust fumes of an industrial boiler.

The functional unit is defined as follows:

- Electricity: 4,44 TJ (1,11 TJ/year)
- Thermal energy: 8,88 TJ (2,22 TJ/year)
- CO₂ produced: 2045 tons (511 tons/year)

These amounts reflect the potential performance in the 4-year duration of the project under the hypothesis of the study carried out.

The B4B plant will be compared with the present scenario in which energy needs and greenhouse gases are considered as follows:

- Covering the energy needs with traditional fossil fuels (EN590 diesel for heat and fuel mix representative of Italian thermoelectric power generation);
- Release of boiler flue gas into the atmosphere.

An overview of the process used in the B4B plant is shown schematically in the block diagram in (Fig.1):

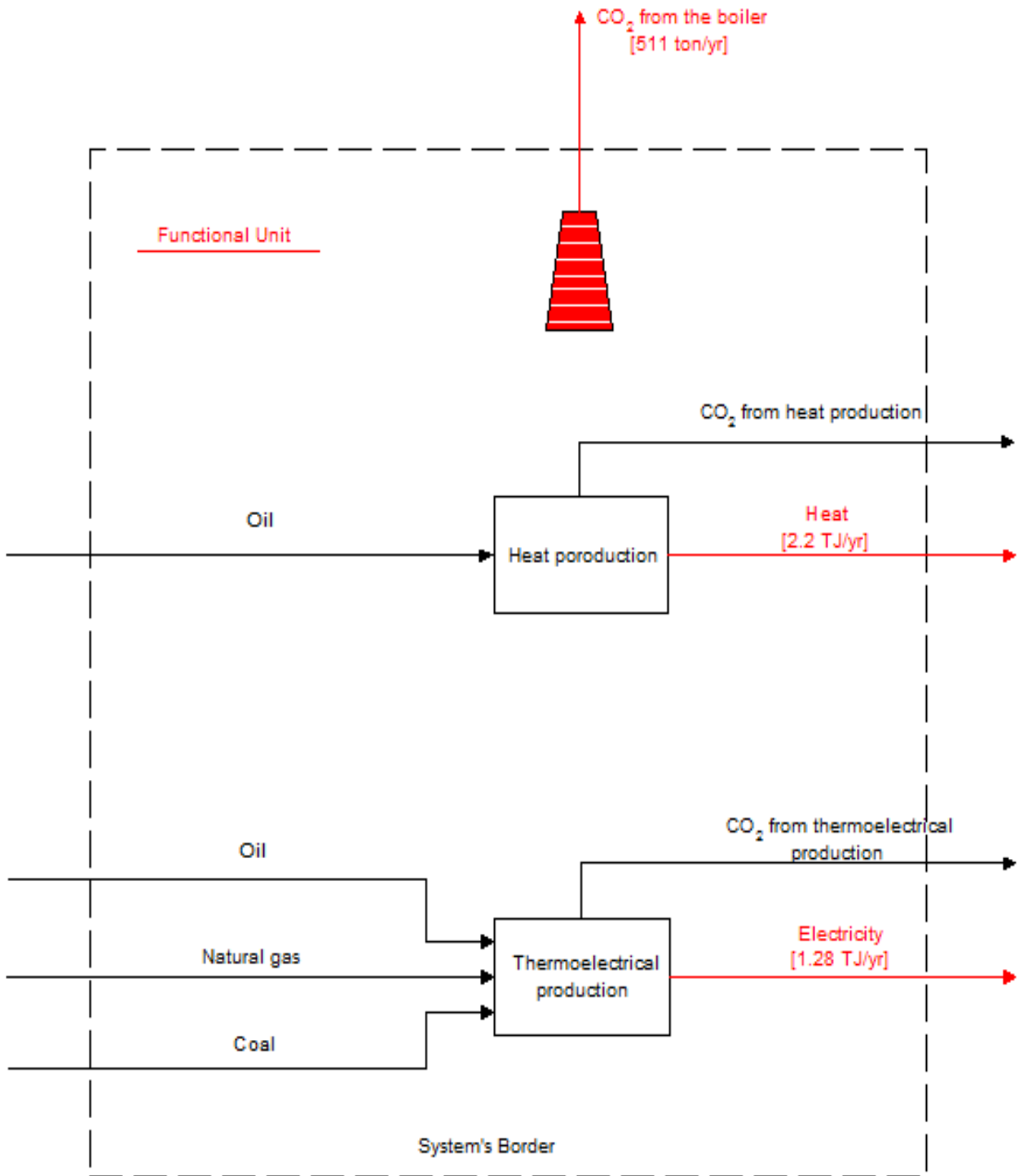


FIG.2. BLOCK DIAGRAM OF THE SCENARIO REPRESENTING THE PRESENT SITUATION.

The focus of the process is the cultivation of algae that occurs in a system of pools created by floating pontoons in HDPE (High Density Poly Ethylene) and geomembrane sheeting EPDM (Ethylene Diene Monomer Propylene).

Algae broth should be fed with the necessary elements to guarantee optimal photosynthesis rate:

- Carbon dioxide [49];
- inorganic nutrients (N, P, K) [22,23, 24, 39].

The CO₂ is piped from a boiler to an industrial fan that mixes it with ambient air and sends the resulting gas to the algae cultivation ponds.

The inorganic nutrients come from local available manure, rich in NH₃, NO_x and PO_x.

The manure must be collected and transported daily from the surrounding farms to the plant and dissolved in water to facilitate the best chemical and physical conditions for algae uptake.

The resulting enriched water is sent for cultivation with an appropriate system of pipes and pumps, while the solid residue of the treatment is prepared by a grinding pump to co-feed the anaerobic digester for biogas production.

The algae are grown for an appropriate time and then extracted with a mechanical system of grids placed in the exit channels of each bath and then shredded and sent to digesters.

The anaerobic digestion process that allows the transformation of biomass into biogas takes place in the digesters. It is then used in a process for the cogeneration of electricity and heat.

Each of the processes listed and displayed in the system's block diagram is responsible for an environmental load (in terms of emissions of GHG, those examined in this study) due to the assembling of each examined component (materials, production processes and transport system) and the production phase (energy required to complete the process and associated emissions).

The equivalent system on the current situation is shown in (Fig.2):

IV. LCI- DESCRIPTION OF PROCESSES AND MATERIALS

A. Algae production

The heart of the process is the growth of algae. The most important conversions operated by the system are concentrated in this process: polluting compounds such as nitrogen ones and carbon dioxide are synthesized in plant tissues and then their impact on the environment is avoided, allowing moreover the anaerobic digestion of biomass obtained to produce biogas.

The massive and continuous growing of macro-algae in tanks has yet to see industrial applications and then, waiting to produce experimental data in the system, this assessment will be based on assumptions and predictive models of crop derived from the analysis of literature and the results of the first laboratory studies carried out by institutions that collaborate with the project.

The analysis of cultivation here will be made with the aim to quantify the biomass produced (over each year, for the 4 years of the project) and the remaining greenhouse

gas emissions, namely the amount of CO₂ that the algae cannot absorb.

The key test for defining this assessment is the daily growth rate of algae.

This parameter is defined as [25]:

$$DGR = \left[\left(\frac{W_t}{W_0} \right)^{1/t} - 1 \right] \cdot 100 \quad (1)$$

In which:

- W_t= biomass weight at day "t";
- W₀= biomass weight at day "zero";

And is a function of parameters such as:

- Temperature of cultivation
- Solar energy
- Photoperiod
- Amount of CO₂ injected
- Amount of inorganic nutrients injected.

The joint analysis of these parameters in real Sicilian plant led to the determination of the achievable DGR in Sicilian plant and then the expected biomass production.

Literature references used to develop the cultivation model are: [2, 3, 6, 7, 11, 12, 13, 14, 15, 18, 19, 21, 22, 24, 25, 34, 47, 48, 49].

By knowing the need for inorganic nutrients, the amount of manure needed to sustain the cultivation can be determined.

TABLE I
MONTHLY INPUTS AND OUTPUTS FROM THE CULTIVATION PROCESS

Month	Biomass production	CO ₂ absorbed	CO ₂ released	Poultry manure
	ton/month	ton/month	ton/month	ton/month
January	37	9	19	25
February	71	17	21	49
March	164	39	3	114
April	158	37	3	110
May	178	42	0	124
June	178	42	0	124
July	178	42	0	124
August	178	42	0	124
September	172	41	0	120
October	184	43	0	129
November	178	42	0	124
December	52	12	16	36
tot [ton/yr]	1729	408	62	1203

The data in the table relates to a constantly updating model developed by “Sapienza” University of Rome that refers to the knowledge achieved at the time of its completion. The development of the model is constantly evolving and updated results will be published in the near future.

The LCA study has the aim to define and quantify emissions and consumptions, related to the processes involved in the B4B project, necessary to produce electricity and heat previously defined in the Functional Unit [4]. In order to assess algae production impact it is necessary to define:

- Emissions that are ahead of the growing phase and that make it possible;
- Emissions which make possible the transformation of algal biomass in the energy service examined and defined by the Functional Unit.

B. Algae cultivation tanks production and transport

The construction of these components is a very important element in the impact assessment process, as those examined are very heavy structures made of plastics, whose manufacture requires a lot of energy and a lot of valuable raw materials.

In order to assess algae cultivation impact, it is necessary to set up the LCA on the basis of data provided by the manufacturer.

Tanks manufacturer:

- EPDM (ethylene propylene diene monomer): 7400 kg
- Distance transport (TIR): 200 km
- Distance transport (boat): 1400 km

Pier manufacturer:

- Aluminum: 1200 kg
- HDPE (High Density Poly Ethylene): 24550 kg
- Distance transport (boat): 1000 km.

C. Water pumping and transport infrastructure

The water that comes out from the manure washing process is subsequently pumped to the tanks.

The environmental burden related to this process mainly depends on the energy consumption of the circulation pump, and on the resources consumed to build the machines used and the transport of the finished product.

In order to evaluate the impact due to water pumping among the pipes, it is necessary to know exactly all the characteristics related to water flow and pipe geometry that allow to calculate the type and size of the machine and, subsequently, the materials used to build it.

The system of pipes for enriched water supply consists of two sections:

The first section makes use of a PVC pipe with a diameter of 0.3m to carry water from the pumping station up to the tanks (40m approx.).

The second section makes use of PVC piping of 430m with a variable diameter along the duct to get into the tanks for the enriched water.

Applying the “Darcy-Weissbach” formula it is possible to calculate the pressure drop in the ducts that corresponds to about 67 kPa.

In order to guarantee a correct algae broth mixing inside the pools, it is necessary to furnish a constant water flow of about 36 m³/h.

The pump that accomplishes this work has a power of 3.5 kW and is in operation for 24 h/day for 320 days a year implying an energy consumption of 27 MWh/year.

The selected pumping system has a mass of about 110 kg and consists primarily of steel.

D. Gases insufflations and transport infrastructures

The procedure adopted for the evaluation of environmental burdens associated with this process is similar to that performed for the analysis of the water distribution system.

The pipelines for the conveyance of gas from the boiler to the tanks will also consist of two sections:

The first section makes use of PVC pipes with a length of 50m and a diameter of 300mm. It carries gases from the ventilation station to the tanks,

The secondary section makes use of PVC pipes with a length of 430m and a variable diameter along the duct for distributing the gas mixture inside the tanks.

The ventilation will absorb a total capacity of 15 kW and an energy requirement of 56 MWh/year.

The pair of fans that perform this function has a total weight of 320 kg and consists primarily of steel.

E. Manure treatments

Before being processed through the anaerobic digester, manure shall be subjected to different treatments.

Firstly, it should be finely chopped and then subsequently crossed by a stream of water that allows ammonia to dissolve, representing the nitrogen form preferentially absorbed by the algae.

It is necessary to filter the enriched water resulting from this process in order to avoid the presence of suspended particles that can absorb light useful for algae's photosynthesis.

The solid residue of the washing will be sent to the anaerobic digester in order to contribute to the production of biogas.

To perform this task, a chopper pump and a circulation pump are needed.

On the basis of data provided by the manufacturers and considering 4000 h/year of functioning it is possible to determine:

- Installed power: 0,8 kW
- Electricity consumption: 3 MWh/year
- Weight of equipment: 200 kg
- Transport distance: 100 km

F. Manure transport

Algae subjected to intensive cultivation require a large amount of inorganic nutrients, particularly ammonia(NH₃), nitrates (NO_x) and phosphates (PO_x).

The average manure daily need is equal to 3,3 ton/day that has to be regularly fed to the system with a van, the fuel consumption and emissions of which should be considered in the evaluation of the life cycle.

The distances that the van has to cover daily depend on which farms will conclude the agreement for the disposal of sewage. At this stage the assumption made is that the distance traveled daily by truck is 50 km/day.

G. Algae harvesting

This point is one of the major advantages of the B4B with respect to the current prototype of algal cultivation for the production of bio-fuels through the cultivation of micro-algae, because of the ease of the collection of biomass in the process studied.

The separation of micro-algae from the culture medium represents one of the most critical challenges in the energy balance of the production processes of biodiesel. Today it is necessary to centrifuge the culture medium with suitable sieves in order to obtain the isolation of unicellular algae to extract the lipids to be treated later.

It is therefore clear that, from the standpoint of the LCA, the process of separation of micro-algae is a critical step that requires a high amount of energy and the use of equipment and materials with high production costs.

The use of macro algae in the B4B plant dramatically simplifies this process using simple, inexpensive and less energy intensive harvesting system. The process proposed in the B4B foresees the use of separation grids and a mechanical comb to be placed in the collection channel in order to remove produced biomass. The grids are sized considering the flows that affect the component and the size of the material to be filtered.

Growing conditions supposed for the B4B project expect to reach an outlet flow from each of 4 bowlsof around 9m³/h, while the size of macro algae collected will

vary depending on time of cultivation from a few centimeters to a few tens of centimeters.

On the basis of data provided by the manufacturers and considering 8000 h/year of functioning it is possible to determine:

- Installed power: 2 kW;
- Electricity consumption: 16 MWh/year;
- Weight of equipment: 1000 kg;
- Transport distance: 100 km (local manufacturer).

H. Archimede Rotors for Anaerobic digestion

The B4B project adopts an innovative rotating biological contactor capable of increasing anaerobic digestion efficiency reducing maintenance costs and energy consumption.

The archimede system is based on rotating biological contactors (RBCs) exploiting fixed biomass processes including low energy consumption, simple operability and good capacity to withstand shock loading.

“Archimede Rotors” represent advancement in the state of the art in comparison with existing equipment for several reasons as described below.

Even if the main application of RBCs is for aerobic processes, the B4B project adopts a fixed film for producing Biogas through anaerobic process.

The two-Phase anaerobic digestion has the advantage to create a microenvironment existing between the medium and the liquor, determining the activity and functionality of a fixed biomass system.

RBCs “Archimede Rotors” will permit to obtain:

- The largest surface to volume ratio;
- Improved mass transfer through the biofilm;
- Biofilm renewal with proper turbulence;
- Enhanced operative flexibility;
- Reduced energy consumption.

The Archimedes rotor is placed inside a conventional anaerobic digester and rotates on its axis by the effect of air or gas inflated. Its particular structure act as a support for the growth of microorganisms.

The turbulence caused by the movement allows for continuous mixing of the liquid medium, promoting contact and exchange with the biofilm. The available surface for the settlement of the biofilm is 200 m² per m³.

It can process a quantity of volatile solids up to 2 times higher than that of common anaerobic systems because of the largest amount of bacteria and improved stability of the system due to the fixed film. The Archimede Rotor is placed into a pool with a total volume of 35-50 m³.

Literature biogas yields for the algal species studied ranges from 180 ÷ 540 $\frac{l_{CH_4}}{kg_{VS}}$ [7,8,17,29,30, 35,36,37], within this wide range of values was empirically determined the theoretical yield of 270 $\frac{l_{CH_4}}{kg_{VS}}$ assuming [5, 34, 38, 10]:

- Carbon content in the algal tissues: 30% of dry weight;
- Volatile solids removed: 80%;
- % CH₄ in biogas: 60%.

Taking into account the total amount of algae and manure injected into the digester, the amount of biogas produced per year and the average hourly amount of fuel available for the cogeneration engine were estimated.

The calculation assumptions are the following:

- CH₄ yield of algal tissues: 270 $\frac{l_{CH_4}}{kg_{VS}}$;
- Manure yield: 20 m³/ton (50% of raw material yield, since manure is diluted into water) [8,45,20];
- Hourly biogas production referred to an usage of 24 h/day

The following production of biogas can be achieved from the Archimedes Rotor:

TABLE II

BIOGAS PRODUCTION FROM DIFFERENT BIOMASSES IN THE ARCHIMEDE ROTOR

Biomass production	Poultry manure	CH ₄ from algae	CH ₄ from manure	CH ₄ total	Biogas total production	Biogas hourly mean production
ton/yr	ton/yr	m ³ /yr	m ³ /yr	m ³ /yr	m ³ /yr	m ³ /h
729	1203	7281	2406	9687	161461	42

On the basis of data provided by the manufacturers and considering a 1 kW pump working for 8000 h/y it is possible to determine:

- Electricity consumption: 8 MWh/year
- Steel: 1100 kg
- Transport distance: 500 km.

I. Co-generator engine

The biogas cogeneration will convert the energy contained in the biogas into electricity and heat.

The energy conversion occurs through the combustion of biogas in an internal combustion engine, which converts fuel's chemical energy into mechanical work, and then through a generator into electrical power.

Heat losses associated with this process, rather than being dissipated into the environment are collected by a carrier fluid that then heats the stocked fuel oil, thus reducing the workload of the boiler that feeds the plant.

Assuming:

- η_{el} : 30%;
- η_{th} : 60%;
- Biogas Low heating value: 21,6 MJ/m³.
- Biogas consumption: 20 m³/h;

The data on the production of biogas can be used to define the co-generator to be used and its energetic outputs:

- Installed power: 40 kW_{el};
- Hours of operation: 7700 h/year;
- Weight of equipment: 1000 kg;
- Transport distance: 100 km;
- Lubricant oil consumption: 116 kg/year;
- Electric power output: 308 MWh/year (1,11 TJ_{el}/year);
- Thermal energy output: 2,22 TJ_{th}/year;
- CO₂ emissions: 1800 g_{CO2}/m³_{biogas} [9].

V. LCIA LIFE CYCLE IMPACT ASSESSMENT

A. Method used

The characterization of the effects on climate change of any substance has been issued on the basis of the GWP

Global Warming Potential $\frac{\text{equivalent kg}_{CO_2}}{\text{kg}_{\text{substance}}}$

Emissions related to the production phase are summarized in the following table:

TABLE III

ENERGETIC AND ENVIRONMENTAL SIGNIFICANT OUTPUTS FROM CULTIVATION

CO ₂ emissions BioWALK4Biofuels plant (4 years)				
Boiler's exhaust gases released	-	-	248	ton CO ₂
Biogas produced	629.288	m ³	-	-

Heat from cogeneration	8,80	TJ _{th}	680	ton CO ₂
Electric energy from cogeneration	5,13	TJ _{el}	396	ton CO ₂

Each substance in the inventory has been converted, through the factors defined GWP Global Warming Potential in CO₂ equivalent.

All emissions are calculated as summarized in the following table:

While referring to the assembly phase and processes, each of the entries in the previous tables was analyzed with the software SimaPRO obtaining the impacts on GHG emissions for those processes and materials.

TABLE IV

GHG EMISSIONS (IN TERMS OF EQUIVALENT CO₂) OF THE BIOWALK4BIOFUELS PLANT

Material	Amount	U.M.	CO ₂ specific release [g _{co2} /unit]	CO ₂ released (project life = 4 years) [kgCO ₂]	Description
AISI 304 Steel	200,00	kg	3680,66	736,1	Poultry manure treatment
AISI 304 Steel	1100,00	kg	3680,66	4048,7	Archimede Rotot
AISI 304 Steel	320,00	kg	3680,66	1177,8	Fans
AISI 304 Steel	110,00	kg	3680,66	404,9	Pump
AISI 304 Steel	1000,00	kg	3680,66	3680,7	Algae separation grids
HDPE	24550	kg	2515,47	61754,9	Floating dock
HDPE	1200	kg	2515,47	3018,6	Archimede Rotor
EPDM	7400,00	kg	3198,26	23667,2	Ponds
Aluminium	3300,00	kg	6088,66	20092,6	Floating dock
Cogeneration unit	40,00	kW	-	1095,0	Cogenerator
Anaerobic Digestert	50,00	m ³	-	3621,4	Anaerobic digestion plant
Lubricating oil	465,68	kg	105,72	49,2	Cogenerator

Tot. [ton]	123,3
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Processes	Amount	U.M.	CO ₂ specific release [g _{co2} /unit]	CO ₂ released (project life = 4 years) [kgCO ₂]	Description
Transport, railway	10,00	tkm	5,73	0,1	Manure treatment components
Transport, railway	7,00	tkm	5,73	0,0	Pumps
Transport, railway	100,00	tkm	5,73	0,6	Algae separation grids
Transport, railway	2000,00	tkm	5,73	11,5	Archimede Rotor
Transport, sea	10000,00	tkm	2,54	25,4	Ponds
Transport, sea	38000,00	tkm	2,54	96,6	Floating dock
Transport, road	1350,00	tkm	12,52	16,9	Ponds
Transport, road	20,00	tkm	12,52	0,3	Fans
Steel Product treatments	200,00	kg	189,03	37,8	Manure treatment components
Steel Product treatments	320,00	kg	189,03	60,5	Fans
Steel Product treatments	110,00	kg	189,03	20,8	Pumps
Steel Product treatments	1000,00	kg	189,03	189,0	Separation grids
Steel Product treatments	1100,00	kg	189,03	207,9	Archimede Rotor

Tot. [ton]	14,9
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Production processes	Amount	U.M.	CO ₂ specific release [g _{co2} /unit]	CO ₂ released (project life = 4 years) [kgCO ₂]	Description
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Electrical energy, MV	3,00	MWh/year	580,00	6960	Manure treatments
Electrical energy, MV	56,00	MWh/year	580,00	129920	Gases somministration
Electrical energy, MV	28,00	MWh/year	580,00	64960	Water pumping
Electrical energy, MV	16,00	MWh/year	580,00	37120	Algae's separation
Electrical energy, MV	8,00	MWh/year	580,00	18560	Anaerobic Digestion
Transport, van	224000,00	tkm	63,32	14183,0	Poultry manure daily gathering

Tot. [ton]	271,70
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- Electricity: fuel mix representative of mean Italian thermo electrical generation.

Emissions related to this system, equivalent to that under study, are in Table V:

TABLE V

GHG EMISSIONS (IN TERMS OF EQUIVALENT CO₂) FOR THE SCENARIO REPRESENTING PRESENT TECHNOLOGY SATISFYING THE FUNCTIONAL UNIT

CO ₂ emissions (present situation, 4 years)				
Heat produced	8,88	TJ _{th}	700	ton CO ₂

VI. LCI OF THE CURRENT SITUATION

As mentioned earlier, assessment of the results obtained should be made on the basis of comparison with an equivalent system corresponding to the current situation.

In this comparison scenario it is assumed that the services rendered by the system, quantified with the functional unit are met in the conventional way:

- Heat: Diesel "EN 590" burned in conventional industrial furnace;

Electricity produced	4,4	T _{jel}	1059	ton CO ₂
Boiler's exhaust gases	-	-	2045	ton CO ₂

It is possible to compare the GHG emissions of both the analyzed scenarios:

TABLE VI
GHG EMISSIONS FOR THE COMPARED SCENARIOS

GHG emissions [CO ₂ equivalent]		
	ton	ton
BioWALK4Biofuels plant assembly	123	0
Production processes	15	0
Processes' electrical energy needs	272	0
Emissions related to energetic products	1133	1648
Boiler's exhaust gases	248	2045
tot [ton]	1791	3693

The following graph shows the expected reduction of Green House Gases, highlighting the contribution of each class of aspects accounted.

The adoption of the installation of biogas production from algal biomass produced in Augusta will allow, according to this assessment, the production of heat and power with a GHG reduction of 52%, for the same services provided by the plant.

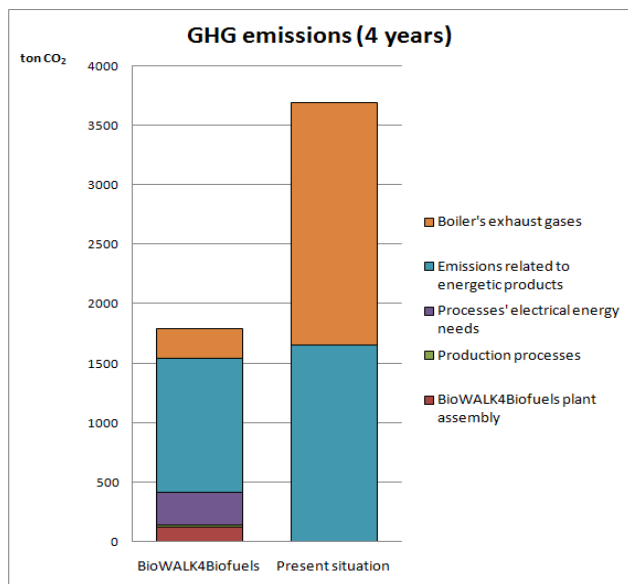


Fig.3. Comparison of GHG emissions for both the analyzed scenarios.

VII. FURTHER STUDIES AND PUBLICATIONS

Sapienza University of Rome is carrying out an LCA study that analyzes in greater detail different methods of cultivation and

use of biogas to produce an LCA study that takes into account the environmental impacts on all the major categories of impact (Human Health, Ecosystem quality, Resources depletion) of different production and utilization of biogas scenarios.

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Andrea Cappelli, Emanuele Gigli, Luca Muzi, Roberto Renda, Silvano Simoni. Transportēšanas un komplektēšanas procesu ietekme uz enerģētiku un vidi biogāzes ražošanas rūpnīcā no jūras mikroalgēm (FP7 projekts BioWALK4Biofuels)

SEG emisijas, citofikācijas un enerģētiskā atkarība ir problēmas, ar kurām ES saskarsies tuvākajā nākotnē. Projekta BioWALK4Biofuels galvenais mērķis ir atrast kopīgu risinājumu šīm problēmām, izmantojot bioloģiska procesa priekšrocības - alģu augšanu un anaerobisku biomasas noārdīšanos.

Šis projekts tiek realizēts, pateicoties Eiropas 7. Ietvarprogrammas finansējumam. Lai novērtētu iegūtos rezultātus, tika izstrādāts pirmais dzīves cikla analīzes (DCA) pētījums, kas balstās uz infrastruktūras un rūpnīcas plānu datiem, kas tika iegūti no ražotājiem. Savukārt alģu augšanas pētījums tika modelēts ar kultivācijas modeļa palīdzību, kas iekļauj dažādu datu un pieņēmumu kopu. Kopā atlasītie faktori izvēlēti, vadoties no būtiskuma principa: parametri, kuri visvairāk ietekmē galveno ražošanas procesu starp visiem procesiem, kas darbojas koģenerācijas stacijā.

Elektrība un siltums, kas tiek saražots koģenerācijā, darbinot to ar biogāzi, kas tiek ražota no alģu biomasas, saskaņā ar pētījumu ir atbildīgs par siltumnīcefekta gāzu (SEG) emisiju samazinājumu par 52% salīdzinājumā ar tradicionālajām tehnoloģijām. Biogāze, kas ir saražota projekta 4 gadu laikā, atļauj aizstāt 85 tonnas naftas ekvivalenta (toe).

Андреа Капелли, Эмануэл Гигли, Лука Муци, Роберто Ренда, Сильвано Симони. Влияние энергетических и экологических факторов на процессы транспортировки и сборки станции производства биогаза из морских водорослей (проект FP7 BioWALK4Biofuels)

Выбросы парниковых газов, заболачивание и энергозависимость – это проблемы, с которыми ЕС столкнётся в ближайшем будущем. Главная цель проекта BioWALK4Biofuels – найти общее решение этих проблем, используя преимущества биологического процесса – рост водорослей и анаэробное разложение биомассы.

Проект осуществляется благодаря финансированию Европейской 7й Рамочной Программы. Для оценки полученных результатов было разработано первое исследование анализа жизненного цикла (АЖЦ), основанное на данных об инфраструктуре и планах завода, полученных от производителей. Исследование роста водорослей было смоделировано с помощью культивационной модели, включающей в себя множество различных данных и предположений. Итоговые факторы были выбраны на основе принципа существенности: параметры, оказывающие наибольшее влияние на главный производственный процесс из всех процессов, происходящих на станции когенерации.

Электричество и тепло, произведенные в процессе когенерации с использованием биогаза, полученного из водорослевой биомассы, по результатам исследования обеспечивают снижение выбросов парниковых газов на 52% по сравнению с традиционными технологиями. Биогаз, произведенный за 4 года проведения проекта, позволит заместить 85 тонн нефтяного эквивалента (toe).