Algae-based Biofuels:

Challenges and opportunities for developing countries

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Early assumptions

- “Energy security”, rapid transition to renewables
- Climate change and environmental benefits (greenhouse gases, less competition land, inputs)
- Biofuel cost structures that are competitive with fossil fuels
- Biofuel blending targets, mandates and support in EU, Usa will drive markets

Developments during 2007-2008

- Biofuels have modest impact on energy security, fossil fuels will continue to dominate energy consumption
- Varied benefits for greenhouse gas reductions depending on feedstock
- Impacts on agriculture and land use
  - food prices and food security
  - natural resources – land, water, biodiversity
  - expanded production, income (longer term)
- 2009: A return to reality?

Looking forward ...

- Higher food prices likely to be sustained (biofuel impact on food prices – ca. ~20%)
- Bioenergy offers significant opportunities to some developing countries
- Land use change will pose greater challenges but careful management can lead to benefits in agriculture sector
- Technology will play a significant role over the medium-term; shorter-term investors need to consider risks

FAO views on sustainable biofuel development

- Protect the poor and food insecure
  - assess bioenergy potentials in light of food security risks – tenure, access
- Ensure environmental sustainability
  - good practices for soil, land, water, biodiversity
- Invest in rural development and innovative production
  - 2nd-generation technologies, adapted crops, processing infrastructure, algae-based biofuels
- Adjust current biofuel policies
  - reduce distortions and trade barriers in Ec, Usa, support frameworks
- Coordinate domestic bioenergy policies/strategy
  - international forums - agriculture, environment, trade, energy

FAO and algae-based biofuels

- FAO Inter-Departmental Working Group on Bioenergy reviewed the state-of-knowledge on algae-based biofuels to assess relevance and potential applications in developing countries
- FAO review paper on algae-based biofuels: challenges and opportunities for developing countries - finalized in May 2009

Outcomes and challenges

- ABB hold promise for developing countries ... but probably not in short- or medium-term
  - a new industry, potential to generate jobs and income, contributor to diversified energy mix
  - developing countries are often situated in regions suitable for algae cultivation (solar, low labour costs, availability of suitable land esp. arid zones)
  - need for assessments of potential suitability in developing countries
- ABB requires capital investment, technology capacity
  - economies of scale are significant for ABB
  - access to foreign investment is limited or unreliable
  - technologies require high levels of engineering expertise which will probably remain limited in lower income countries

Parameter or issue	Open ponds and raceways	Photobioreactors (PBR)
Required space	High	For PBR itself low
Water loss	Very high, may also cause salt precipitation	Low
CO_2-loss	High, depending on pond depth	Low
Oxygen concentration	Usually low enough because of continuous spontaneous outgassing	Build-up in closed system requires gas exchange devices (O_2 must be removed to prevent inhibition of photosynthesis and photo oxidative damage)
Temperature	Highly variable, some control possible by pond depth	Cooling often required (by spraying water on PBR or immersing tubes in cooling baths)
Shear	Usually low (gentle mixing)	Usually high (fast and turbulent flows required for good mixing, pumping through gas exchange devices)
Cleaning	No issue	Required (wall-growth and dirt reduce light intensity), but causes abrasion, limiting PBR life-time
Contamination risk	High (limiting the number of species that can be grown)	Low (medium to low)
Biomass quality	Variable	Reproducible
Biomass concentration	Low, between 0.1 and 0.5 g/l	High, generally between 0.5 and 8 g/l

Parameter or issue	Open ponds and raceways	Photobioreactors (PBR)
Production flexibility	Only few species possible, difficult to switch	High, switching possible
Process control and reproducibility	Limited (flow speed, mixing, temperature only by pond depth)	Possible within certain tolerances
Weather dependence	High (light intensity, temperature, rainfall)	Medium (light intensity, cooling required)
Start-up	6 – 8 weeks	2 – 4 weeks
Capital costs	High ~ US $ 100,000 per hectare	Very high ~ US $ 250,000 to 1,000,000 per hectare (PBR plus supporting systems)
Operating costs	Low (paddle wheel, CO_2 addition)	Higher (CO_2 addition, oxygen removal, cooling, cleaning, maintenance)
Harvesting cost	High, species dependent	Lower due to high biomass concentration and better control over species and conditions
Current commercial applications	5000 (8 to 10,000) t of algal biomass per year	Limited to processes for high added value compounds or algae used in food and cosmetics

Outcomes and challenges (2)

- Capacity requirements:
  - productivity gains require innovation, knowledge, experience with industrial processes
  - operation, maintenance, processing can be mostly done without specific educational requirements

- Knowledge gaps:
  - due to limited industrial scale experiments, insufficient knowledge to adequately judge accurately economic viability
  - productivity data often extrapolated from limited experiments; is varied and lacks consistency
  - analysis of energy balances, GHG balances and CO_2 abatement potential

Thank you

... and, thanks Alessandro Flammini
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