

“If we were to develop new technologies and new improvements on growing materials, there is a likelihood that demand will increase and this is a dilemma that will need not just technical solutions, but political and societal solutions as well.”

Edgar Blanco, Andigestion Ltd

Building resilient energy supplies

How could photosynthesis-based technologies can provide a sustainable and rapidly-deployable energy source for rural communities?

At a glance

For our final three meetings centred on ‘risk, resilience and response’, we focused on energy resilience. Between April and June 2016, expert witnesses helped us to explore ways in which photosynthesis-based technologies can provide a sustainable and rapidly-deployable energy source for rural communities.

In April, we focused on off-grid situations and to explore existing approaches and possible challenges while using local resources. In May and June, we turned to ways in which existing bio-energy technologies linked to photosynthesis can provide sustainable and rapidly-deployable energy and the role of policy in applying the principles of the circular economy to bioenergy provision.

This article provides an overview of key emerging themes and some of the ‘wicked problems’ and questions generated during these discussions. This theme was carried out in partnership with the Energy@Cambridge Strategic Initiative and the CamPlants Hub.

Living off the grid

One of the main points of discussion concerned the appropriateness of different technologies for providing energy solutions to developing areas. Professor Sir Brian Heap, Scientific Advisor of the ‘Smart Villages Initiative’, discussed biomass as a rapidly deployable off-grid energy solution but suggested that improvements needed to be made, including new and higher quality crops, new crop rotations, improved market efficiency and more affordable finance. However, overdependence on one particular energy approach can have unsustainable environmental consequences. Policy challenges for biofuels include the tension over land-use between energy and food production as well as issues regarding land rights; rebound effects, such as cheaper energy driving consumption higher; a lack of regulation to combat deforestation; and the need for better transport infrastructure.

The importance of biomass for food and resources led the Forum to consider additional technology options. Dr Heinz Ossenbrink, the Head of Renewables and Energy Efficiency Unit at the EC Joint Research Centre, discussed photovoltaic energy as an efficient option for energy production. Edgar Blanco, the Research & Development Manager at AnDigestion Ltd and a specialist on anaerobic digestion, mentioned various photosynthetic opportunities such as photosynthetic fertilisers and a need for more water-based solutions. Professor Chris Howe, Professor of Plant and Microbial Biochemistry in the the Department of Biochemistry at Cambridge, discussed biophotovoltaics, a new technology that harnesses electrons produced as a byproduct of the photosynthetic process, which could potentially be scaled up to charge mobile phones.

Key questions

Through our discussions, we identified four key areas where more research is needed:

- **How can bioenergy innovation be introduced wholesale into communities and how can technology be implemented in areas of rural poverty?**
- **How can sustainable and cost-effective fuels from biomass be delivered at a large scale, and what would encourage investors and markets to make long-term commitments?**
- **How important are technical solutions to solving global energy problems and how can these be developed in parallel with novel, and potentially unconventional, policy solutions?**
- **Is it feasible or sensible to move towards a circular economy primarily based on biological resources?**

Catalyzing new research

A recurring theme during these discussions centred on ways in which photosynthetic processes can be part of a bioenergy technology 'package' that might also address energy, water, nutrition and waste challenges in the developing world. The term 'circular photosynthesis' was coined to encompass this concept, and the ideas discussed in the Forum have since been developed further and been included in research funding proposals.

It was agreed that although improvements can be made, generally the technological capacity to solve problems already exists. No one technology will provide a solution, and direct and indirect energy savings need to be considered. Thus, in all three of the meetings the necessity for a holistic and multidisciplinary approach to energy was highlighted. The human energy footprint, encompassing food, water, energy and space requirements, must be considered as a whole. This could also help grasp the opportunity to combine energy production with other industry sectors, such as agriculture or waste disposal. Dr Rana Pant, from the Life Cycle Assessment and Environmental Footprint, Sustainability Unit at the EC Joint Research Centre (JRC), advocated a process known as life-cycle assessment, whereby a situation is assessed so that all ramifications of an action or policy are understood so as to avoid shifting the energy burden to a different region, time or part of system.

“Access to electricity is not the end goal in itself, it has to be a means towards an end and it has to mean something for the community.”

Dr Muhammad Tayyab Safdar,
Centre of Development Studies, University of Cambridge

From the ground up

It was frequently emphasised that there needs to be better engagement with and understanding of local populations; different areas need different solutions, and these must be tailored for a local context. For example, Dr Muhammad Tayyab Safdar, a Post-Doctoral Research Associate at the Smart Villages Initiative, pointed out that off-grid energy must serve a purpose, be it improving access to business opportunities, health care or education. The communication pathways between scientist and consumer need to be improved so that public scepticism regarding new technologies can be overcome. Dr John Mullett, the Director of SOWTech and an expert on waste solutions, emphasised that traditional practices are a key barrier to the success of energy projects, and the continued use of inefficient cooking stoves and charcoal was used to elucidate this point. Conversely, rural or developing communities can also be creative and innovative. Community engagement, education and further research into the mechanisms by which behavioural change can be encouraged are required.

Financial and policy challenges were a constant theme of the forum. New markets are needed that can adapt to the business model required for renewable energy sources, which involves heavy initial investment but long-term savings. Currently, companies need a lot of capital and it can be difficult for developing countries to establish subsidies, which may not be necessarily be a sustainable solution but can help demonstrate the viability of business models to encourage future private investment and consumer uptake. These financial barriers are exacerbated by subsidies for

fossil fuels. There needs to be greater policy clarity in developing countries, and globally the international community needs to explore unconventional policy solutions such as carbon passports or pricing, waste taxes and making people aware of the impact of their energy choices.

To aid policy decisions and create interventions that are appropriate for any given area requires interconnected modelling of the different elements. Paul Newell, a statistician in the Energy Science team at the Met Office, highlighted the unified nature of their models for local, regional and global hazards. They can also provide data regarding the best location for wind turbines or solar panels. Dr Jeremy Woods, a lecturer in bioenergy at Imperial College London, introduced the Global Calculator, a tool that shows the major points of action to mitigate climate change and the unforeseen impacts of policy change.

Circular economies

Combining these threads, the final forum focused on circular economies. Rob Mills, the Head of European Energy Markets at Ofgem, observed that in developing communities resource efficiency is often already high as a result of necessity. Again, a holistic view is needed to factor the interplay between household economics, price signals, societal norms and undermining existing markets and all the other possible trade-offs and rebound effects. The mechanisms that help motivate and inform people so they commit to environmental efforts need further research.

The Cambridge Forum for Sustainability and the Environment

was established in 2013 in the University of Cambridge. Chaired by Lord Martin Rees, it meets once a month, bringing together thought leaders from the worlds of research, policy and industry to talk about some of the great sustainability challenges the world faces in the future and the research pathways which will help to prepare for and address those challenges.

Secretariat: Prof. Paul Linden (Director); Dr Rosamunde Almond (Executive Secretary); Dr Konstanina Stamati and Dr Lizzie Tyler (Acting Executive Secretaries during maternity leave); and Simon Patterson (Content Writer and Editor).

Forum members for this topic were drawn from 15

Departments, Centres and Institutes, and included: Prof. Alan O'Neill (Cavendish Laboratory); Prof. Alison Smith and Prof. Howard Griffiths (Dept. of Plant Sciences); Prof. Danny Ralph (Centre for Risk Studies); Dr Emily Shuckburgh (British Antarctic Survey); Dr Helen Curry (Dept. of the History and Philosophy of Science); Dr Hildegard Diemberger (Dept. of Social Anthropology); Prof. Ian Hodge (Dept. of Land Economy); Prof. Ian Leslie, (Computer Laboratory); Dr Jake Reynolds and Polly Courtice (Cambridge Institute for Sustainability Leadership); Dr Julian Huppert (POLIS); Prof. Koen Steemers (Dept. of Architecture); Dr Miles Parker, (CSaP); Prof. Peter Guthrie (Dept. of Engineering); Dr Shailaja Fennell, Lecturer (Centre for Development Studies); and Prof. Susan Owens (Dept. of Geography).

Witnesses: Prof. Sir Brian Heap (Smart Villages Initiative); Dr Heinz Ossenbrink and Dr Rana Pant (EC Joint Research Centre - JRC); Dr Muhammad Tayyab Safdar (Institute of Continuing Education (ICE), University of Cambridge); Edgar Blanco (Andigestion Ltd); Prof. Chris Howe (Dept. of Plant Sciences); Dr John Mullett (SOWTech (Sustainable OneWorld Technologies) CIC); Rob Mills (Ofgem); Paul Newell (Met Office); and Dr Jeremy Woods (Centre for Energy Policy and Technology - ICEPT).

Guests: Dr Nicolette Bartlett (Cambridge Institute for Sustainability Leadership); Dr Matthew Davey and Dr Mariana Fazenda (Dept. of Plant Science); Prof. David Newbury (Faculty of Economics); Dr Marc Ozawa and Dr Isabelle de Wouters (Energy@Cambridge Strategic Research Initiative). Early career researchers included Carolina Feijao (Dept. of Biochemistry), and Richard Sidebottom (Centre of Development Studies).