Biofuels, Micro or Macro?

Arnolfini Bristol: Ocean Earth

Situation Room: Technology Change/ Climate Stability

An installation by Peter Fend and his colleagues which forms the culmination of the 100 day series of exhibitions counting down to the Copenhagen Climate Summit

The proposition for renewable energy production in the Bristol Channel exhibited at the entrance to the Ocean Earth Situation Room at Arnolfini carries a delectable misprint, delectable in that it paraphrases in two letters the global and political issues at the core of the fossil-fuelled climate crisis.

The misprint lies in the word *micro* as in micro-algae which in the context of the Bristol Channel should read *macro*-algae (big seaweed). It highlights the salient set of micro/macro conflicts evident at many levels in the crisis. Basically, the crisis is macro-climatic but the solutions are micro-climatic and the problem is that the people at the Copenhagen Summit only do macro, which is to say , they are bound by macro-scale over-generalised policy settlements for which there is no chance of delivery. And this arguably is just the way that over-consuming industrialised macro-economies and the oil trafficking macro-companies are content to keep it. The solutions offered by Ocean Earth and articulated by Peter Fend, in contrast, are of the micro- persuasion in so much that they involve local actions for the generation of green renewable energy (as bio-fuels) based on local material surpluses[1]. The solutions are dependent upon primary photosynthetic energy and CO_2 fixation in the form of anaerobically digestible biomass chiefly by ***macro-algae*** (eg natural forests of kelp or simple artisanal mass culture systems, rope or net-supported installations) growing in shallow coastal and intertidal waters. Methane is the combustible product and nutrient run-offs from the land, littoral zones and sunlight represent the local material surpluses which support the feasibility and installation of locally organised energy harvesting systems.

Ocean Earth is not alone in pursuing this kind of locally-situated solution based on macroalgae in low impact open systems, though it was among the first . See for example a current initiative at:
http://www.thebioenergysite.com/news/3472/energy-minister-launches-6-million-biofuels-project and also http://www.biomara.org/newsletter-1 . It is often the case that higher value algal products are cited as the primary objective for such initiatives with bioenergy conversion as a secondary outcome. This may vary from location to location depending on local scales of opportunity and circumstances. Nevertheless, macro-algal solutions remain very much a side-shadow next to the more publicised wind-tide-wave macro-engineering solutions and the micro-algal propositions favoured with large investments by the oil trafficking macro-corporations.

---

[1] The concept of a surplus has been adapted from that originally elaborated by Quesney leader of the French Physiocarats or Economistes of the eighteenth century. He argued that the growth of plants, under the influence of sunlight (agriculture) was the only reliable source of a net surplus capable of driving an economy or society

The Ocean Earth Situation Room presents itself as a global map centred on the Antarctic continent around which are drawn sites at which pilot projects are planned or underway. The team have used hydrological and geophysical features: currents estuaries, bays, lakes, catchments, as well as bio-geographical features: nutrient runoffs, substrata and natural populations, to define his preliminary sites and is at ends to point out the irrelevance of the normal priorities of political and national zoning of the landscape.

An obvious objection to the harvesting of natural stands of macro-algae or aquatic plants is the possibility of damage to coastal ecosystems just as terrestrial farming has destroyed arboreal, savannah and grassland ecosystems and replaced them with monocultures ashore. However, Ocean Earth maintains that these are simply matters of design and enlightened management, citing traditional sustainable harvesting of kelp in Brittany and Southern Ireland. It is purely a matter of resisting the over-exploitation of the commons and of instituting a protected commons. The key words are 'local' and 'self-organisation'. Self-organised local groups (micro-systems) are more likely to be aware of the limitations of the local surpluses on which bioproductivity depends and to institute a protected commons both for consumable inputs and outputs. Of course, the history of the fisheries has ensured that environmental protection agencies are more concerned about the possibilities of irresponsibility and the risks of overexploitation of the commons (the well documented tragedy of the commons) than persuaded by the possibilities of responsible management of sustainable extraction coupled to low impact digester installations. So we can expect licences, even for pilot studies, to be a difficult proposition. This is perhaps not unreasonable in anticipation of muchneeded design and research on harvesting systems and population growth and dynamics. However, it would be sadly ironic if the chief agencies with responsibility for sustainable environments were the main obstacle to this approach to sustainable local bio-fuel production. Within the UK the recent Marine and Coastal Access Act (November 2009) provides the mechanisms to negotiate extraction licences within a framework of conservation and locally designated authorities but it may take some time to bring them up the learning curve and to break the vicious circle of producing evidence without taking small experimental risks.

In principle the kelp harvesting and cultivation proposition is similar to short rotation coppice of plantations of trees and grasses except that the kelp are indigenous and already part of a complex and stable ecosystem and the product can be mixed in with other surpluses like agricultural and food wastes to feed anaerobic digesters. All the technology is already in place and well understood. Science is needed to optimise and couple production systems to local infrastructures, ecologies and surpluses and the £60 million promised to the aforementioned Biomara initiative should go a long way in this context.

Fend turns his critique against terrestrial solutions like biofuel crops and the displacement of food production from land which is patently not in surplus. He is even more critical of micro-algal solutions and of course the corporations which favour them. He picks out Exxon and its investment of $600 million in a joint venture Craig Venter's outfit Synthetic Genomics (july2009) for special criticism.

The practical social benefit of micro-algal ideology is that it employs more scientists, more materials more infrastructure, more investment, and presents more opportunities for patents and external control by the resource-rich. The small problem is that no one knows how to make micro-algal systems work. All the available or currently envisaged technologies have significant problems not least in relation the practicalities of solar capture and energy consumption.

The capture and biological harnessing of free sunlight to fix and recycle the surplus of CO_2 of the global atmosphere while delivering part of itself as energy in the form of handy fuels such as methane , ethanol, and combustible seed-oils or even ligno-cellulose sounds a compelling proposition. For an energy-hungry species like Homo sapiens bent on driving the consumption and combustion of fossil hydrocarbons to the environmental limit, it may seem, paradoxically, to be a no-brainer. Therein lies the problem, the no-brains of policy-making and commercial opportunism are riding a wave of enthusiasm based on hope rather than reason.

In this context, for micro-algal solutions the problem lies in trapping the input solar energy at less than the input energy cost of doing so in closed culture systems (raceways, trickle plates, spiral photo bioreactors, all of which require significant investment, maintenance and energy imputs), or in the shear unmanageability of open mono-cultural systems (ponds, lakes), to say nothing of the environmental damage.

This is beautifully illustrated by a recently published patent application:

US 2009/0291485 A1 WO2009142765A2 (patent application) APPARATUS AND METHOD FOR OPTIMIZING PHOTOSYNTHETIC GROWTH IN A PHOTO BIOREACTOR

In their preamble the inventors point to the problems associated with all other approaches to micro-algal culture. They do a good job, listing and highlighting the problems of; light penetration of the sorts of cell population densities required for economic production rates, the problems of gas transfer and hold-up (CO_2 in O_2 out; O_2 toxicity), the problems and costs of mixing (liquid/mechanical sheer) to avoid over-illumination (resulting in photo-inhibition) of one part of the culture while keeping the rest in the dark; fouling of transparent surfaces required for light transfer, the control of temperature and so on. The novel culture vat or photo bioreactor they describe is designed like an inside-out tree with a central rotating trunk and branches immersed in a cylindrical tank of algae suspended in water and nutrients. Light is distributed to the culture via the branches (light wands) as they rotate. A perfect solution it might seem but the inventors do not provide a means of introducing natural sunlight in the wands. No, they bring in various forms of electric light. For a poor innocent sceptic of perpetual motion this has an odd ring to it. Photosynthesis has at best an efficiency of about 6 percent (theoretical quantum efficiency of 10% for the sunlight spectrum). This implies at best that an output of a fraction of the 6% of the energy supplied from the burning of fossil fuels or transmutation of nuclear fuels might be expected. Not, perhaps the most persuasive of strategies for sustainable bio-fuel production but a very pretty way of growing algae if one has other reasons for doing so.

Of course it may be that the laundering of nuclear energy (fission) via electricity generation, electric lighting, photo bioreactors and microbial oil conversion, into jet fuel has an overall politically advantageous balance in terms of CO_2 emissions per air-mile, but with an overall efficiency of a fraction of a percent we are bound to question economic sustainability.

So, perhaps Fend's rejection of the micro-algal solutions and ideology favored by the macro-agents has some justification at least for the foreseeable future. Evolution has already provided solutions to the difficulties of farming micro-algae by creating the macro-algae. In time, modern biology and materials science may well harness photosynthesis in ways not yet envisaged and improve upon the macro-algae, but whether such can be developed and implemented at reasonable cost and scale remains to be seen. In the meantime it is worthwhile lending an ear to Ocean Earth and the principle of working with the oceans rather than against the land.

The problem lies in the mobilization of local groups to study and resolve their own issues and opportunities of surpluses and energy production. Local groups organize well when there is a mutually perceived unwelcome change to be resisted (like a cell-phone mast, a wind farm or a casino) less so when some imagination is needed to produce a positive solution. *No* is a far easier proposition than *how*. However, locally self-organised initiatives to segregate and recycle waste are not without precedent and perhaps this is the place to start. In support of this perhaps Ocean Earth might be persuaded to publish a manifesto for local groups "How to identify and evaluate your local surpluses and sustainably harvestable ecosystems – The triumph of the commons"

The micro/macro discourse is ripe for some juicy debate, so do visit the Situation Room for a taster.

Steve Hughes, Exmouth UK