Introduction

Fossil fuels are dwindling and in order to maintain the current levels of energy use and the transport systems we rely on we need to find alternatives. There are also environmental concerns about the effects of using fossil fuels such as pollution and climate change. Bioenergy may be part of the solution to these problems

Bioenergy is the energy derived from harvesting biomass such as crops, trees or agricultural waste and using it to generate heat, electricity or transport fuels.

The benefits of bioenergy include, sustainable and renewable fuels, decreased carbon dioxide release into the atmosphere and turning the problem of waste into a source of energy. Biofuels can be 'effectively' carbon neutral and in some cases may use emissions from power plants as a carbon source.

Biofuels could power our cars, heat our homes and maybe fuel our planes. Liquid biofuels represent the only sustainable alternative to current transport fuels. BBSRC research is focusing on advanced biofuels from inedible and non-food crops as well as waste. Currently biofuels are combined with oil-based fuels so that typical UK petrol is composed of 3-4% biofuel. At present much of this biofuel comes from sources that directly or indirectly compete with land and resources that would otherwise be used to grow food.

Biomass can be burned directly to generate heat and/or power either on its own or 'co-fired' alongside conventional fuels such as coal. Alternatively, biomass can be treated to create gaseous or liquid biofuels which can be used on their own or in conjunction with conventional fuels such as coal or natural gas. The initial emphasis is on motor vehicle fuels, but the same principles apply to aviation fuels, where bio-products provide the only sustainable alternative to kerosene.

Biofuels, biofuel feedstocks and the technologies involved in producing them can be considered in terms of current bioenergy and advanced bioenergy. There are a wide range of sources of biomass used in producing biofuels commonly referred to as feedstocks. The procedures used to convert these feedstocks are equally varied as are the potential fuels produced. A number of terms have been used to describe this variety of approaches, the research being undertaken and developments that are taking place including 1st, 2nd, 3rd and 4th generation. These terms are in common use and have therefore been used on occasion in this document. However, this doesn't reflect the complex nature of the field and cannot completely describe the differences between biofuels.

Current or conventional bioenergy is often referred to as first generation whereas advanced bioenergy refers to second and third generation biofuels. First generation biofuel refers to established technologies used to produce biofuels, in particular the use of food crops such as sugar cane and maize, but also including biogas. Second and third generation biofuel refers to bioenergy solutions that either make use of waste or rely on non-food crops that can be grown on marginal land.

Advanced bioenergy solutions hold the unique promise of being able to provide a sustainable alternative to current oil-based liquid fuels, particularly for aviation, shipping and haulage.

While other technologies, such as electric or hydrogen vehicles, may someday replace the need for liquid fuels they are not a viable alternative at present. Electric vehicles may be excellent for short journeys, but the range provided by current battery technologies, and lack of infrastructure, make them impractical for longer journeys, haulage or aviation use, and hydrogen-based vehicles likewise still require technological and infrastructural developments.

Liquid biofuels, to replace petrol, diesel and aviation kerosene, can come from:
(a) converting the large amounts of energy locked up in plant cell walls (lignocellulose)
(b) harnessing the capabilities of algae and microbes

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BBSRC bioenergy research focuses on sustainable energy (liquid fuels, heat and electricity) either from non-food feedstocks or from inedible elements and waste from agriculture, food crops or food processing. Research suggests that there is enough land in the UK to grow biomass for renewable electricity production without affecting food production. Changes in land use will inevitably affect the environment, for instance biodiversity, soil structure or water availability. Some changes may be positive while others may have negative impacts. The farmed and natural environment provide vital ecosystem services and it is important that proper assessments of environmental risks are carried out throughout the development of crops and new technologies before they make it to the farm.

New and better sources of bioenergy may come from: non-food crops, inedible parts of food crops, waste, microbial and algal metabolism, and biomass processing into biogas. Advanced bioenergy (rather than current or conventional bioenergy) solutions either make use of waste, agricultural residues or rely on non-food crops that can be grown on marginal land. For instance, research focuses on improving yields and conversion efficiencies for producing biofuels from miscanthus, willow and barley straw.

Sustainably produced biofuels offer the only mid-term option for replacing liquid transport fuels such as petrol. Crude oil production is expected to be in decline by the middle of the century. Even without the pressing environmental reasons for reducing the 'carbon footprint' of transport and manufacturing, the inevitable depletion of fossil fuel reserves means that we need to find alternative sources of energy and raw materials. Plant-based industrial biotechnology provides a viable route to achieve this. Industrial biotechnology can substitute for dwindling fossil fuel stocks by providing fuel and other high value products such as plastics, pigments and antioxidants.

Scientists are using biotechnologies to carry out their research and these include:

- Plant breeding
- Systems biology
- Genetic modification
- Metabolic engineering
- Directed evolution
- Anaerobic digestion
- Synthetic biology

It will take a decade or longer to develop new sources of biofuel from research being carried out today. Research is currently focused on developing biofuels from plant sugars while future options may include using synthetic biology techniques and algae to produce biodiesel directly.

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KEYWORDS

Bioenergy, biofuel, biodiesel, sustainable, renewable, biomass, biogas, yield, waste, food security, second generation, bioethanol, lignocellulose, lignin, cellulose, cell wall, microbes, yeast, enzyme, fermentation, gribbles, photosynthesis, algae, varieties, electricity, heat, transport, crops, straw, miscanthus, willow, barley, oilseed rape, wheat, maize, wood, sugar, starch, aerobic, anaerobic, oil, catalyst, carbon dioxide, combustion, chlorophyll, fossil fuels, glycerol, genetic modification, hydrolysis, synthetic, saturated, viscosity, arable land, biodiversity, advanced plant breeding, feedstock, environment, agriculture, biodegradable, biorefinery.

Keywords courtesy of http:/www.wordle.net/

FACTS and FIGURES

- To help combat climate change the UK has a target to reduce carbon emissions by 80% by 2050.
- 30% of the UK renewable energy could come from biomass heat and electricity by 2020.
- To meet the European Renewable Energy Directive, the UK's is aiming for 10% of transport energy to be from renewable sources by 2020.
- By 2020, 8% of our petrol and 5% of our diesel could come from crops grown in the UK.
- Photosynthesis is only 6% efficient and it may be possible to improve this to produce higher yielding plants or develop novel ways of capturing solar energy.