

DURHAM ENERGY INSTITUTE REVIEW

ISSUE 6: SUMMER 2015



**WORLD
SOLAR CAR
CHALLENGE**

**ENERGY
TRAINING
@DURHAM**

**OFF-GRID AND
RENEWABLE
TRANSITIONS
IN ENERGY
LIVELIHOODS**



IN CONVERSATION WITH
...our artist in residence

Energy
networks
analysis
research

Which way
should the wind
blow for our
national grid?

Carbon
Democracy
& Revolution

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// A MESSAGE FROM THE



DEI EXECUTIVE DIRECTOR

Welcome to the latest edition of the DEI's Review magazine. Since the last issue we have been able to move forward with a number of our strategic objectives including, ensuring the Institute is sustainable, boosting our international profile, contributing to large grant capture and nurturing relationships with key partners.

The DEI Office staff and Director team has remained the same over the last year. However, we have just completed the process of appointing the next wave of DEI Fellows.

The previous incumbents included Andrew Crossland (PhD) who successfully completed his thesis in December 2014 and is now working at Network Rail, Maria Kastrinou (Early Career) and Corina Hess (Mid Career) who have both now left Durham for academic positions at other Institutions. Victoria Wells (Mid Career) from DUBS has stepped down from her Fellowship after 3 years of sterling service, including recently completing a brand awareness exercise for the DEI. We thank all of these people for the time, effort and commitment that they have dedicated to DEI during their Fellowships.

We were delighted with the response generated by our advert earlier in the year for the next round of DEI Fellows which resulted in the successful appointments of Charlotte Adams (Earth Sciences), Ivana Evans (Chemistry), Budhika Mendis (Physics) and Hong Sun (Engineering) as Mid Career Fellows, Daniel Knight (Anthropology) and Amy Wilson (Mathematics/Engineering) as Early Career Fellows, and Taras Fedirko (Anthropology) as our new PhD Fellow. The fellows have a wide range of energy research interests which are briefly outlined on the opposite page and these will inform our future series of DEI events and articles in the DEI Review magazine.

The DEI's strategic focus on supporting international engagement by the University has led to a range of activities and events in recent months.

// **Find out more about our past events www.durham.ac.uk/dei/events/past.events/**

In April I travelled with Janet Stewart from the Centre for Visual Arts and Culture to Rice University in Houston to deliver a DEI session at their Center for Energy and Environmental Research in the Human Sciences Spring Research Symposium. Professor Stewart and I gave presentations on current research activity at Durham in nuclear energy spanning all three Durham University Faculties ranging from developing Nuclear Fusion technology, to public and community responses to the technology. This served to underline the interdisciplinary nature of Energy research at the University. The DEI is also strongly engaged with the initiative to establish an International Institute of Energy Systems Integration (iiESI) being led by Mark O'Malley from University College Dublin. On behalf of the DEI Chris Dent (Engineering) and I have attended iiESI meetings in USA, Europe and Japan and the DEI has hosted Professor O'Malley in Durham for research discussions and for him to deliver one of our recent DEI public lectures. Other recent activity on the international front includes a DEI-led H2020 bid which has been submitted under the leadership of Simone Abram (DEI Co-Director from Anthropology)

and which resulted from discussions that took place during a joint DEI/IHRR research visit to Utrecht University in 2014.

The DEI has continued work to support the University in strengthening, maintaining and developing new relationships with major collaborative external partners. One key relationship is with DONG Energy which continues to deliver mutual benefits. Peter Matthews (Engineering) completed a period of several months working in the DONG offices in Denmark during a recent sabbatical period. This has resulted in some excellent feedback from the Company on the value of the work undertaken by Peter, and has led to opportunities for postgraduate and undergraduate students to undertake placement periods in Denmark this year. The DEI also arranged a successful public event on DONG's behalf held at Manchester University earlier in the year, focused on the key problem we are currently facing of integrating more renewables, particularly wind, into the grid. The event also helped to increase awareness of the Company in the Northwest.

We are looking forward to continuing to progress our strategic aims over the coming months and feel strengthened by the influx of new DEI Fellows. There are some exciting new opportunities emerging involving Haringey Council and Greenport Hull which we are exploring at the moment and which may develop into new areas of activity for Durham University and the DEI for report in future editions of the DEI Review magazine.

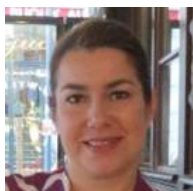
DEI NEWS

// New members of DEI community



DEI Mid-Career Fellows

Dr Charlotte Adams is the research manager for the BritGeothermal Research Partnership and is based in the Department of Earth Sciences. Her research interests include hydrogeology, hydrogeochemistry, geothermal energy and ground source heat and microgeneration.



Dr Ivana Evans (Chemistry) runs a research programme on oxide-ion conductors, materials needed as electrolytes in solid oxide fuel cells (SOFCs), devices for clean and efficient generation of electrical energy. She has also recently started new research into visible-light oxide and mixed-anion photocatalysts for hydrogen production.



Budhika Mendis (Physics) works on microstructure and defect characterisation of thin-film solar cells (both inorganic and organic) primarily using electron microscopy.



Dr Hongjian Sun (Engineering) focuses on communication system integration with smart grids, demand side management and demand response, and integration of renewable energy sources. He currently leads Durham's smart grid laboratory.



Early Career Fellows

Dr Daniel M. Knight (Anthropology) is currently Addison Wheeler Research Fellow. His research focuses on renewable energy and sustainable economic development in Greece and Turkey, exploring the social and political impact of solar and wind energy developments in times of fiscal austerity.



Amy Wilson, (Engineering) focuses on statistics for energy systems and the modelling of uncertainty in computer models. Particular applications have included methods for capacity adequacy assessment in Great Britain and a study of the effect of uncertainties on the outputs of a generation investment computer model used by DECC.



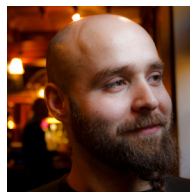
PhD Fellow

Taras Fedirko is studying a PhD within the Anthropology department. His doctoral research explores how and why British NGOs, civil servants and extractive companies seek to prevent the 'resource curse' in 'developing countries' by negotiating transparency policies that increasingly bind the governance of natural resources with the audit of resource revenues.

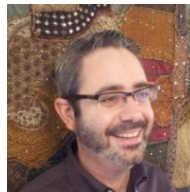


New Faces at Durham

Dr Rui Carvalho has joined the department of Engineering and Computer Sciences (ECS) as a Lecturer. His interests lie in algorithms for energy networks, their mathematical underpinnings, and applications. Including the integration of methods of convex optimization, control theory, game theory and statistics to characterize and model networks in energy. He has applied these methods to Gas networks, Electric Vehicles and Urban networks.



Manuel Llorca has joined Durham Business School as research fellow in energy economics. His key research interests are efficiency and productivity analysis, energy demand, regulatory economics and transport economics.



Dr Gruffudd Edwards joins ECS as Postdoctoral Research Associate on the projects 'Energy Storage for Low Carbon Grids', and 'Green Growth Diagnostics for Africa'. His research focuses on renewable resource modelling and probabilistic forecasting, operational strategies for storage, and use of these to increase economic viability of renewables.



Dr Chiara Bordin joins ECS as Research Associate for the EPSRC projects "Pumped Thermal Energy Storage" and "Autonomic Power System". She received her PhD at the University of Bologna, Italy. Her research interests are related to mathematical optimisation applied to thermal and electrical energy systems.



Dr Mahmoud Shahbazi has joined ECS from Sharif University in Tehran as Research Associate for the EPSRC project "High Energy And Power Density (HEAPD) Solutions to Large Energy Deficits".

Other news

NERC Ambassador: Professor Bob Holdsworth, from the Department of Earth Sciences, has been appointed as an 'Anniversary Ambassador' by the Natural Environment Research Council. During 2015 Bob will be meeting politicians, stakeholders and the general public, to promote the geoscience and environmental advances of NERC-funded science in the 50 years since the research council was formed, while also highlighting the impacts that Durham scientific discoveries have on our future economic prosperity and wellbeing. Bob is a former NERC Knowledge Exchange Fellow and has been appointed due to his close research and regulatory links to the UK oil, gas and nuclear industries.

European Strategic Energy Technology Plan: Douglas Halliday, Director of DEI's Energy CDT, has been invited to join the UNI-SET Steering Committee. The UNI-SET project aims to mobilise the research, innovation and educational capacities of Europe's universities in Energy by strengthening university involvement in, and contribution to, the European Strategic Energy Technology Plan (SET-Plan). The Steering Committee consists of invited experts from 17 leading universities across Europe; their role is to provide expert advice on energy-related research and education. **Further details at <http://www.eua.be/uni-set>**





LEADING THE PUBLIC ENERGY DEBATE



Over the past few months DEI has hosted a number of exciting events which have engaged a wide range of people from industry, policy, the community sector and the general public. Here are summaries of just a few of the events we have held.

To read a full review of all our events and to watch the videos go to www.durham.ac.uk/dei/events/past.events/

Which way should the wind blow for our national grid? A Durham Energy Institute and DONG Energy UK public debate.

On 18 March DEI co-hosted a public debate in Manchester with DONG EnergyUK. The debate focused on the issue of how the UK can integrate more wind into the electricity system to achieve and exceed Government targets to deliver 15% of our energy demand from renewable sources by 2020. Wind is identified as the major source for renewable electricity in 2050 by the UK Renewable Energy Strategy. However given the dispersed nature of onshore and offshore wind generation, as well as the fluctuations in wind power generation, it will be necessary to implement a number of changes to achieve this future.

The debate was chaired by Barbara Vest Director of Generation at Energy UK whose members generate more than 90 per cent of the UK's total electricity output. The panel comprised of;

- Vandad Hamidi, SMARTer System Performance Manager at National Grid;
- Dr Alastair Martin, Founder and Chief Strategy Officer, Flexitricity;
- Bo Hesselbæk, Head of Electrical System Analysis, DONG Energy UK; and
- Professor Tooraj Jamasb - Chair in Energy Economics at Durham University.

The evening was a great success with full and active participation of the audience comprising academics, policy makers and industry from the NorthWest region.

The debate allowed key players in the energy sector to discuss the challenges we really face, the range of available solutions and the implications for energy policy. The panel agreed that a future which is more reliant on renewable wind energy is possible while also ensuring reliability of the system. However it is important to recognise that this will require changes in the UK energy market, investment in energy infrastructure and increased energy links with Europe.

Key areas discussed in the debate were:

- 1) The lessons that can be learnt from the experience in Denmark which last year achieved 40% penetration of wind whilst also achieving the highest security of supply in Europe.
- 2) The key role that demand-side response mechanisms are already playing in dealing with fluctuations in supply and demand. It was argued more emphasis needs to be placed on mechanisms to shift the loads of industrial, commercial and domestic users. Consumers, both domestic and large commercial, also need to become more aware of the options they have at their disposal for shifting their energy use.
- 3) What changes are required to the UK energy market? Debate centred on whether subsidies should be used to encourage renewable technology development and to ensure on-going conventional generation potential, or whether this was an interference in a free energy market.

nationalgrid

DONG energy

flexitricity
Unlocking smart grid revenue

Carbon Democracy and Revolution: Critical perspectives from the Middle East and the Mediterranean by Maria Kastrinou. Maria was formerly DEI Early Career Fellow and a member of Durham's Anthropology Department. She is now a lecturer at Brunel University.

Inspired by Timothy Mitchell's Carbon Democracy: Political Power in the Age of Oil, Matteo Capasso and I organised an interdisciplinary workshop in order to explore themes related to energy, political power, history and ideology in the broad area of the Middle East and South-Eastern Mediterranean.

Social revolutions, civil war and crippling economic crises: what is going on in the Middle East and South Eastern Mediterranean? Are the revolutions and wars in Egypt, Syria or Libya connected to the economic crises in Greece, Italy or Cyprus? How do carbon resources and energy competition affect these tense social, economic and environmental inter-relations?

Starting with a keynote lecture by Timothy Mitchell entitled 'Carbon Democracy and the Corporate Future,' the two-day workshop took place at Durham between 13th and 14th February. It combined exploration of regional case-studies with critical analyses of power relationships, resources and the frailty or persistence of democratic practices. Mitchell's public lecture and the workshop were extremely well-attended and thought-provoking.

Mitchell reminded us what Carbon Democracy is about: how the exploration, production, distribution and consumption of oil changed political power and made representative democracy possible in the 20th century. By examining rent and debt, Mitchell's lecture emphasised the need to locate energy, infrastructure, and power in geopolitical connections, regional and international circuits, and in critical interdisciplinary conversations. The keynote reinforced our own assumptions that indeed



there are interconnections between civil wars and economic crises, and that the challenges to ‘democracy’ across the Mediterranean are not due to context specific reasons of endemic violence, for the Middle East, or endemic laziness, for Southern Europe. Indeed, the keynote underscored how energy and infrastructure are fundamentally related to both democracy and violence, and the urgent need to research these connections if we truly want to understand what’s wrong in the Middle East and Mediterranean. In this direction, the workshop brought together critical comparative approaches from different disciplinary backgrounds to examine and rethink ‘democracy’ and revolution through the politics of energy conflicts.

Contestations over ‘clean’ and ‘dirty’ energy opened the first day of the workshop, with Jim Coxon, from Durham University, talking about coal mining in county Durham, and Nasim Alatrash showing an exclusive trailer of his documentary *The Windbag of Aeolus*, which exposes social and political struggles regarding green energy in Greece. Energy as a site of struggle was the theme that permeated all the presentations in the second day. Roberto Cantoni (LATTS – IFRIS, Paris, France) and Martha Murso (University of Cambridge) detailed the history of hydrocarbon resources, transportation (pipelines and diplomacy), and the politics of expertise in Algeria’s struggle for independence. Joanna Allan (Leeds University) took us to Western Sahara, the last colony of Africa, exploring how resources have been at the heart of the conflict especially since 2010.

From struggles of independence to struggles within the state, the next panel explored geographic and national contestations around energy, with studies on electricity and water: Eric Verdeil (Université de Lyon, CNRS) looked at the securitisation of urban electricity supply in the cases of Jordan and Lebanon, and Edward G. J. Stevenson (Durham University) examined the political discourses of dam building and land-grabbing in Ethiopia. The last workshop panel took ‘democracy’ to task, with Andrea Teti (Aberdeen University) presenting on confession, democratisation and Orientalism in the Middle East, and Matteo Capasso (Durham University) talking about the politics of oil and humanitarian interventions in Libya and Bahrain. Connections were drawn out through the critical engagement of the invited discussants: Wilf Wilde, James Piscatori, Elisabeth Kirtsoglou and Steve Lyon.

Bringing together interdisciplinary research on energy and power relations in the workshop revealed the need for further research engagement

with issues of infrastructure, energy and conflict in the Middle East.

Off-Grid and Renewable Transitions in Energy Livelihoods: LCEDN @Durham by Ben Campbell (Anthropology, DEI)

The UK Low Carbon Energy for Development Network (LCEDN) exists to bring academics into interdisciplinary collaborations over the particular kinds of socio-technical issues that are encountered in developing world contexts. It aims to promote learning from the activities of different partners and to develop partnerships with NGOs, private enterprises and government policy representatives in Department of Energy and Climate Change and Department for International Development.

The Durham conference theme was ‘Off-Grid and Renewable Transitions in Energy Livelihoods.’ Prof. Simon Hogg welcomed the sixty-five attendees on behalf of the DEI. The first keynote speaker was the dynamic and inimitable Dipak Gyawali, former minister of water and energy in Nepal. He treated the audience to wise reflections from four decades of experience in the electrification of Nepal, in protesting ill-conceived big-dam projects, and in successfully promoting community-based energy solutions. He shared his observations about the current policy directions of nexus-thinking around energy water and food, and entreated the conference participants to practice looking at energy issues from different scales of understanding development processes: the eagle’s eye-view and the toad’s eye-view. The second keynote was delivered by Judith Cherni from Imperial College, Centre for Energy Policy and Technology, who shared her approach to socio-technical decision-making, using multi-criteria energy livelihood analysis, drawing on examples from rural communities in Colombia and China.

Table-discussions moved the event into workshop mode, with participants pouring their thoughts and questions about energy livelihoods onto sheet after sheet of marker-penned flip charts, taking on various connector-themes of households, ecology, city-regions, governance and transitions.

After lunch the conference listened to ten minute presentations from ongoing research in the energy for development field by Asha Singh (Imperial), Joshua Kirshner (York), Raihana Ferdous (Durham), Ankit Kumar (Durham – whom we thank for his opening line ‘the answer’s simple “it’s

complex”’), and Jamie Cross (Edinburgh).

Next up came 10 minute presentations from some of the projects funded by the Understanding Sustainable Energy Solutions programme (EPSRC, DFID, DECC). Jon Cloke (Loughborough) spoke about Solar Nano Grids (SONG) and Renewable Energy and Decentralisation (READ). Mirjam Roeder (Manchester) spoke of the Energy from Rice Straw project based in Philippines. Rupert Gammon (Newcastle) reported on the ESCOBox project identifying major challenges to microgrid control as politics and culture rather than technology. Ana Pueyo (Sussex) presented on the Green Growth Diagnostics project in Africa. Chian Chan (Newcastle) spoke about Renewable Energy for Food in Sierra Leone and Kenya. Lastly Simon Batchelor reported on the SAMSET and AGRICEN projects.

After tea, Leanne Jones (Innovation Adviser for Climate and Environment at DFID) was given the stage to present on DFID’s energy research priorities. Various opportunities in the pipeline were discussed, which include the Energy and Economic Growth call, and the Renewable Energy Smarter Electricity Systems and Storage, which the LCEDN membership is looking forward to respond to when the call is announced later in the year.

Monday evening had involved a Durham energy tour taking in the Durham Council Freeman’s Reach archimedian screw, installed by Carillion. A walking talk passed iconic sites of Durham’s coal history led by Jim Coxon, and ending up at the science site for a Durham campus energy hub reception to watch Raihana Ferdous’ film from Bangladesh, and enjoy a tour of Durham’s smart-grid lab led by Hongjian Sun.

The Durham Energy Institute has played a pivotal role in the formation and coordination of the LCEDN network. The network is managed by a committee consisting of representatives of DEI, Midlands Energy Consortium, Sussex Science Policy Research Unit, Imperial College, Practical Action, UK Collaborative for Development Sciences, UKERC, DECC, and DFID.

Find out more about LCEDN and partner activities at www.lcedn.com

THE CUSTOMER-LED NETWORK REVOLUTION – LEADING THE WAY TO A SMARTER, LOW CARBON FUTURE.

Durham University has been at the forefront of one of the largest smart grid projects in the UK – the Customer-Led Network Revolution (CLNR) – alongside project partners Northern Powergrid, British Gas, Newcastle University and EA Technology, who looked at ways to create a smarter powergrid, which can cope with the new challenges we are facing as a result of the low-carbon revolution.

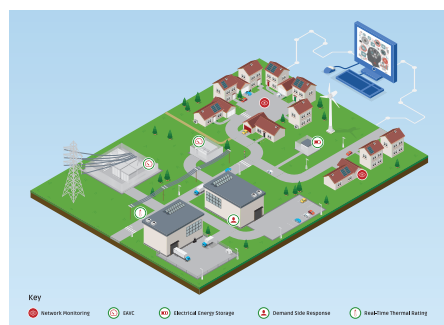
The adoption of renewable energy sources and the electrification of heating and transport will play a key role in realising UK government targets to reduce carbon emissions by 80% by 2050. However, customer uptake of electricity-dependent low-carbon technologies, including electric vehicles and heat pumps, is creating new demands on the current electricity network, whilst micro-generation in the form of solar photovoltaic cells (panels) has reversed the traditional ‘network to customer’ flow of electricity, thus presenting network operators with new challenges to manage.

The project, which finished in December 2014 and recently published its findings, carried out important new research, trialing a range of novel network technologies, alongside new commercial arrangements and customer demand response propositions.

More than 13,000 domestic and business customers have taken part in the project, some of which were monitored via smart meters over a two-year period. Over 1000 online customer surveys and almost 300

face-to-face in-home interviews were carried out; the results from which have been analysed by social scientists at Durham University. This research, which is one of the largest qualitative studies of consumer energy practices ever recorded, has produced groundbreaking research into current, emerging and possible future electricity demand and generation trends which will be used to help manage future electricity networks.

Dr Liz Sidebotham, Communications and Compliance Manager at Northern Powergrid, outlines the benefits the project could bring to the UK energy sector: “The Customer-Led Network Revolution project will help the industry maximise customer and network operator efficiencies through the deployment of new smart grid technologies, customer flexibility and demand-side response solutions. Ultimately, these advances will give customers more choice over the way they use and generate electricity and ensure they continue to receive a safe, secure and affordable supply of electricity both now and in the low carbon future.



“To give an example, it’s estimated there are roughly 40 million cars on the road today; if, at some point in the future, just half of those were electric vehicles and all those EV owners charged their cars battery at the same time, it could equate to 80GW of power, which is the entire generating capacity we have available in Britain today.”

“When you take into account that the overall peak demand for electricity

in the UK at the moment is typically 40GW we’d have to double our existing generating capacity to cope with EV demand alone.

“It’s clear that low carbon technologies pose emerging challenges for the electricity industry, and that’s why the CLNR project sought to find the most cost-effective methods to meet the demands of a low carbon future, with the aim of keeping consumers’ energy prices and carbon footprint as low as possible.”



Customer Trials

Dr Sidebotham continues: “We’ve studied thousands of electricity customers – many with electric vehicles, solar photovoltaic panels and heat pumps – to better understand when, why and how much electricity people use.

“The current debate on security of supply in the UK has largely overlooked the role of demand-side response so we also wanted to ascertain whether financial incentives or new technology, like in-home energy displays and new smart appliances, can encourage users to shift their usage away from periods of peak electricity demand.”

Network technology trials

A range of network ‘smart grid’ technologies – including six electrical energy storage batteries, real-time thermal rating devices and a complex active network management control system developed for the project by Siemens, called GUS (Grand Unified System) – have also been deployed for the project. The results from over 200 trials of these technologies were analysed by academics from Durham University and Newcastle University to make optimal network solution



recommendations which will help network operators to future-proof the network.


Dr Sidebotham explains: “We are moving on from fit-and-forget arrangements to something smarter, particularly when connecting generation from onshore wind farms or solar farms, for example. By understanding which solutions to use, when, and on which type of network, electricity networks are capable of responding to continuing change and can therefore continue to operate in an efficient manner and deliver value to consumers.”

Project conclusions

By combining one of the largest studies of customer energy practices ever undertaken in the UK with new technologies and some of the most sophisticated network control technology in Europe, electricity network operator Northern Powergrid has identified a pathway to smarten local networks through time. Following a consultation phase, during which the project’s findings underwent a peer review by expert industry stakeholders, CLNR has now published reports on suggested optimal network solutions and the roles customers will play in the development of smart grids.

Key project findings

- Low carbon technologies proved less disruptive and domestic customers are more flexible than was previously predicted.
- We found little evidence to suggest customers’ low carbon installations were creating the power quality problems we anticipated.
- The qualitative learning revealed that the older generation and those with younger children found it most difficult to be flexible with how and when they used electricity.
- For those customers who were willing to be flexible, the household practices of laundry and dishwashing were most commonly used to flex the times at which electricity was used.
- Time of use tariffs proved popular with domestic customers. The majority of customers taking part saved money on their energy bills (between £30 and £350) and demand for electricity in the 4pm to 8pm peak was up to ca. 10% lower.
- Further development by industry and policy makers of the tariff design and customer engagement methods are needed to better incentivise the desired peak load shift, at the time it matters most for network operators (typically in winter, during 4-8pm).
- Initially Small and Medium Enterprises (SME) showed a keen interest in the idea of demand side response. However, during the course of the project it became clear they were unwilling to risk disrupting their business practices by flexing their electricity usage.
- Closer work is needed with this particular group to develop new and more appealing propositions.
- The learning from CLNR has allowed network operator Northern Powergrid to create a ‘smart grid plan’ that will benefit customers both now, and in the low carbon future.

 All reports, data and findings can be downloaded from the project library on the CLNR website, <http://www.networkrevolution.co.uk>



ENERGY TRAINING @ DURHAM

“ I encourage all of my team to attend this Masters’ Short Courses as it provides a wonderful opportunity for them to question the experts on the societal and technical challenges that my staff face every day.

Maggie Bosanquet, Sustainability and Climate Change team leader, Durham County Council

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International Summer School: Energy Transitions in Contemporary and Emerging Societies Durham University, 13 - 24 July 2015

This two-week course offers an in-depth view of the connections between energy and society. By attending you will gain a unique interdisciplinary understanding of how energy is implicated in issues associated with development, politics, climate change and sustainability, technologies and lifestyles.

The course is aimed at current university students from outside Britain who wish to enhance their studies by attending summer school at a leading centre of energy studies.

Researchers and faculty from Durham University will introduce you to the latest social science research from both the Global North ('developed' countries) and the Global South ('developing' countries). The summer school will help you to gain a critical social perspective on the interconnections between energy and society and how these relate to energy research and practice. Key theories, methodologies and understandings from geography, sociology and anthropology will be explored.

// To find out more go to <https://www.durham.ac.uk/international/summerschool/home/courses/>

DEI MASTERCLASSES: A UNIQUE OPPORTUNITY TO ACCESS TRAINING DIRECTLY FROM EXPERTS ACROSS DURHAM UNIVERSITY AND THE ENERGY SECTOR.

These four and half day courses are aimed at energy professionals from central government, local councils, industry or higher education, who wish to gain a broader understanding of energy and insights into the social aspects of energy. Previous attendees have included staff from DECC and Durham County Council. The courses include presentations from leading experts across Durham University and externally. Each theme is introduced through theoretical discussion and case study examples. A site visit may also be included.

Energy Contexts and Challenges: 2 to 6 November 2015

From global geo-histories of energy and energy transitions to human eco-biology and resource engineering, we look at energy from a range of different perspectives.

Contents include:

- 1) global geo-histories of energy using archaeologies and histories of energy to highlight changing concepts of natural and 'unnatural' energy;
- 2) contemporary political economies of energy, global political issues, energy as a geopolitical tool, energy wars and energy transitions;
- 3) social, political, economic, scientific and technological challenges facing societies today, interconnections in global energy and climate change contexts.

// To find out more go to: www.durham.ac.uk/dei/events/contexts

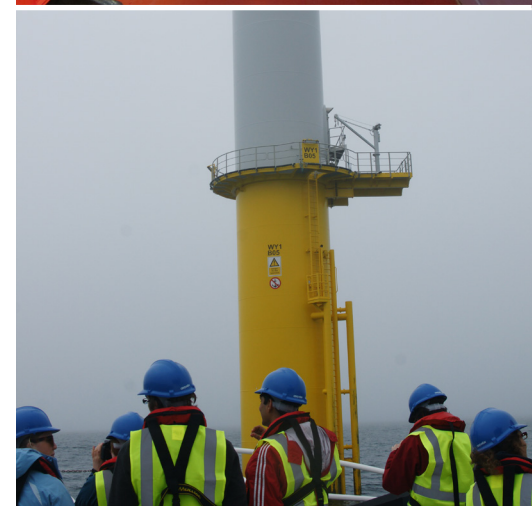
Energy Society and Practices: 16-20 February 2016

From material culture studies to practice theory, from economics to visual studies, we explore the analyses available in the social science and humanities that are needed to make sense of energy and to change the way we organise energy practices.

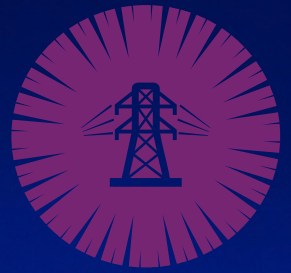
Contents include:

- Key social science theories and methods, such as the idea of material cultures, everyday practices, organisational forms and social relations;
- Economics and finance in the energy sector, from the perspectives of economic theory and anthropology of economics;
- Energy policy and how to understand governance;
- Understanding the grid – technical and commercial issues; and
- Historical and visual approaches to energy questions.

// To find out more go to: www.durham.ac.uk/dei/events/practices



NEW DEI BRIEFING NOTES



Other DEI briefing notes available include:

- The UK Geothermal Resource: Addressing the myths, identifying the challenges and exploiting the opportunities.
- Briefing note on Customer flexibility (Customer Led Network Revolution)
- Understanding the Economics of Domestic Energy Use (Customer Led Network Revolution)
- An Introduction to shales and fracking (ReFINE)
- Well integrity & drilling for shale gas: Is the UK well-prepared? (ReFINE)

From national to fracknational: will fracking come to Britain's National Parks? (April 2015)

This DEI briefing, written by Dr Liam Herringshaw, reviews existing geological data to identify the potential suitability of each of the country's 15 national parks for fracking activity according to their rock type. The briefing was prompted by confusion around Government policy in relation to fracking in national parks. The issue has since continued to hit the headlines with new Energy and Climate Change Secretary Amber Rudd telling the Sunday Times that the government would push ahead with its promises to expedite the extraction of shale gas and change the law to allow frackers to drill beneath national parks.

The briefing categorises the suitable geology for fracking in the UK's national parks as:

Red (fracking possible). There are four national parks - North York Moors, Peak District, South Downs, and Yorkshire Dales - with rocks of possible interest to companies looking to frack for shale gas, shale oil, or coalbed methane.

Amber (fracking unlikely). Another four parks - Brecon Beacons, Exmoor, New Forest, Northumberland - were shown to have shales or coals present, but other aspects of the geology make fracking unlikely.

Green (no fracking). A final seven National Parks - Broads, Cairngorms, Dartmoor, Lake District, Loch Lomond & The Trossachs, Pembrokeshire Coast, and Snowdonia - had geology which rules out fracking for shale gas, shale oil, or coalbed methane, according to the brief.

We hope that this review of existing information about the geology of the UK's national parks will help provide all sides involved in the fracking debate with some

clarity about the potential for fracking in these areas, which currently appears to be lacking.

The brief has already received significant attention with articles in ITV, The Journal, The Yorkshire Post and interviews on Farming Today, ITV TyneTeas and Made in Tyne and Wear.

Sustainable Electricity Grid Development: Whose Power?

This DEI briefing is based on new research by Professor Tooraj Jamasb and Wenche Tobiasson into public engagement in the development of transmission networks. When electricity grids are extended or upgraded, a major challenge is how to address the concerns of local communities with the adverse environmental impacts of the projects. While the impacts are local, the benefits of the projects accrue to country as a whole.

The research explored two high profile cases of community opposition to new transmission lines in Scotland (the Beaully-Denny line) and Norway (Hardanger Power Line).

Their research suggests that a mismatch of distribution of costs and benefits, together with an outdated planning and decision-making framework, give rise to conflicts between stakeholders. They recommend a sustainability-based economic approach which offers a way-out of costly conflicts through a new organising principle and increased public engagement in design, decision making and implementation. The approach evaluates projects according to how strongly or weakly they meet key criteria, such as social sustainability, environmental sustainability and intergenerational equity.

It also focuses attention on how to use some of the system benefits of the projects to compensate the natural environment rather than short-term compensation of individuals.

The need for a framework through which tensions can be resolved will become more pressing now that the electricity system needs substantial upgrading. More research is needed into community compensation and how a good citizenship and environmental investment model could be developed.

The insights from the research can also have implications for many other contexts, such as the locations of wind farms, shale gas wells, and waste, including nuclear waste, from energy production.



To read all DEI briefings go to
www.durham.ac.uk/dei/resources/briefings/



ENERGY NETWORKS ANALYSIS RESEARCH AT DURHAM



Over the coming years, electrical energy systems will become more complex based on a smartgrid paradigm with a much greater number of customers and generators interacting with the network. This will require management of greater level of variability and uncertainty due to higher penetrations of renewable generation which has variable and uncertain output. There is also a desire to plan, operate and maintain the system based on cost and reliability risk analysis, as opposed to using traditional approaches such as requiring the system to be operable with any one or two components on outage.

These developments inevitably mean introducing new mathematical and statistical technologies into system operation and planning. Researchers in the School of Engineering and Computing Sciences, and in the Department of Mathematical Sciences, are working to meet these challenges.

Resource adequacy assessment.

Chris Dent has worked with National Grid and Ofgem on the Great Britain Electricity Capacity Assessment Study since 2011, along with Stan Zachary from Heriot-Watt University (who is a Durham PhD alumnus). This annual study has received a great deal of attention in the media and in public policy (for instance headlines about Ofgem warning of the risks of the lights going out). Industrial work on this study has further provided the inspiration for research on statistical modelling of the wind resource in Great Britain, and on the theory of the underlying risk model structures. In the last year, ongoing work funded by National Grid and the Electric Power Research Institute (the research organisation of the North America Industry), also involving Amy Wilson, is developing new approaches to modelling statistical dependence between demand and available variable generation (the question of “will the wind be blowing when we really need it”).

Low voltage DC networks.

An increasing proportion of electricity demand (including digital electronics and new lighting technologies) and generation (solar photovoltaic) is intrinsically direct current, in contrast to the alternating current systems with have been used universally in large scale applications for the last century. This raises the question of where the AC to DC conversion should happen – should each device have its own converter, or should there be a local DC network with a single converter? An EPSRC project (“High Energy And Power Density (HEAPD) Solutions to Large Energy Deficits”) in collaboration with Bath and Cardiff Universities in the UK, and leading institutes in India, is looking

at this question, and at the interaction between local DC networks and the whole electricity system. The Durham work is led by Behzad Kazemtabrizi (Lecturer in Electrical Engineering) and Chris Dent, with Dr. Mahmood Shahbazi as a postdoctoral researcher.

Integration of energy storage.

Another key current challenge is the integration of energy storage into power systems. This provides new capabilities for systems to time-shift demand, and will require new approaches in control and planning to realise these benefits. Work at Durham led by Chris Dent, Matthias Troffaes and Behzad Kazemtabrizi within the EPSRC “Energy Storage for Low Carbon Grids” consortium includes valuation of storage at whole system level, including in day-to-day operation, security of supply, and markets (with postdoctoral researcher Dr Gruff Edwards and PhD student Sarah Sheehy). We are also working on operation of storage in off-grid systems (with Chiara Bordin as a visiting PhD student); and analysing in detail the operation of pumped thermal energy storage within the electricity system (as a further EPSRC project with Chiara Bordin as postdoctoral researcher, and PhD student Ahmad Ibrahim).

Uncertainty in large scale energy systems models.

An EPSRC project led by Chris Dent and Michael Goldstein, with Amy Wilson as postdoctoral researcher, is using statistical methods to quantify uncertainty in the relationship between complex energy systems models and the real systems which they are intended to represent. Large scale computer models are increasingly used to support high level decision making both in industry and in public policy, and the new approaches being developed are aimed at enabling better outcomes to real decision problems. There is related work by Antony Lawson, as part of his PhD within the EPSRC Autonomic Power System consortium, on network capital planning under uncertainty.

Green Growth Diagnostics for Africa.

This EPSRC project, in collaboration with the Institute of Development Studies, Newcastle University, The Kenya Institute for Public Policy Research and Analysis and the University of Ghana, is investigating the barriers to investment in renewable energy technologies in sub-Saharan Africa. The Durham-Newcastle engineering part, with Gruff Edwards as postdoctoral researcher, will look at quantifying the additional access to energy which new resources can bring, based on experience of reliability analysis in the very different circumstances of Great Britain and North America. Mathematics of energy systems. In addition to collaborations involving

the statistics group at Durham described above, we also collaborate actively with mathematical scientists at other institutions on statistical modelling and control approaches. An EPSRC project on “Mathematical foundations of energy networks” brings together Durham and Newcastle engineers with mathematicians at Heriot-Watt and Cambridge Universities to study the statistics of ensemble wind forecasts, and approaches to control and valuation of energy storage within power systems. Further collaborations include the Edinburgh Operational Research group and graph theorists at Southampton on understanding and mitigation of wide area blackouts.

Decentralised control.

One of the great overall challenges in energy systems is the development of hierarchical control approaches which can coordinate the actions of all users of the power system, from individual households through to large generators connected to the national transmission system. It is clearly impractical for such a system to be managed by one central control system, as the size of both the optimisation and data management problems would be intractable. Manolis Loukarakis is working on decentralised optimisation approaches as part of his PhD within the EPSRC Autonomic Power System project, and within the same project Jiangjiao Xu is investigating the interaction between control approaches and the capabilities of communication systems. Durham’s skills in this area have been strengthened by the arrival of Rui Carvalho as a lecturer in Engineering Science who previously worked at Cambridge as part of the “Mathematical foundations” EPSRC project.

Smartgrid communications.

Hongjian Sun, Lecturer in Smartgrids is Durham lead on the EU Horizon 2020-funded project “Smarter Grid: Empowering SG Market Actors through Information and Communication Technologies” on which Jing Jiang will soon join Durham as a postdoctoral researcher. This will develop telecoms solutions compatible with the EU Smart Grid Architecture Model, and investigate the extent to which current telecoms networks can provide the necessary capabilities.

With this exciting portfolio of projects and a strong and growing team, Durham can look forward with confidence to continuing our long tradition of energy networks research, and to increasing our international prominence in both research and research impact.



Find out more about our Energy, Generation and Distribution work at www.durham.ac.uk/dei/research/energyconv_trans_distrib/



// RECOVERING ENERGY CAN BE EXHAUSTING WORK:



ENERGY HARVESTING IN AUTOMOTIVE APPLICATIONS USING ANTENNA / DIODE ARRAYS

Around 45 per cent of engine power is dissipated as heat via the exhaust. Even though others have looked at ways to recover this heat, all the options have had flaws. This has prompted Professor David Wood and his team from Durham's Microsystems Technology Group in the School of Engineering and Computing Sciences to see if there was a better way.

It is work that is worth doing and is achievable even if it looks daunting. The most significant advantage exhaust pipe energy recovery has over other methods is that it works all the time. The exhaust is always hot, if the engine is on. You are literally throwing a huge amount of energy away down the exhaust.

The intense development of the internal combustion engine has produced considerable gains in fuel economy over the last 20 years, but the industry acknowledges that it is now against the limits of fundamental science. Energy recovery systems such as regenerative braking and engine stop/start work well, but are only functional for very small portions of a journey: our work is developing an idea that promises continual energy recovery.

A petrol internal combustion engine is around 25-30% efficient in turning chemical energy into vehicle mobility, with around 40-45% being lost down the exhaust pipe. Many attempts have been made to access this waste energy, but none have been successful at overcoming the associated problems of disrupting the airflow which could damage the way the car works. Instead, we have looked at the more accessible radiant heat from the outer

surface of the exhaust pipe, where any scavenging technology will not disrupt the main function of the pipe. Although

only 10 to 20% of the exhaust heat (i.e. 4-9% of the overall combustion energy) is lost this way, this still represents a large source (well into the kW range) of recoverable energy.

Our work has produced world-leading results in using thin film metal-oxide-metal (MOM) diodes with an associated antenna, known as rectennas. These promise to be simple to install via a flexible substrate wrapped around the exhaust.

With a Jaguar four-litre V8, we estimate we could recover up to 17kW. If the system was 100% efficient it could lead to a 4 to 9% cut in CO² emissions. The team used an antenna style device for picking up radiated heat. However, the circuit needed a very fast switching diode, so we designed our own. The result though was only producing microwatts of energy. So we then designed a wrap that goes round the exhaust that could contain 10¹² devices. Although this mechanism would currently cost too much with current cost reductions being achieved by the integrated circuit industry we are confident that each wrap could be made for around \$100, a much more realistic prospect.

With a device that is much simpler than a transistor, made using fewer mask levels and in a cheaper factory, the scope for further cost reduction in the same timescale means the manufacturing cost will become acceptable.

The UK carbon reduction strategy means a 34% reduction in CO² output by 2020, with an 80% reduction by 2050. Transport contributes around 26% to UK-based CO² emissions: a technology that reduces fuel consumption by up to 9% will give a 2.1% reduction in emissions on its own. Moreover, the technology is intended to be implemented in an exhaust wrap, which is reusable. With many kilowatts of power currently lost from exhaust pipe radiation, this represents probably the last major opportunity for energy harvesting in an automotive environment. And, of course, the devices would work equally well in other environments where large amount of heat are generated.



Find out more about the microsystems technology group.

Professor David Wood, Chair of Engineering in the School of Engineering and Computing Sciences, david.wood@durham.ac.uk

A CRITICAL ANALYSIS OF EU-ARCTIC POLICY-MAKING: A PHD PROJECT



Mika Laiho is part of the new cohort of Energy CDT students at Durham. His PhD is based in the Department of Geography under supervision from Professors Gavin Bridge and Phil Steinberg. Mika has organised a number of events in Durham concerning the international divestment campaign, which calls on institutions to remove their investments from fossil fuel companies. He is also co-chair of the Council of the Association of Polar Early Career Scientists (APECS) and an executive within the UK Polar Network (UKPN) social science committee.

My PhD in the Department of Geography at Durham University, titled 'A critical analysis of EU-Arctic policy-making: hegemonic discourse and imaginaries of Arctic space as carbon,' explores EU policy-making discourse on Arctic security and development whilst taking a critical position to notions of space, place and power.

Find out more about Arctic research at Durham at www.durham.ac.uk/international/collaboration/networks/uarctic/research/

Prior to coming to Durham, my postgraduate research centred on the governmental influence of the European Union (EU) on the Arctic region, which stands geopolitically 'outside' the EU's formal sphere of influence. However the EU is involved in Arctic governance and sustainable development despite only having sovereign jurisdiction over a small portion of Arctic space located in the European High North. This governance functions through a complex series of socio-economic networks, such as trade and free-market agreements, scientific research, indigenous peoples' representative bodies and issues of global maritime and environmental law.

I first approached this theme of research from a conventional state-centric and institutional viewpoint within International Relations (IR) scholarship. Namely with the EU at the centre of soft power relations between 'Europe' and the 'Arctic,' since the EU provides large capital investments for developing the region and hence holds a stake in Arctic decision-making. European security issues like climate change or energy policy tend to have a direct impact on the region as the EU continues to contribute substantially to global warming in the Arctic as a result of its carbon footprint while remaining perhaps the largest importer of Russian or Norwegian oil and gas.

My PhD project embraces the tradition of post-structuralism by critically investigating the nature of power in hegemonic discourse in EU policy-making with regard to how EU policy-making simultaneously shapes and becomes shaped by discourse about Arctic space. This approach has been used in the field of political ecology, for instance, to focus exclusively on power, which exists formally, through a network of institutions and their agents, and informally, drawing on the social struggles, inequalities and marginalisation taking place between the lines of policy-making.

The notion of Arctic space is brought into scrutiny because many Arctic space-s exist within a network of conflicting discourses, such as 'energy security' or 'climate change.' The project draws on discourse analysis in order to illustrate two spaces of carbon in particular, hydrocarbon resources and anthropogenic climate change. As a result of the practice of policy-making, discourse is institutionalised and incorporated into official EU policy which aims to 'develop' Arctic space.

Alternative approaches to understanding the governmental practice of EU policy-making

are rarely undertaken within mainstream literature, which seems fixated on tangible legal or political issues surrounding the development of the region. The project aims to contribute to the field of European and Arctic studies by deconstructing Arctic space in such a way that one comes to question the true origins of the EU's strategy for the region's 'development' (i.e. what/whom is develop(ing/ed), who is deciding, who is benefiting, etc) and how Arctic space is 'imagined.'

In the world of contemporary academic training, interdisciplinary research is looked to for pushing the boundaries of knowledge. My own contribution is driven by my desire to enhance a reflexive discussion within academia on the topic of EU policy-making and Arctic development by drawing on critical social theory, geopolitics and post-structuralism.

For more information about my work please contact me at: m.j.laiho@durham.ac.uk. You can also follow me on Twitter @arcticspace. My PhD thesis will be completed in 2017 and published by the Department of Geography, Durham University.





OFF THE GRID:



// NOTES FROM A FORGOTTEN ISLAND

Raihana Ferdous, an Energy CDT student based in the Department of Geography, has produced a short documentary of her work in collaboration with filmmaker Meghna Gupta, *The Soul Rebels*. The film shows the importance of solar energy to those who live off the electricity grid and how central electricity is to all our lives in the modern world.

Raihana embarked on this project in order to take her research to a wider audience. She said

“ Visual representation is an extremely powerful tool. I wanted to find a new way to bring to life the incredibly difficult conditions that many people live in – the struggles that I have witnessed during my PhD fieldwork. I wanted people to understand why energy matters so much and the huge impact it has on people’s lives”.

Off the Grid is a documentary set in Sandwip, Bangladesh, where there is no electricity. The documentary explores the arrival of solar energy to homes on this remote island and shows the dramatic impact this has on the lives of families there. We see how solar power opens up opportunities for study, reading, television entertainment, and mobile phone access allowing families to speak to the many men who migrate internationally in search of work. Guided by a young solar engineer, we enter the lives of those who remain here—women and children—whose fathers and husbands must leave to find jobs where industrial electricity exists. The film also shows that although solar power seems to offer a clean and green basic solution to many of the islanders’ difficulties, it still has limitations for fulfilling their hopes and dreams.

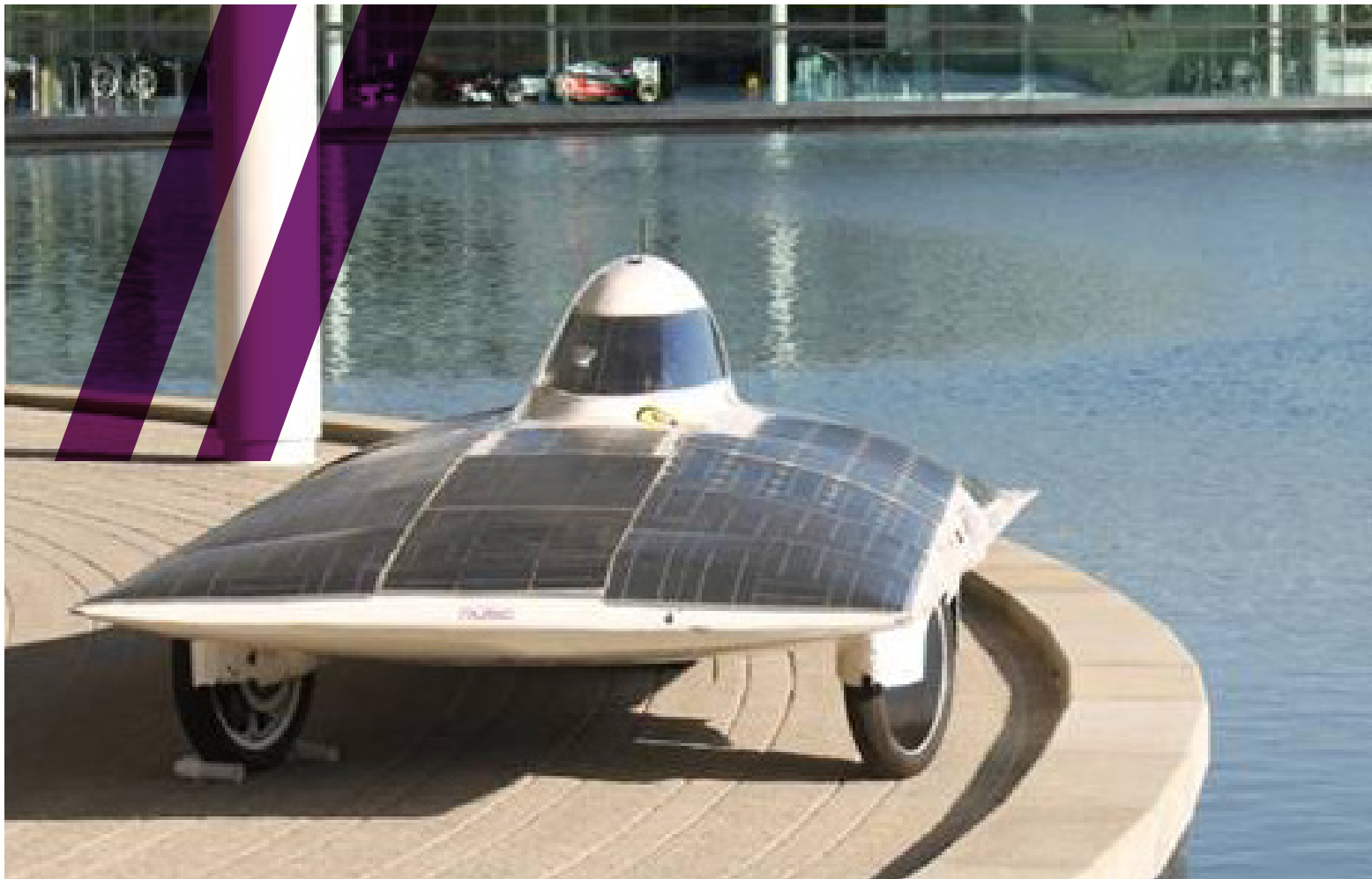
The film has now been screened at various events including the ‘On light’ event at Wellcome Collection, RichMix-Freedom week 2015 in London, and the Low Carbon Energy for Development Network conference in Durham.

// The trailer of the film can be watched at <https://vimeo.com/121374407>

View an interview with Raihana and Meghna on Arise TV www.youtube.com/watch?v=3ad1MVXGnEs

// Mika and Raihana are both members of the DEI Centre for Doctoral Training in Energy.

Find out more about the interdisciplinary programme and outreach work at www.durham.ac.uk/dei/cdt/



// DURHAM UNIVERSITY SOLAR CAR ENTERS

WORLD SOLAR CHALLENGE

Durham University Electric Motorsport (DUEM) is a student led project that aims to design and manufacture innovative solar powered cars to compete at international competitions. The students will be setting off on a sun-powered adventure this autumn when they take their new DUEM car design to Australia for the World Solar Challenge. Using nothing but solar power, the team will travel 1,864 miles (3,000km) from Darwin in the north of Australia to Adelaide in the south. The race, which will involve solar powered cars from

across the globe, is scheduled to take place between October 18 and 25.

The DUEM vehicle, which has a top speed of 67mph, has been built from scratch at Durham University, with key elements such as the in-wheel drive motor and flexible solar panels, developed as student research projects. A feature of the new car is a fully carbon fibre monocoque chassis which will drastically reduce the overall weight of the car, and hence rolling resistance. Since there is comparatively little energy available from the solar cells compared

to a petrol engine, the car has to be as efficient as possible. This means the aerodynamic shape has to have the minimum amount of drag, the electric motor has to as efficient as possible, and there needs to be the minimum of rolling resistance.

The main component of the solar car is the solar array on the upper surface of the car. This is made from 392 flexible silicon photovoltaic solar cells. The car itself is made from carbon fibre, just like an F1 car, and has an aerofoil shape of an aerofoil to reduce drag. The car

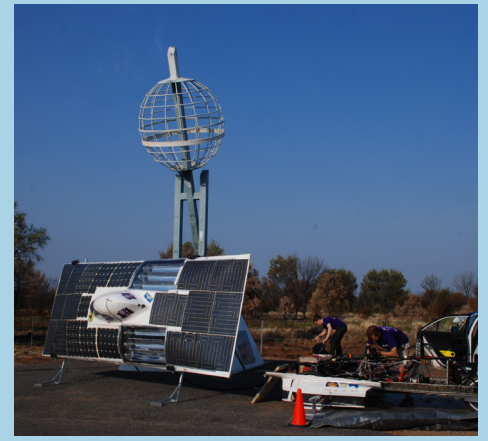
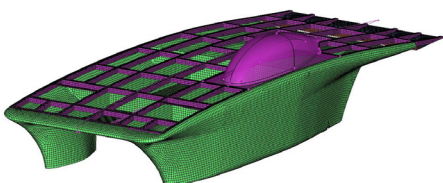


The Durham University Solar Car is an official entry in the 2015 Bridgestone World Solar Challenge. The event will see the Durham team's new solar car cross Australia from Darwin to Adelaide in October 2015.

also features an in-wheel electric motor inside one of the rear wheels, designed by the team, and that is optimised for the car and achieves over 94% efficiency.

The new car was officially unveiled at the MotoExpo event in Canary Wharf 8 - 14th June. The Durham car is now taking part in endurance testing in the UK prior to being shipped from Southampton to Australia in mid-July for the competition.

Dr David Sims-Williams, academic advisor to the project from the School of Engineering and Computing Sciences, at Durham University, said: "The World Solar Challenge pushes teams to develop high-efficiency vehicles, which is the real key to reducing the emissions of everyday vehicles. These cars have to be able to drive at highway speed all day with less power than an electric kettle."



"The students have led the project and it will be a tremendous experience for them to put what they have learned at Durham into practice against some of the best solar cars in development when they take part in the competition."

Many different skills are needed to produce a winning car from marketing skills to electrical engineering. The team has members from across many different departments, including Engineering and Computing Science, Physics, Maths, Biology and Economics. The new team incorporates two previous clubs: Durham University Formula Student and Durham University Solar Car (DUSC). Alumnae from the previous DUSC team are now working in a range of industries including aerospace, rail and Formula 1, as well as in the automotive sector.

DUSC previously won "Top Rookie Team" in the 2008 North American Solar Challenge and was the only UK entrant in the 2,400 mile (3,862km) race from Dallas to Calgary. The previous generation Durham solar car has also been an exhibitor at the McLaren Motorshow in 2012 and has taken part in the GreenFleet Scotland and Evolution Scotland exhibition 2015 which exhibit the latest low carbon vehicles around and promote green transport to companies and the general public.

Team leader Andrew Messenger said:

"The DUEM team are aiming to move us closer to a world where cars no longer require fuel and therefore no longer damage the environment but also have no limits to the distance they can travel. New technologies such as electric cars and hydrogen powered cars suffer from short operating ranges and a lack of infrastructure for refuelling. One day it should be possible to charge the batteries of a solar car during the day while driving, so the car would be able to continue driving during the night: that is the goal we are aiming for."

DUEM relies on sponsorship and donations to fund its activities and sponsorship opportunities are still available for DUEM's World Solar Challenge Campaign, including the opportunity to adopt a solar cell. Durham Energy Institute provides support to the team through sponsorship, sharing expertise and developing links with industry.

// For more information on the team and sponsorship opportunities, email electric.motorsport@durham.ac.uk, or visit www.duem.org

IN CONVERSATION WITH...



// STEPHEN LIVINGSTONE, LEVERHULME ARTIST IN RESIDENCE AT THE SCHOOL OF ENGINEERING AND COMPUTER SCIENCE

What is the artist in residence scheme?

The Leverhulme Trust scheme supports the residency of an individual artist in a UK university in order to foster a creative collaboration between the artist and the staff and students.

How did you come to Durham?

I began my 12 month residency in the Engineering department in September 2014. I am working with Dr. Karen Johnson who is investigating the regeneration of brownfield sites through the addition of minerals to contaminated soils. Key to her research is the use of the waste materials from water treatment processes. I first met Karen around six years ago at the launch of her ROBUST research project where I exhibited some drawings made using coal dust. We immediately realised that we shared a common interest in the effect of industry upon landscape, in particular the legacy of coal mining in North East England. With the support of the Leverhulme Trust funding I am able to devote two days each week making my own responses to what I observe and discover.

What is the focus of your art?

My work deals with human impact upon landscapes and habitats and takes the form of drawings, installations, books and digital prints. I studied at Wimbledon and Chelsea

Colleges of Art in the 1970's where I first started to experiment with powdered pigments such as graphite, chalk and ochre. I later refined my processes by mixing pigments with water soluble gum arabic to form a gritty watercolour. A major part of my residency work has involved making drawings using the raw materials associated with Karen's work - manganese and ferric oxides, lead and coal. The old lead works at St. Anthony's on Tyneside has provided the team with useful soil samples heavily contaminated with lead.

I have been carrying out my own experiments with lead ore (galena) and more recently lead tetroxide (red lead) in a number of drawings which are currently exhibited in the Engineering Department. They are called "Degrees, Minutes, Seconds" and have been made by depositing galena onto paper inscribed with designs built up using drawing templates, protractors and french curves. The forms repeat and rotate through small increments suggesting the movement of machine parts and propellers or alternatively the orbits of moons and planets.

How does your art work relate to energy?

I have become increasingly interested in issues relating to the exploitation of mineral sources to provide energy and I am currently working on four large scale drawings to be exhibited

in the Earth Sciences building which refer to drilling into the Earth to extract minerals and tap into geothermal veins. The designs are based upon engineering drawings of twists and screws and will be made using coal, lead and iron pigments. They are 10 metres high so I am hoping that they will have quite an impact!

How has the experience influenced your work?

As well as enabling me to develop ambitious work, the residency has provided ample opportunities to meet academics with areas of expertise covering soil science, civil engineering, geology, astro-geology, mathematics, archaeology and chemistry. These encounters have provided me with a complex net of connections to which I am striving to give visual form. For instance conversations with Dr Howard Armstrong about his work with the fossilised remains of microscopic marine organisms in chalks and shales has led me to consider developing a body of work which explores the impact of fracking upon landscapes and underlying geological structures. I would certainly be interested in linking up with anyone who has detailed knowledge of this issue.

// You can find out more about Stephen's work at stephenlivingstone.wordpress.com

WE WELCOME NEW COLLABORATIONS!

DEI addresses energy challenges collaboratively through strong partnerships with industry, international partners, governments, community groups and other academic institutions. This ensures our research is relevant and effective.

Durham Energy Institute draws on the expertise of world-leading researchers across Durham University's science, social science and humanities departments. This enables the institute to put together tailor-made interdisciplinary research in response to quickly changing energy policy, research and industry landscapes.

// If you would like to explore collaborating with us on new research, a secondment or would like to support our energy students, please do get in contact at dei.admin@durham.ac.uk

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