# Risk, resilience and response Energy

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Cambridge Forum for Sustainability and the Environment

# **Cambridge Forum for Sustainability and the Environment**

# A rising world population, declining resources and a changing climate are all reshaping where we live and how we live. So how do we respond?

This key question is the focus of a new Forum in the University of Cambridge which aims to stimulate cross-disciplinary conversations about some of the planet's most pressing global sustainability challenges and to bring fresh ideas and perspectives to research which will help to prepare for and address those challenges.

On a global scale, we need to find a way in which 7 billion people, expected to rise to 8 billion by 2030 and 9.6 billion by 2050, can live a high quality of life that is less demanding on our planet. And to adapt, be efficient and be sustainable, we need to know where to place our energies – nationally and globally – to meet the challenges the future will bring. Unfortunately there is no silver bullet: the solutions will need to be 'multi-pronged' and multi-disciplinary, requiring knowledge from many different sources.

'Sharing the knowledge' and catalyzing those connections are two of the goals of the Forum, which is Chaired by Professor Lord Martin Rees and has 25 core members who work in areas ranging from energy, biodiversity and food security to anthropology, architecture, history and economics.

One of the Forum's aims is to bring people together who would not usually meet each other but who are working in areas which overlap enough to stimulate an interesting discussion. Each month, during term time, three expert 'witnesses' are invited to help us to explore a particular area. They tend to be from outside Cambridge, and by inviting a rich mixture of policy and decision-makers from governments, researchers and business and technical experts, the Forum aims to derive fresh and innovative perspectives and generate new trans-disciplinary research questions.

#### Our themes

The general theme of all the Forum discussions is 'sustainability in an uncertain future' and specific topics change each academic year. In our first year, we brought together a rich mixture of policy and decision-makers, technical experts and researchers to talk about sustainable cities. In October 2014, our focus shifted to a second topic, 'Land-use change', which aimed to stimulate connections between three of the University's Strategic Initiatives: Cambridge Conservation Initiative, the Cambridge Global Food Security Initiative and Energy@Cambridge. During these meetings, we explored the challenges we face as we place ever increasing and sometimes competing demands on land and natural resources.

Our third topic was 'risk, resilience and response', and each term we explored a different theme. In addition to the meetings outlined in this report, in October, November and December we discussed food and water security and supply chain resilience in meetings jointly hosted with the Joint Research Centre (JRC). In January, February and March 2016, we focused on resilience in cities and ways in which big data and technology will shape the way we view and live in them in the future.

## Forging new connections

Our topic for the year was risk, resilience and response and in the third term, we talked about energy resilience.

In April, we focused on off-grid situations and exploring 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.

As always, a panel of three witnesses joined us each month to provide their perspective on gaps and future research questions, followed by an open question and answer session.



**Between April and June 2016:** 

10	26	£5,000
Expert witnesses, including technical experts at the Met Office and the Joint Research Centre (JRC), a policy expert at Ofgem and business leaders from Andigestion Ltd and SOWTech, and people from	University departments, Centres and Initiatives and…	Seed funding from the Isaac Newton Trust to support the development of activities related to ideas regarding 'circular photosynthesis' which were developed as a result of these meetings

# **Meeting themes**

# Living off the grid

In the the first meeting in the series on 19<sup>th</sup> April, our three 'Expert witnesses' helped us to get an overview on off-grid situations and to explore existing approaches and possible challenges while using local resources.

Our first witness, **Professor Sir Brian Heap**, Scientific Advisor of the 'Smart Villages Initiative', joined **Dr Heinz Ossenbrink**, Head of Renewables and Energy Efficiency Unit, Institute for Energy and Transport, European Commission, Joint Research Centre, Italy and **Dr Muhammad Tayyab Safdar**, Affiliated Lecturer at the Centre of Development Studies and a member of the Tutor Panel at the Institute of Continuing Education (ICE), University of Cambridge.

# **Emerging technologies**

For the second meeting in the series on the 10<sup>th</sup> May, the three witnesses explored how existing bio-energy technologies linked to photosynthesis can provide a sustainable or a rapidly deployable solution.

Our first witness **Edgar Blanco**, R&D Manager at AnDigestion Ltd, **j**oined **Professor Christopher Howe**, Department of Biochemistry, University of Cambridge and **Dr John Mullett**, Director of SOWTech.

# Catalyzing changes in energy

This was the third meeting in the series and the three witnesses brought a policy perspective to the discussion and helped us explore ideas inspired by the concept of a circular economy entirely based on biological resources.

At the forum on 14<sup>th</sup> June, **Rob Mills**, the Head of European Energy Markets, Ofgem, joined **Paul Newell**, a Statistician for the Energy Science Team at the Met Office. They were also joined by **Dr Rana Pant**, a Scientific Technical Project Officer in Life Cycle Assessment and Environmental Footprint, Sustainability Unit of the European Commission's Joint Research Centre (JRC), and **Dr Jeremy Woods**, Imperial College London, co-director of the Centre for Energy Policy and Technology (IECPT) and a member of the Bioeconomy Platform of Climate-KIC.



# Theme summary

The overall theme for this term was risk, resilience and response with regard to energy. Whilst the three meetings are summarised individually in more detail over the following pages, this section highlights some of key themes that were discussed over the course of the entire term.



One of the main points of discussion concerned the **appropriateness of different technologies for providing energy solutions** to developing areas. Sir Professor Brian Heap 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 discussed photovoltaic energy as an efficient option for energy production; Edgar Blanco mentioned various photosynthetic opportunities such as photosynthetic fertilisers and a need for more waterbased solutions; and Professor Chris Howe 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.

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 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.



## **Risk, resilience and response: energy**

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 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 Mullet 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 modelling of the different elements. Paul Newell highlighted the unified nature of the Met Office's model for local, regional and global hazards, as well as their ability to provide data regarding the best location for wind turbines or solar panels. Dr Jeremy Woods introduced the Global Calculator, a tool that shows the major points of action where humanity can mitigate climate change and the unforeseen impacts of policy change.

Combining these threads, the final forum focused on **circular economies**. Rob Mills 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.

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# Living off the grid

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## **Research gaps**

This forum reviewed the global off-grid energy situation and existing mechanisms for improving access to energy. Key challenges include the lack of available finance and awareness of opportunities, the need to be efficient with land and material use and wider policy issues that can reduce renewable energy solutions.

There are over a billion people currently living off-grid. To address this challenge, **Sir Professor Brian Heap** highlighted the concept of Smart Villages and the need to communicate with both local populations and various policy stakeholders to overcome technological, social and financial barriers. Biomass represents a rapidly deployable off-grid energy solution. However, less developed countries tend to be highly bio-based and this can create overdependence, leading to unsustainable environmental consequences. Thus there is a need for progress in other areas, such as novel and high quality crops, new crop rotations, disease management, improved market efficiency and affordable finance. In Europe there is a lack of consensus regarding the sustainability and feasibility of biomass. There are three main policy issues: the tension between the provision of bioenergy feedstock and food production; the threat of invasive species to food security; and rebound effects, such as the initial uptake of cheaper energy leading to increased consumption.

**Dr Heinz Ossenbrink** emphasised the need for a holistic view of the human energy footprint including food, water, energy and space requirements. Photovoltaic energy is an efficient and economic solution for energy production, and biomass is extremely important for food and material production. Using land and materials at the highest possible efficiency is necessary for a sustainable environment. The built environment and urban planning strategies should reflect this concern. Current market models are geared towards low initial investment and continuous cash flow. Consequently, a market needs to be created for renewable energy sources which need heavy investment but will yield long-term savings and benefits.

**Dr Muhammad Tayyab Safdar** also discussed the Smart Villages Initiative and a holistic approach to rural development. For example, rudimentary cooking stoves must be considered as part of the energy system. They can be inefficient and hazardous but overdesigning a solution may not meet the end-users' requirements. Providing off-grid electricity must serve a function, such as improving access to jobs, healthcare or education. There are big policy and business challenges to overcome when creating off-grid energy, particularly with regard to mini grids: companies require lots of working capital and developing countries lack access to finance; subsidies for fossil fuels remains a barrier to renewable energy uptake; and there is a lack of policy clarity in developing countries. Additionally, much biomass usage is unregulated and better legislation is necessary to combat deforestation.

# Wicked problems and questions generated by the open discussion

**How sustainable are biomass solutions?** There are indirect environmental costs from transporting fuel and conservation issues such as potential deforestation. As a result, biomass is not always an appropriate energy solution, but for off-grid areas it has much potential and is rapidly deployable. Increasing efficiency through a number of technological and behavioural changes is important.

Where does the investment come from? Often the technology exists to vastly improve energy efficiency but the high initial investment required discourages both consumers and businesses. Initial government subsidies, which demonstrate viable business models, may represent a solution but are not necessarily sustainable.

How can we encourage uptake of sustainable energy solutions? Understanding the 'demonstration effect' will help improve uptake at both ends of the energy chain. The demonstration of the long-term profitability of

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renewable schemes will encourage private schemes, and providing sceptical end-users with proof of a fully functioning and durable energy solution will stop regression to prior practices. Ensuring quality products is a crucial aspect of this process as, for example, sometimes non-branded solar panels will lack warranties and upon breakdown reduce confidence in the technology.

**How can solutions be tailored for local contexts?** There are a variety of challenges regarding land types and societal variations which mean that different off-grid energy solutions are required for different areas. At times, even end-users will not fully understand their needs or ability to pay. Sometimes lower-tech and small-scale solutions will be more appropriate and easier to maintain for a rural, developing population.

**How can we use land most efficiently?** There are approximately 1.6ha available globally per capita. With this in mind, it is important to understand how much land is needed for all human activities. Photovoltaic energy may be more efficient than biomass solutions, but it requires storage and does not fulfil all our highend fuel needs or provide food and raw materials. Balancing land usage, particularly with regard to biomass, in an economically fair and sustainable manner is a real challenge. There have been major changes in the US concerning economic biofuel production but will Africa and other regions follow suit and what will be the resulting indirect land use changes?

**How can we use material most efficiently?** Using biomass to its highest value by extracting its most useful components and utilising as much residual material as possible is something that requires both research and behavioural change. Waste as part of the energy system is an important factor requiring consideration.

Are the problems surrounding photosynthetic energy solutions intrinsic to this technology? Many of the problems appear to be related to wider market forces that also affect other energy markets. Proper infrastructure and policy frameworks are required to support newly implemented technologies and practices, which may be more difficult in developing countries. The green paradox, whereby fossil fuels can become cheaper if supplemented by other energy sources, must be countered by careful energy policy management.

# Witness profiles

#### **Professor Sir Brian Heap**

Scientific Advisor at the Smart Villages Initiative, Research Associate at the Centre for Development Studies, University of Cambridge

Sir Brian is a biological scientist who has published extensively on endocrine physiology, reproductive biology and biotechnology. Amongst his many achievements, he was the past President of the European Academies Science Advisory Council and former Master of St Edmund's College, Cambridge. He is an Honorary Fellow of the Royal Agricultural Society and Honorary Senior Scientific Consultant and Director of the Programme for Food Security and Sustainable Development at the Malaysian Commonwealth Studies Centre. He has been the UK representative on the European Science Foundation and the NATO Science Committee and has worked with WHO, the UK-China Forum and the EC.

#### Dr Heinz Ossenbrink

Head of Renewables and Energy Efficiency Unit, Institute for Energy and Transport, European Commission, Joint Research Centre (JRC), Italy

Heinz has a PhD in Nuclear Physics from Hahn Meitner Institute, Berlin and joined the EC's JRC in 1982, developing their photovoltaic research. In 1995, he became the Head of the Unit for Renewable Energy and more recently he has been developing the Unit's portfolio to support Africa's efforts for a renewable energy supply, amongst other projects. His work covers measurement and testing methods for photovoltaic generators, global environmental impacts of extended biofuel and bioenergy use and the economic assessment of renewable energy and of energy efficiency policy as a means for climate change mitigation.

#### Dr Muhammad Tayyab Safdar

Affiliated Lecturer at the Centre of Development Studies, Member of the Tutor Panel at the Institute of Continuing Education (ICE), University of Cambridge

Dr Tayyab Safdar is currently working as a Post-Doctoral Research Associate at the Smart Villages Initiative, an innovative research project that focuses on improving energy access for people based in remote off-grid rural areas in developing countries. He has previously worked as an independent consultant for multilateral organisations including the World Bank, the Food and Agriculture Organisation (FAO) and the International Fund for Agriculture Development (IFAD). His research interests include renewable energy, agricultural policies in developing countries, agro-industrial value chains and globalisation, food security and the impact of renewable fuels.

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# **Emerging technologies**

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## **Research gaps**

This forum introduced some new photosynthetic technologies and examined the extent of the contribution new and existing technologies can make in helping to alleviate problems faced in off-grid energy areas.

**Edgar Blanco** described various photosynthetic opportunities to improve energy production, although such solutions must be used in conjunction with other energies (as, for example, covering the UK with energy crop would not meet our current energy needs). Both direct and indirect energy savings must be considered. Thus, photosynthetic fertilisers could save energy by decreasing the need for ammonia production. Land-based energy crops are available for rapid deployment, and crop yields and biomass production could be increased by modifying photosynthetic pathways. However, more focus is needed on water-based photosynthetic solutions, such as improving water treatment by using phototrophic, instead of heterotrophic, algae. There is also an opportunity to capture more energy from UK green waste disposal. Despite such advances, rising energy demands mean political and societal improvements have to be made.

**Professor Chris Howe** introduced a new technology, biophotovoltaics, which could provide another option for producing off-grid energy. As part of the photosynthetic process algae and plants also produce electrons, some of which escape through the cell and can be harnessed by an electrode. The current energy production is measured in milliwatts but with more research this may be scaled up to a useful power source that could, for example, charge mobile phones and power LEDs. There are potential advantages to this methodology over solar photovoltaics despite the disparity in power output: some energy is produced even when it is dark; they are simple to make and maintain; and their environmental impact is lower. There is scope for combining this energy production with bioremediation or large-scale agriculture. A key problem is generating funding and overcoming public scepticism for a technology with a smaller power output.

This talk was supplemented by a live demonstration of the technology from **Paolo Bombelli**. A photosynthetic organism is placed in an anodic compartment and they settle on the anode after a few hours forming a bio film. Electrons are collected and pass through an external circuit to a cathode. A byproduct of this process is the purification of water around the cathode.

**Dr John Mullett** focused on the energy requirements of a rapidly increasing Sub-Saharan population, particular those in slums. A primary energy need is fuel for cooking, and the favoured fuel is charcoal, which is cheap, light and energy dense. Charcoal is the second biggest expenditure, after food, for a family. The current rate of consumption is unsustainable and causing tree degradation. This, combined with increasing population, is leading towards fuel starvation. Other solutions, such as rapid growth biomass to make feedstock for biogas, are needed. Key challenges include changing traditional practices, the lack of adequate land rights for ethical investment and a lack of infrastructure to transport fuel. Decentralised technologies for energy production and more efficient stoves are crucial for off-grid areas.

# Wicked problems and questions generated by the open discussion

There is a danger that climate change, although it is a key challenge, is obscuring other significant problems that humanity faces. Escalating fuel starvation, global soil degradation and issues concerning competition for land and resources are being neglected. These issues need both research and action.

**Can more be done to combine renewable energy solutions with other major development projects?** It may be possible to combine biophotovoltaic technology and similar schemes with other large-scale projects, such as agriculture or water treatment, making them more attractive for business investment. Combining different technologies provides the opportunity to reduce waste and use materials more efficiently.

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Is it possible or realistic to get energy to densely populated, off-grid conurbations? Understanding how to get energy into such areas is one of the most challenging issues faced by humanity. Technological solutions (roof panels, urban agriculture, waste recycling, etc.) will only go so far, and behavioural practices, such as cooking methods, need to be changed. Technological solutions, such as wired grids, can be materially valuable and thus are vulnerable to theft in economically deprived areas.

How important are technical solutions for solving global energy problems? Technological solutions can have unintended consequences or simply shift the problem to another area. Therefore the entire system needs to be examined through a multidisciplinary lens, with social sciences playing an important role. Research Councils and other funding sources need to fund more interdisciplinary work. Novel and potentially unconventional policy solutions should be explored, such as carbon passports/pricing or waste taxes to make people more aware of the impact of their energy decisions.

How can we better understand the local context? Talking to people who understand the populations and their needs is extremely valuable. Efficient ways of bridging the gap between scientist and consumer helps ensure you find the right place to intervene with appropriate technology in a way that is appreciated by the local population. In many ways the biggest barriers to change or technology uptake are social issues. Having young researchers from the relevant country could offer greater indigenous, sociological insights but this requires basic education. Community engagement and improving education in the area is fundamental to a successful technological intervention.

How can we encourage serendipity in technological progress? Often solutions appear in counter-intuitive ways and initially technologies may even be perceived as unnecessary. Identifying what populations need when they themselves may not know - requires deep sociological research. As it stands, market research is largely focused on incremental change which can hinder innovation. Social attitudes and public perceptions of necessity and harm significantly affect the development of technology, policy and our understanding of what may be considered as progress.

# Witness profiles

#### **Edgar Blanco**

Research and Development Manager, Andigestion Ltd

For the last 19 years Edgar has worked as an industrial researcher targeting developments with measurable financial returns. Since 2006 he has worked for Andigestion Ltd and provided the technical and scientific knowledge required to transition from landfill gas recovery to anaerobic digestion (AD). Edgar worked with regulators, industry and academia on the development of technical standards for the AD industry. Amongst other projects, Edgar has been working on new feedstocks for AD from "green biomass", such as arable by-products, green waste and micro and macro algae.

#### **Professor Chris Howe**

Professor of Plant and Microbial Biochemistry, Department of Biochemistry, University of Cambridge

Chris has over 25 years of experience in plant molecular biology, with an emphasis on prokaryotic and eukaryotic algae and the biochemistry of photosynthesis. He is particularly interested in modifying the components of photosynthetic membranes that harvest and utilise light energy and harnessing the electron transfer reactions of photosynthesis for direct generation of energy or hydrogen ('biophotovoltaics'). His lab was one of the first to identify the unusual chloroplast and mitochondrial genomes of dinoflagellate algae and discovered cytochrome c6A, an unusual form of cytochrome c6, formerly thought not to exist in plants.

#### **Dr John Mullett**

Founder and Director, SOWTech (Sustainable OneWorld Technologies) CIC

John is currently working to achieve a significant increase in the treatment and reuse of organic waste materials, including human sewage in hot low-income countries. SOWTech is a non-profit organisation that works with partners to bring new low cost options for sanitation, biogas and biofertiliser production. Currently he is involved in projects in Malawi, Uganda, Sierra Leone, Ethiopia and Tanzania. The latter of which is in association with the Cambridge Development Initiative, of which John is a trustee.

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# Catalyzing changes in energy

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## **Research gaps**

The four witnesses offered different perspectives on how to create circular economies using photosynthetic technologies. Much of the discussion concerned problems regarding policy requirements and social and cultural behaviour which can suppress the successful implementation of pre-existing technological solutions.

**Rob Mills** described some of the policy and finance challenges behind using bioenergy to create circular economies in off-grid areas. There are a number of possible business models: supply can come from large-scale industry – although the transport of biofuels to off-grid areas requires infrastructure – or small utility, community-level projects, and demand can be at a community or household level. There were three main observations regarding circular economics: resource efficiency is already high in areas of rural poverty out of necessity; it is easier to implement than design circular economies because of the complex interplay of household economics, personal incentives, price signals and broader societal norms; and there is a danger of technological interventions undermining pre-existing markets.

**Paul Newell** offered some insights into how the Met Office's modelling work could influence sustainable decision-making. The Met Office has a unified model for local, regional and global climate that can be used to predict hazards. This can help with rapid aid deployment and assessing and mitigating the risk of climate change for important agriculture. Wind resources can be modelled at different atmospheric levels for different turbine types, and the best places to harness increasing solar resources can be identified.

**Dr Rana Pant** explained how life-cycle assessment attempts to comprehensively assess a situation so that the ramifications of any changes are fully understood, particularly to avoid simply moving burdens to a different region, time period or part of a system. Three key problems for creating circular economies in developing areas were described. First, analysis becomes more complex as you scale up a problem. Thus, understanding trade-offs within a system and any future rebound effect is crucial. Second, user behaviour has an impact on the environmental performance of a system and social scientists need to study how to motivate and inform people in varying contexts to help environmental efforts. Third, new innovations can be inhibited by a lack of data when compared with existing solutions.

**Dr Jeremy Woods** highlighted the challenge of maintaining trust in the evidence base and the need to question how values elicit scientific outcomes as science moves from reductionism to multidisciplinarity and systems perspectives. He also introduced the Global Calculator: a tool designed to encapsulate major points of actions which humanity could use to mitigate climate change. This tool can demonstrate unforeseen impacts of policy change; for example, by examining the interaction between bioenergy and food production it can be seen that the nature of human diet is as important to climate change as our response in the energy sector. Bioenergy systems are deeply complex and uncertain as they have an impact on social, health and resource availability issues to a unique degree. The local, environmental context must also be considered. This was demonstrated through the example of a circular economy created in Malawi to promote resilience in the local supply chain and enhance income provision for poor rural farmers.

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# Wicked problems and questions generated by the open discussion

**Is a top-down or bottom-up approach to solving development problems more appropriate?** The complexity and heterogeneity of local contexts can make a top-down technological solution difficult to implement. A variety of different solutions for different areas and problems will be required, and by initially viewing things on a global scale nuances can be missed. Combining these approaches is likely to be crucial.

What are the appropriate metrics for human wellbeing? GDP is still used as a metric for wellbeing in some reports. Although this is problematic and value-laden, having comparison tools that allow you to measure this metric against others may mitigate some of those issues.

**Is it feasible or sensible to move towards a circular economy entirely based on biological resources?** Photosynthetic solutions are likely to be at the heart of responses to climate change and sustainable communities, although they may be one solution of many. Although photosynthesis may not be the most efficient means of drawing energy there are methods that would increase its efficiency to meet future demands. Photosynthesis is also valuable because it can convert solar radiation into both electrical energy and food. However, there can often be problems after technological improvements stemming from imprudent policy decisions. It is also important that we use biological materials in an appropriate way and avoid harmful waste.

How can we implement technology in areas of rural poverty? Often the technological solutions for creating sustainable development exist; the problem is in their implementation. A common theme of the energy forums has been issues concerning local contextual challenges and how to encourage the behavioural changes needed for acceptance of new technologies. Nonetheless, it is important to remember that, despite conservative practices sometimes being a barrier to change, people in rural communities can be creative and innovative in unforeseeable ways. Using market forces to encourage businesses built around technologies is an effective way of ensuring long-term change. Another possible strategy is to learn lessons from effective marketing strategies and make technologies seem exciting rather than prescriptive.

How can we encourage the development of new technologies? Innovative ideas often lack the data to demonstrate their worth and may carry an element of uncertainty. Current systems often encourage incumbency, so policy changes are needed to encourage new solutions.

## Witness profiles

#### **Rob Mills**

Head of European Energy Markets, Ofgem

Rob leads Ofgem's work on European energy markets, heading a group of three teams negotiating and implementing policies to integrate cross-border gas and electricity markets. Prior to joining Ofgem, Rob worked for eight years at the World Bank, where he managed a portfolio of energy investments in southern Africa and advised governments on policy and regulatory reforms. Earlier in his career, he worked on international issues at the Prime Minister's Strategy Unit, following four years in Brussels at a development finance think tank and in the European Commission. Rob started his career at a leading strategy consulting firm focusing on banking and financial markets. He has a graduate degree in economics from Columbia University and an undergraduate degree from Oxford.

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#### **Paul Newell**

Statistician for the Energy Science Team, Met Office

Paul Newell is a statistician and programmer who analyses weather and climate data for the Met Office to enable the energy industry to make good decisions in the face of weather and climate effects. This results in increased efficiency, improved health and safety and a more secure supply of energy. He joined the Met Office in January 2014, after spending six years as a medical statistician at Plymouth University. He has a BSc (Hons) in Mathematical Science from the Open University and an MSc in Statistics from the University of Sheffield.

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# **Dr Rana Pant**

Scientific/Technical Project Officer, Institute for Environment and Sustainability, European Commission, Joint Research Centre (JRC), Italy

Rana is an environmental engineer by training. Before joining the European Commission in 2008 he worked over 8 years with a multinational consumer goods company on topics related to integrated waste management and Life Cycle Assessment (LCA). From 2005–2008 he co-chaired the LCA Steering Committee of the Society of Environmental Toxicology and Chemistry (SETAC). Since Rana joined the European Commission in the Institute for Environment and Sustainability of the JRC he has been applying Life Cycle Thinking to solid waste management, Life Cycle Impact Assessment, The European Platform on LCA (EPLCA) and the International Reference Life Cycle Data System (ILCD) Handbook.

## **Dr Jeremy Woods**

Lecturer in Bioenergy at Imperial College London, Co-director of the Centre for Energy Policy and Technology (ICEPT), Member of the Bioeconomy Platform of Climate-KIC

Jeremy works on the interplay between development, land-use and the sustainable use of natural resources. He coordinated the land/food/bioenergy and climate science components Environment he worked on the 'Bioenergy: bridging the gaps project' and was lead author of the 'land and bioenergy' chapter. He is also a member of the Royal Society's DFID Africa Capacity Building Initiative Assessment Panel. His research links environmental impact, techno-economic and sustainability assessment frameworks and is applied to policy-making standards.

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"This issue of bioenergy is actually an extremely complicated issue – it is both broad and deep and it touches what might be called uncertainty."

JEREMY WOODS, IMPERIAL COLLEGE LONDON

"You cannot say access to electricity is the end, it has to be a means towards an end and it has to mean something for the community."

DR MUHAMMAD TAYYAB SAFDAR, UNIVERSITY OF CAMBRIDGE

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#### Forum members

**Chair: Lord Martin Rees** 

**Director: Professor Paul Linden** 

**Executive Secretary: Dr Rosamunde Almond** 

## Acting Executive Secretaries: Dr Konstantina Stamati and Dr Elizabeth Tyler

The Forum was founded in January 2013. For this topic, members are drawn from five University Schools and 20 University departments, centres and institutes, ranging from the Departments of Architecture, Land Economy, and Plant Sciences to History and Philosophy of Science and the British Antarctic Survey. This year new members have joined from the Computer Laboratory, the Cavendish Laboratory of Physics and the Centre for Development Studies. People from the Cambridge Institute for Sustainability Leadership (CISL) and the Cambridge Centre for Science and Policy (CSaP) are also founding members of the group. In addition to the expert witnesses detailed in this report, the following people attended the forum during this series.

Core Members: Professor Alan O'Neill, Emeritus Professor of Meteorology, University of Reading and visiting professor in the Cavendish Laboratory; **Professor Alison Smith**, Professor of Plant Biochemistry, Department of Plant Sciences; Professor Doug Crawford-Brown, Executive Director, Cambridge Centre for Climate Change Mitigation Research (4CMR), Department of Land Economy; Dr Emily Shuckburgh, Head of the Polar Oceans Team, British Antarctic Survey; Dr Helen Curry, Peter Lipton Lecturer, Department of the History and Philosophy of Science; Dr Hildegard Diemberger, Senior Associate in Research, Mongolia and Inner Asia Studies Unit (MIASU), Department of Social Anthropology; Professor Howard Griffiths, Professor of Plant Ecology, Department of Plant Sciences; Professor Ian Hodge, Professor of Rural Economy, Department of Land Economy; Professor Ian Leslie, Professor of Computer Science, Computer Laboratory; Dr Jake Reynolds, Director of Sustainable Economy, CISL; Dr Julian Huppert, Director of the Intellectual Forum, Jesus College; Professor Koen Steemers, Professor of Sustainable Design, Department of Architecture; Dr Miles Parker, Associate Fellow, CSaP; Professor Paul Dupree, Professor of Biochemistry, Department of Biochemistry; Professor Peter Guthrie, Centre for Sustainable Development, Department of Engineering; Polly Courtice, Director, CISL; Dr Shailaja Fennell, Lecturer in Development, Department of Land Economy; Professor Steve Evans, Director of Research in Industrial Sustainability, Institute for Manufacturing; and Professor Susan Owens, Professor of Environment and Policy, Department of Geography.

<u>Cambridge University Guests</u>: **Professor Andy Hopper**, Professor of Computer Technology and Head of Department, Computer Laboratory; **Dr Beatrix Schlarb-Ridley**, Director of Innovation and Impact, British Antartic Survey; **Professor David Newbury**, Emeritus Professor of Economics, Empirical Microeconomics Group, Faculty of Economics; **Dr Isabelle de Wouters**, Director of Scientific Development, Energy@Cambridge Strategic Research Initiative; **Professor Loraine Gelsthorpe**, Professor of Criminology and Criminal Justice, Director of the Centre for Community, Gender and Social Justice, Director of the Cambridge ESRC Doctoral Training Centre, Joint Convenor of CAMMIGRES (Cambridge Migration Research network) and Deputy Director of the Institute of Criminology; **Dr Marc Ozawa**, Policy Research Associate and Programme Co-ordinator in Search of 'Good' Energy Policy, Energy@Cambridge, CSaP; **Dr Mariana Fazenda**, Innovation and Enterprise Officer, Department of Plant Sciences; **Dr Matthew Davey**, Senior Research Associate, Department of Plant Science; **Dr Michael Price**, Winton Scholar Optoelectronics Group; **Dr Nicolette Bartlett**, Senior Programme Manager, Corporate Leaders Network for Climate Action (CLN), CISL; and **Theo Hacking**, Director of Graduate Programmes, CISL.

<u>Early Career Researchers</u>: **Carolina Feijao**, PhD student, Department of Biochemistry; **Dr Paolo Bombelli**, Postdoctoral Researcher, Department of Plant Sciences; and **Richard Sidebottom**, PhD student, Centre of Development Studies.

# Cambridge Forum for Sustainability and the Environment

For more details about the Forum and the meetings please contact Dr Rosamunde Almond (<u>r.almond@damtp.cam.ac.uk</u>) and Dr Konstantina Stamati (<u>ks712@cam.ac.uk</u>)

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