“ A presentation on Biobased economy developments in the EU, and a Laboratory application research in Taiwan on microalgae culture for biofuels production”

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Abstract

Facing limited resources on Earth, sustainable economical development has become a priority in the US and the EU, relying on the advance of their high technologies creativity and efficiency that may transform future generation’s needs and environment. New Biotechnologies looks very promising during the past decades, offering innovative systems and transitional viable options or progress to turn down Carbone emissions and Global warming risks, reduce Wastes excess and bear resources limitations. Many strategies to grow this new Sector Bio- Based knowledge and Economy, using plants or non mineral resources and operate conversion from Biomass into valuable agro-foods, nutraceuticals, industrial chemicals or bio energies forms . This primary resource in terms of entropy could reverse situations and threats against environmental, climatic, social and economical sustainability. This may change the way we live and create new professions and work in long term visions – for arable and livestock farming, forestry, food, aquaculture, chemical industry, materials manufacturing and energy supply. The US, and the EU are becoming leaders in Biotechnologies research and Industrial applications. Taiwan although situated in Asia, is presently world leader for microalgae high technologies cultures and large scale productions. In this vision , is presented a ” study of Bioenergies production from Microalgae culture on wastewater” through sewage treatment (nitrogen, phosphor, organic carbon, GHG, conversion into feedstock biodiesel, co-products, high lipid content and growth microalgae) associated to power plant emissions and production controls that might contribute as most sustainable new alternative for transitional third generation biofuels industrialization against the clean energetic solutions developed in the Western countries. The race of biotechnologies engages closer assessment of side effects, transitional changes or choices that might occur in the longer term: at experimentations phase for target products further during their processing and on effects further down the road on the Environment.

Keywords: **Bioeconomy, microalgae, resources, sustainability, waste water**

Contents :

1) Introduction:

At early stages, EU economical and political development and integration looked for securing energies resources, efficiency policies combined to energy alternatives and energy savings or stabilization. However EU energy chart shows more and more dependency to imported fossil fuels. Further to this consideration has grown the Climate change and greenhouse gas emissions worrying irreversibility and threats to our future generations

Many of the EU Members States have pushed since, for the developments of a Biobased new industrial sector 25 years ago through funding to comply and support EU Energy Targets 2020 and horizon 2050. More recently the term of Bioeconomy or Biobased-Production / Biobased-Know-How has surged out, like a plausible second Industrial Revolution to grow and play a major economical dynamism for the most advanced economies in the West as suggested in the Stern report conclusions on Climate changes evidence and carbon emissions, adopted by UNEP countries to reduce these negative effects. The US and European countries has been suffering of a deep structural and vicious economical crisis during in 2006 and 2008 respectively. Energy and Climate change policies have become a priority in the EU too, during past years, evidences of impact of climate and skeptical debates have focused on emissions level and possible direct impact on the atmosphere, and our environment since IPCC (2007 assessment report). It lead to several actions supported by EU and many of the member countries, bearing legislative modification to reduce and control total Greenhouse Gas (GHG) emissions in the atmosphere. As many of the EU members countries are willing to secure their energy sources and suppliers and establish related policies. Traditional Fossil fuels depletion, are essential in our daily electricity and transport energy supply, but they are coupled to high concentration of CO_2 and CH_4 emissions and the past decades, popularity have grown for pushing to invest into new less polluting systems, able to offer high energy efficiency, with competitive prices for the future, and increase security to reduce high Energy bill costs and eradicate negative impacts on social and economical development. Renewable energies would guaranty more sustainability to our Environment and future generations on Earth. Many states support alternative energies and measure new opportunities that high tech in advanced biotechnologies fields can create with the Second industrial Revolution of Humanity, creating new jobs and stimulate investing countries future GDP growth. This goes at same time with drastic economy of energy plans to liberate these countries on their imported energy dependency and moderate substantially total energetic needs and increase total efficiency with recycling and boost for biowaste processing. In particular, sectors such as escalating transport and heating needs, becoming the more importance; representing 40% of total energy consumption, which goes to heating and lighting of households or to supply Industries electrical demand. Beyond these actions, EU boosting research to convert transport fossil fuels demand into more sustainable: forms, so called, clean Biobased Energy versus aircrafts and sea vessels exponential growth effects.

Therefore this study proposes to assess the progress of Bioeconomy in the EU for transitional period and for advance technologies use, as well as a review of renewable resources productions that mean to replace fossil fuels by-products, and assess their possible limitation and depletion in the short term. In other fields, particularly in the chemical industries, priority was given to develop viable and more sustainable alternatives, with use of bio-originated genes, to produce new molecules easier to degrade, or use bioprocesses in wastes streams for value-added products synthesis, which biological compounds to show on labels and communication will appear safer, healthier or less worrying to consumers.

2) Progress of Bioeconomy in the EU

EU Energy mix is the sum of all members' energy mixes reflecting more of less each country's dependency to energy supply. Most generally demand of electricity is largest for powering buildings, industries; such as energy generating industries themselves, or heavy industries. Residential appliances or transport are most worrying due to depletion of less expensive energy cost: such as Fossil fuels. Volatility of the price reveals the urgency of other alternative energies availability. The UK altho9ugh they can beneficiate of some domestic extraction, ahead of other 15 EU Governments common framework has been preparing the future in consideration of Carbon emissions and energy supply, their impacts costs and challenges to sustain economical growth, and the need for creating much more job opportunities during present economical crisis period and in the longer term. The belief in new high technologies such as renewable wind energy, transmission of knowledge and skills to smaller enterprises for the building of local nuclear power plants across the country, justify heavy investments in Research, Development, Innovation or Deployment technologies infrastructure which they already nurture. The resulting choices for energy and future economical evolution, although uncertainty on Electricity market Reform (how it can operates in the reality and electricity price future liberalization, as well, the Green Deal taxations rates and terms for household to bear not clear), UK Government has confidence in monitoring successfully transitional period for its electricity market reform, grids and funding or actions plan with complementary policies and laws to step into nationwide compliances, combined to energy waste elimination, raise of efficiency in largest supply sectors and consumers awareness. Other countries such as Germany, Netherland, France, Sweden, Denmark, Spain have poured important budget shares into funds for further clean energies research , cooperation and industrial applications such as wind or solar,… Present energies researches and demonstrating field's production or roofs installment, that IEA charts shows can illustrate the past decade developments trend and efforts, during this period.

3) Common Regulations and targets

EU Governments under common framework has been preparing the future in consideration of polluting gas, energy supply, impacts costs and challenges to sustain economical growth, create job opportunities during present economical crisis period and in the longer term (presently above 3 trillion euro).
Parliament ensure an integrated, coherent, cross-sectoral and interdisciplinary approach to bioeconomy, and calls for the harmonisation of the different EU policies involved and the related guiding principles – such as the precautionary principle – in the various sectors (the Resource Efficiency roadmap; the Innovation Union; the Raw Materials Initiative; Horizon 2020; the Environment Action Programme 2020; the Cohesion, Common Agricultural and Common Fisheries policies; the Renewable Energies, Water Framework, Waste Framework and Packaging directives; and specific measures on biowaste); and it considers it necessary, as well, to establish a uniform, long-term, stable, regulatory environment, both at EU-level and nationally, aiming at promoting and increasing investments for the bioeconomy in Europe;
EU proposed Europe 2020 strategy, including a framework through to achieve a series of goals : economic, social and environment by 2020. Growth of bio-based production will open pathways towards the use of renewable with greenhouse gas emissions. The conducted production and adopted processes to make water and energy economy and generate less waste that industry occurring with present

means and system. The biomass resources to supply the new bioindustries cannot be for food purpose. This will ensure Food prices and supply stability, while the non-food crops and will constitute a complement income for farmers,that will be able to supply the feedstocks with reasonable and competitive price costs for energy or chemical industries purposes and help to stimulate rural development and create new jobs with renewable energies and resources from the biomass. The new bio-based products and emissions cut potential is estimated at 2.5billion tons of CO2 equivalent per year (report of WWF). This contribution to Climate Change may justify financial investments from the EU member states, and full support of the European Commission

It goes along with land management in the perspective of larger surface dedicated to energy crops and increase agricultural waste efficiency (lignocellulosic : Agricultural crop waste, forestry and raw material waste) as well as industrial products without pressure on food cultures in respect of the Common Agricultural policy and environment sustainability.

Therefore this programme EUR 4.5 billion budget proposed by the Commission to involve wide research cooperation ERA-nets for industrial biotechnologies intraEurope and international exchanges through National funds partnerships (Public laboratories and private industries partnerships) and grants of research for all sized industries particularly for smaller or medium sized enterprises, to develop multidisciplinary and cross-sectoral information and training programmes and establish findings of research to be made accessible to stakeholders, including consumers, creating opportunities to increase awareness and involvement.and use Regional and Structural Funds and European Investment Bank risk sharing facilities for pre-commercialization stage requirements and stimulate SME’s. The inter-fields know-how laboratory cooperation and help to coordinate and boost research experimental schemes, scale-up experimentation funds to build up Pilot plant and achieve all assessments before technological final stage of production and refine industrial processes and their effects and return on investments costs.

EU Biobased economy to rely on a legislative and regulatory framework to develop a high-value, coherent policies for structuring a fast growing new sector capable of generating more jobs than in the past, in service sector, industries and rural area as well with new skills, new knowledge and new disciplines Impact on the Environment are increased and need to strain on global agreements such as the Convention of Biological Diversity (CBD) and the UN Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (REDD); and strengthen land governance systems developing countries, forest production under the Forest Law Enforcement, Governance and Trade

(FLEGT) Action Plan;. Finally EU Council will implement long term initiative for the European Economic growth and demonstrate the need for inclusive green economy at international level;

4) Evolutions in other part of the World and interests for Taiwan

A decade ago, US NREL reported non vialbility and new views on microalgal possible contribution in renewable energies supply and stopped large investment of credit for researchers in this field. The past two decades and evidences of climate changes in Stern report, has brought to International consciousness of the important impact of the fossil fuels emissions and negative evolution on global Environment. The conferences and recommendations encouraging advanced high tech countries to work for the future and invest in Clean and renewable Energy technologies. The steps taken will help the US and main EU members to develop idealistic or proper energies for the future.
Classification in 4 generations steps give a roadmap, to go.

IEA proposed charts and that follow each country energy mix and resources or needs, to adopt regulations and prepare financing conditions and targets for the new era.

At the beginning of the age, was heavily charged in dioxide Carbone and azotes, the atmospheric gas content has evolved considerably with the time resulting of long periods of marine varietal algae photosynthetic activities. Microalgae mainly, acted as Carbon sink and inexorably contributed to reduce of Carbon dioxide on Earth to present atmospheric composition. Although the metabolism of these unicellular processes are need to be more explored Then these “photocells“, offer fast growth fixing atmospheric Carbone and able to produce long chains of hydrocarbure and byproducts which characteristics offers broad potentials applications. They constitute a bios stem transforming wastes liberating oxygen and energetic biomass. The cell activity has been studied and assimilated to a refinery~ so called Biorefineries Studies has been brought in many countries, and seems costless in tropical countries in open ponds, although submitted to higher risks than bioreactors, with a minimum land surface occupation, continuous production around the year and able to recycle wastewater, an idealistic solution for our economical developments impact, depleting resources and plethoric wastes or greenhouse gas emissions in the air.

- Taiwan’s microalgal productions, research development and directions.

Considering above characteristics, the geographical location of Taiwan, the promotion of microalgal production capacities and high technological developments for new renewable energies strategy could be viable. As Taiwan is the World leader for open ponds cultivated microalgae and nutriments extracts from microalgal origin. If experimental results can be conducted at larger scale and show proof of environment and economic criteria microalgae could be an alternative for the depleting fossil energy system. This has been the same strategy for many HighTech-developed countries, that combined efforts through exchange and complementary cooperation which could optimize the results, if can manage to break through some of the present research bottlenecks and bring about the best solution for a sustainable environment.

However progress and researches made all over the world, there are very few publications on life cycle assessment for industrial microalgal biodiesel production and the energy balance compared to other clean or renewable energies has yet to be established for the involved technologies. A complete assessment on the environmental impacts is not available yet, such as analysis of the possible resulting N_2O emissions from large scale microalgal biodiesel production for example. Assessments as such can help to judge what proportion of the depleting fossil fuels should be replaced by biofuels (Lardon, 2009; Kelly et al, 2011). Biofuels trade may induce similar problems encountered by the conventional, intensive agricultural productions, with distorting price supports or aids, severe competition and risks such as surplus in storage production and price destabilization that would affect the investments and efforts of each producing country. Asian countries, in particular, would gain from developing local biofuels production, but they would also be the first to be hit if international biofuels prices become destabilized.

There are more than 30,000 species of macro and microalgae on Earth; there might be 1,000 in the oceans of Taiwan. Only a few of these species and their strains have been studied as not all bear the targeted capabilities for oil and other valuable productions. It means that there is not one unique super strain capable of producing the lipids for biodiesel and at the same time possessing other qualities such as high value by-products. At this moment different strains are cultured for their valuable abstractions; research needs to enhance the understanding of the biology, biosynthesis parameters and genetic to optimize the present productions; and the modification of genome to result in new metabolites equilibrium and will require experiments to understand the possible impacts under scale up

productions.
Moreover, the best environment for microalgal growth kinetic needs to be identified and optimized as well as water recycling and harvesting processes.

A study of heterogenic culture as an example of Taiwan research potential allow to make some assessment on the laboratory scale research that may lead to pilot and larger scales production, and measure at same time the implications and impact on environment of energy focused large scale production.:

For the labortatory studies and results refer to attached poster (see annex 1 document) and studies detail (annex 2 document)

5) Conclusions:

The determination of the Western research directions and importance of Bioeconomy on our future can show the speed of evolution during this period of time. Climate Change and Green house gas emissions as well as the decisions of UNEP do accelerate the research and investments for the sake of future economy, High Tech Energies and Resources management

The present first transitional period will allow European Union researches in term of bioenergies and Bioeconomy to mostly rely on cellulosic or agricultural wastes for the progress obtained in microalgal production cannot offer low costs production. At the difference of the EU territories, more tropical climate countries as in the example given for a performing Taiwan laboratory where yield results are remarkable good , and while large scale production know-how is currently available. The costs of production are much lower too due the practice of culture under very strict conditions in open ponds and not in much costful means such as bioreactor

Challenges and bottlenecks met to upscale experimental results, Phenomena as well as the assessment of production for life cycle structure would require to be completed with and assessment on the environment such as the illuminating paper of Annick Hedlund-de Witt using the Integrative Worldview Framework (IWF)to analyze Bioeconomy perceptions and risks. This framework helps to give a larger perspective to the assessment and sustainability of the emerging biotechnologies potential and possible disequilibrium impacts on resource management introducing societal debate to the industrial or economical viability analysis. From her paper can discover different axis on different views and possible impact of biotechnologies solutions, and substitution in our evoluting systems on which we could only retain the modern and post modern worldviews to conclude on their sustainability.

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Annex 1 : doc to resume Taiwan laboratory experimentation focus and performent results

(1) A study on the growth characteristics of microalgae cultivated in the synthesized domestic wastewater

Taiwan has been actively implementing the national sewage-based system, centralized sewage, reducing the amount of sewage discharged to rivers. It is the same way to cultivation of microalgae and sewage treatment system to provide a suitable environment and adequate nutrition source of biological purification mode of operation. It is replaced by cultivating microalgae to deal with sewage treatment, and it is not only improved the traditional sludge processing issue, producing algae can also made biofuel, feed and also other environmental and economical benefits.

In this study, microalgae (Chlorella sp.) cultivated in synthesized domestic wastewater as the matrix, in a batch culture, culture environment is fixed at 25 ℃, light intensity was 90 μmol・m-2・s-1, photoperiod L：D=12：12 (h), ventilation air flow rate is fixed at 1 L・min-1. It is to explore Chlorella sp. cultivated in synthesized domestic wastewater growth characteristics and growth factors. And use the concept of controlling activated sludge process — food：microorganism ratio(F/M) in order to explore the ratio of synthesized domestic

wastewater and biomass of Chlorella sp. (F/M=TOC/ Biomass) range.
The results showed that, the pH was relatively stable while using urea as the only nitrogen source to culture Chlorella sp.. Environment fix at pH 7.5 compared to pH 4 and pH 6 is good for the Chlorella sp. growth. And it is more efficient to removal nutrition. The F/M =0.05 and F/M= 4 are reached the limit, because lower or higher are not suitable for Chlorella sp. the F/M range of 0.5~2 cultivated in the synthesized domestic wastewater is more suitable. In this research, The main was to remove nutrition and the supplement by algae production. The best result was F/M=0.5,and the removal efficiency of carbon and nitrogen were 528.44 TOC mg / g-algae and 64.98 NH4-N mg/g-algae respectively, Algae production mainly supply by removing nutrition, the best result is F/M=1, the specific growth rate of 1.52d-1, and the removal efficiency of carbon and nitrogen is 398.0 TOC mg/g-algae and 47.17 NH4-N mg/g-algae respectively.

2) A study on the optimum operation parameters and growth characteristics of Chlorella sp. in the high concentrations nitrogen wastewater treatment
The high concentration nitrogen wastewater supplies microalgae with enough nutrient and suitable environment when using the microalgae treated the wastewater. The microalgae is provided with the characteristics of reproduce rapidly and quick adaptation, which have high efficiency to treat high carbon and high nitrogen concentration of wastewater. The microalgae would be a new clean energy source in this energy crisis days.
In order to find the optimum parameters of Chlorella sp. to treated wastewater, the aim of this study is to treat the high concentration of nitrate-based wastewater and observe the growth characteristics of Chlorella sp. The results indicated that the efficiency of the treatment is limited. The concentration of the nitrate nitrogen was decreased form 38 mg/L to 28 mg/L during treated time of 72 h. The removal efficiency only has 27%. But that would get the best removal efficiency and growth characteristics when the glucose was added as the carbon source. Furthermore, the removal efficiency of the nitrate nitrogen will up to 80% when the reaction obtained enough phosphorous and the reaction time was within 20 h. At this condition, the study could gain the highest specific growth rate 1.93 day-1 during 16-20 hours. Therefore, the carbon source is the main impact factor for treating the high concentration nitrate-based wastewater.

(2) Study of the Studies of Nutrients Uptake and Lipid Production by Immobilized Chlorella sp.

Microalgae are useful material to treat wastewater. Nitrogen and phosphorus of the wastewater are the necessary elements of microalgae growth. Microalgae could quickly purify wastewater and also could generate a large amount of biomass. Microalgae are great producer for fuel because it has higher photosynthetic efficiency and growth rate than other energy crops. However, a big problem for using microalgae to treat the waste water is separation of the microalgae and liquid. Immobilization of microalgae is one of the solution methods for this problem.

For finding out the optimum parameters of microalgae growth and nutrient removal, this study used the different C/N ratios of photosynthetic heterotrophic culture as basis to understand the mechanism of the microalgae growth. And then the optimum parameters of the C/N ratios and the different F/M ratios of the immobilized particle number and particle size were used to find the optimum growth parameters of the immobilized culture.

The experimental results show that the highest specific grower rate is 2.44 1/day in different C/N ratios in photosynthetic heterotrophic culture when the C/N ratio is 10. And the highest removed rate of N and C were 16.71 mg/g•hr and 86.99 mg/g•hr, respectively. Furthermore, in immobilized culture, the more of particle number and the less of the F/M ratio did not improve the Chlorella sp. growth and nutrient removal. In addition, the particle without coated with any microalgae, the remove effect of the nutrients is good. Nitrate nitrogen and total organic carbon were removed 141 mg/L and 684 mg/L, which indicated that the blank experiment could absorb that nutrient. Therefore, in this study, when the F/M ratio is 0.2 and particle number is 6:1(v/v), the highest removed quantity of nitrate and total organic carbon were 141 mg/g•hr and 684 mg/g•hr, respectively.

Summary and Conclusions for Taiwan microalgal heterotrophic culture resumed in the poster attached.

Annex 2 : Poster document
exhibited by BioCongress Philadelphia (USA May 2014)
(attached pdf file)