

Algae vs. Energy: an analysis of their potentials and limits

A work conducted by Algogroup

Dr. Xavier Montagne



Agenda

- Context
- Algogroup: objectives
- Algogroup: structure
- Algogroup: deliverables



Algo group: Objectives

- A strong interest has been focused on the algae pathway, considering it as high potential alternative strategy for energy production
- Large hurdles have been identified: energetic yields, economic and environmental positioning
- Need to combine the broader knowledge to elaborate answers to the existing questions

=> large vision sharing between the major French algae "players"



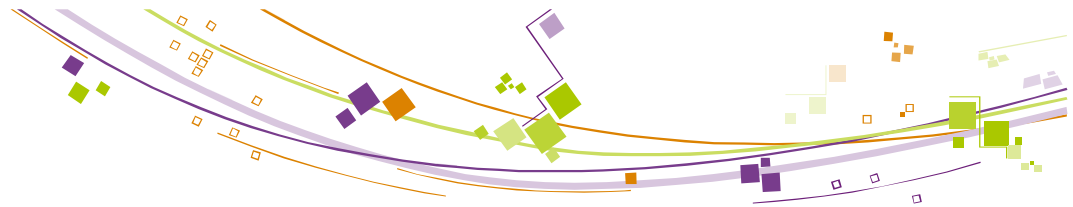
Algo group: structure (1/2)

- Core group: Airbus, EADS-IW, CEVA, IFPEN, IFREMER, INRA, Safran, Sofiprotéol,
led by IFPEN
- Start Point : April 2010 (first meeting : June 2010)
- Conclusion point : 2012
- Contributors: DGEC, CEA, GEPEA, INRIA, PSA, Total, GDF-Suez, Rhodia, Lafarge, "pôles de compétitivité",
.....



Algogroup: structure (2/2)

- Algogroup is an information sharing group which analysed existing data and knowledge coming from Algogroup members / contributors and from the literature (no specific experiments)
- Worked on 5 specific axes
 - 1) Design of a road map leading to the production of biojet, according to product profile requirements determined by the aeronautic industry (Airbus)
 - 2) 4 taskforces dedicated to the
 - µalgae technological hurdles (led by IFREMER)
 - µalgae environmental hurdles (led by IFPEN)
 - µalgae economical hurdles (led by EADS-IW)
 - macro-algae pathways (led by IFPEN)



Algogroup: deliverables

Action	Deliverables
Road map proposal for biojet	Done (not published)
TF 1	Specific report
TF 2	Specific report
TF 3	Specific report
TF 4	Specific report
Global report	Public report



Technological hurdles taskforce (1/2)

1 Biology

- Selection of organisms, according to requirement
- Selection of species variants, including genomes and mutation changes considerations
- Genetically Modified Organisms (GMOs)
- Phototrophic / heterotrophic / mixotrophic behaviour
- Predators' control
- Risk for pathologies
- Self spreading risk
- Attention to co-products
- Industrial property

2.1 Water

- Water supply
- Needs for a water complement of open systems
- Water recirculation
- Used water retreatment

2.2 Substrates and nutrients

- CO₂ supply
- Nutriments (supply and costs optimisation)
- Energetic balance



Technological hurdles taskforce (2/2)

3 Bioreactor and process

- Selection / design of PBR (light, shacking....)
- New materials development/needed
- CO₂ transfer and O₂ elimination
- Mixing optimisation
- Control and regulation of physico-chemical constraints
- Setting of the production parameters (timings...)
- Process automatisation
- Modeling of the whole process

4 Bio refinery

- Algae biomass concentrating
- Extraction
- Post-treatments
- Global process

5. LCA

Transversal approach



Technological hurdles taskforce

Recommendations

Research orientation towards fully integrated options

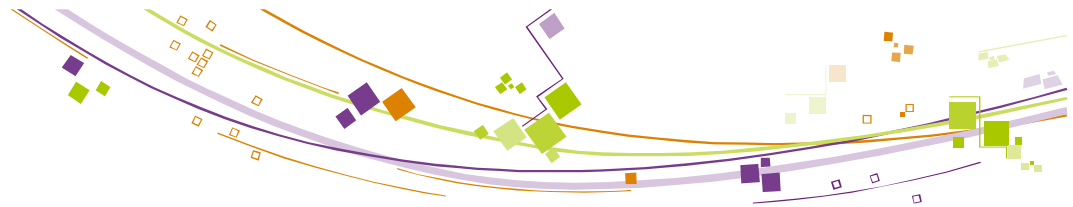
..... and develop controlled research

Quantify the true biomass production

Which tool to work on industrial scale up production?

Need for tools to enable reliable economical assessment

Need for a better identification and potential analysis of co-products



Environmental hurdles taskforce (1/3)

A large scope of data but how should these values be interpreted ?

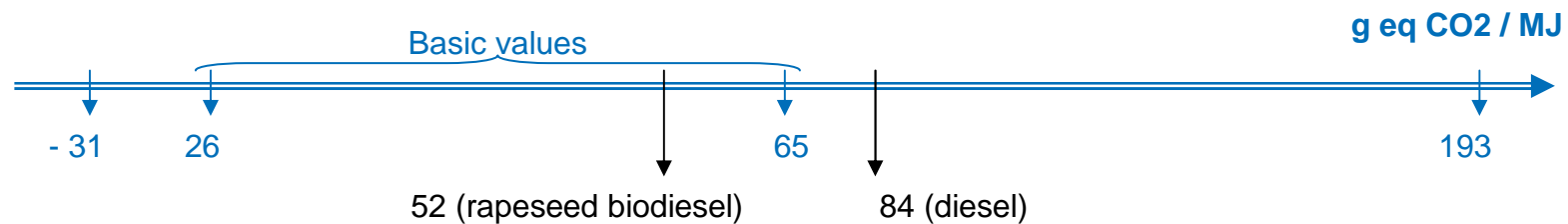
■ Energetic balance

- Apparently not in favour of these pathways, but literature shows wide variation ranges, which could leave room for very significant improvements:



■ Greenhouse gas balance

- The average is about in the same range of G1 pathway : to work to be better than G1





Environmental hurdles taskforce (2/3)

■ Mitigated environmental balance

- It is a new topic and results are not homogeneous, results are not complete (assessments centred on energy and greenhouse gas emissions), not done at industrial production scale
- Wide variations between studies: considered scenarios, calculation methods, basic data, etc.
- Thus, need to go more in depth for LCA studies
- What should be considered currently as a relevant environmental balance? Or energy balance? What is really the greenhouse gas balance for these options? Results are showing very wide variation ranges
- Algae growing and harvesting / oil extraction are major steps with very strong impact on assessments (/ transformation, distribution and fuel use)



Environmental hurdles taskforce (3/3)

- **No societal balance available**
 - No study on the societal impact of the pathway is available
 - One point to be mentioned: the algae fuel pathways are different from the biofuel pathways G1 / G2:
they do not share the issues linked with the competitive use of agricultural areas, usually exploited for food production (even if open ponds may need large areas, and some questions on the choice of production sites have to be considered)
- **Current status**
 - Energy balance rather unfavourable
 - Greenhouse gas balance rather favourable in comparison with reference fossil energy and G1 options
 - but RED 2008 Guideline: - 60 % greenhouse gas emission required over reference / fossil in 2018



Economical hurdles taskforce (1/2)

- The economic viability depends on co-products attributable values: the business model has to include these benefits into the model
- The ex µalgae biofuel cost is 10 times higher than the cost of biodiesel G1
- Opportunities for improvement:
 - Increase yield up to x 10 at same cost: very improbable, or unrealistic
 - Reduce the production cost: could be an option thanks to
 - genetic selection,
 - co-products optimisation,
 - Process improvement



Economical hurdles taskforce(2/2)

- Identification of new outlets to reach economic equilibrium
 - animal food
 - green chemistry, building blocks
- But the impact of a massive supply of these new products on current equilibriums has to be considered when estimating values



Macro-algae taskforce (1/2)

- The macro-algae option could be a strong opportunity to answer to the request of biojetfuel. There are significant bolts to open, specially around the pathway structure and around the estimation of the volume this resource could really represent once developed
- The final costs to produce fuels still have to be determined
- Technical difficulties could be solved
- The environmental balance still has to be determined
- The analysis of the value chain has to be better determined and the players needed to develop the pathway



Macro-algae taskforce (2/2)

- Environmental assessment:
 - Wait for the results of the projects Winseafuel (2011) and IDEALG (2014 - 2021) for the resource quantification
 - LCA to be done on entire chain (specially towards kerosene)
- Technological survey to continue
- Feasibility:
 - Evidence in favour of the concept to obtain in Lab (products: sugars? kerosene?)
 - The resource is already available
- Too early for a pre-industrial test* on the entire pathway:
 - Need to determine the path towards kerosene production
 - Need to reach the target costs during harvesting

****pre-industrial test = 1/10 of industrial scale***



Balance and perspectives

- **Algogroup: what are the options to propose program / action orientations to move towards industrial pathways**
 - Economical balance is largely influenced by the co-products production: fuel production limited by the co-product outlet
 - No true leveraging option has really emerged and starting soon some pre-industrial scale-up seems premature
 - Significant work still has to be done in Labs before starting to scale up for pre-industrial development

Algogroup has been a very promising structure to share and to help to structure the algae pathway



Algogroup: current status

- A full set of analysis and recommendations have been produced
 - Notes and reports :
 - Technical notes of each taskforce
 - Reports of each taskforce driving committee
 - Technical presentations
 - A complete report has been published
 - A scientific paper will be published in OGST journal this summer

Algogroup works are now included in GP1 of ANCRE