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Biomass Technologies

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The use of various types of primary and secondary biomass materials as sources of fuels, chemical feedstocks, and fine chemicals is as a very broad and heterogeneous field. It is important to note that there is a very large variety of local opportunities and problem solutions due to varying environments.

As regards the impact of this renewable energy source it is generally recognized that the quantity of biomass potentially available is enormous; the amounts annually synthesized are equivalent of roughly 10 times the total world consumption of energy in calorific terms. However, a systems study of various opportunities in the field of biomass technologies is needed as no universal approach will apply for its utilization. The great attractions for industrial use are large quantities, flexibility of processes and end products. Bioconversion is a low-temperature process involving no hazardous chemicals, as opposed to conventional chemical industry that often employs high temperatures and dangerous chemicals. Moreover, there is negligible augmentation of the «greenhouse effect» compared to burning fossil fuels. The variety in local conditions has until now discouraged novel large-scale biomass utilization. The flexibility in choosing raw materials and processes is, however, an advantage if properly exploited.

Such a systems study should cover the following items (which are particular to the local conditions in question):

- Choice of raw material:
  - plant species;
  - plant breeding for improved species;
  - other biomass sources (manure, dairy waste, etc.).
- Plant cultivation methods.
- Long-term agricultural sustainability (need for fertilization, irrigation, possible crop rotation, multispecies cultivation).

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- Raw material harvesting and gathering, transport and storage.
- Pretreatment (mechanical, chemical).
- Conversion to:
  - fuels (e.g. hydrogen, methane, methanol, ethanol);
  - chemical feedstocks (e.g. ethylene, propylene, methanol, benzene, toluene, xylene, hydrogen);
  - fine chemicals (e.g. agar, alginate, precursors, pharmaceuticals).
- Downstream processing (separation and cleaning).
- Transportation and storage.
- Long-term environmental questions.

The need for research on each of the above steps can be described by a Development Need Index (DNI) as examplified by the study of kelp provision and conversion to methane (Table III 2).

Table III 2. Development Need Index (DNI) derived from the total cost A and the degree of commercialization B of different steps in methane production from kelp.

	Seeding and Outplanting	Harvesting	Conversion	Gas Cleaning
A: % of total cost	26	44	18	12
B: % level of commercialization[a])	25	75	25	100
DNI (A/B)	1.04	0.56	0.72	0.12

[a]) 100% = commercially available; 75% = pilot scale; 50% = demonstration scale; 25% = laboratory scale; 5% = concept.

As mentioned it is unlikely that one single technical concept will prove generally useful, but rather optimal combinations of existing alternatives adapted to local conditions should be looked for. In this way, apart from systems development, many of the different elements comprising the chain of biomass utilization can be individually improved by intensified R & D efforts.

As brought up during the brainstorming sessions recent trends in high-pressure gasification and subsequent upgrading of the gas offer new possibilities of great potential. Further biochemical and biological research in the area is fundamental. The following elements which call for R & D in basic biology and are specific to biomass utilization come into prominence (in addition to the chemical and engineering aspects):

- Photosynthesis:
  - no clear correlation between photosynthetic rate and field yield;
  - need thorough understanding of photosynthetic apparatus;
  - photorespiration control;
  - hydrogenase enzymes (for H_2 production).
- Distributing the fixed energy within the plant:
  - plant yield;
  - metabolic pathways partitioning;
  - polysaccharide (e.g. cellulose) synthesis;
  - energy cost of various metabolic processes;
  - plant chemotaxonomy to choose the right plants;
  - micro-algae producing fuels.
- Environmental stress and plant productivity:
  - minimizing cost input for plant growth;
  - water use;
  - mineral requirements;
  - adaptation to highly saline conditions;
  - the role of soil micro-organisms with respect to plant nutrition and growth;
  - effects of extreme temperatures on plants (membranes);
  - pathogens and predators.
- Genetic manipulation for improving biomass productivity:
  - genetic control of development;
  - molecular biology of genetic transmission and expression;
  - plant cells expression vs. whole plant expression;
  - vectors for genetic information transfer;
  - inheritance of characters controlled by multiple genes.
- Bioconversion:
  - biodegradation by microbial enzymes;
  - microbial production of chemicals and fuels;
  - ethanol enhanced process;
  - methane;
  - solvents and acids;
  - mixed cultures;
  - process coupling;
  - microbial genetic engineering;
  - stability;
  - toxicity.

Some of these items, notably in vitro photosynthesis, have enormous scientific and commercial interest, and interface with other renewable energy projects.

The different requirements and opportunities in each local situation will be governed by the following factors:

- Area availability (both land and sea).
- Plant species and biomass byproducts.
- Climate.
- Links to locally available technologies and development prospects.
- Local economic situation.
- Industrial infrastructure.
- Local cultural and political environment.

Our specific recommandation is that IEA set up a task force to gather data and information regarding the possibilities and needs of the various biomass technologies, and then to carry out a systematic analysis leading to the identification of several promising specific research projects and the development of further strategies. In the group of about 10 persons the following fields should be represented: *biology, microbiology (e.g. fermentation), plant breeding, soil science, agricultural economics (incl. systems and analysis), chemical engineering*. Leads to forming this group can be found in the following national and international bodies:
SERI Biomass section;
COST projects (e.g. COST 48, COST 87);
Board of Agriculture, US-National Research Council;
EC Biomass projects;
EC Energy from Biomass programme;
EC Biotechnology programme;
Pulp & Paper technology associations;
FAO-CNRE (European Cooperative Networks on Rural Energy).

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