CONFERENCE ON AVIATION AND ALTERNATIVE FUELS

Rio de Janeiro, Brazil, 16 to 18 November 2009

Agenda Item 4: Production and infrastructure

THE EXISTING AND EMERGING RISKS REGARDING THE SCALE-UP, THE RENEWABLE ENERGY SOURCES AVAILABILITY, THE LOGISTICS AND THE CO2 SOURCING AS MAIN CONSTRAINT ISSUE[1].

(Presented by Brazil)

1. INTRODUCTION

1.1 This plan bio feedstock are autotrophic photosynthetic marine Microalgae, Bacteria and Cyanobacteria which may be used in bio based synthetic fuel processes and as pure vegetable oil (PVO), an alternative to heavy fuel oil for Marine Propulsion Engines (in accordance to Annex VI of the MARPOL 73/78). On August 4th, 2009 ASTM International Committee on Petroleum Products and Lubricants passed an indirect conversion synthetic fuel standard, D7566,"Aviation Turbine Fuel Containing Synthesized Hydrocarbons", which will allow fuels containing synthetic hydrocarbons derived from nonpetroleum sources to be used in aviation. ASTM is taking into consideration certifying a direct conversion standard, the Hydrotreated Renewable Jet (HRJ) fuel probably next year, and Boeing is focusing on accelerating the viability of low-temperature hydrocracking process and advances in hydrotreatment catalysis. In other words, the conversion technologies are technically feasible even though there are uncertainties concerning the feedstock commercial production.

2. FEEDSTOCK PRODUCTION: SCOPE AND METHODOLOGY

2.1 The first step is outlining the research priorities required to achieving the targets given the current state of algal development, the prototype purpose and future commercial projected dimension. The aimed experimental results shall prove that certain microorganisms cultivated under those conditions are able: to acclimate to irradiance values as high as about 2000 µmol m-2 s-1; to prove a biomass concentration ranging between 1.2 to 2.2 g L–1, which results in a net productivity of about 0.5 g L–1 d–1 corresponding to a biomass yield of 32.5 g m–2 d–1 (based on the large-scale surface area of the cultivation system); to produce substantial amounts (e.g. 35% dry cell weight) of triacylglyceride (TAG) accumulation under photo-oxidative stress, nutrient limitation, high pH and cell cycle inhibition or other adverse environmental conditions. All raceways shall employ proprietary patented technology.

---

[1] The ideas and propositions expressed in this paper are the result of ongoing research by Coppe – Alberto Luiz Coimbra Institute – Graduate School and Research in Engineering. The information presented in this paper is subject to change pending the final results.

2.2 The P-I projected yield at 32,5 gr/m²/day/35% lipids results in an oil production rate from the raceway system of 11.37 gm−2 d−1 , or 39.82 toe ha−1 yr−1. The prototype projected size is a nominal (not considering down timing) 10,000 tons of oil equivalent (toe) lipids production in a State-of-the-art facility occupying a 251 ha raceway area. Assuming 100% extraction efficiency, this is equivalent to 68.400 barrels of oil equivalent (boe) a year, or 2,863,771 gallons or 10.839.374 litters for extracted oil only. The dry biomass is projected to be 14,78 gm−2 d−1 or 53,97 tons ha-1 yr-1 which, at an energy content of 20 GJ/tone, is equivalent to 1079 GJ ha−1 yr−1 which is equivalent to 6.130 toe yr-1 or 1,761,319 gallons yr-1 or 6,666,591 litters. In other words, assuming 73 downtime days, the expected total production (including lipids and biomass equivalent) is 55,905 litters ha-1 yr-1 or 14,770 gallons ha-1 yr-1 or 5,977 gallons acre-1 yr-1. The prototype I (a time frame of 12 months may be required to the construction period, between 2010/2011) shall produce an estimated 3,707,295 gallons of oil equivalent a year by 2011-2012. The water needs are over 6.000.000m3 to fill-up and to complete after evaporation and percolation. Circa 50.000 ton of CO2 will be needed, and shall be nearby available, as well as the nutrients demand and the work force requests shall be evaluated.

2.3 The data from international experiences and the P-I completion shall validate the commercial feasibility and identify the risks associated to large-scale feedstock production and bio-fuel conversion. A scale-up to 251.000 ha, on a par with 5.020.000 raceways shall be considered. The water needs would reach 6 billion m3 plus (due to evaporation and percolation), and the CO2 needs would be circa 50 million ton yr-1, which can be viable in the region at little or no cost. The output can reach 3,7 billion gallons of oil equivalent a year by 2020 (equals almost to 20% US, 4 times Brazilian or all American Airlines consumption in 2005), corresponding to 242.000 barrels a day/365 days. It is possibly workable a 1 barrel ha-1 day-1. As a comparison, Sapphire Energy predicts 1.4 billion as possible world production approximately in 2020. The output would increase dramatically when and proviso achieving a possible target near or @ 50 gr/m²/day/50% lipids.

2.4 Microalgae's key attribute (beneficial reuse of CO2) must be fully exploited. If the facility intends to produce fuel, it may not be workable its implementation at the CO2 point source emitters where no NEG or sustainability would be attained concerning the logistics, the water stress, the energy demand, et cetera.

The scale-up to other target levels is reliant on the availability of all inputs included renewable energy sources. The CO2 sourcing may become the main constraint issue, although it shall be affordably imported from Europe and USA due to the proximity to Maranhao. Potentially, raceways occupying 753.000 ha could be located in the area, and @ 32,5 gr/m²/day/35% lipids, at least 12 billion gallon could be feasible to produce.

2.5 **There are existing and emerging risks regarding to:** The algal production is in the early stages, the complete process has not yet been sufficiently being developed at an industrial level and as result it may become difficult to implement such large scale production facilities, as never before has been through; The required new infrastructure build-up shall cope with time delays as the technical, economic, environmental and policy issues may also holdup the completion; The likely NEG may be partially achieved since the knowledge shall be acquired; There are multiple sector interdependencies that shall be difficult to address as a number of technological fields have to be developed, so as to achieving the mass production of microalgae as precursors of biomass and oil; Although they are technically feasible, Brazilian national institutions catalysis groups shall develop proprietary conversion technologies and it's worth noting that although HRJ technology has significant advantages over BTL concerning capital costs and energy efficiency, both must be simultaneous addressed since the former employs vegetable oil as bio fuel originator and the latter uses algae dry biomass as bio fuel precursor depending on the F-T process.

2.6 The logistics role is extremely important regarding the NEG and sustainability and is addressed in Agenda Item 1: Environmental sustainability and interdependencies.

2.7 The non-refundable bio fuel technology development and scale-up grants are essential to expand the production regarding the high risk involved; the long-term biding contracts are due to assure and prioritize bio jet fuel offer instead of developing the feedstock as precursor to other bio fuel to be used by diverse transportation systems, such as PVO. This is tackled in Agenda Item 3: Measures to support development and use, at the same time as WHY BRAZIL? THE BIO POTENTIAL, THE TECHNOLOGIES & THE EXPERIENCE.

3. ALFA CONSORTIUM & COPE-UFRJ

3.1 The technology aggregator and main institution will be COPPE-UFRJ, leading other Brazilian and International bodies in a consortium (alfa consortium). These institutions shall be invited or already have been, such as INT (National Institute of Technology), IME (Military Engineering Institute), ITA (Aeronautics Technology Institute). Alfa consortium shall provide the R&D and implementation strategies, microalgae bio-prospection/development, raceways proprietary technologies, conversion technologies development, knowledge management and coordination; The Brazilian Army Command's Trompowsky Foundation may be responsible to implement the P-I engineering work and logistics; The States of Maranhao and Piaui shall be part of the project (Piaui's Environmental Department is already working). The roles and responsibilities as well as a timeline of actions shall eventually be identified.

3.2 Coppe and Centroclima proposed in September 2008 to establish the Brazilian National Institute of Microalgae Technology as a Source of Renewable Energy-IMA (Tender No. 15/2008 - MCT / CNPq / FNDCT / CAPES / FAPEMIG / FAPERJ /). It aims to develop new strategies and products to mitigate the GHGs emission, included the semi-arid region development in partnership with the PAN-Brazil - National Action Program of the Combating Desertification and Mitigating the Effects of Drought (MMA), the INT (National Institute of Technology - MCT), with several laboratories and / or departments of UFRJ, UERJ, UFMA, UFPI, FURG,UNESP, FIPERJ, and researchers from other institutions, such as IME, ITA, UCB, UnB, UFBA, UNICAMP, Agro Embrapa, Embrapa Genetic Resources, IOC-FIOCRUZ, MIT, Harvard Medical School, etc. The General Coordinator was Emilio Lebre La Rovere and Executive Coordinator M. Azevedo. The advisory board suggested was Ignacy Sachs (Ecole des Hautes Etudes en Science Sociales ") and Jean Charles Hourcade (CIRED - Centre International de Recherche sur l'Environnement et le Développement).

3.3 **Coppe – Instituto Alberto Luiz Coimbra de Pós-graduação e Pesquisa de Engenharia** - Over four decades, Coppe has become the largest education and engineering research center in Latin America. It has 12 programs for post-graduate programs (MSc and PhD), has trained more than 11,500 teachers and doctors and now has 320 professors in exclusive dedication, 2,600 students and 350 employees, among researchers and technical and administrative staff. To meet the demands of its growing scientific research projects development it has 116 modern laboratories, which makes up the Brazilian largest engineering complex.

— END —