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Introduction and General Questions

Question 1
What is your view on society moving towards greater use of biofuels?

Biofuels are an essential component of governmental policies aimed at reducing GHG emissions and dependence on oil. Today, transport is a major contributor to GHG emissions and so changes in this sector will be unavoidable. Clearly, biofuels will only form part of the solution and other measures, such as intelligent city transport networks will be required. Moreover, long-term investment in new technologies that will provide viable alternatives to the combustion engine is needed.

Question 2
What are the most important ethical challenges raised by the prospect of future generation biofuels?

The obvious ethical challenge is linked to land allocation and competition with the food chain. However, the situation is almost certainly not as simple as it would first appear to be. Therefore, it is vital to integrate the question of biofuels production into a larger debate on the use of world resources. A second issue is linked to the use of land in under-developed world regions for the production of biofuels destined for use in other more developed countries. Finally, biofuels raises the question of equitable technology transfer (from developed countries to under-developed ones).

Question 3
The CEPIA division of INRA is composed of several scientists who share complementary expertise in the biofuels field? Where do you get your information from?

Our information is mainly derived from scientific literature, attendance at conferences and from reports. The combined expertise of CEPIA qualifies our division as a specialist group of scientists in the area of renewable carbon, although biofuels is not our only focus area.

Drivers, hopes and benefits

Question 4
Which factors are going to be the most important in driving the development of biofuels in the future? To what policy concerns should priority be given? What advantages not mentioned here could and should future biofuel production aim to deliver?

The three factors cited are very difficult to prioritise, because they are linked to quite different areas of public concern. However, economic development is likely to be the key driver. Climate and energy security are still being perceived as long-term threats, whereas economic progress is a very tangible, medium-term aim. Therefore, priority should be given to the development of policies that will promote the economic efficiency of renewable carbon products.
Biofuel production should be tightly linked to the generalized development of a renewable carbon-based economy. One might also imagine that biofuel production could contribute to the emergence of neo-rural societies, both in Europe and elsewhere. This could lead to a radical halt to the current tendency towards the formation of (mega)metropoles.

Climate change

Question 5
Which of the new approaches to biofuels will be most successful in generating GHG emission savings? How should these be encouraged? Are there any reasons why these new approaches should NOT be encouraged?

Clearly, the use of lignocellulosic feedstocks needs to be strongly encouraged. The GHG balances are definitely better than for 1st generation biofuels. Advanced generation fuels (based on alcohols, or long chain alkanes etc) should thus be preferentially derived from this biomass. However, land use needs to be monitored and biomass supply zones need to be carefully identified and/or "designed". Also, in all cases the use of other resources such as water, nitrates and phosphates by lignocellulosic production systems needs to be monitored.

Energy security

Question 6
Which of the new approaches to biofuels will be most successful in improving energy security? How should these be encouraged? Are there any reasons why these new approaches should NOT be encouraged?

Altering energy consumption habits will be the major contributing factor towards achieving energy security. Biofuels will only become a viable solution for transport when demand for transport energy is significantly.
The localized production of biomass resources and bioenergy is an interesting model that could help to secure energetic independency, but this will almost certainly be coupled to the use of a diversified biomass feedstock.

Economic development

Question 7
Which of the new approaches to biofuels will be most successful in supporting economic development? How should these be encouraged? Are there any reasons why these new approaches should NOT be encouraged?

Biofuels production within advanced biorefinery concepts will be the best way to support economic growth. To promote this approach, fiscal support for renewable carbon-based products should be implemented and further public support for R&D and demonstration projects is necessary.

Science, technology and research

Question 8
Of all the new approaches to biofuel feedstock development, pretreatment and processing (including any additional to those mentioned here), which is looking most promising for eventual commercial and sustainable use? Over what timescales might such developments be commercialised? Are there any risks associated with these developments?

Many pretreatments have been developed in a “cellulose to fuel” framework. Generally, these “glucocentric” approaches should not be pursued, because they fail to optimize the use of biomass resources. Currently, organosolv technologies constitute the best option for biomass fractionation. It is well known that, in addition to cellulose, some of the organosolv variants provide high quality lignin and hemicelluloses fractions and employ quite modest reactions conditions (<100°C). The biggest challenge for organosolv technologies lies in the recycling of the catalysts. To our knowledge several organosolv pilot plants already exist and at least two industrial units are planned. These should be on line within the next 3-5 years. Therefore, it is possible to envisage within the next 10 years the use of organosolv as a core technology for a full-scale biorefining industry.

In the longer-term, it is possible that chemical-based pretreatments will be supplanted by biotechnological processes. However, so far this prospect is far off, because current technologies are immature. In this regard, synthetic biology will be source of technological ruptures.

Advanced plant breeding strategies, genetic modification and synthetic biology

Question 9
Is the use of the following technologies to develop new approaches to biofuel production appropriate? Why?

Advanced plant breeding strategies

Genetic engineering

Synthetic biology

All of these technologies will probably play important roles in the development of biofuels and biorefining. **Advanced plant breeding** strategies will allow the creation of new varieties that will be optimized for multiple criteria such as productivity, water and fertilizer requirements, disease resistance and aptitude with regard to fractionation and end-uses.
Genetic engineering will definitely be required for the development of new biotechnological tools, such as enzymes, microorganisms and, in some circumstances, plants. The motivations are two-fold: (i) obtain variants that would otherwise be difficult to obtain through normal selection procedures and (ii) accelerate the overall discovery process. On target for genetic engineering could be the redirection of carbon flux towards sugar or lipid formation in targeted organs such as stems and leaves. This will alleviate limits linked to limited capacity of the natural organs (seeds etc).

Synthetic biology will be an increasingly precious tool for the development of biotechnological tools, notably microorganisms, which will be completely designed and tailored for industrial purposes. In particular, synthetic biology will be one of the major driving forces providing biotechnological tools for the catalysis of non-biological or non-natural processes.

Intellectual property issues

Question 10
What are the most important intellectual property and access issues raised in new approaches to biofuels? What is the best way of governing these?

Research and development (R&D)

Question 11

What are currently the main constraints to R&D in new approaches to biofuels?
R&D is hampered by several factors. One is linked to insufficient knowledge concerning plant structures, especially structure-function relationships. Causal relationships between structure and fractionability are not yet clearly identified. To overcome these hurdles, progress in phenotyping needs to be made in order to fully profit from the fruits of the high-throughput post-genomic era. This is also true for the development of biotechnological tools, such as enzymes. Genomics, metagenomics and enzyme engineering open exciting new ways to develop enzyme technologies, but phenotypying and high-throughput data handling are limiting full exploitation of these approaches. Finally, the development of biofuels is also being hampered by the lack of solutions for lignin and hemicelluloses. These components must be used in order to achieve "whole-crop" approaches

Question 12
Where should R&D for new approaches to biofuel be targeted, and who should decide about future biofuel R&D strategies?

Future R&D should address a variety of areas and questions. Clearly, there is a considerable amount of work to be achieved on the production of biomass in a sustainable framework (agronomy, ecology etc). Likewise, generic research needs to be pursued in plant sciences with an emphasis the most promising lignocellulosic resources. Research on woody biomass should be a privileged, but cereals should not be neglected, because these are a major source of lignocellulosic by-products and, as such, can perform a double food/non-food function.
Concerning pretretament there is still a considerable amount of R&D to perform, because this is still a major obstacle. This R&D must be coupled to intensified research on the use of lignins and hemicelluloses. For lignins, new technologies releasing the aromatic subunits for use in the industrial chemistry sector is vital. Likewise for hemicelluloses new transformation itineraries that account for the specific attributes of 5-carbon sugars should be developed, notably through more intensive research on metabolic engineering and heterogeneous catalysis.
For downstream conversion processes R&D is need to expand the panel of technological itineraries that can be applied to biomass derived building blocks. Notably, it is vital to develop new technologies that will allow the facile production of molecules that awkward to access through natural (biological) processes (e.g. olefins, alcanes etc). Big efforts in industrial biotechnology and in the smart integration of chemistry and biotechnology are required.
Biofuels are clearly important components of the EU strategy for the future. Therefore, R&D strategies need to be coordinated at the European level. Poorly coordinated national strategies will lead to a dispersal of R&D effort. Nevertheless, R&D decisions should be made in both bottom-up and top-down processes. Considerable innovation will come from bottom-up initiatives. Top-down incitation should provide a suitably large framework for bottom-up projects and programmes.

Land use, environmental and food security and human rights

Question 13
Are new approaches to biofuels likely to raise problems related to land use? If yes, how? If not, how do new approaches avoid these issues?
New demands for biomass will inevitably create new situations and potential problems. The use of lignocellulosic feedstocks will not completely avoid this. However, using lignocellulosic biomass will provide a certain margin for manoeuvre. Forestry products should be exploited, but careful planning of this new activity should take into account factors such as the maintenance of biodiversity and the risk of soil quality depreciation. Concerning the use of marginal land and indirect land use changes, these need to be monitored and tied into a strict legislative framework that must take a holistic view of biomass resource management.

Question 14
What differences are there between the developed world and developing countries with regards to the potentially problematic effects of future generation biofuel production on land use?

There is a strong risk that developing countries will be exploited for the production of biomass, without benefiting themselves from the advantages associated with the biofuels strategy (i.e. energy security and environmental benefits). Likewise, there is a risk that transformation technologies that are considered to be unreasonable/not viable for highly developed economies will be operated in under-developed countries where health and environmental legislation is weak. Finally, there will be a strong temptation for land use changes, leading to increased pressure on the local food chain.

Question 15
Should iLUC be considered when evaluating the GHG emissions savings of new approaches to biofuels, and if so, how?

Environmental security

Question 16
What advantages and disadvantages for environmental security could new approaches to biofuels have? How could harms for environmental security be dealt with?

Food security

Question 17
Are new approaches to biofuels likely to raise problems related to food security? If yes, how? If not, how do new approaches avoid these issues?

Question 18
What differences are there between the developed world and developing countries with regards to the potentially problematic effects of future generation biofuel production on food security?

Rights of farmers and workers

Question 19
Are new approaches to biofuels likely to raise problems related to rights of farmers and workers? If yes, how? If not, how do new approaches avoid or benefit these issues?

Question 20
What differences are there between the developed world and developing countries with regard to the effects of the production of future generation biofuels on the rights of farmers and workers?

Investment, policy and governance

Question 21
Where do you think investment in new approaches to biofuels should be directed and where should it come from (public sector, private sector or public-private partnerships)?

The development of biofuels and biorefining will be a long process involving a considerable amount of R&D. This must be financed principally by public funding bodies. To stimulate rapid technology transfer, public-private partnerships will also be pertinent for the funding of R&D and demonstration projects. Private funding must take over at the demonstration phase.

Question 22
Which policy issues in relation to new approaches to biofuels would you like to bring to our attention?

Question 23
What would be the most effective policies a) to promote and incentivise; and b) to regulate the development of new approaches to biofuels?

Indirect policies will probably be most effective. These include a carbon tax.

Any other issues

Question 24
Are there any other issues not mentioned in this consultation that we should consider in the ethical evaluation of new approaches to biofuels?
Please expand below.