

**Engaging the public with bioenergy in the UK;
science education, communication and discussion**

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Abstract

Fossil fuels are a finite resource and with a growing global population there is an urgent need to find alternative energy supplies. Oil, coal and natural gas are non-renewable and burning these fuels releases large amounts of greenhouse gases, which contribute to climate change. Part of the solution could come from renewable bioenergy, which offers the promise of solving environmental, social and economic issues. This raises questions such as "Should we be using farm land to grow energy crops when food prices are rising?". The development and production of renewable liquid biofuels from plants and organic waste face challenges in public acceptance as well as scientific and technological improvements. Engaging the UK public with bioenergy and communicating the latest scientific research has focused on cutting edge scientific developments and opportunities for sharing views and opinions, often centered around *advanced biofuels*, transport, waste and feedstocks available in a temperate climate. In order to significantly enhance science education the decline of practical experimentation carried out in class was addressed with biofuel feedstock kits, a guide to related class practical experiments and discussion toolkits. The topic of biofuels provides a wide scope for developing students' understanding of science and ample opportunity to facilitate discussion of controversial issues. These approaches reflect the specific needs of UK students and members of the public. The development of the resources, activities and events is described with evaluation of the impact of the educational materials.

Introduction

With growing populations and increased energy demands the world faces the challenges of food and energy security whilst dealing with environmental change. The increasing cost of non-renewable fossil fuels is driving the development of alternative energy supplies; bioenergy is a part of an energy diversification that offers the promise of solving environmental, social and economic issues (1). Scientific and technological developments in this field have the potential to produce clean energy that protects the environment and benefits all members of society. However, there are legitimate concerns that renewable liquid or gaseous biofuels from plants and organic waste will exacerbate environmental damage and compete with food crops (2). In order to engage the public with bioenergy research it is crucial that the field remains responsive to public views, concerns and aspirations, as the science develops. It is also essential that the future citizens of the UK are informed and scientifically literate, to enable them to participate in public debate on important scientific issues.

As well as the potential economic and environmental benefits of adopting bioenergy, the UK is subject to the European Parliament Directive 2009/28/EC on the *Promotion of the use of energy from renewable sources*. This directive set energy efficiency targets to be achieved by 2020: to cut greenhouse gas emissions by 20%; to reduce energy consumption by 20%; and establish a 20% share for renewable energy, including 10% renewable transport fuels (3). Only 18% of the sustainable renewable road transport fuel used in the UK between April 2012 and April 2013 came from UK feedstocks (4) but the future impact of biofuel usage is likely to be significant, with estimates suggesting UK consumption of transport biofuels could increase six-fold by 2020 (5).

The development and production of biofuels capable of such a dramatic change in energy supply face challenges in public acceptance, as well as scientific and technological improvement. Amongst the UK public, bioenergy is one of the least familiar renewable energy technologies (6) and yet the UK is a research leader in this field with a strong focus on *advanced biofuels* (utilizing the non-food parts of crops, waste and plants that can be grown on non-arable land) and fundamental research.

Attitudes to science in the UK are predominantly positive with the Public Attitudes to Science (PAS) survey 2014 (7) finding that 90% of respondents think that scientists make

a valuable contribution to society, describing them as creative, interesting and open-minded people. The importance of engaging the public with science, to address people's concerns and deal with any misconceptions is highlighted by the findings of PAS in which 69% of respondents think that "scientists should listen more to what ordinary people think" and 75% think that "the Government should act in accordance with public concerns about science and technology". Science communication and education activities are not simply government driven initiatives without public demand; PAS has found a clear desire for more information on science with 51% of those surveyed saying they hear and see too little about science.

Where do biofuels fit into this public understanding of science? The baseline awareness is reasonably high; a Department of Energy and Climate Change survey in 2009 found that 77% of respondents 'had heard of' biofuels. However, there is very little publicly available literature on UK attitudes to biofuels; a recent review suggests that about half the UK population have positive views of bioenergy (6) but research conducted in 2007 found that support for biomass in the UK was among the lowest in Europe (8). This high level of awareness and lack of support present the potential for misconceptions in regard to bioenergy and biofuel research. For example a respondent in a 2013 UK Energy Research Centre survey said "I think burning rain forests and burning trees or whatever, so it is that association." (9), which contrasts markedly with research focused on the production of liquid biofuels from waste or algae. This highlights the need for communication and education initiatives.

Since 2004 the UK curriculum for 14-16 year olds has featured 'How Science Works'; aiming to provide students with a grounding in the scientific literacy required to be 'future citizens' by teaching students an understanding of what scientists do, the nature of science, and the way that science relates to the broader society. This led to an increased demand from teachers for information to support their teaching of unfamiliar topics and cutting-edge research. In addition, the content of many science subject specifications at GCSE and A-level (age 14-19) now explicitly mentions biofuels, though often as a part of chemistry or physics qualifications rather than biology (10).

The Biotechnology and Biological Sciences Research Council (BBSRC) is the primary funder of biological research in the UK, with a commitment to engage young people with research "to enthuse and inspire them, to empower them as future citizens to

participate in public dialogue about science, and to pursue science-based careers”(11). This led to the development of materials and resources with the aim of supporting researchers in their public engagement on the topic of bioenergy and biofuels, and helping teachers in their delivery of practical experiments set in a context of cutting-edge research. In conjunction with the BBSRC bioenergy dialogue (12) the materials were supplemented with activities to enabled informed discussion in the classroom.

Methodology

From the outset, consultation with stakeholders was undertaken to ensure an initiative was provided that met the needs of the research community, funders of research, young people and educators. An initial workshop was held to share existing activities, identify what was required and suggest suitable approaches. The workshop was attended by researchers involved in fields ranging from algae to perennial bioenergy crops, educationalists and science communication professionals. A range of ideas were suggested, and collated, from smart phone apps to pub science props. This was followed with a review of existing practical science resources available to teachers. Taking into consideration the outcomes of the workshop and the needs of teachers and researchers, as well as the biofuel research being undertaken and associated policies, a combined programme of outreach activities and the development of teaching materials was undertaken. With positive attitudes to science in the UK and a degree of familiarity with renewable energy amongst the UK public it was decided to focus on communicating the cutting-edge research being undertaken, supporting teachers in their delivery of science practicals and providing opportunities and supporting materials to facilitate discussion through educational materials, science fairs and public events.

Practical Biofuel Activities, feedstocks and molecular models

Over 20 practical activities suitable for use in the classroom that could be related to bioenergy were identified. These activities were collated, modified where required, and underwent testing with school groups and young people by science communicators and researchers. Select activities were also shared with public audiences at science fairs and outreach events. Following testing and feedback fifteen practical investigations were chosen covering a range of science topics including: plant science, microbiology and

chemistry, and assigned as *current biofuel* or *advanced biofuel* activities. These activities were organized into the ‘Practical Biofuel Activities for School Engagement and Outreach’ (13) featuring recent research in the field, health and safety guidance, curriculum links and further reading. The materials were compiled with attention to pedagogical information to assist teachers and practical advice for researchers undertaking outreach with school groups. The practical investigations were supplemented with five ‘dry’ classroom activities, a glossary and key scientific vocabulary to support learners understanding and scientific literacy. Alongside these dry activities a biofuel ‘kit’ was created, featuring resin encased samples of key biofuel feedstocks and molecular models (Figure 1).



Figure 1

Engaging young people in discussions about bioenergy and biofuels

As part of the BBSRC bioenergy dialogue a Democs card game was developed to enable the public to engage with the issues associated with bioenergy and biofuels. Democs is a group discussion method, based around cards, that does not require expert knowledge. The game was modified for use in the classroom and with a young audience, with supporting resources and activities to allow delivery at public events. In addition to the Democs game, a discussion resource based on successful format of role-play and

voting focusing on a specific crop, *Jatropha curcas*, and the challenges faced in the developing world was produced specifically for a younger audience 'Jatropha curcas: A solution or false hope?' (Figure 2) (14).

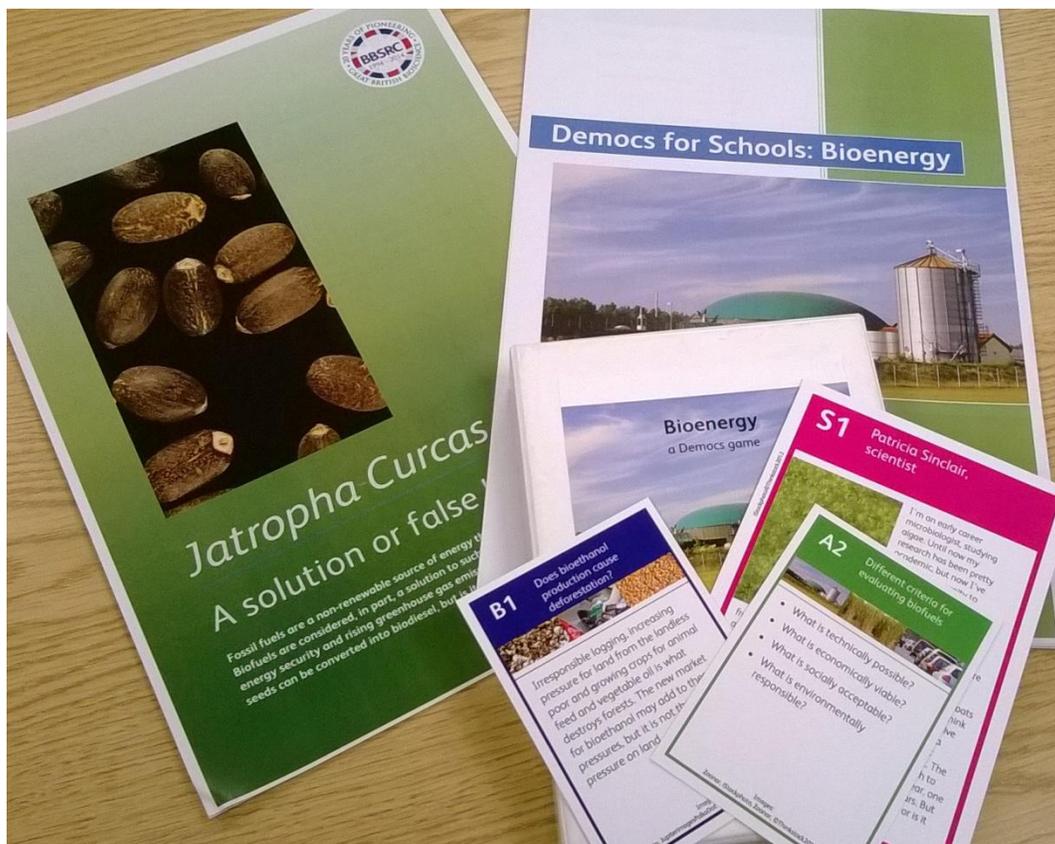


Figure 2

Results

The 'Practical Biofuel Activities' and powerpoints were made available on-line and copies distributed with biofuel 'kits' to schools, teachers, researchers and Science Learning Centres across the UK. There have been over 20,000 downloads of 'Practical Biofuel Activities' guide files and 97 biofuel 'kits' have been distributed. Feedback and on-line comments were collated and an evaluation survey was sent out to the 23 researchers, 49 teachers and 17 science communicators who received the materials. Response rates were 61% for researchers and 63% for schools, only one survey was completed by a science education organisation. The feedback was very positive with comments from teachers such as "They increased ideas for engaging students practically

with this topic” and “They allowed me to make a theory heavy topic quite interesting and hands on”, “feedstocks - students loved the tactile feel of them and was far better than a picture of a plant”. The resources were rated as brilliant (42% of researchers and 40% of teachers) or good (58% of researchers and 60% of teachers). One teacher reported “More researchers have been in the school to teach about biofuels and GM crops” and 79% of researchers said that they improved their bioenergy activities. 69% of teachers reported that their students showed more interest in bioenergy due to the materials, 92% had improved lessons on bioenergy and 65% had improved practical lessons. Some teachers did provide negative feedback related to the curriculum such as “powerpoints - not linked to the syllabus enough” and “A little complicated for lower attainment GCSE students”. The Democs card game was trialed with a teacher focus group and shared with science communicators and biofuel researchers. Initial feedback has been positive with comments on the format and readability of the Democs card game leading to development of the *Jatropha curcas* activity, specifically for a younger audience. Initial use of the modified Democs card game at the Big Bang Fair with over 1000 members of the public suggests it is effective at stimulating discussion and raising interest in science.

Discussion

The approach undertaken to engage young people and the public with bioenergy research that is described here, has been significantly influenced by three developments. Firstly, the primary funder of bioenergy research in the UK, BBSRC, undertook the largest single UK public investment in bioenergy research in January 2009, establishing the Sustainable Bioenergy Centre to provide focus for research underpinning sustainable bioenergy and biofuels. One of the key aspects of this research focus is to investigate *advanced* bioenergy technologies that do not conflict with the challenge of food security. In-line with the research funding, BBSRC focused its public engagement around strategic research priorities, including *Industrial biotechnology and bioenergy* (11), which led to a focused educational initiative centered specifically on the topic of biofuels.

The second major influence was a reported decline in practical experimentation within schools that led to government inquiries and a number of initiatives to support teachers’ skills and ability to provide hands-on learning experiences for students (15). A review of the evidence for effective engagement of young people with Science

Technology Engineering and Maths (STEM) by the National Foundation for Educational Research concluded that “Where STEM subjects are taught through practical activities set in real-world contexts, which allow pupils greater freedom to use their initiative and be creative, this can be particularly engaging...They come to understand the links between school science and exciting, cutting-edge developments.” (16). The ‘Practical Biofuel Activities’ were designed to provide these experiences and convey current research.

Finally, the shift from the deficit model of science communication to a dialogue model, with a greater emphasis on listening and discussion (17) received formal support with the launch of the Concordat for Engaging the Public with Research (18) and Manifesto for Public Engagement (19), signed, respectively, by the major funders of science in the UK and universities in 2010. The discussion materials produced reflected this greater use of a dialogue approach to engaging the public. Consultation with stakeholders and a review of existing materials took into account these developments during the production of the materials to produce effective resources.

Conclusion

The initiative was well received by researchers in the biofuel community. The development process, including trialing activities and providing outreach events, and materials led to more public engagement by researchers. The materials were gratefully received by teachers who cited a lack of resources as a hindrance to hands-on science lessons. Teachers have been very keen to use the discussion materials but further trialing and feedback will be required to ascertain the impact of the resources. The initiative led to a BBSRC strategy for engaging young people that states the importance of cutting-edge research in science communication and education, parallel with a redevelopment of existing BBSRC educational materials with a focus on inquiry and practical work.

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