European biofuels to 2020 and beyond
Executive Summary

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Background

Europe urgently needs to change gear in its ambitions to develop a market for transport biofuels in the coming decade. Liquid fuels of one form or another will remain the major source of energy for transport in 2020 and beyond, as other alternatives to oil such as renewable electricity and hydrogen cells, struggle to deliver equivalently effective energy solutions. Biofuels are, of course, not without their own problems. There is no doubt that some alternatives perform better than others in terms of climate change performance. There is also the issue of how cultivation of feedstocks competes with other uses of land. But, the central question remains: to what extent will Europe reduce dependency on oil for transportation over the next decade and beyond – and what role can biofuels play? We believe that Europe needs to look to biofuels alongside other options, to face the twin challenges of the approaching energy crisis as oil supplies diminish, and to reduce greenhouse gas emissions.

The Sustainable Consumption Institute funded European Biofuels 2020 project sought to develop a better understanding of how biofuels could make a significant and sustainable contribution to European transportation in 2020 and beyond. To do so, the project team analysed the current European biofuels landscape and interviewed expert stakeholders on their initial expectations of what would happen to European biofuels by 2020. Following this, SCI researchers conducted a foresight exercise with a scenario workshop to consider what could happen to create a situation where biofuels do make a significant and sustainable contribution to European transportation. The headline conclusion from this research is that if Europe is to stand any chance of making the transition away from its dependence on oil for transportation, sustainable biofuels should be promoted in Europe.

The Global Context

Globally, the emergence of biofuels for transport has been driven by depleting oil stocks, the need to address climate change, efforts to stimulate rural communities and by economic opportunities for firms and nations. Global biofuel production is currently dominated by Brazil and the USA, based on bioethanol from sugarcane and maize respectively. Europe lags behind with its focus on biodiesel produced from rapeseed. Levels of biofuel consumption also display significant geographical variation, largely as a result of the way that different drivers have entered the political agendas in different countries. Early expansion of the Brazilian biofuels industry in the 1970s was motivated by energy security and the need to find alternative economic uses for sugar. It is now also shaped by the economic opportunities from the creation of an export market.

The more recent and rapid expansion of biofuels in the USA also emerged as a political response to energy security. By contrast, the main driver for the use of biofuels in Europe has been mitigating climate change and this has not mobilised the same degree of political support seen elsewhere. However, the project research team believes that the issue of energy security, associated with rapidly depleting oil stocks and a fractious global oil market, will move up the European agenda over the next few years. This will create a renewed demand for biofuels in the absence of any other viable technological alternatives. Even the most
optimistic predictions for electric vehicles do not envisage major substitution of the European road transport fleet within a decade – and no-one is seriously contemplating the electric aeroplane. Finally, we anticipate growing recognition that increasing oil prices present a serious risk to the prospects of Europe moving out of the current economic downturn – and this will add to the growing demand for oil alternatives. Overall, the demand for liquid fuel-based transportation is unlikely to fall dramatically over the next decade or more. This places an urgent need to find alternatives to conventional oil-based fuels. Despite what we found to be widely acknowledged challenges, biofuels have the potential to become part of the solution.

**Overcoming obstacles**

Two issues will require resolution in order to establish a renewed demand for biofuels: how to deal with competing demands for land, widely discussed as the food vs. fuel debate; how to ensure that biofuels offer real greenhouse gas savings compared to fossil fuels. The project acknowledged that these were serious concerns that had come to the fore in the past few years. But it also formed the view that these challenges could be overcome.

The food vs. fuel debate needs to be placed in the context of much wider concerns about global food security. There are many drivers at work here, including population and demographic trends, changing food tastes, and the persistent inequity of food distribution and access across different global regions. Opportunities to drive up agricultural productivity for all types of farming will need to be seized: the diffusion of existing agricultural best practice can make much progress in this respect; the development and adoption of agricultural biotechnologies even more. The results from this project are based on an assumption that the sustainable intensification of agriculture is a realistic possibility. Increased agricultural productivity will help to alleviate the growing competition between different uses of land. Competition between food and energy crops will also be reduced where the latter are grown on marginal land unsuitable for food crops and also where agricultural residues from food crop cultivation are used as the biofuel feedstock.

The greenhouse gas (GHG) saving potential of alternative biofuels has received considerable attention. The current scientific debate, in which there is little consensus, involves models and estimates of GHG emissions that result from changes in land use associated with new biofuel crop cultivation. Recent studies have estimated emissions related to direct and indirect land use change for a range of crops and locations. The results show considerable variation in GHG performance, with some crop location combinations associated with higher emissions than fossil fuels and some much lower. There is a clear need to improve the science in this area, especially in relation to the indirect effects that assume particular economic dynamics in the global agricultural system. But, it is now clear that some biofuels will be much greater GHG savers than others, and those that perform badly in this respect will fail to find a market. New policies, technologies and practices can be developed to manage the climate impacts of direct and indirect land use change. Europe is in a position to lead the way towards developing clear sustainability standards and regulations that can maximise the GHG saving potential of biofuels in the future.
Box 1: Success Scenario for European Transport to 2020 and Beyond: “Driving Europe towards sustainability and security”

As the world pulled itself out of recession, the price of oil began to rise significantly, with a considerable amount of volatility, from between $110 to $160 per barrel. In the early part of the decade to 2020, the recession had damaged investment in new oil fields, and continuing political instability in the Middle East had led to uncertainty of future supply. But it had been recognised that diminishing supply in relation to growing demand in BRI C countries (Brazil, Russia, India and China) raised a renewed threat of global recession from an energy crisis. Amongst developed economic regions, Europe had been particularly badly affected, because of its high dependency on fossil-fuel diesel, and low targets for renewable transport fuels.

By the time of the review of renewable energy in 2014, it had become clear that even the original 2020 targets were unlikely to be achieved without much stronger governmental action. The European economy was suffering with high energy prices and oil dependency. In comparison, more ambitious targets in the US had stimulated the emergence of commercial-scale cellulosic biofuels by 2014 and raised the overall level of all biofuels to 15% of total consumption, on track for achieving 30% by the mid-2020s.

Economic stagnation and rising unemployment in Europe, had become increasingly identified with high energy costs and fossil fuel dependency, and this pushed the political leadership in Europe into a new sense of urgency. Oil prices and energy security – both initial drivers for the US and Brazil – required that targets for renewables were driven higher than had been the case to meet Global Climate Change commitments alone. The impact of high energy prices proved to have a more direct, immediate and publicly recognised effect in changing policy than the threat of global warming. The demand for strong political leadership in shaping future energy markets had risen to the top of the public’s agenda.

Following the 2014 review, the 2020 target of 10% renewable energy for road transport had been abandoned in favour of a longer term, progressive plan for incremental increases of 1% per annum from the then current average European level of 6.5%. Although subsidiarity had been permitted for the exact measures to be nationally adopted, these new mandatory targets, enforceable through significant penalties for shortfalls, were monitored by the Commission.

Reliance on diesel powertrains in the European transport fleet had been recognised as a barrier to switching to renewables on the scale required. Tax advantages for diesel fuel and cars were reversed in order to rebalance the European transport fleet within 10 years to be more in line with other economic regions. Mandates for ethanol flex-fuel vehicles as a European standard had been put in place for all new cars from 2018.

To achieve the new targets, the policy framework had recognised that in the short and medium term, the European transport fleet would require high volumes of liquid transport fuel. The preferred powertrains, promoted by incentives and scrappage schemes, had been hybrid biofuel-electric and flexfuel bioethanol cars. Biodiesel retained a smaller but significant share of the market that varied from country to country. Electric cars had assumed a niche share especially for intra-urban traffic by 2020, but the low energy efficiency for their use of ‘green’ electricity meant that it had not been a widespread governmental priority across Europe. Moreover, renewable and nuclear electricity had been slow to come on stream, and was considered better dedicated to other forms of energy consumption.

The requirements for sustainability for biofuels, previously set out in the 2009 Renewable Energy Directive, and the 2009 Fuel Quality Directive, were now encompassed in a wider global regulatory framework. Progress had been made towards establishing a level
sustainability playing field across all uses of land, in order to regulate land use change. The strategic use of land as a global resource with multiple claims had been included in the Copenhagen 2018 meeting, as subject to international agreement. Fossil fuel extraction (e.g. oil and coal) had also been included, so as to take account of the higher carbon footprint of non-conventional oil (e.g. oil shale and tar sands) and open-cast mining. As a consequence, the timeframe for liquid fossil fuel substitution by renewable alternatives had been reinforced and accelerated.

To achieve the new progressive and incremental targets to 2030, the new Renewable Energy Directive promoted the continued and expanding use of imported bioethanol from sub-tropical regions. ‘First generation’ biofuels from sugarcane had improved their performance, with new hybrid strains being adopted, and Brazilian agricultural and refinery technology had been developed across the subtropics. European trade barriers had been scrapped to facilitate and diversify the sourcing of biofuels, and to simulate rural economies especially in sub-Saharan Africa and India.

However, it had been recognised that advanced lignocellulosic biofuels and the use of biowaste feedstocks were to become an increasingly important share of the overall biofuel market. The European Commission invested heavily in new demonstrator projects, and many countries had provided innovation incentives for next generation technologies. Integrated multiproduct biorefineries achieved commercial scale for the first time in Europe in 2019, some five years behind the US. Feedstocks for advanced refineries were being planned to be primarily grown on set aside land in Europe. Advanced refineries were also envisaged as an integral part of recycling of carbon waste. The use of GM technologies for non-food crops and for biorefinery processes had been ratified by the European Parliament in 2016, although restrictions on dual-purpose foodfuel crops still placed Europe at a competitive disadvantage to most other regions in the world.

Rapeseed biodiesel had continued to enjoy a significant share of the market, benefiting from improved agricultural techniques and hybrids, and the raising of yields across Europe. Biodiesel had become increasingly dedicated to the HGV segment of the European transport fleet. But investment in advanced biodiesel from syngas (via the Fischer-Tropsch process) had been relatively limited, owing to the decline in the proportion of diesel vehicles in the transport fleet.

From 2014, clear political leadership and the 1% annual increase in targets for European consumption of biofuels had created a new impetus for commercial investment in biofuels. Major European oil and agri-businesses had joined forces in joint ventures and partnerships to integrate across the new value chains. Smaller specialist companies with successful technologies and business models had been acquired in highly lucrative deals. A vibrant biofuel innovation climate across Europe had resulted in a proliferation of new technology start-ups in the latter part of the decade to 2020 to create yet more opportunities for European economic competitiveness.

As a consequence of the strengthening of European political leadership, the greater ambition of the biofuel targets, and the threat of an energy crisis, biofuels had already achieved 12% of the liquid fuel market by 2020. Europe was set on an upward trend in line with the mandate for progressive expansion. Biofuels had become accepted as central to the vision for sustainable, climate-friendly, economic growth and energy security.
What would a significant and sustainable European biofuels sector look like?

The scenario created by the expert stakeholders at the foresight workshop took the view that certain circumstances could propel demand for biofuels in Europe and then set out to elaborate what a biofuels sector for Europe would look like in 2020 and beyond. To provide focus, the discussion was structured around an assumption that biofuels would constitute 12% of the transportation fuel market by 2020, with potential to develop to 30% over the following decades.

A scenario for European biofuels in 2020 and beyond was developed in the foresight workshop, based on a set of assumptions relating to a specific combination of the key drivers. In particular, workshop participants constructed a vision of the future based on assumptions that the need to substitute oil in transportation would continue to escalate, and that the current challenges facing biofuels outlined above could be overcome. It is important to note that scenarios are not developed to be concrete predictions of the future. Rather they are developed and used to explore what could happen within the context of specific circumstances.

But, if the drivers do combine in the ways suggested by this project, we would expect European policy to respond with a revision to the way that alternative transport fuels are promoted. In this view, the Renewable Energy Directive would need to create a longer term framework for developing European biofuels, extending beyond the current 2020 cut-off point. If policy moved in this direction, a viable European biofuels sector could develop by 2020 and expand significantly into the following decade. The key features of this scenario (presented in more detail in Box 1), where biofuels can make a sustainable and significant contribution to European transportation, are as follows:

- The technologies already exist (in 2010) to meet the 2020 targets, the emphasis would be on optimisation and implementation of the best technologies much more widely over the next decade;

- New technologies, for example converting waste to bioethanol, would become increasingly important over the longer term to achieve the higher targets in the decade after 2020;

- Biofuel technologies would play a complementary role in substituting for oil, alongside developments in electric powertrains – in particular, there would be the prospect to develop efficient hybrid electric vehicles that run on biofuels;

- European biofuel consumption would be provisioned by domestic production and by imports – the balance would depend on the comparative performance, in sustainability and economic terms, of biofuels from different global regions. As such European consumption of biofuels would diversify away from rapeseed biodiesel;

- The sustainability of biofuels would be regulated by global standards and Europe would lead the way in establishing these new international governance regimes;
A vibrant European biofuel sector would provide significant opportunities for European firms – new supply chains would emerge engaging oil and agriculture firms in novel industrial configurations.

The expert stakeholder group recognises this vision stands in sharp contrast to other prominent views. Three alternative visions are described in order to locate our vision within the wider debate (see Box 2).

**What are the alternative visions for European transportation in 2020?**

The business-as-usual scenario for Europe assumes the continued existence of targets for biofuel uptake set out in the Renewable Energy Directive. But, judging by current trends, the scenario also assumes that these targets will not be met. In some circles, most prominently advocated by the UK Gallagher Review1, this downward adjustment of targets, whether by statute or by default, would be very welcome.

Alternatively, in the “eco-Europe” scenario, opposition to biofuels would grow to such an extent that Europe would effectively become a biofuel-free zone. Proponents of this scenario advocate a varying mix of improved fuel efficiency, major breakthroughs in electric car technology (with the necessary decarbonisation of electricity supply) and an overall reduction in levels of transportation. The environmental NGOs2 are the most vocal supporters, although the King Review for Low Carbon Cars3 also identifies with this vision to a large extent.

At the other extreme, it is possible to imagine a future for European biofuels that would develop in parallel to some of the most technologically optimistic visions currently held in the US. The “all technological hands to the pump” scenario assumes technological ‘gamechangers’ in the biofuels field, as predicted by US Secretary of State for Energy, Steven Chu4.

These alternative visions are predicated on different assumptions about how the key drivers relating to transportation will evolve over the next decade. The scenario developed by the workshop is distinct from each of these views. It rejects the assumption that electric vehicles will become a widespread reality by 2020. It assumes that political leadership will be mobilised in response to energy security concerns, breaking with the current stagnation in the support for European biofuels. But, it also dismisses extreme optimism founded on a technological silver bullet.


Box 2: Alternative visions for European Transportation 2020

Scenario 1: Business-as-usual Europe
Following a period of huge volatility of fossil fuel prices, and lack of any clear political direction at the European level, the European 2020 targets of 10% renewable transport energy had, in general, not been met. European nations had adopted different strategies, resulting in an uneven uptake of biofuels, some countries remaining strongly committed to home-grown biodiesel, others to imported bioethanol. Oil majors and car manufacturers, in times of economic difficulty (particularly affecting Europe), had been unable to shift investment into developing new markets for biofuels or flex-fuel vehicles, or biofuel powertrains above 10% blends for bioethanol and 7% blends for biodiesel. Europe was becoming increasingly contrasted with other regions, where the development of biofuels had been championed by political energy and direction. The US had seen significant technological breakthroughs in advanced biofuels, across the spectrum of fuel types. Brazil and China had emerged as economies leading the use of first generation biofuels.

Scenario 2: Eco-Europe
Following major ecological disasters, such as drought and flooding in Europe, and escalating food and fuel prices, the NGOs and political parties competed with each other to take the ecological high ground. Biofuels had been restricted to minimal and marginal use in Europe for terrestrial transport, on the grounds that they were ecologically unsustainable, presenting major threats to biodiversity, and resulting in environmentally disastrous land-use change. Greens proclaimed Europe as a ‘biofuels free’ zone, and heralded an era of ‘low-slow-local’ consumption. There had been massive investment in electrical cars, but also a major shift towards the use of public transport.

Scenario 3: All European technological hands to-the-pump
Major ecological disasters, and the consistently rising price of fossil fuels, threatened economic growth and led to a shake up across European governments. This made possible agreements on more ambitious targets, and enabled concerted investment in the development of new science and technology infrastructures. For ground transport, there had been a successful push towards second generation bioethanol and biodiesel, in combination with ‘green’ renewable electricity. Public procurement, at the local and national levels, had become a widespread policy tool for creating a basic level of demand for new technologies. Car manufacturers had been given support for the development of biofuel hybrid technologies and flex-fuel cars through incentives and scrappage schemes. Europe converged with other economic regions by progressively reducing its diesel fleet and the use of biodiesel for private cars. Internationally, new agreements had been reached to stimulate global markets in biofuels, and encourage imports from sub-tropical agricultural zones.

More detailed versions of these scenarios are available in the full project report available at www.sci.manchester.ac.uk/publications/projectreports/EuropeanBiofuels
Biofuels for European Transportation

Overall, the workshop scenario was constructed around the following stepwise logic, which illustrates how stakeholders believed it to be a credible and desirable vision:

1. The twin drivers of energy security and climate change mean that there is an urgent need to reduce Europe’s – and the world’s – overwhelming economic dependence on oil;

2. Of all economic activities, transportation (road, marine and air) is by far the most dependent on oil, and therefore a priority in the search for alternatives;

3. This endeavour should be addressed through a portfolio of initiatives, including innovations in fuel efficiency, electric vehicles and biofuels;

4. Any gains from efficiency (potentially significant) and alternative vehicle technologies are unlikely to make much difference by 2020, due to the time it would take to replace the transport fleet. Gains could be significantly enhanced by adopting biofuels into the liquid fuel supply mix destined for European transportation;

5. Technologies already exist to produce biofuels at competitive prices and with significant greenhouse gas savings (especially Brazilian sugarcane-to ethanol);

6. These existing technologies can be adopted and optimised in other global regions;

7. Current technology development programmes will produce better performing biofuels, in environmental and economic terms, in order to optimise location-specific agronomic conditions around the world;

8. Strong political leadership in instituting standards to regulate the sustainability of biofuels can play an important role in maximising the gains and reducing the risks of a significant uptake of biofuels.

Whether the amount of liquid fuel consumed by the European transport system increases, decreases or stays the same, the choice remains over what proportion of that liquid fuel will be fossil-based or bio-based. We have set out an argument and a scenario that sees biofuels making a significant contribution to European transportation by 2020 and continuing on an upward trend beyond that.

It is clear that one of the conditions for the achievement of the success scenario as outlined in Box 1 would be a vigorous change in political direction at national and European levels. This was clearly identified by the scenario workshop participants as critical to the future growth of European economies. Consequently, as authors of the report, based both on the research and the development of the workshop scenario, we have drawn out the principal policy implications, and expressed them as a series of recommendations. The twin challenges of depleting oil stocks and climate change require bold political thinking. Our recommendations aim to open up the policy debate, by setting out the measures that could be implemented to increase the potential for biofuels to make a significant and sustainable contribution to the future of European transport.
The project team recommends that the European Commission and European national governments:

1. **Promote the expansion of renewable biofuels as a contribution to transport energy (for road, air and sea), in recognition of the imperative to reduce fossil fuel dependency in the context of an impending energy crisis.**

To date, climate change concerns have provided the main motivation for the European transportation system to adopt biofuels into the fuel supply mix. This stands in sharp contrast to Brazil and the US, where the initial driver has been the threat of diminishing energy security. We believe that there is an urgent need to reduce fossil fuel dependency in transportation through a portfolio of different approaches. Based on the assumption that the great majority of European transportation will still be dependent on liquid fuels by 2020, we strongly recommend the promotion of sustainable biofuels as a viable substitute for a growing proportion of that liquid fuel supply.

2. **Replace the existing single target of 10% renewable transport energy for Europe in 2020 with a more ambitious, progressive mandate of a 1% per annum increase in the biofuel proportion of transport energy until 2030.**

At present, the principal policy framework for European biofuels is short term and is punctuated by a final target for the cut off date of 2020. The twin drivers of energy security and climate change mitigation require much longer visions, and also a recognition that progress will necessarily progress along an incremental trajectory. Instituting a 1% per annum incremental target would take levels of biofuel uptake to around 12% by 2020 and also provide a context for continuing momentum into the decade to 2030 and beyond.

3. **Promote the development of a robust, comprehensive and integrated regulatory framework for the sustainability of all agricultural commodities and energy supply sources in place of one that singles out biofuels. This framework should cover:**

   a. **Impacts of direct and indirect land use change for all agricultural outputs (logging, food, energy, cosmetics, etc.)**

   b. **All forms of energy, including extraction of non-conventional oil (tar-sands, shale oil, etc.) and the refinement of the current estimation of the carbon footprint of conventional oil extraction.**

The environmental impact of biofuels has been the subject of considerable debate. It has arguably received disproportionate attention compared to other demands on land and the greenhouse gas performance of all other energy sources. While clear that regulatory standards will be required to promote the sustainability of biofuels, we recommend that this should be developed within a wider framework that addresses the bigger picture of sustainable land use change for all purposes and the greenhouse gas performance of all energy sources.
4. **Review trade barriers and tariffs to facilitate imports of biofuels from more land-use efficient geographical zones, notably the sub-tropical zones in South America, Africa, India and East Asia.**

The recent phase of the expansion of global biofuel production has been shaped by national interests in protecting and developing fledgling production capacity. Many global governments have instituted trade barriers and tariffs for this purpose. But these measures have stifled the establishment of global export markets for some of the better performing (in cost and sustainability terms) biofuels. These measures should be reviewed and the European government should seek to establish trading relationships to source the most sustainable and effective biofuels from sub-tropical zones.

5. **Promote the diffusion of best practice farming techniques and eliminate barriers to the use of biotechnology such as genetic modification for intensifying and enhancing sustainable land use for agricultural crops of all kinds.**

Currently, there are very wide global differences in the productivity and environmental impact of agriculture. Significant improvement is possible through the widespread diffusion of current best practice farming techniques and these improvements have the potential to significantly reduce pressures on the availability of land for cultivation. However, we believe that much greater advances are possible with the application of modern biotechnologies to agriculture to increase yields and to develop crops that are more amenable to conversion into biofuels. Moreover, innovation needs to be directed to achieving complementarities between energy, material, and food crops, as well as developing crops in high stress environments, in order to increase carbon capture and to optimise land use generally.

6. **Fund demonstrator projects to promote integrated biorefineries, using advanced technology based on cellulosic feedstocks and bio-wastes, for the production of sustainable energy and chemical building blocks.**

Europe should match the level of technology development support seen in the US to overcome the ‘investment gap’ that currently acts as an obstacle to the translation of promising laboratory/prototype research into commercial scale operations. There is considerable potential for further technology development at that scale to enhance yields and open up the possibility for a greater range of feedstocks. In addition, significant improvements in economic and sustainability performance can be achieved by integrating the production of fuels with co-products, including animal feed and higher value chemical building blocks. This can have a significant impact in reducing the carbon footprint of biofuels.

7. **Implement public procurement for biofuels to stimulate markets and signal clear political leadership and commitment.**

Although public procurement of biofuels will at most provide a minor proportion of the total market opportunity, it can demonstrate political leadership and commitment to raising levels of consumption of renewable fuels. Several initiatives are already in place across Europe, (e.g. the Stockholm bus fleet, urban transport in 35 cities in France). It is significant that those countries with public
procurement policies are also those which have already achieved progress towards meeting European targets.

8. **Promote and assist in the formation and coordination of biofuel supply and distribution chains, especially in the context of the use of carbon waste as a feedstock.**

Governments can play an important role in facilitating the development of new infrastructure required to achieve the more ambitious levels of biofuel consumption. Policy frameworks on blends and fuel quality set necessary standards across biofuel markets in Europe. There is much greater scope for coordination between recycling and the use of carbon waste as a feedstock for biofuels which will require additional coordination between public and market actors.
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