Appendix 2: Wider consultation for the Report

The aim of the consultation was to gain the views of interested professionals, organisations and members of the public. The consultation was available online and publicised in both national and specialist media. It comprised a document containing background information and 24 questions. Respondents were invited to answer as many of these as they wished. Ninety-three responses were received, 50 of which were from individuals, and 43 of which were from organisations. The Working Party would like to thank all those who responded to the consultation.

The responses were distributed to the Working Party and informed their deliberations. This summary of the consultation responses does not attempt to reproduce exhaustively all the comments made by the respondents, nor is it a systematic selection. Instead, the summary aims to identify broad areas of consensus, as well as significant or unique points in the debate. To aid the reader in their navigation of the material, comments have been clustered around themes, for example, food security, environmental sustainability etc. We tried to avoid redundancy wherever possible. However, due to the interconnectedness of many of the issues, there remains a certain degree of thematic overlap. We felt that this was appropriate, as it serves to highlight the complexity of the debate. Indeed, many respondents did not limit their comments to the issue mentioned in a particular question, but rather offered analyses of the interactions between several aspects – for example food security, environmental impacts, and land use – and how these could contribute to benefits, or lead to harms in biofuels development and production.

The opinions and recommendations expressed in this summary are intended to reflect those of the consultation respondents and do not necessarily reflect the views of either the Council or the Working Party. The consultation was open to anyone to respond, rather than being conducted as a survey or poll. As such, the responses cannot be interpreted as an accurate representation of the population. The complete text for all responses for which the Council was given permission to publish may be found at the Council website.[562] A version of the original consultation document can also be found on the website.[563] Technical terms are explained in the Glossary.

1 Food security

Issues relating to food security are important in the context of biofuels. For example, when respondents were asked for their opinion on society using more biofuels, several respondents were in favour as long as food security was not compromised. Conversely, several respondents were against such a move, stating that biofuels production contributed to increased demand for land, raised food prices, speculation on food markets, and thus food insecurity. Many respondents mentioned threats to food security (e.g. posed by increased competition for agricultural resources such as land, fertiliser, water, etc.) as one of the most important ethical challenges raised by new biofuels. Although there was a view that countries like the UK could be affected, threats to food security in the developing world were highlighted in particular. Several respondents also thought that policy should focus on food security in the context of biofuels as a priority.

With regards to some of the new approaches to biofuels such as lignocellulosic biofuels and algal-based biofuels (ABBs), respondents were asked whether they believed these would cause problems in relation to food security. A summary of the responses is given below. Some respondents did not answer. Those who did submit responses were broadly divided, with some suggesting that new biofuels were likely to threaten food security, and some believing that new biofuels could avoid conflicts or reduce these i.e. relative to current biofuels. Several respondents even suggested that new

[562] See: http://www.nuffieldbioethics.org/.
[563] Nuffield Council on Bioethics (2009) *New approaches to biofuels: consultation paper*, available at: http://www.nuffieldbioethics.org/sites/default/files/Biofuels%20Consultation%20Master%20-%20PRINT%20FINAL.pdf.

biofuels or biofuels in general could *aid* food security. Suggestions were made for governance; interestingly, there were those that could apply to production of any biofuel type.

a) New biofuels could reduce or avoid food security harms, or could be beneficial in other ways

Avoids or mitigates harms

- New biofuels production does not make use of the edible parts of food crops, and therefore removes a direct threat to food security.
- Some new biofuels can be derived from feedstocks that can be grown on land unsuitable for crop production (e.g. nutrient-efficient perennial trees and grasses, feedstocks designed to grow under stress conditions). This removes direct competition for arable land.
- Some new biofuels can be produced from feedstocks that do not require any land (e.g. wastes, marine algae).
- New biofuels produced via the lignocellulosic pathway provide more energy per plant, per hectare of land and per inputs compared to current biofuels, therefore minimising agricultural requirements and reducing any conflict with crop production.
- Cultivation of some algae could require land but the demand is likely to be less compared with current biofuels given the potentially high biomass productivity of algae.
- With regards to the effects of new biofuels in developing countries on food security, these will be minimal given that developing countries will be unable to invest in new biofuels on account of the prohibitive costs.

Potential benefits

- Cultivation of some lignocellulosic crops (e.g. perennial grasses) can reduce the need for fresh water and improve the land's soil quality, stability, and carbon stocks for any future production of food crops.
- Production of grain crops will be incentivised to meet the market demand for agricultural residues that are to be used in lignocellulosic biofuels production.
- Technology transfer of new biofuels to developing countries could benefit research and development (R&D) in food production there. There is significant opportunity for improvements as currently food production is below its full potential in many developing countries.
- In general, biofuels could create income-generating opportunities for farmers in developing countries; with this income, individuals could buy food. This has been seen with Brazilian sugar cane bioethanol.
- Use of biofuels generally can mitigate climate change and its adverse effect on food crop production around the world.

b) New biofuels could harm food security

- New biofuels, despite avoiding the edible parts of food crops, will threaten food security due to increased competition for agricultural resources, e.g. land, water, human capital etc.

- Using agricultural residues will impact on feed availability for livestock, limiting livestock numbers for food production. In addition, more land could be cultivated to make up the shortfall in feed, taking the land out of crop production for humans.

- Use of wastes from agriculture and forestry will prevent these from being recycled into the soil. As such, the soil will be depleted of nutrients, affecting any future arable farming there.

- Although some new biofuels feedstocks can be grown under sub-optimal conditions (e.g. low inputs, low quality soil), there will nevertheless be an economic incentive to cultivate these under optimum conditions and on a large scale in order to achieve greater returns.

- The focusing of R&D and human resources on the production of new biofuels could limit the development of food crops, e.g. such that they too are able to grow in hostile conditions.

- Some new biofuels feedstocks can be cultivated on less fertile land (e.g. nutrient-efficient perennial crops); however if the land is fertile enough to grow biofuels crops, it is also fertile enough to grow food crops, e.g. using genetic technologies or advanced farming practices.

- There will be an economic incentive to cultivate algae on flat land, and ABBs could also draw significantly on freshwater supplies. Algae grown offshore might conflict with fisheries.

- The exercise of intellectual property rights (IPRs) over new biofuels feedstocks could effectively remove some crops from food and feed in developing countries.

- If current incentives change such that biomass feedstocks are competitive with grain prices, higher quality arable land will be converted to biofuels crops. This has been the case with cash crops such as tobacco and cotton.

c) Observations for developing countries regarding food security

- In developing countries, even small impacts on food security can be a matter of life and death and lead to social conflict:

  a Food insecurity is often already endemic and severe here, e.g. due to poor growing conditions and farming practices, and adverse climate change effects.

  b There are fewer regulatory 'safety nets' both to prevent harm (e.g. agricultural subsidies) and to protect citizens against it (e.g. state provision of benefits).

  c The poorest people already devote a large proportion of their income to food so that any price increase has a larger effect proportionally.

  d Subsistence farming is common, which increases the directness of the risk.

- There is not a neat 'developing/developed world' divide. Whether there are harms will be determined by the availability of land and other resources, and political and social infrastructures (e.g. sustainable farming practices). The public opinion of genetic modification could also be a determinant.

- Food security in developing countries is affected by more than biofuels alone. Poor growing conditions and farming practices are also contributors. Thus, food security should not be used as a barrier to the adoption of biofuels.

- In developing countries, current biofuels production is linked with hunger not because the land used could be used to produce food crops, but because their production denies individuals the land or labour wage to feed themselves.

- There is a risk of 'green imperialism', a situation where, directed by land and resource availability, developed countries produce new biofuels in developing countries for their markets back home.

d) Suggestions for governance on food security

- Global food security and food sovereignty should take primacy over biofuels production.
- There is potential for new biofuels production to have minimal impact on food security; however, this can only be realised through appropriate governance.
- There is a need for joined-up thinking. For example, whilst some suggest the prohibition of biofuels crops on arable land, this potentially encourages the clearing of natural land.
- It is necessary to ensure that biofuels development does not interfere with any measures intended to aid food security in the context of climate change, such as dedicated programmes of crop production or R&D into stress-tolerant crops.

Specific potential measures regarding food security

- Certification schemes could be used. For example, the developed world could only source biofuels that have been certified as not harming food security.
- Regulation of land use could licence cultivation of biofuels feedstocks when arable land is in surplus. In developing countries, purchase of land by foreign companies could be prohibited if it is likely to be at the expense of domestic food production.
- Large-scale production could be avoided. Furthermore, a range of feedstocks could be used, with each requiring a different set of agricultural inputs. This could help diversify pressures on food security.
- It could be ensured that developing world farmers are not incentivised to produce cash crops at the expense of food.
- An access and benefit-sharing mechanism could be devised for biofuels production which considers food and feed crops of importance to food security. This could help to avoid negative impacts on food security from IPRs.

2 Land

Land issues are clearly important to the biofuels debate. A few respondents mentioned that it was acceptable for society to move to an increased use of biofuels as long as, for example it did not compete for land that would otherwise be used for food crop production or remain under natural forest. Many respondents considered land issues to be some of the most important ethical challenges raised by new biofuels. Examples included: the allocation of land given its limited availability and the plurality of demands; and land use that was socially and environmentally sustainable. Several also mentioned land issues as policy concerns to be prioritised, including those relating to land ownership in developing countries.

Respondents were asked whether they believed new biofuels would cause any problems with regards to land. Some respondents did not answer; another respondent mentioned they felt not expert enough to do so. It was apparent that many believed that new biofuels *would* create problems, for example by increasing land demand; however, several respondents believed that they would be better than current biofuels due to their reduced demand for land. A few suggested there would be no issues. Where respondents believed that new biofuels were likely to cause problems, there was in a few

respondents the recognition that this issue affected agriculture as a whole and was not specific to biofuels.

The environmental and social consequences of land use are not presented below as these are clustered under the other themes, e.g. food security, environmental sustainability etc. Below is an outline of the debate regarding the demand of new biofuels for land.

a) New biofuels might avoid or mitigate land demand

- Use of wastes, e.g. from agriculture, forestry and municipal waste streams, and offshore algae will not require any land use per se.
- New approaches making use of wastes could reduce the space required for landfills.
- There will be reduced demand for agricultural land given that some new biofuels feedstocks can be grown on poor quality agricultural land or marginal land. Cultivation of some algae will also not require fertile land.
- Use of the entire crop in lignocellulosic biofuels production will enable greater energy yields per crop, per area of land, enabling land demand to be minimised.
- In addition, some new biofuels feedstocks are high yielding, or yields might be increased using genetic technologies – again, reducing land demand.
- Some new biofuels feedstocks help to improve soil quality by fixing carbon in the soil. Arid land could also be revitalised in developing countries.

b) New biofuels could increase land demand

- There will be increased land demand unless production uses feedstocks exclusively derived from existing waste streams.
- Large-scale cultivation (domestically or abroad) will be necessary: to produce sufficient amounts of biomass to replace current fossil fuel use; to achieve economic return on high initial capital costs; and to meet targets.
- Despite feedstocks that can be grown on land of low agricultural value, there could be an environmental incentive to use cropland since this has a low carbon stock.
- There will be an economic incentive to grow even low-input new biofuels feedstocks on fertile land to achieve greater yields and economic returns.
- There are existing considerable demands for land, such as rising world population, growing demand for meat etc. This raises the question whether new biofuels should be cultivated.
- In developing countries, ‘underutilised’ land already has other purposes, e.g. grazing, foraging, and firewood harvesting. It might also be used by nomadic herders at various points in the year. The use of such land will generate increased demand for land to replace these purposes.
- The exertion of IPRs could prevent developing countries from adopting feedstocks that are more sustainable with regards to land use.

c) Observations for developing countries with regards to land

- There is likely to be greater land use in some developing countries because of their favourable climate and the amount of available land. Furthermore, some of the richest habitats exist here and food security is already an acute issue. Thus, the threats of land use are much greater here.
- Land ownership in developing countries is often poorly defined or informal, making communities there particularly vulnerable to displacement. For example, communities – and in particular women – might have only customary use of land with no security of land tenure.
- Communities are often unlikely to be consulted where governments agree to lease land to foreign companies. Also, in negotiations over land ownership, they typically have little leverage against large private corporations.
- Communities giving up their access or rights to land could effectively deprive themselves of local resources on which they depend, e.g. for food, feed and fuel.
- Developing countries can have less stringent environmental and social safeguards in place for agricultural land development. In addition, there is a risk that practices considered inappropriate in developed countries will be operated here by foreign companies due to weak governance.
- There are different priorities in developing countries for land, e.g. economic development, gender issues, energy access. These can take priority over food security and climate change mitigation.
- A trend is developing where developed countries use land and associated resources in developing countries for their own purposes. These actions, sometimes known as 'land grabs' (a term reflecting the controversial nature in which the land can be obtained) can be great in scale and can involve violence. Such a trend could be observed with biofuels production.

d) Other observations with regards to land

- Land demand depends on the feedstock used, the existing farming practices and the scale of development. For example, the land demand for algal-based biofuels will depend on whether algae are cultivated offshore or in photobioreactors.
- There are only a few examples of land use change causing problems, including threats to food security and environmental harms; it is wrong to focus solely on these exceptions.
- Currently there is no good, agreed-upon methodology for assessing land use. There are doubts as to whether indirect land use change (iLUC) can be monitored accurately.
- Underused agricultural land offers significant potential, particularly in view of feasible biomass yield increases.

e) Suggestions for land governance

- Land issues should be discussed at an international level given the global dimension of land use. There is a need, however, to make evaluations on a case-by-case basis so that local complexities and views are understood.
- A political framework to ensure sustainable land use is required. For example, there could be legislation, land-use planning or certification at the international, country or regional level.
- There is a need for interdisciplinary discussions, e.g. there should be consideration of the development agenda.

- Any land regulation should be transparent and based on evidence.
- Land use change and its consequences are neither new nor restricted to biofuels. Thus, in the interests of fairness and to prevent 'leakage' of bad practices into other areas, the scrutiny applied to biofuels should also be directed towards other uses of land, e.g. other agriculture or urban development.

Specific potential measures regarding land use

- There could be a role for public scrutiny and corporate social responsibility in addressing land use issues.
- Any individual that is adversely affected by land use change (e.g. is displaced) could be compensated by having a stake in the development of new biofuels.
- Degraded land that cannot be used for food production and other ecosystem services could be used for biofuels production. Measures to maximise energy produced per hectare – thus reducing land competition – could also be employed.
- Diversification of feedstocks enables materials to be used from a wider range of land resources. This would aid land security. Furthermore, there is the opportunity to create resource bases that are more sustainable in terms of land for that location.

3 Health and water

Several respondents discussed health and water security in their submissions. The scope of their comments is presented below.

Health issues arising from agricultural pollution were seen as one of the most important ethical challenges raised by new biofuels. It was argued that biofuels production should aim to address health issues due to air pollution. There was a view that challenges to working conditions, for example because of chemical use, were not unique to biofuels production, rather they were common to agriculture in general.

A societal move to increased use of biofuels was disapproved of based on the belief that biofuels had led to water insecurity. In light of growing water insecurity (i.e. because of limited sources and a growing population), the amount of water used in biofuels production (the 'water footprint') was highlighted as one of the most important ethical challenges of new biofuels. Efficient water use was highlighted as a policy concern to be prioritised, and it was elsewhere proposed that new biofuels should aim for lower water consumption. The threat to water security was more pronounced in developing countries where climates were more arid and infrastructure for accessing any water resources was limited.

4 Environmental sustainability

Consultation respondents discussed issues related to environmental sustainability. Several respondents believed that a societal move towards greater use of biofuels was acceptable or favourable if their production was environmentally sustainable, e.g. did not involve ecosystem losses, or provided net greenhouse gas (GHG) emission savings. However, several respondents asserted that increased biofuels use was unacceptable or not desirable as biofuels production led or could lead to environmental harms. They cited land use change which reduced biodiversity and generated GHGs. Many respondents suggested that environmental sustainability was one of, if not the, most important ethical challenge posed by new biofuels. Either environmental sustainability was mentioned specifically or constituent aspects were highlighted, e.g. sustainable use of biomass, land, or water, or

conservation of biodiversity. Similarly, some respondents drew attention to environmental sustainability, or its constituent elements, as a policy concern to be prioritised.

When asked about the potential advantages and disadvantages of new biofuels for environmental security,[564] many respondents did not answer. One other respondent wrote that they did not feel expert enough to comment. The degree of certainty with which arguments were made about harms and benefits varied from the absolute to the potential. With regards to dealing with harms, respondents suggested measures that were permissive of new biofuels developments or asserted the need for preventative measures.

a) Environmental benefits of biofuels in general

- Biofuels development removes the need to search for oil in inaccessible or pristine areas, or to make use of tar sands – activities that can pose significant risks to the surrounding environment.
- Biofuels by nature do not pose the same hazards as fossil fuels: e.g. in direct contrast to oil spills, a biofuel spill is not toxic. Biofuels also reduce the amount of fossil fuel used in transport.
- The scrutiny applied to the development of the biofuels industry could improve environmental stewardship in agriculture in general.

b) New biofuels could provide environmental benefits

- Some new biofuels production uses wastes from agriculture and forestry, as well as municipal wastes. This requires neither inputs, e.g. in terms of water and fertiliser,[565] nor land use.[566]
- Use of wastes affords a means of dealing with waste which can otherwise decompose, causing environmental harms, e.g. GHG production.
- With lignocellulosic biofuels production, the whole feedstock is used, which maximises the energy-input ratio, and thus minimises the amount of water, fertiliser and land used with regards to biofuels yield. In addition, some feedstocks, such as energy grasses, require less fertiliser, herbicides and pesticides than arable crops. This minimises any subsequent air or water pollution.
- Some new biofuels feedstocks (e.g. algae, certain energy grasses) can be grown on less hospitable land, such as that with low soil quality, aridity, lack of freshwater etc. This reduces the drive for land use change of natural land. Where new biofuels feedstocks are grown in less hospitable environments, these environments can be effectively revitalised.
- Some new biofuels feedstocks, e.g. short rotation coppice (SRC) willow or miscanthus, can display greater biodiversity than existing arable crops. Perennial energy crops can also provide flood control.
- New biofuels production using algae can be integrated with biological 'cleaning' of waste water (bioremediation) and with 'scrubbing' of carbon dioxide from factory emissions.
- Development of new biofuels will increase the demand for residues, and could consequently promote agriculture and forestry, affording new habitats and carbon 'sinks'.

[564] The term 'environmental security' was considered by the Working party to be interchangeable with 'environmental sustainability'.
[565] Fertiliser use can lead to water pollution and GHG emissions.
[566] Any lowering of land use minimises the need for land use change which is associated with GHG production and habitat loss.

c) New biofuels could cause environmental harms

- The use of the whole feedstock and wastes in lignocellulosic biofuel production prevents them being recycled into the soil, and leads to depletion of soil minerals and soil biodiversity.
- It is unclear whether there are large enough areas of land that are suitable for cultivating new biofuels feedstocks (e.g. algae, dedicated energy crops) without causing land use change (either direct or indirect). Additionally, there is doubt as to whether new biofuels feedstocks will require so little inputs of water and fertiliser etc.
- If new biofuels feedstocks are cultivated on land which has reduced agricultural value, this might threaten the biodiversity and ecosystem services already present there.
- The invasiveness of some new biofuels feedstocks, such as switchgrass and miscanthus, threatens local biodiversity. Also, any genetic modification in these crops would therefore be more of a concern. Foreign feedstocks can also harm water balance.
- The disposal of the used medium that algae have been cultivated in is problematic. Also, if seawater is used in cultivation, the land could be made unsuitable for future crop production and extensive infrastructure would also be needed.
- To achieve large-scale production of new biofuels, high inputs of water will be necessary, as well as fertiliser, chemical and pesticide use which are associated with water and air pollution. Monoculture, which threatens biodiversity, is also a likely practice and there will be pressure for land use change.
- Some genetically modified crops that are herbicide tolerant and pest resistant are associated with herbicide-resistant weeds, pest-resistant populations of insect and the emergence of secondary pests that require additional insecticide. Such issues could afflict new biofuels feedstocks that are genetically modified.
- The use of genetically modified trees for lignocellulosic biofuels poses a heightened risk of genetic pollution because tree pollen can travel greater distances. There could be serious environmental consequences if genetically modified microorganisms capable of enhanced cellulase production are released into the environment.
- There is also the issue of large-scale cultivation of genetically modified algae, which could represent a case of wide environmental release if cultivated in open ponds.

Issues of environmental policy

- Unconditional biofuels support in the form of targets and subsidies has been effective in promoting biofuels development but not in ensuring its sustainability.
- The effectiveness of voluntary schemes to certify environmental sustainability is questionable. In the absence of binding criteria, it is unlikely that suppliers will make the efforts to improve their performance.

d) Other comments on environmental sustainability

- More information is needed regarding the issues affecting environmental sustainability, especially with regards to what constitutes a full life cycle assessment (LCA).
- The developing world is likely to be the location for much new biofuels production. The developing world is also home to some of the richest habitats, and any potential environmental harm would be most keenly felt here.

e) Suggestions for environmental governance

- There should be case-by-case evaluation of the environmental impacts of biofuels. Solutions should be local but framed within the global context. International regulation could assist.
- Unified legislation on environmental issues across the board is necessary, which takes into account other targets and agendas.
- It is not appropriate to examine environmental sustainability in isolation of socio-economic issues.
- The current use of fossil fuels is not morally neutral. This needs to be considered when evaluating alternatives like biofuels.
- The precautionary principle should apply: i.e. all of the risks associated with new biofuels must be thoroughly investigated before there is adoption.
- Sustainability criteria need to apply to all uses of biomass to prevent 'system leakage'[567] and must not – without great benefit to the environment – penalise producers.
- Where renewable targets are established with implications for biofuels, they should be complemented by robust, objective and verifiable sustainability criteria.

Specific potential measures regarding environmental policy

- International certification/ traceability schemes could be adopted that verify the sustainability of biofuels based on environmental (and social) criteria.
- Imposition of taxes on unsustainable biofuels practices could curb their development. Tax incentives and input subsidies could promote environmentally sustainable biofuels processes specifically. This would incentivise environmentally sustainable biofuels and also potentially compensate for efforts to comply with voluntary certification schemes. However, these initiatives might come into conflict with World Trade Organization rules.
- GHG emissions, deforestation and other environmental harms, e.g. associated with fossil fuels or current biofuels use, could be accounted for in the market.
- A more technology-neutral and goal-specific approach could be adopted in which governmental support is given to biofuels pathways based on the evaluation of their full life cycle and related externalities.
- Scaling of support based for example, on how carbon-efficient a pathway is, could be adopted.

5 Climate change

Climate change, or issues relating to this, featured often in consultation responses. For example, a few mentioned that increased biofuels use by society was acceptable as long as it did not exacerbate climate change or provided net GHG reductions. Several respondents regarded GHG emissions or climate impacts resulting from land use change as one of the most important ethical challenges raised by new biofuels. Several respondents thought that climate change and related aspects, such as land

[567] I.e. where use of biomass elsewhere, such as in bioenergy production or timber harvesting, continues in a non-sustainable fashion.

use change leading to GHG production, GHG savings, reliable LCA, or the use of other options to mitigate climate change, should be prioritised within policy.

In respondents' submissions on how they felt about society moving towards a greater use of biofuels, there was some discussion on the role of biofuels in climate change mitigation. Respondents were divided as to whether they believed biofuel use would mitigate climate change and as such was desirable/necessary; or that biofuel use would exacerbate climate change and as such was undesirable/should not take place. There was also discussion on the limit of biofuels' role.

When asked which new biofuels would be most successful in generating GHG emission savings, there was little consensus. When asked about how such new biofuels should be encouraged, respondents were divided broadly between market-based mechanisms and those based on certification. A distinction was also apparent between measures that would be technology-specific or goal-specific. Some warned that new biofuels should not be encouraged, or there should be care, based on certain risks they posed. A few respondents presented criteria for considering when new biofuels should not be encouraged. Some respondents did not respond to these questions at all.

a) Role of biofuels in climate change mitigation

- Sustainably produced biofuels contribute to climate change mitigation through reducing GHG emissions produced by transport. As such, they are desirable.
- Biofuels use is an essential part of responses to mitigate climate change given that there are no other carbon-neutral options for fuelling aviation and heavy vehicle transport.
- To have reason to move towards increased use, biofuels must generate net GHG emission savings, which are greater than those that would be achieved if money was invested in alternative renewable technologies.
- Increased biofuels use is only part of the solution for climate change mitigation. Other measures, which are perhaps more cost-effective or efficient, should not be impeded by biofuels. These could include:

  a hybrid vehicles,[568] electric vehicles and vehicles making use of hydrogen fuel;

  b intelligent public transport;

  c use of alternative energy sources – such as solar/wind – in other areas of society;

  d broader societal energy efficiency measures;

  e behavioural changes to lower energy consumption of society;

  f ecological restoration;

  g alternative uses of biofuels, e.g. to power fuel cells that are more energy efficient than the internal combustion engine; and

  h alternative uses of biomass, e.g. for heat, or heat and electricity generation.

- Biofuels use can help mitigate climate change, but this will be necessarily limited in scale to avoid harmful environmental impacts.

[568] Vehicles making use of petrol/biofuel blends and electricity.

- Biofuels produced on an industrial scale exacerbate climate change through increasing net GHG emissions, e.g. by land use change and fertiliser use.
- Increased biofuels use limits or discourages the adoption of other existing potentials to mitigate climate change.
- Biofuels use perpetuates the use of fossil fuels in transport, which contribute to climate change.

b) Most successful new biofuels for GHG emissions savings

- Lignocellulosic biofuels, including biochemical and thermochemical conversion pathways, can be relatively successful with regards to climate change mitigation, since all of the biomass is used. This optimises the energy-input ratio, minimising the need for inputs (e.g. fertiliser, land[569]) and displacing more fossil fuel.
- The use of wastes, e.g. agricultural, forestry, municipal, can reduce GHG emissions as it does not involve the cultivation of any crops and therefore any associated inputs. The use of wastes also avoids the production of GHGs produced by decomposition.
- The use of perennial crops as dedicated biofuels feedstocks – e.g. SRC willow and miscanthus grasses – produces less GHG emissions on account of their low fertiliser requirements.
- ABBs can be successful in producing lower GHG emissions due to the potentially high productivity of algae, the requirement for less land, and the use of waste carbon dioxide gas from power plants.
- The use of genetic technologies, e.g. plant breeding or genetic engineering, can help to achieve GHG emissions savings, e.g. through reducing the need for fertiliser, or raising productivity.
- There is a role for higher energy fuels such as butanol, which optimise the energy-input ratio.

c) Encouraging new biofuels that save GHG emissions

Technology-specific mechanisms

Market-based suggestions

- Financial support, e.g. subsidies, tax concessions etc., could be used to incentivise technologies known to deliver GHG savings, or cultivation of feedstocks that require minimum land.

Goal-specific mechanisms

Certification schemes

- Certification schemes that certify biofuels on the basis of their life cycle GHG emissions should be implemented. Standards could apply throughout the production pathway, e.g. excluding land that has high carbon stocks.
- Certification schemes should be evidence-based, standardised and achieve wide consensus. Certification should occur on a case-by-case basis.

[569] As previously mentioned, any lowering of land use minimises the need for land-use change which is associated with GHG production.

- Certification schemes should be applicable internationally and to other sectors to prevent 'system leakage', i.e. where biofuels production or the agricultural sector elsewhere continues in a non-sustainable fashion.

- Certification schemes should be complemented by robust regulatory mechanisms to ensure compliance. These could include mandatory reporting or the threat of penalties.

Market-based suggestions

- Provision of any support should consider whether alternative low carbon solutions exist.

- Commitment of governments or companies to source certified biofuels would reward and thus encourage their production.

- Taxes on GHG emissions, carbon credits or taxes on fossil fuel use could be used to support the production of any biofuels leading to lower GHG emissions.

More general methods to support biofuels that save GHG emissions

- Greater public investment in R&D and more private investment in mature technologies should take place. There should be sufficient flexibility with regards to investment to avoid impeding development.

- A strong biofuels market supported by long-term, clear governmental policy will encourage further investment – particularly private investment – in biofuels in general.

- Caps on biofuels use could be implemented where demand exceeds what can be supplied, thus preventing expansion into land that is carbon rich.

Other comments on GHG emissions

- Any taxation on liquid transport fuel could be problematic if there are no real alternatives for the consumer.

- It is important that biofuels delivering GHG savings are cost-effective and available in a reasonable timeframe.

d) Reasons for not encouraging GHG-saving new biofuels

Criteria

- New biofuels should not be encouraged if they displace other crops and thus cause iLUC.

- New biofuels should be discouraged if their use harms aspects of human security (e.g. food security, human rights, public health etc.).

- The amount of feedstock likely to be produced for new biofuels will only achieve small GHG emissions savings. Any decision to encourage/discourage must therefore consider the role for other measures too.

- There should be no encouragement if human and economic capital can be better invested in other climate change mitigation strategies.

Risks

- Dedicated biofuels feedstocks will exert demand for land, and could in this way prompt land use change and production of GHG emissions. Large-scale production is likely to be necessary to enable returns on economic investment; this could drive further land use change.

- Use of forestry waste for new biofuels could create perverse incentives leading to deforestation and GHG emissions production. This is especially relevant to some developing countries where governance is weak. The use of forestry wastes – typically used as organic fertiliser – could also lead to nutrient depletion of soil, soil erosion and losses of soil biodiversity.

- In developing countries, agricultural and forestry wastes are already used, e.g. for heat and power generation; sources of cooking fuel, fertiliser or animal feed etc. Use of these residues for new biofuels could drive greater use of fossil fuels in substitution. iLUC could also be caused if the residues are replaced by growing crops on land elsewhere.

- There are alternative uses of biomass that are better in terms of the energy yield and the net GHG emissions savings. Examples are biomass combustion for heat or heat and power, or co-firing power stations. Use of biomass for new biofuels could limit these methods.

Other comments on new biofuels and GHG emissions

- Not enough data exists to predict which of the new biofuels will be most successful in achieving net GHG reductions. It is unlikely that there will be a single new approach that is adopted. Different locations are likely to require different and perhaps multiple solutions.

- All new approaches should be considered. It is risky to consider endorsing a single technology given present uncertainty and the need for suitable approaches for different locations.

- New biofuels could provide GHG emissions savings but are currently not a realistic prospect. More R&D is needed to realise their potential.

- Current biofuels production should not be disregarded; there are ways of improving their GHG savings. Additionally, they are important for paving the way for new biofuels, e.g. driving sale of flex-fuel vehicles, encouraging the implementation of biofuels infrastructure etc.

6 Just reward and fairness of trade

In their submissions, respondents described issues that related to just reward and/or fairness of trade. For example, when questioned about the most important ethical challenges raised by new biofuels, fair return for farmers and appropriate wages and working conditions for workers were mentioned. Transparency of revenue dispersal was cited as a policy concern to be prioritised. Many responses regarding intellectual property (IP), land use and the rights of farmers and workers clustered around issues of just reward and fair trade. These typically related to developing countries. In these responses, there was mainly the view that new biofuels would cause problems related to just reward and/or fair trade. However, there was also the view that this depended on other factors and the problems were not exclusive to (new) biofuels production. Respondents also made suggestions for policy.

a) New biofuels could cause problems related to just reward and/or fairness of trade

Issues for farmers, workers and communities

- Market pressure for cheap biofuel will drive biofuels production in countries with minimal employment welfare standards (e.g. regarding wage and working conditions) so that companies are able to increase their profit margins.

- Large-scale production will dominate new biofuels production, enabling producers to benefit from economies of scale in achieving returns on sizeable investments. Historically, transitions to large-

scale corporate production have been associated with deteriorating employment standards.. Large-scale monoculture often leaves little profit at the local level.

- Large-scale production will increase the demand for land; this may pressurise local communities to give up their right of access to land that has economic, cultural or social value. Even so-called 'unused' land often has uses, e.g. grazing, firewood harvesting.

- Communities who have given up their right to land could be deprived of their rightful share of benefits derived from any future biofuels production on this land.

- There is a question as to whether it is ethical to enforce upon rural populations in developing countries a particular means of earning a living. This has happened for example with jatropha cultivation in some Asian countries.

Intellectual property issues

- There is a risk that traditional knowledge could be appropriated by companies, denying the community that developed the knowledge both the benefits of its day-to-day use and just reward from its use in new biofuels production.

- The same concerns may arise over naturally-occurring varieties that are indigenous to a particular location/country and appropriated for new biofuels production.

- The extensive use of genetically modified crops for new biofuels could mean that farmers using them become 'hostage' to expensive licensing agreements with the major seed companies. For example, the use of patented seeds can prevent the farmer from saving part of their crop for seeding next year. Thus, farmers may suffer financially due to seed producers demanding high prices and biomass traders offering low prices for biomass.

- New biofuels development is likely to require high levels of investments and developers will seek to protect this. They will try to achieve financial reward through exercising any IPRs.

b) New biofuels might not cause problems related to just reward or fairness of trade

- Technologies that reduce the need for new land – for example, lignocellulosic biofuels derived from waste – will reduce the risk of violating communities' right to access land.

- In developing countries, the trend towards industrialisation of agriculture in both food and fuel production could lead to improved labour standards and improved employment regulation.

c) Observations for the developing world regarding just reward

- Governments leasing land to foreign companies for the cultivation of feedstock are unlikely to engage local communities to identify their needs and perspective.

- There are fewer – or less well-enforced – regulatory safeguards for employment, e.g. regarding wages, health and safety.

- There is a risk of unscrupulous developers employing child labour.

d) Other observations regarding just reward

- Whether new biofuels will raise problems related to the rights of farmers and workers depends on which new biofuels approach is adopted, the scale and ownership of the production facilities, and how the new industry develops with regards to wider society.

- The negative effects on workers' rights seem to have less to do with the form of production and more to do with the existence of adequate frameworks at the national level for the protection and enforcement of labour rights.

- Land use issues are not exclusive to new biofuels production; they will arise where any agricultural or industrial practice requires land. Similarly, concerns regarding inadequate wages for workers/farmers and poor working conditions are common to the employment in the agricultural sector in general.

- There is little room for investors to profit from high-tech innovations in the new biofuels production chain which have been protected by IP, as ultimately the end market is a commodity market.

e) Suggestions for just reward and fair trade governance

Protecting farmers and workers

- There is a need to establish governance that is fair to all stakeholders, i.e. investors, companies, groups possessing traditional knowledge and making use of local varieties, farmers and workers.

- Projects developed together with local communities will favour the implementation of farmers and workers rights. The formation of strong cooperatives could also play a positive role.

- There could be recognition of farmers and workers as co-owners/participants of new biofuels production, rather than just feedstock producers. Indeed, recognition of local contexts by biofuels companies using local farmers and contracted workers has had little direct negative impacts on land access, and has represented a more positive model for local livelihoods.

- Corporate social responsibility and reputation management could be effective in preventing poor practices by companies, and there is a role for sharing best practice as the industry evolves. The Brazilian Government publishes a list of companies engaged in the sugar cane industry that have been found to use slave labour. By citation on this list, a company loses access to some federal finance.

- The implementation of national and/or international legislation regarding the rights of farmers and workers, such as the International Labour Organization Conventions, could be sufficient.

Protecting communities

- When companies acquire land, the free, prior and informed consent of the communities involved should be secured with adequate consultation. Compensation should be provided where appropriate. Moreover, developed countries should give compensation to any developing country losing economic development opportunities by keeping some land unconverted to achieve environmental sustainability.

- Policies which encourage land tenure development should be promoted in developing countries so that farmer groups have a recognised right to access land.

- It is important that biofuels production commits to transparency. It should be possible at any moment for companies to report about their business model and impacts on people and the environment. A standard/certification might achieve this objective.

Intellectual property issues

- The country of origin could have a share of the IPRs associated with new varieties.
- IP rules should prevail as according to international law. With regards to subsistence farming, the Convention of the International Union for the Protection of New Varieties of Plants (UPOV) contains a compulsory exception to the breeder's right whereby the breeder's right does not extend to acts done privately and for non-commercial purposes (breeder's exemption). Parties to the UPOV Convention may also permit farmers on their own farms to use part of their harvest of a protected variety for planting crops in the future.
- Commercial interests might require protection of just reward in new ways, e.g. through prize funds, patent-pooling, or open-source models.

7 Equitable distribution of costs and benefits

In their submissions, respondents described issues that related to the equitable distribution of costs and benefits. For example, some respondents described issues of this nature when discussing the most important ethical challenges raised by new biofuels, and several respondents described these as policy concerns which should be prioritised. These included, for example: the access of rural communities in developing countries to new biofuels production; technology-transfer; and the use of resources in developing countries for the production of biofuels destined for use in developed countries – and potentially at the expense of developing countries' food production and environment.

Of those who responded to the questions regarding IP/ access issues, and potential problems for farmers and workers,[570] some discussed issues relating to the equitable distribution of costs and benefits (these typically related to developing countries, though IP issues related to both the developing and developed world). There was a view that new biofuels could cause such problems. A few cited the importance of other factors – such as governance or the type of biofuel adopted – in determining whether any problems emerged. A few respondents also commented that the IP/access issues were not new or specific to new biofuels. Respondents also made suggestions for policy, the majority of which related to the developing world context.

a) New biofuels could raise problems that relate to equitable cost–benefit distribution

Regarding farmers and workers

- Developing countries may lack financial capacity or skilled personnel to engage with new biofuels, given that new biofuels are likely to be more technology intensive than current biofuels.
- Large-scale production will dominate new biofuels production to enable producers to benefit from economies of scale. Research into the highly-capitalised, industrialised sugar cane industry has shown that there is a low demand for labour from poorer groups, e.g. due to mechanisation, and that the model is incompatible with traditional farming methods. This has contributed to an increase in economic inequality and a lack of autonomy on the part of the rural poor.
- New kinds of job will require different skills; it may be easier to bring in a new workforce rather than re-train the existing workforce.

[570] Many respondents did not respond to the question on intellectual property and access issues. Some respondents did not respond to the question regarding the rights of farmers and workers.

- The model of biofuels production for an export market that simultaneously benefits domestic economic development could be simplistic. Historically, such production has largely benefitted those controlling the plantations, as well as fuel companies and international commodity traders. Local communities have suffered because of for example, slave-like working conditions, forcible removal from their land etc.

Intellectual property and access issues

- The existence of IPRs – and restrictive exercise of these – could raise issues of access by other new biofuels developers, e.g. to enzyme technologies, conversion processes, and plant varieties.

- The IP/access issues are not in principle different from those seen in other areas of biotechnology. However, some of the problems may be more pronounced given the fragmentation of research efforts, with different groups sponsored by different industrial partners, thus making communication more difficult.

- IPRs could generate issues of access in particular by groups in developing countries, which cannot afford the costs of licensing. This would impede technology transfer and raises the spectre of a possible 'biofuels technology divide'.

- Given the range of technologies likely to be involved in the production of new biofuels, the area seems particularly prone to patent-stacking and patent-thickets.

- Developing countries which own IPRs for organisms could be overprotective, and thus hinder research progress.

b) New biofuels might not raise problems that relate to equitable cost–benefit distribution

Regarding farmers and workers

- Production of new biofuels could create more jobs especially in rural areas.

Intellectual property and access issues

- IPRs could facilitate technology transfer. Published patent documents constitute an accessible global source of information, translated into various languages. Technological development is then dependent on a country's ability to use the technology.

- Compared to their role in the pharmaceutical industry, IPRs will play a different role in the biofuel industry given that patents will typically be sought for specific technology components, for example for. improvements. There will be competition amongst such patented products within the industry – and with alternative energy sources. This could drive licensing fees down.

- Trade and tariff barriers and other restrictions with agricultural products pose greater threats to access of developing countries to new biofuels technology than IPRs.

c) Other observations regarding equitable cost–benefit distribution

- Whether there is equitable distribution of costs and benefits will be variable and depend on which new biofuels approach is being considered, as well as the scale and ownership of the production facilities. For instance, new biofuels production need not be as centralised as fossil fuel production; decentralisation could benefit small producers.

- Governance at both the local and national levels will matter. For instance, the formation of farmer cooperatives or unions could ensure more equitable arrangements.

d) Suggestions for governance for distributing benefits to farmers and workers

- Emphasis should be placed on ensuring that biofuels development actively involves all stakeholders.
- Local benefits should be a central requirement of new biofuels production. For example, there should be access to affordable energy in the region before any export is considered, and there could be initiatives to employ a local workforce.
- Countries in the global South should be assisted to establish a green economy, as well as defences against climate change and diminishing quantities of readily available oil ('peak oil').

Specific potential measures to support equitable cost–benefit distribution

- Grants could be made available to farmers and growers – in both developed and developing countries – to enable their participation in value creation.
- Investment could be directed towards technology options that would facilitate the participation of farmers and workers globally. For example, decentralised varied production can mean greater social benefits at the local level.
- There could be promotion of technology transfer to enable participation by developing countries. There also could be opportunities for sharing best practice as the industry develops.
- New biofuels technologies that minimise environmental and socio-economic impacts of biofuels could be made freely available, especially to developing countries.
- In the developing world, small-scale farmers and workers could be protected in large-scale production by participatory schemes, e.g. shares, minimum price regulations etc.
- To empower developing world farmers in their relationships with biofuels distillers, farmer alliances could be established or promoted, and the use of multi-option crops adopted.
- Public–private partnerships (PPPs) could provide investment for large-scale demonstration of technologies developed for the production of new biofuels and this could lead to sharing of the rewards.
- Policy makers should ensure that any sustainability requirements do not unnecessarily (i.e. without significant benefit to the environment or people) restrict producers.

e) Suggestions for governance for intellectual property and access

- It is important that companies do not hinder development and use of new biofuels technologies by the overprotective use of IPRs. Developing countries that own IP behind organisms such as plant crops should similarly also not hinder progress.
- It is likely that much of the new biofuels industry will rely financially on licensing of IPRs. To forge a meaningful industry, robust protection of IPRs will be necessary.

Specific potential measures

- The International Treaty on Plant Genetic Resources for Food and Agriculture and its Multilateral System on Access and Benefit-Sharing focuses on food and feed crops of importance to food security. A similar system could be designed for biofuels feedstock.
- International organisations could hold the patents for technologies for new biofuels to ensure access for all. A two-tier fees system could be established depending on the wealth of the country seeking licence.

- Issues of IP and access should be left to industry to deal with; governments should not play a role here.
- Increased public investment in R&D, e.g. by universities, would help to ensure greater public ownership of socially valuable technology, as well as greater access through appropriate licensing agreements.
- A multi-stakeholder process from the start of R&D would help ensure access. There are already a number of joint industrial ventures designed to co-develop and share IP, to enable access to enzyme technologies and thermochemical processes.

Regarding licensing agreements

- Cross-licensing among firms may permit each to use some of the technological features developed by others in a non-monopolistic way.
- Licensing agreements should include clauses which allow exploitation by other parties if the original commercial partner is not interested in doing so. Such a clause might include a timeframe for commercialisation beyond which the licence would be forfeited.
- Exclusive licensing agreements should be avoided as these can obstruct research. Compulsory licensing with fair license fees would help advance wider R&D.

Regarding developing countries

- Much IP can and should be generated in developing countries where both new biofuels feedstocks and final products will be produced. For example, there could be collaborative generation of IP between developed and developing countries, with IP and any value produced shared.
- A system whereby payment in kind (e.g. knowledge transfer, reduced seed costs etc) replaces monetary transactions could be adopted with developing countries.
- Licensing agreements should contain special provisions for developing countries.

8 Research and development

Consultation respondents were asked which of the new approaches to biofuels looked most promising for commercial and sustainable use, and over what timescales these developments might be commercialised. Some did not respond. Several other respondents explained that they could not respond because they either did not have enough information or were not expert enough to make an assessment. A few respondents commented that it was difficult to predict as it was still at an early stage. Amongst the answers that were submitted, there was a range of opinion and detail, of which broad areas of consensus are presented below. Respondents tended to single out feedstocks, processes or end products rather than whole production chains.

When asked about R&D (what were the current constraints; where should R&D be targeted and by whom) many respondents did not submit answers; a few other respondents indicated that they felt unable to comment. Of those that answered, respondents were divided in opinion regarding constraints that related to current steers for research (for new biofuels and biofuels in general), funding, IPRs and the wider 'regulatory' environment. The developing world context was also considered. When asked about where R&D should be directed, many cited specific technological targets for R&D; these are not reproduced here. Some respondents made wider observations, for example, regarding the nature of R&D that should be encouraged or the type of new biofuel that

should be developed. A few suggested that R&D should be targeted elsewhere rather than at new biofuels.

a) Current state of research and development

Technologies and feedstocks

- Lignocellulosic biofuels production involving biochemical processes appears promising. This might involve pretreatment of feedstock followed by microbial fermentation or enzymatic digestion. Production of enzymes by the feedstock itself is also a possibility.
- Lignocellulosic biofuels production involving thermochemical technologies, such as pyrolysis and gasification have potential. These might make use of a range of feedstocks including waste, especially in light of increasing urbanisation and large waste outputs.
- ABBs hold promise, including those produced from microalgae or macroalgae (e.g. seaweed). Biofuels can be generated by production of fatty acids which can then be converted to synthetic hydrocarbons.
- Technologies that use waste (e.g. agricultural, forestry and municipal) could play a role in the future. For example, use of agricultural residues would enable farmers to achieve best returns on their investment and yield a low carbon footprint.
- Use of energy crops, including miscanthus or switchgrass, could deliver in terms of cost, availability and GHG emission performance if there is also a reduction in enzyme costs and feedstock yield improvement.
- The use of genetic technologies, e.g. genetic modification and synthetic biology, appear promising.
- The biorefinery concept has potential where thermochemical processing and biochemical processing routes are combined, with a wide range of feedstocks converted into fuels and chemical intermediates.
- The production of biobutanol – a so-called ‘drop in fuel’ due its compatibility with existing petroleum fuel infrastructure – is also a potential avenue.

Problems

- Thermochemical technologies present problems. For example, pyrolysis generates oil of poor quality, requiring significant and costly pretreatment before it can be upgraded by a conventional refinery. It is also energy intensive. For gasification, biomass is a poor substrate due to its high oxygen content.
- Lignocellulosic biofuels production is associated with high costs, e.g. due to processing costs, which could limit efforts to scale up production. It is also likely to be high-tech, potentially restricting access by small-scale producers in the developed world and populations in developing countries.
- Much ABB production relies economically on the generation of high value co-products. Such a business model cannot be scaled up since this would result in increased levels of co-products, thus reducing their market value.

Timescales for commercialisation

- Estimates for commercialisation of lignocellulosic bioethanol production (produced by biochemical processing) vary between around five to ten years. Technological developments necessary to its

production – e.g. production of efficient affordable enzymes – are taking place or are expected broadly in the next five years.

- Estimates for commercialisation of ABBs production are around the ten-year timescale.
- Commercial development will depend on whether subsidies or incentives are available for biofuels production. Sufficient funding and policy infrastructure are also determinants.

Other comments on research and development

- As oil prices rise, new biofuels production may become more feasible.
- The most promising approach will be one that combines optimised aspects along the entire production pathway.
- There is considerable hype regarding the potential of new biofuels, and this may be in order to secure investment.

b) Constraints for research and development for new biofuels

Current direction

- There is an absence of a centralised, for example government-led, programme providing funding or direction. As such, fragmented research initiatives led by industry have arisen. Research has focussed more on biological breakthroughs than scaling up biofuels production. This has delayed the translation of research into commercial applications.
- The breadth of technological pathways was down-sized – and may continue to be so – by the US Government agencies to focus funding on a few possibilities, in the hope of accelerating their development. This prevented serious consideration of other pathways.
- Too much is being invested in R&D for current biofuels rather than new biofuels.
- There has been a broader tendency to concentrate on benefits that can be achieved in the short term, e.g. there has been some focus on using biomass for combined heat and power generation, rather than biofuels production. This is due to a plurality of competing alternative approaches and uncertainty about biofuels.

Funding and the 'regulatory' environment

- There is a lack of public *and* private funding for new biofuels development, attributable to: an absence of policy supporting or promoting R&D activities; a lack of investor confidence in both future political support for biofuels and their economic viability;[571] the current state of the economy.
- Funding is complicated by a fragmentation of research efforts. Additionally, there is competition for investment with other types of technologies, e.g. electric vehicles.
- There is a risk of negative publicity and public opinion partly due to the problems with current biofuels and the lack of clarity or resolution of these. Uncertainty about the public acceptability of new biofuels could stifle funding.

[571] For example, with regards to competing with fossil oil, or the sufficient availability of feedstocks.

- There is uncertainty over European legislation with regards to the release of genetically modified organisms, which could feature in new biofuels production.

- There is insufficient time to develop new biofuels to achieve political commitments by 2020 as set by the Renewable Energy Directive.

Regarding the developing world

- Insufficient capacity, e.g. in terms of skilled personnel, is a problem in developing countries. This might also become a problem in the UK in view of the decline in funding for basic plant sciences as well as a prevailing low esteem of plant sciences in schools.

- There has been a lack of research that would enable translation of basic research to locations worldwide, and there is also little research that would benefit small-scale producers in developing countries.

Other comments on research and development

- R&D for new biofuels receives significant financial and political support; this support should be re-evaluated in the context of their social and environmental consequences, as well as economics.

- R&D is not constrained enough by the requirement to consider the effect of biofuels production on land use, food security and the environment.

Suggestions for governance

- There should be some coordination of research efforts, perhaps at the international level to prevent duplication of efforts.

- The governmental and industry-led groups should help facilitate translation of research into commercial applications, e.g. through connecting researchers and manufacturers.

- Credible, substantiated information on new approaches to biofuels should be made available to the public at large.

- There needs to be an economic or regulatory incentive to use biomass for biofuels.

c) Suggestions for research and development targets

Types of research and development along the production pathway

- There is a need for an integrated approach to biofuels R&D that considers the entire production pathway, from basic research to scaling-up production.

- Cross-disciplinary research – e.g. biological, chemical sciences, agronomy, ecology etc. – should be targeted through policy and funding.

- More R&D should focus on optimising downstream systems, e.g. generating greater value from biorefineries.

- Focus should be given to integrating production systems into existing societal frameworks, e.g. feed, materials, paper production systems.

- R&D will be necessary to assist in the transition from a society widely dependent on petroleum-based fuels to biofuels, e.g. in terms of increasing efficiency; engine design; infrastructure for distribution and storage.

- There is need for constant review of R&D targets since it is unclear which approach will be most effective. Evaluation should be evidence-based and could consider LCA, transferability etc.
- Improved modelling and analytical methods are necessary. LCA research should be prioritised, with LCA including energy gains, GHG emissions, environmental and social impacts and considering the molecule from 'field to tank'.
- R&D should be directed towards achieving objectives, rather than at technologies.

Types of new biofuels

- R&D should be directed towards:

a increasing utilisable biomass per unit or land;

b biofuels derived from wastes;

c lignocellulosic biofuels derived from mixed biomass streams;

d biofuel produced from new sources such as algae;

e new biofuels based on competitive and efficient use of inputs, e.g. biomass and energy inputs;

f 'entry-level' feedstocks that would enable the transition from traditional agriculture to production of new biofuel feedstock;

g approaches that are not reliant on subsidies to be economic;

h producing fuels other than bioethanol and biobutanol and fuels intended for aviation;

i new biofuels derived from feedstocks that can be easily grown by marginalised farmer groups in developing countries; and

j new biofuels based on more decentralised, small-scale production.

d) What should the decision-making process be like?

- The decision-making process should be more transparent. Many stakeholders should be consulted on their views, e.g. developers, vehicle manufacturers, policy experts, the public, non-governmental organisations.
- Some stakeholders should have greater say, e.g. wider society; or industry and end-users.
- There should be international consultation to ensure that the interests of different states and populations are recognised equitably. There should be international agreements to this end.
- In relation to publicly-funded research, industry and academics should be brought together to identify the most promising route.

Who should decide?

- Government should provide a policy background to encourage biofuels development. Targets could be set, allowing industry and other bottom-up initiatives the freedom to develop solutions.
- Strategy needs to be decided by a steering body representing and reconciling the views of different stakeholders, such as academics, biomass users, producers, and Government.

- The market will decide which developments are pursued, but guidance from responsible environmental agencies will be needed.
- Government should fund and direct fundamental science *and* its commercial implementation.
- The private sector should finance and direct research aimed at scaling up new biofuels production. Their involvement should be facilitated by Government.

9 Investment

When asked about where new biofuels investment should be directed and who should invest, many respondents did not respond; one respondent commented that they felt unable to answer the question. Of those that did respond, several described types of new biofuels that should be invested in (e.g. should not compete with food). A few respondents mentioned specific targets for investment. Several respondents believed that the public sector, private sector or PPPs each had a role to play in investing. There was some differentiation as to where their respective investments should be targeted. Attributes of public, private or PPP investment were described.

a) Investment targets

- Investment should be directed towards new biofuels that reduce the impact of human activity on climate change, especially since climate change mitigation is a driver for biofuels development.
- There should be investment in new biofuels that do not have the negative consequences seen with current biofuels, such as large-scale land use change, or competition with food.
- New biofuels that are compatible with rural development (e.g. facilitate the participation of farmers) are also an investment target.
- Small-scale and decentralised production should be prioritised as these are likely to be more sustainable.

b) Who should invest?

- The public sector should invest in the transfer of technology to the developing world.
- Investment in production that benefits small-scale farmers is more likely to be provided by the public sector than the private sector.
- In the developing world, both the public sector and private sector have a more limited capacity to invest; PPPs represent a way forward.
- PPPs have a role in translating innovations into products and getting the product to the market. PPPs should invest in the large-scale demonstration of technologies.
- The private sector could invest in R&D that may be so specialised as to be only relevant to their processes.
- It is likely that the private sector will invest increasingly in R&D, thus taking over from public financing, as commercial value is established.

Attributes of public, private or PPP investment

- Public investment would help to ensure that technological developments are public and capable of being transferred to other developers and countries.

- The provision of public or PPP investment would enable the provision of production pathways that are economically *and* socially sustainable, in contrast to industry where outcomes may be aimed more towards economic viability.

- Private or PPP investment are most efficient in delivering outcomes.

Other comments on investment

- There should be investment from international multilateral financial bodies.

- There is a need for coordination of investment to avoid duplication of efforts.

- It is important to align investment in biofuels production with development and poverty reduction strategies.

- It is wrong to encourage some developing countries' governments to invest in biofuels production. The public sector here is already limited financially and historically, biofuels production has not benefitted the poor owing in part to differing state capacities and difficulties in implementing production and/or enabling use.

10 Issues of policy

Respondents were given the opportunity to indicate policy issues concerning new biofuels. Many did not respond, and one respondent observed that they felt unable to comment. Those that did respond described issues of policy already mentioned in previous analyses, e.g. relating to food, environmental sustainability etc., and these are not reproduced here. Support policies for biofuels in general were discussed, and these were seen broadly as problematic. Regulatory policies such as certification schemes also drew concern. Such issues were believed to relate to new biofuels as well, since these were subject to such policies or were likely to be so in the future.

a) Issues regarding biofuels support policies

- Targets and subsidies have been effective in stimulating rapid expansion of biofuels production but with little oversight for sustainability. Environmental and social harms have been incurred as a result.

- The use of such 'unconditional' biofuels support policies has made all current biofuels economically competitive, and has thus to some extent limited the drive to develop new biofuels that are more cost-effective and sustainable.

- Smaller producers do not necessarily benefit from biofuels support policies. For example, financial incentives provided at the point of duty (i.e. when the Government taxes imports or exports) are paid to the large oil companies involved in distribution, leaving smaller producers to negotiate their share.

- In policy, the economic and energy security interests of major developed countries have outweighed consideration of environmental, food security and poverty reduction issues. Also, in general, there is little consultation by policy makers with social scientists who are studying the harms associated with biofuels production.

- An industry for new biofuels requires large investments of time and money. A policy framework to develop confidence for investment is needed.

- Policies that support specific new biofuels technologies rather than goals (e.g. lower GHG emissions) risk not achieving the maximum benefits possible. At worse, given the difficulty in predicting 'winners', an inefficient technology could be supported.

b) Issues regarding biofuels regulatory policies

- Application of certification schemes for sustainability is currently voluntary. However, this can mean low uptake and a reduced drive to produce sustainable biofuels. There is thus a question of whether such schemes should be mandatory.

- There is limited consensus as to how to evaluate biofuels production pathways. There is a need to develop protocols that are standardised, agreed upon and evidence-based.

- Whilst states recognise the importance of developing sustainable biofuels, there is a lack of political will for their production.

11 Suggestions for governance

Respondents were invited to suggest the most effective policies for promoting or regulating new biofuels development. Many did not respond, with a few of these stating that they had already made suggestions in previous submissions. Another respondent said that they felt unable to comment. Suggestions relating to food security, environmental sustainability etc. are not reproduced here but are in previous analyses. Recommendations are grouped broadly into market-based mechanisms and other types of policy intervention. There were proposals across the production pathway and for wider society, e.g. policy makers and the public were considered. Respondents made some suggestions that were relevant to biofuels in general; these points are presented here as they too have a bearing on the promotion or regulation of new biofuels. Recommendations were also made as to how 'sustainable' biofuels could be governed; rather than new biofuels.

a) Promoting biofuels in general

- Mechanisms to enable use are important. To this end, it could be useful to support collaboration between developers and end-users. Uptake might also be promoted through providing consumer incentives.

- Creation of a 'level playing field' for all agricultural products would prevent certification schemes for biofuels serving as a penalty to the industry.

- Effective regulation would do much to build consumer and market confidence in the sustainability of biofuels, and could promote biofuel development.

b) Promoting new biofuels

Market-based mechanisms

- In the UK, production of biofuels in general has been promoted through the provision of duty rebates and the existence of the Renewable Transport Fuels Obligation. New biofuels production could be specifically and directly promoted by provision of capital grants. A system which rewards their production could also be adopted, e.g. including duty rebates, tax concessions of certain processes etc.

- Mandated markets for new biofuels could be effective. The US requires that an increasing part of its renewable fuel target comprise 'advanced' biofuel. Such markets might also be established at European level or a national level.

- Indirect promotion could be achieved through providing financial incentives for biofuels production which are *goal* specific (e.g. produce lower GHG emissions), rather than being aimed at specific technologies. The scale of the reward could be proportional to the outcome.

- The wider introduction in society of carbon credits (where value has been assigned to reducing or offsetting GHG emissions), incentives for recycling waste, or taxation of GHGs could help promote new biofuels development.

- New biofuels could be associated with increased capital costs, e.g. due to implementation of good practices. Any biofuels certified as sustainable might similarly have additional costs, e.g. due to auditing procedures. These reduce the competitiveness of producers; therefore widespread market commitment is required to promote their production, e.g. where consumers are willing to pay higher prices, companies commit to sourcing only new biofuels, or fossil fuels are taxed to reflect their associated harms.

- Market measures should have an end-date – or a clause to enable their phasing out – to avoid hindering wider development. Where financial support is given, this should be limited as unlimited support tends to encourage inefficiencies.

Other mechanisms

- Political will is important. There is a role for multilateral international organisations, such as the Organisation for Economic Co-operation and Development or the Food and Agriculture Organization of the United Nations, to promote new biofuels. Balanced public engagement, as well as thoughtful engagement with the media for dissemination of information would help both to foster political will as well as stimulate their use.

- Encouraging teaching in new biofuels, for example by engaging with education institutions, would promote their development.

- Appropriate facilities to translate work from the laboratory to large-scale production (a process analogous to translational medicine) are required.

- It is important to establish new necessary infrastructure across the new biofuels production pathway, e.g. to enable the transport of agricultural, forestry or municipal wastes to points of biofuels production.

- Implementation of the Renewable Energy Directive could support new biofuels in Member States. The use of policy to regulate 'biofuels' (e.g. requiring certification scheme use) would drive the development of sustainable biofuels, which could comprise new biofuels.

c) Regulating biofuels in general

- It is not effective to introduce targets and provide incentives for biofuels production first and then to devise regulation. Oversight is required both before and after targets have been set.

- Trade barriers and tariffs could be reviewed to enable the import of biofuels from countries where there is sustainable biofuels production, e.g. involving sustainable land use through the use of zoning.

- Other trade measures could be beneficial such as World Trade Organization agreements on agriculture, technology transfer and IPRs, liberalisation of environmental goods and service, and norms on subsidies.

- Bans, e.g. import restrictions, to stop unsustainable biomass use could be used.

d) Regulating new biofuels

- If incentives were to be introduced to promote new biofuels production specifically, these have to be scaled in proportion to their success. For example, tax concessions for processes that achieve GHG savings would be dependent on how effective those processes were. Financial incentives could even be cancelled.
- The provision of any direct incentives should be reviewed and coupled with funding for further research.
- Sustainability rules for best practice which are evidence-based could be adopted.
- Certification schemes that are standardised, evidence-based and have broad consensus could be used.
- Many initiatives designed to assure the sustainability of agricultural commodities are currently industry led, e.g. the 'roundtables'. Uptake has been a problem in some instances. This raises the question of whether Government should take a stronger role in regulating against harms. Mandatory thresholds could be enforced.
- There is a place for consultation with multiple sectors (including representatives from the rural poor) on an international scale, organised by a multilateral body.
- A halt to and thorough review of current policies is required before policies are enacted in relation to large-scale production of new biofuels.

e) Other comments on governance

- There should be consideration whether biofuels production on an industrial scale should be banned.
- It is necessary to agree a hierarchy for using biomass before any policies are established. Whilst biomass may be used more efficiently to generate heat and/or power, there are currently other possibilities for this. Biofuels production could take primacy since it is currently the only viable substitute for petroleum-based fuels.
- Any regulatory framework for biofuels production, e.g. a certification scheme considering impacts of land use, should be applied for all agricultural production and other forms of energy production. This avoids trade distortion.
- There is a need for integrated policy across the production pathway which examines and addresses policy conflicts. Biofuels also should not be considered in isolation of other energy sources and energy efficiency measures.
- Rapid and effective evaluation of new approaches with regards to their sustainability are important to avoid slowing R&D and limiting innovation.
- Policies alone will not be enough. There needs to be effective actions associated with them based on understanding the real challenges. Indeed, location-based approaches will be necessary.

List of respondents

There were 43 responses from organisations and 50 responses from individuals; 13 respondents (organisations and individuals) requested not to be listed.

Organisations

1. Advanced Biofuels USA
2. Avantium
3. Bahamas Green Energy Solutions
4. Biofuelwatch
5. Biotechnology and Biological Sciences Research Council Sustainable Bioenergy Centre (BSBEC)
6. BP
7. Delft University of Technology, Kluyver Centre for Genomics of Industrial Fermentation, Section BTS
8. EcoNexus
9. ESRC Centre for Genomics in Society
10. EuropaBio
11. Faculty of Science, University of East Anglia
12. Food Not Fuel
13. Friends of the Earth England, Wales and Northern Ireland
14. Gasification Australia
15. GeneWatch UK
16. INRA, CEPIA division: Michael O'Donohue (Research Director, Deputy Head of INRA Department CEPIA), Thierry Chardot (Research Director, Department CEPIA)
17. Institute for Science, Ethics and Innovation
18. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
19. International Union for the Protection of New Varieties of Plants (UPOV)
20. NNFCC
21. Novozymes
22. Rothamsted Research
23. Royal Society of Chemistry
24. Society for General Microbiology
25. spaice
26. Swan Institute, Newcastle University
27. The Linnean Society of London
28. The Society of Biology
29. United Nations Office of the High Commissioner for Human Rights (OHCHR)
30. University of Cambridge Bioenergy Initiative
31. Vertigo SDC Limited
32. Volkswagen Aktiengesellschaff, Group Research, Environmental Affairs
33. World Business Council for Sustainable Development
34. World Trade Institute
35. Worldwatch Institute
36. Geoff Bell, CEO Microbiogen
37. Michael Hammer, One World Trust
38. Simon Graham, Environmental Strategist at Commercial Group
39. Tim Rice, ActionAid

Individuals

1. Anil Hira
2. Ben Phalan
3. Bernardo Ospina
4. C. Ford Runge, University of Minnesota

5. Daniel Asin
6. David Alan Walker
7. Dennis Baker
8. Dr Ben Richardson
9. Dr Gordon Allison, University of Aberystwyth
10. Dr Joerg A Priess, Helmholtz Centre for Environmental Research, Germany
11. Dr Joachim H Spangenberg, Sustainable Europe Research Institute SERI Germany e.V.
12. Dr Magni Bjarnason
13. Dr Matthew Struebig
14. Dr N Baghaei-Yazdi
15. Dr Paul Upham, Manchester Institute of Innovation Research and Tyndall Centre Manchester, University of Manchester
16. Dr Peter J Leggo
17. Dr Thomas Molony, Centre of African Studies, University of Edinburgh
18. James Palmer
19. Jason Hill
20. Jeffrey A McNeely
21. Jonathan Gressel
22. Kyriakos Maniatis
23. Nazia Habib-Mintz
24. P Wadsworth
25. Pete Smith, University of Aberdeen
26. Peter Phillips, Johnson Shoyama Graduate School of Public Policy, University of Saskatchewan, Principal Investigator on Genome Canada funded project Value Generation through Genomics (VALGEN), David Castle, Faculty of Arts and Faculty of Law, University of Ottawa, Principal investigator on VALGEN, Stuart Smyth, Department of Bioresource Policy, Business and Economics, University of Saskatchewan, Collaborator on VALGEN, Henry Venema, International Institute for Sustainable Development, Collaborator on Genome Canada funded project Microbial Genomics for Biofuels and Co-products from Biorefining Processes (MGCB2), Matt McCandless, International Institute for Sustainable Development, Researcher on MGCB2, Colleen Christensen, Acting Executive Director of the Feeds Innovation Institute, Network Lead on Agriculture and Agri-Food Canada funded project Feed Opportunities for the Biofuels Industry (FOBI)
27. Phill Piddell
28. Prof Ali Sayigh, WREC
29. Prof DWH Walton
30. Prof Keith Smith
31. Prof R Sylvester-Bradley (ADAS)
32. Prof Stefano Cavallaro, c/o Dipart. Chimica Industriale dell'Università di Messina
33. Professor Jim Lynch
34. Professor Peter Guthrie, University of Cambridge
35. Robert C Brown, Bioeconomy Institute, Iowa State University
36. Robert G Thomas, Church Farm, Colwinstone
37. Robert Henry
38. Saleh M.K. Saleh
39. Sally Gee, Manchester Institute of Innovation Research
40. Simon Gould
41. Sven Sonander