Future opportunities in engineering research for international development

Report of a roundtable for UK funders and research leaders

29 May 2014, Royal Academy of Engineering

Background

This report contains a short summary of roundtable discussions on engineering research for international development. The meeting, chaired by Professor John Perkins FREng, brought together senior research leaders from a small number of UK universities with EPSRC and DFID to discuss the current opportunities, and barriers to further activity.

Annexed to this document are:

- The agenda, short background paper and list of attendees
- The EPSRC and DFID presentations
- A UKCDS mapping of the UK engineering for development research base that underpinned the discussion.[1]

The opportunities in engineering research for development

Stephen Young, Head of Profession for Infrastructure in DFID, opened his presentation with an overview of DFID's infrastructure spending, at approximately £1bn *per annum*, 50% of which is channeled through partners. He noted that infrastructure research is currently undergoing a renaissance in DFID, with around £45m *pa* invested. This represents threefold growth since 2000, and about 14% of DFID's research budget. Rapid urbanisation and a focus on economic development are more recent drivers for investment in infrastructure research, in addition to long-standing interests in the provision of basic services.

Mr Young profiled research spend across sectors, noting that energy has seen the most significant increase in investment, rising from just over £0.5m in 2008 to an estimated £15m in 2013. Water, Sanitation and Hygiene (WASH) research has also seen a dramatic rise, from around £2m in 2008 to £11m in 2013. Transport and urban research, however, have not seen such increases in funding. Spend on transport research has flatlined at around £2m *pa*, but is set to rise with substantial new programmes in the next couple of years. Urban infrastructure research stagnated after the early 2000s and only surpassed an annual £1m spend in 2012.

Mr Young also noted that DFID infrastructure research projects are becoming larger and more multidisciplinary, integrating engineering with physical, natural and social sciences.

[1] Also available online at http://www.ukcds.org.uk/resources/ukcds-mapping-infrastructure-research-for-development

Professor Chris Whitty, Chief Scientific Advisor and Director of Research at DFID stressed that in all DFID's research funding they sought excellence *and* impact in terms of poverty alleviation. He also noted that DFID research funding, whilst globally open, can go to UK universities if these institutions win the competitive tendering processes.

Dr Kedar Pandya, Theme Leader at EPSRC for engineering, opened his presentation with reference to EPSRC's charter: this includes a mandate to "to promote and support…research…in engineering and the physical sciences" "to advance knowledge and technology…thereby contributing to the economic competitiveness of Our United Kingdom and the quality of life".[2]

Dr Pandya outlined some areas of EPSRC investment relevant to international development, including "Understanding Sustainable Energy Solutions"[3] and water and waste management. He outlined the criteria that needed to be met for EPSRC to support a project: these included "Quality" as the primary criterion, "National Interest" as the major secondary criterion, with "Impact", "Resources and management" and "Applicant(s) ability" as other secondary criteria.

He noted that EPSRC are currently scoping "Engineering Grand Challenges"[4], which will all have international relevance, and may have relevance to developing countries. This thinking will inform investment activity in 2014/15. However, whilst stimuli for research can come from anywhere, the new knowledge and benefit must accrue to the UK.

Summary of the discussion

The attendees agreed that it is a very positive time for engineering research for development, with a significant uplift in funding from DFID, and the Newton Fund[5] coming online too. The impact agenda and REF are actually an opportunity: while the REF has been criticised, development relevant research was considered a good way to demonstrate both reach and significance of impact. Research-derived solutions that scale up well can reach orders of magnitude more people in development contexts than here in the UK – because of the vast gaps in service provision, and sheer population numbers. The global dimension of engineering (some of which could be considered 'development') will only become more important too: by the end of the century nearly 40% of the global population will be African, over 40% Asian and just 6% European.[6] Lastly, anecdotal evidence suggests younger (often female) engineers are motivated by global challenges, potentially supporting retention in the profession.

[2] See http://www.epsrc.ac.uk/about/history/Pages/royalcharter2003.aspx
[3] See http://www.epsrc.ac.uk/funding/calls/2012/Pages/energyandinternationaldevelopment.aspx
[4] This builds on http://www.raeng.org.uk/international/global_grand_challenges_summit.htm
[5] See https://www.gov.uk/government/publications/newton-fund-building-science-and-innovation-capacity-in-developing-countries/newton-fund-building-science-and-innovation-capacity-in-developing-countries
[6] Medium projection. Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2013). World Population Prospects: The 2012 Revision. New York: United Nations. Available at http://esa.un.org/wpp/Documentation/pdf/WPP2012_Volume-I_Comprehensive-Tables.pdf

While there was not consensus, balance of opinion among those present suggested universities do face barriers to working more in this area: multiple soft factors accumulate to become a disincentive system for engineering for development research. These barriers vary significantly from institution to institution, and in severity (from non-existent, to perceived, to real) but include:

- The challenge of publishing applied research in prestigious journals
- Data on impact is relatively hard to find for developing countries, and as such development-focused REF case studies are not easy to put together.
- Research Council funding is seen as prestigious, and EPSRC fund very little in this space
- The 'institutional fit' for engineering for international development is not always clear: it was felt to fall between disciplines and Research Councils
- Drivers internal to universities e.g. promotion panels, may not favour international development
- Issues around potentially negative perceptions of a 'development engineer' relative to more conventional branches of engineering.

The group noted that skills pipelines ebb and flow slowly, so focusing on early career researchers is key to supporting future UK capacity for engineering research relevant to development. Defining outcome focused research challenges with significant practical impact was considered crucial to this.

Next steps

In addition to one objective of the meeting (raise awareness of increased funding opportunities with key universities), a number of follow-on actions were identified. UKCDS will continue to circulate information on funding opportunities[7], incorporating relevant individuals from the universities represented into its engineering 'community of practice'.

In addition, Professor Whitty will seek an early meeting with Philip Nelson, Chief Executive of EPSRC to discuss how DFID and EPSRC might do more together. Professor Perkins, as a member of the Council of EPSRC and Board member of UKCDS, offered to facilitate such a meeting if required.

Finally, UKCDS will meet DFID and the Royal Academy of Engineering to discuss further steps in the partnership. For updates on UKCDS' engineering work, please see the engineering pages of the website.[8]

[7] All advertised on the UKCDS website: http://www.ukcds.org.uk/funding
[8] http://www.ukcds.org.uk/our-work/23?tid=30

Future opportunities in engineering research for international development

A roundtable for UK funders and research leaders

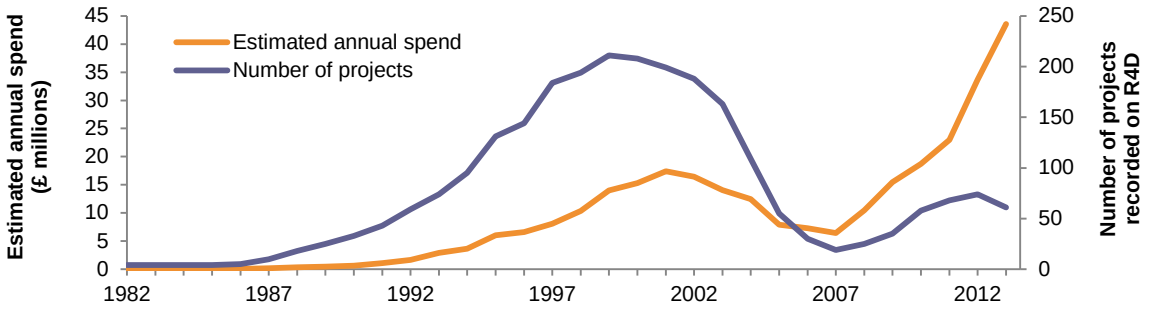
Thursday 29 May 2014, 10.00 - 12.30
National Grid Room, Royal Academy of Engineering, 3 Carlton House Terrace, London

Background: a renaissance in engineering research for development

The value of infrastructure in international development is regaining mainstream appreciation. A UN High Level Panel, co-chaired by David Cameron, reported last year on development priorities for the next 15 years. It stated unequivocally "everyone should have access to modern infrastructure – drinking water, sanitation, roads, transport and information and communications technologies (ICT)". In addition, the recent Perkins' Review noted engineering skills will play a crucial role in confronting "the bigger challenges that the world faces", and BIS' Eight Great Technologies policy acknowledges the ancillary benefits for developing countries of UK investment in engineering technologies, providing new opportunities for UK trade and investment while driving development.

In addition to EPSRC funding for engineering relevant to development, research on infrastructure is currently undergoing a renaissance in DFID: in 2013 the Research and Evidence Division (RED) invested an estimated £45m in infrastructure research[9], representing a threefold increase since 2000 and 15% of the 2013-14 Division's budget[10].

Figure 1 - Estimated DFID RED spend on infrastructure research



Programmes currently include research on cities as potential engines of growth, roads to provide access to rural communities, distributed energy services, mobile enabled water supplies and more. The increasing investment in infrastructure reflects DFID's emphasis on sustainable economic growth as a route to long-term poverty reduction, in line with a new economic development strategy. Themes such as the enabling environment for infrastructure (including the political economy of infrastructure investment and governance), transport and infrastructure to support the urban poor are likely to see increasing investment in the near future.

[9] UKCDS analysis of figures from R4D (http://r4d.dfid.gov.uk/).
[10] The DFID RED budget was £305m for 2013-14:
http://www.publications.parliament.uk/pa/cm201213/cmselect/cmintdev/751/75105.htm Accessed 30/04/14

The aim of this roundtable

A recent mapping, carried out by UKCDS and DFID, identified those organisations invited to this roundtable as leading UK institutions in engineering research relevant to international development. This mapping analysed who was winning competitive research calls, complementing this information with qualitative data from a survey and semi-structured interviews with research leaders.

Given the step up in activity from funders, and recent developments in strategic thinking, it is a timely opportunity for dialogue between funders and the research base. Professor Chris Whitty (Head of DFID Research), Stephen Young (DFID Head of Profession for infrastructure) and Dr Kedar Pandya (EPSRC theme leader for engineering) will present funders' latest thinking. The funders are keen to discuss the growing opportunities in engineering research for development with senior research leaders and managers. It is expected that greater understanding of universities' drivers for engagement in this space, and the barriers they face, will help maximise the potential impact of UK research in international development.

Questions for discussion

1. Do the UK funders' strategies presented align with universities' ambitions in engineering research relevant to development?
2. What barriers do UK universities face that prevent their researchers from having more impact in engineering relevant to development?
    a. In developing partnerships?
    b. In the policies, funding and incentive structures that influence UK universities' research?
3. What roles can organisations such as the Royal Academy of Engineering and UKCDS play?

UKCDS and Royal Academy of Engineering's previous work

The Royal Academy of Engineering is the UK's national academy for engineering. It has had a longstanding interest in international development, including helming the Africa-UK Engineering for Development Partnership, producing the 2012 report *Engineers for Africa: Identifying engineering capacity needs in sub-Saharan Africa,* and running the Enhancing Engineering Education Programme and the Africa Prize for Engineering Innovation.

UKCDS is the group that brings together UK funders and government departments with interests in international development, including BIS, DFID, and five of the Research Councils. The UKCDS Secretariat has been tasked by the funders to explore whether UK engineering research is having the maximum possible impact in development. Work to date has included cross Government discussions, a roundtable for academics in 2013, and the mapping work with DFID that underpins this roundtable.

Agenda

Thursday 29 May 2014, Royal Academy of Engineering

10.00	Welcome and introductions	Professor John Perkins, CSA of BIS
10.20	Background on engineering for international development	UKCDS and the Royal Academy of Engineering
10.40	EPSRC's work in international development	Dr Kedar Pandya, Head of the Engineering Theme, EPSRC
11.00	DFID's infrastructure research funding strategy and current/future opportunities	Professor Chris Whitty, Head of DFID Research Stephen Young, Head of Profession for Infrastructure
11.30	Open roundtable discussion – how can UK engineering research contribute more to international development?	Chaired by Professor John Perkins
12.30	Lunch	
13.30	Close	

Attendees

Professor Brian Collins FREng	University College London
Dr Andrew Cotton	Loughborough University
Professor Sarah Curtis	Durham University
Dr Val Curtis	London School of Hygiene and Tropical Medicine
Professor Giles Davies	Leeds University
Dr Chris Dent	Durham University
Meredith Ettridge	Royal Academy of Engineering
Dr Ian Forristal	Royal Academy of Engineering
Professor Lynn Gladden FREng	Cambridge University
Steven Hardy	University of Nottingham
Professor Peter Ireland	Oxford University
Professor Walter Johnstone	Strathclyde University
Professor Michael Kearney	Surrey University
Dr Elizabeth Miles	Coventry University

Dr Michelle Moram	Imperial College
Professor Ray Ogden	Oxford Brookes University
Dr Kedar Pandya	EPSRC/Royal Academy of Engineering
Professor John Perkins FREng	BIS
Mylene Ployaert	Southampton University
Hayley Sharp	DFID
Dr Hayaatun Sillem	Royal Academy of Engineering
Professor Mark Sterling	Birmingham University
Ian Thornton	UKCDS
Professor Kevin Warwick	Coventry University
Professor Jeremy Watson FREng	University College London
Professor Chris Whitty	DFID
David Woolnough	DFID
Alistair Wray	DFID
Stephen Young	DFID

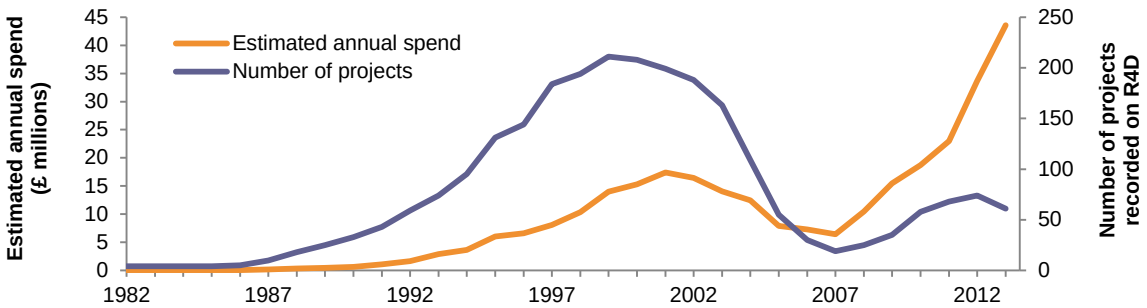
The engineering for development research base: a mapping to underpin the RAG discussion

Executive summary

The report of the High Level Panel on the post-2015 development goals highlighted an unmet need for modern infrastructure, including drinking water, sanitation, energy, roads, transport and information and communications technologies. In addition, infrastructure acts as an enabler of wider development ambitions and poverty reduction. Research on infrastructure is currently undergoing a renaissance in DFID: in 2013 the Research and Evidence Division (RED) invested an estimated £45m in infrastructure research[i], representing a threefold increase since 2000 and 15% of the 2013-14 RED budget[ii]. This R&D seeks to provide the evidence base both to inform and deliver infrastructural improvements and innovations, thus reducing poverty and improving lives. The increasing investment in infrastructure reflects DFID's emphasis on sustainable economic growth as a route to long-term poverty reduction[iii], in line with the new economic development strategy and directorate.

This increase in funding for infrastructure research (traditionally primarily engineering) has been

Figure 2 - Estimated DFID RED spend on infrastructure research



accompanied by a shift towards larger, more multidisciplinary projects which integrate engineering with the physical, natural and social sciences. There is a growing awareness that interconnected pillars of infrastructure need to be considered holistically. For example, the inherent interdependence of water and energy supply is increasingly being recognised in the face of climate change and mounting resource scarcity.

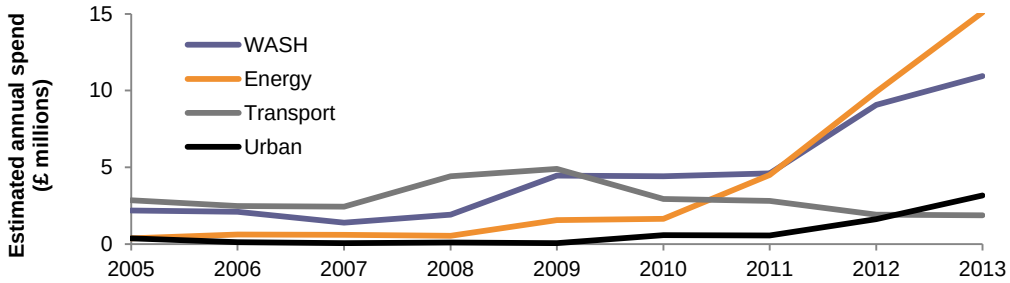
In light of this renewed interest, the UKCDS Secretariat has conducted a very brief scoping exercise to underpin the Research Advisory Group discussion. This paper aims to synthesise diverse pockets of knowledge rather than present wholly new findings. Analysis of funding data has been complemented with semi-structured interviews and a survey to provide a snapshot of UK and international research capacity in this area. The UK engineering for research base appears relatively small and fragmented, with a diverse range of individuals, consultancies and academic institutions undertaking infrastructure research. Many of the foremost in engineering research for development are world leading institutions such as Cambridge University, Imperial College and University College London (UCL), although "newer" universities such as Loughborough, Birmingham, Coventry and Oxford Brookes also have expertise in specific facets of development relevant engineering research. Across the breadth of infrastructure research for development, the

Universities of Loughborough, Cranfield, Cambridge, Imperial College and UCL could be considered leading UK institutions.

Beyond universities, DFID infrastructure research funding flows to private consultancies, NGOs and increasingly to social enterprises. Several of the latter are piloting and exploring the scale up of distributed technologies for marginalised communities, reflecting a shift in the nature of infrastructure provision in developing countries, with opportunities for leapfrogging and 'reverse innovation'[iv].

Much of the research is also aiming to tackle the operational, rather than the scientific or technical, challenges of engineering in developing country environments, by creating the enabling environment for, decreasing the cost of, and strengthening local capacity to build, extend and maintain, essential infrastructure.

Figure 3 - Changes to research spend across sectors since 2005



Within infrastructure research, energy has seen the most significant increase in research spend, rising from just over £0.5m in 2008 to an estimated £15m in 2013. WASH research has also seen a dramatic rise, from around £2m in 2008 to £11m in 2013. Transport research flatlined in the mid-2000s at around £2.5m a year, increasing to around £4.5m in 2009 before declining to £2m a year. However, this is set to increase through a £24m, six year programme launching in 2014[v] and a planned high volume transport research programme. Urban infrastructure research stagnated after the early 2000s and only surpassed an annual £1m spend in 2012 with a new Future Proofing Cities programme and research into Growth and Urbanisation in Low Income Countries.

In light of these tentative conclusions from a brief scoping exercise, the RAG may wish to consider the following questions:

1. Does the funding accorded to infrastructure research align with the priority of infrastructure within DFID? Within infrastructure, does the relative funding accorded to the various sectors align with policy and research priorities?
2. The UK research base seems relatively fragmented. Are proactive measures needed from funders to change this? How can greater 'residual' or institutional knowledge be retained as project funding comes and goes?
3. How can UK infrastructure capability which is currently untapped be exploited for its development potential? How can UK engineering researchers be better incentivised by funding and policy levers?
4. What is the role of capacity building within infrastructure research at DFID? Should more be done to build Southern capacity for infrastructure research, and if so, how?

Introduction and background

The report of the High Level Panel on the post-2015 development agenda states unequivocally that "everyone should have access to modern infrastructure – drinking water, sanitation, roads, transport and information and communications technologies (ICT)"[vi]. As noted in DFID's infrastructure position paper, strengthening the global evidence base for infrastructure decision-making through research remains crucial for improving infrastructure sustainably[vii], and for expanding access to women, girls and marginalised groups to ensure no one is left behind[viii]. This role for infrastructure as an enabler of development is supported by academic research; a recent paper from Japan's International Cooperation Agency (JICA) demonstrates through impact assessment of infrastructure variables across 91 countries that reducing "infrastructure poverty" is a prerequisite to overall poverty reduction[ix].

Thus infrastructure, and the engineering research and development which underpins it, is rising (back) up both the DFID and international donor community agenda. This paper therefore aims to inform the discussions of the DFID RAG by providing a snapshot of current UK research capability in the key infrastructure sectors and how this has changed over time. An additional objective is to understand overseas, particularly developing country, capacity in engineering for development and encourage thinking around future partnerships. The report also includes examples of where UK research not necessarily conducted with developing countries in mind could be logically extended to developing countries.

While DFID's infrastructure research portfolio is the main focus of this paper, engineering research for development involves numerous funders working across diverse remits. EPSRC records over £17m of current grants under their "International Development" socio-economic theme[x], although this does not capture the full extent of EPSRC grants with development relevance[xi]. NERC, MRC, BBSRC, and ESRC all fund research which would come under the broad umbrella of engineering research for development. Other bodies such as the Bill and Melinda Gates Foundation fund significant research in development relevant engineering, and the Royal Society and the Royal Academy of Engineering also contribute through fellowships, challenge funds and innovation prizes.

This paper has been compiled by the UKCDS Secretariat in April 2014. It aims to draw together, synthesise and present diverse pockets of knowledge and stimulate discussion. It does not aim to produce new data, nor to conduct a comprehensive, systematic survey of UK and global engineering research for development capacity, which would require a much longer period of sustained study.

UKCDS is the group which brings together 14 UK government departments and research funders working in international development. These include DFID, and five of the Research Councils. A small coordinating team (the Secretariat) brings this group together with researchers and other key organisations to share knowledge and identify opportunities for collaboration. By stimulating collaboration, UKCDS ensures the best science is funded and used to benefit international development, as well as the UK. The UKCDS Secretariat was tasked by its Board in 2012 to explore whether UK engineering research was having the maximum possible impact in development, and this scoping paper is one part of that workstream. The Secretariat would be willing to carry out further work in line with DFID/RAG, and other funders' priorities should this be desired.

Structure, methodology and definitions

This mapping considers infrastructure in five sectors: WAter, Sanitation and Hygiene (WASH), energy, transport, urban infrastructure and other forms of development engineering. Each sector was analysed in a similar way, using mixed methods to produce:

1. **An overview of changes in research spend over time.** The R4D database (which lists DFID Research and Evidence Division (RED) projects) records the overall cost of the projects. This figure was then smoothed by dividing the total cost by the number of years over which the project ran. This method is imperfect, with weaknesses explained in Annex 1A. Consequently, members of the DFID Climate and Environment and Growth Research Teams were consulted to supplement and correct the data.
2. **Lists of leading institutions in the UK, other developed countries and developing countries.** Identification of the strongest institutions was primarily achieved through face-to-face and telephone interviews with DFID advisers, partner institutes and other key UKCDS engineering for development stakeholders. A short survey was also sent out to reach a broader audience, and 24 responses were received. See Annex 1B for more details and for the survey questions.
3. **Analysis of funding call data**. For the WASH, energy and transport sections, data was obtained from DFID programme managers on submissions of expressions of interests/outline proposals and grantees within specific funding calls. The countries and institutions submitting bids, and their subsequent success were analysed. This can provide a proxy measure for research quality, though there are clear limitations in using this method to understand research capacity (see Annex 1C).
4. **Insights from qualitative scoping.** This includes information on fields in which UK capabilities in engineering could be extended to developing countries, and examples of issues which require further research.

One key caveat relevant throughout the paper is the difficulty of defining development-relevant “infrastructure” or “engineering” research. This paper focuses on the engineering components of infrastructure research. However infrastructure research is clearly more than just engineering and encompasses diverse disciplines including the social sciences and economics. Conversely, some engineering research relevant to development does not deliver infrastructure. To align with DFID’s understanding of infrastructure, a deliberately broad view of “engineering” has therefore been adopted.

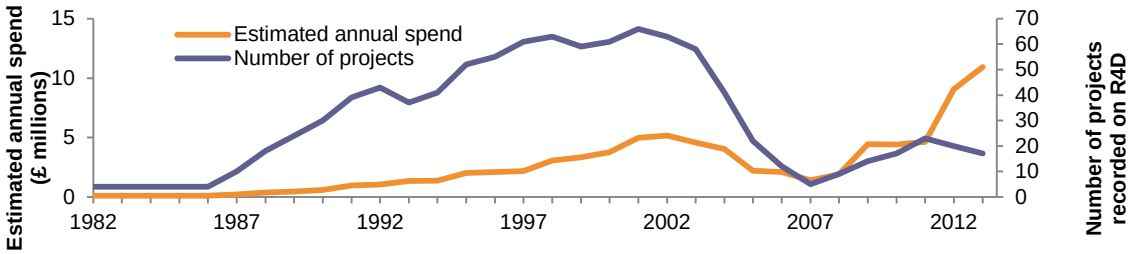
There are thus no systematic criteria for what counts as “in” or “out”. UKCDS has aimed to take a common sense approach and to be guided by the ways in which DFID categorises its research. Where research themes have some, but not solely, infrastructural elements, for example the agricultural innovation theme, subjective judgements have been made. E.g. the programme "mNutrition - Business models for mobile phone based delivery of nutrition services in Africa and South Asia" has been included as infrastructure but "Innovative Metrics in Agriculture and Nutrition" was not.

WAter, Sanitation and Hygiene (WASH) research for development

Developing country progress towards meeting MDG targets on WASH has been mixed; over two billion people have gained access to drinking water coverage since 1990[xii], yet 2.4 billion people will remain without access to improved sanitation in 2015[xiii]. Research into improvements to WASH infrastructure is increasingly moving towards holistic programmes, combining technical and social sciences research in response to complex emerging challenges such as rapid urbanisation, climate change, resource scarcity and complications of water resource management in fragile states[xiv].

While research funding for WASH has risen recently to an estimated £11m per annum, and

Figure 4 - Estimated DFID RED spend on WASH



continues to rise, there is a consensus that formal UK engineering expertise for WASH used to be stronger. Dedicated environmental engineering institutes such as Silsoe, Robens at Surrey University and HR Wallingford - the latter leading on almost 40 DFID research projects in the late 1990s and early 2000s - no longer predominate. WASH research in the UK is often undertaken more by expert individuals than entire institutions.

Qualitative feedback suggests that leading institutions today include: Loughborough's Water, Engineering and Development Centre (WEDC); Cranfield University's Water Science Institute; and the London School of Hygiene and Tropical Medicine. WEDC was one of eight institutions globally to receive funding through the Gates Foundation's "Reinvent the Toilet Challenge" in its 2011 phase[xv], and Cranfield was one of four in 2012[xvi].

Other notable institutions include the University of Leeds, the Institute of Development Studies (IDS), Sussex (on the Community Led Total Sanitation approach[xvii]), and the University of Oxford's Smith School of Enterprise and the Environment[xviii]. NERC's Centre for Ecology and Hydrology undertakes some development relevant research, historically for DFID on glaciers, groundwater and irrigation. The Universities of Newcastle, Surrey and Coventry, as well as Imperial College and UCL, are also strong. Regarding UK expertise outside academia, NGOs such as WaterAid and Oxfam, as well as consultancies such as GHK, carry out significant research in this sector.

Internationally, the Netherlands has several very good institutions with expertise in water and sanitation engineering in developing countries[11], with strong German, Swiss and French institutes too[12]. In North America, the University of North Carolina at Chapel Hill was frequently highlighted as

[11] Examples include the IRC International Water and Sanitation Centre (The Hague, with country offices in Ghana, Burkina Faso and Uganda); the International Water Association (The Hague); and the UNESCO-IHE Institute for Water Education (Delft).

[12] The German Federal Institute for Geosciences and Natural Resources; Sandec, the Department of Water and Sanitation in Developing Countries at the Swiss Federal Institute of Aquatic Science and Technology (Eawag); Programme Solidarité Eau

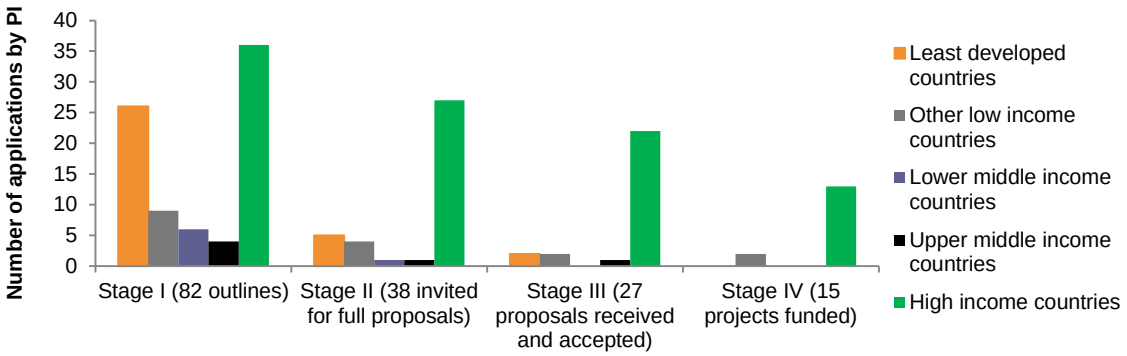
a notable research institution; others include the University of California, Davis; Stanford University; UMass Amherst; Princeton; Harvard; the Centre for Affordable Water and Sanitation Technology (Canada) and arguably the World Bank's Water and Sanitation Programme, to which DFID contributes an average annual £1.2m.

In developing countries, the Water Research Centre (South Africa) and the International Water Management Institute (IWMI), headquartered in Sri Lanka, were two highlighted institutions. The Indian Institutes of Technology (IITs) were highlighted as leaders in development engineering, specifically in technologies for water collection and purification for safe drinking water. The University of Lagos (Nigeria) also has substantial WASH expertise.

Data from the UPGro (Unlocking the Potential of Groundwater for the Poor) Catalyst Grants call was analysed to complement qualitative data on quality institutions. The overwhelming majority of project awards (13/15) are Northern PI led (see below), with five of the 15 projects led by the British Geological Survey[13]. Ethiopia has a Co-Investigator (Co-I) on five of 15 projects, involving researchers from IWMI's East Africa office, the Geological Survey of Ethiopia, Mekelle University and Addis Ababa University. In contrast, Ugandan researchers submitted eight of the 82 outlines, but only one Ugandan institute (Makerere University) is involved as a Co-I. Kenya was strongly represented throughout all stages of the application process, and leads on two of the projects through Kenyatta University and the World Agroforestry Centre, with three other institutions involved in consortia. The Nigerian University of Ibadan is collaborating on two projects.

Qualitative scoping indicated that significant expertise in water research for the UK (in universities

Figure 5 - UPGro Catalyst Grant applications by OECD DAC country category



such as Birmingham, Exeter and Sheffield) does not always overlap with research focussed on developing country environments. Wastewater treatment is one area where UK engineering research could have development applications, particularly through the EPSRC-funded Transforming Waste project consortium. Ongoing research into nutrient recovery and anaerobic digestion could be also explored in low-income countries.

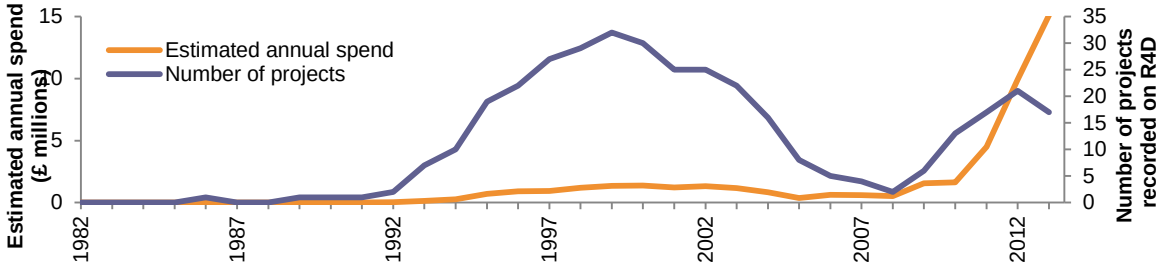
[13] That most final stage "PIs" were UK-based, despite heavy Southern participation, partly reflects greater UK experience in project administration rather than differences in scientific capacity.

Energy research for development

Tackling energy poverty and broadening local access to cleaner, renewable energy sources remains a key priority for infrastructure research. Almost 1.4 billion people globally, and around 600 million in Africa, lack access to any electricity at all[xix], while a similar number have only intermittent access[xx]. 2.8 billion people rely on biomass for cooking and heating their homes[xxi], causing an annual 4.3 million deaths[xxii].

DFID research into energy and low-carbon infrastructure has hugely accelerated and diversified in the last five years, going from an estimated £1.5m in 2009 to over £15m in 2013. Ongoing and pipeline projects include research into renewables; access to grid, off-grid and mini-grid electricity; household energy; bioenergy; energy and gender; and the relationship between energy infrastructure and economic growth.

Figure 6 - Estimated DFID RED spend on energy



EPSRC does also fund energy for development research, both independently and in partnership with DFID. In a first joint call with DFID and DECC, Understanding Sustainable Energy Solutions (USES), EPSRC is providing £5m of funding[xxiii]. Other investment includes the £1.8m SCORE consortium led by Nottingham University[xxiv], and two Off-Grid Electricity Generation Research projects (co-funded by DFID) at a cost of £3.54m to EPSRC[xxv].

The UK has significant expertise in sustainable energy research for developing countries. Leading institutions include UCL's Energy Institute, which leads on three of the 12 current projects under the USES programme; the Energy and Power Group at Oxford; Southampton; Durham; Manchester; Imperial College; Strathclyde; Loughborough, with two projects under USES; Edinburgh; Warwick; Cardiff; Surrey; Newcastle; De Montfort; Science and Technology Policy Research (SPRU) and the STEPS Centre at Sussex; and Bath University. The recently founded (and EPSRC supported) Low Carbon Energy for Development Network seeks to bring together this community to enhance impact. This was prompted by the UK government's increasing investment in the low carbon transition in developing countries and awareness that the substantial body of UK expertise on energy could engage more extensively with international development.

Outside of UK universities, the HEDON Household Energy Network facilitates knowledge-sharing in sustainable energy. Internationally, the University of Twente (Netherlands), the Energy Institute at Colorado State University, Columbia University, MIT (USA) and the University of Cape Town South Africa) are also notable institutions.

Analysis of data from the USES call can act as a proxy for developing country capacity in energy research. The table overleaf shows the countries submitting Expressions of Interest (EOIs) to the USES call, with strong representation from DFID priority countries (as well as China and Thailand).

Of 389 EOIs, 60 high quality researchers were invited to a proposal development sandpit. The geographical distribution of these 60 applicants is mapped below, with India, China, East, West and Southern Africa represented. Ghana enjoyed notable success, with 3 of its 6 EOIs accepted (compared to only 27 of the UK's 116), and all scored in the top decile.

Country	Number of EOIs
UK	116
Kenya	28
Nigeria	26
South Africa	22
India	21
Uganda	11
China	10
Philippines	10
Ethiopia	7
Pakistan	7
Tanzania	7
Bangladesh	6
Ghana	6
Zimbabwe	6
Thailand	5

Figure 7 – Global distribution of high quality researchers applying to the USES call

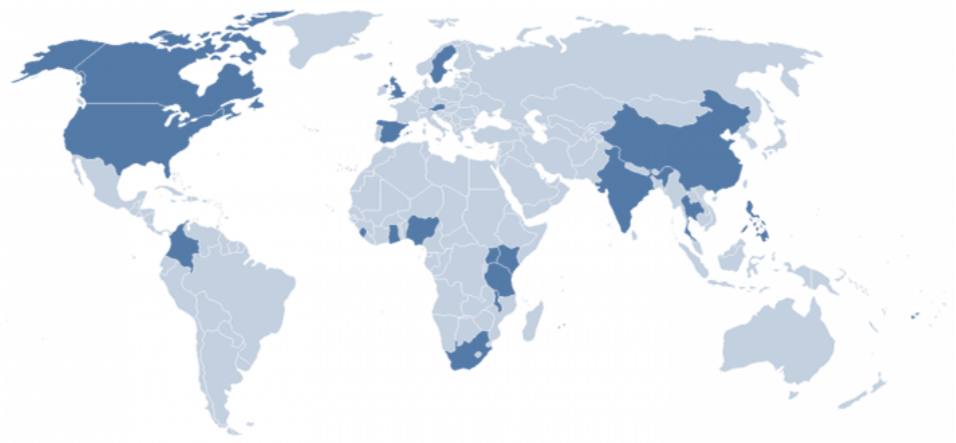
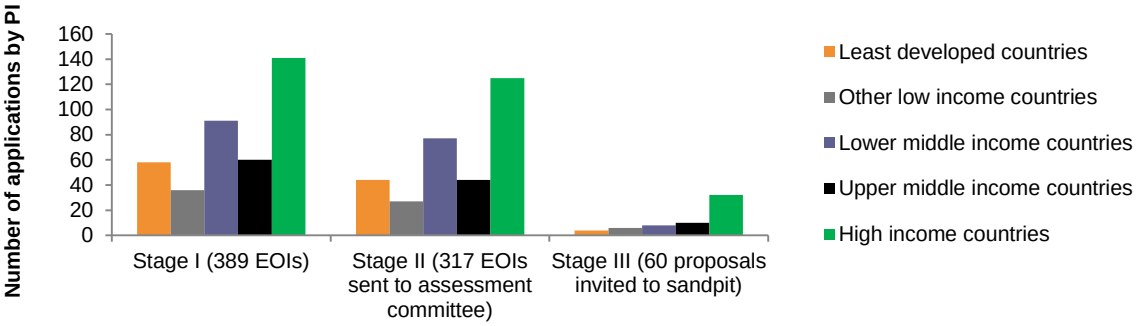


Figure 7 below tracks the success rate of the call applicants by country income groups. It demonstrates that while the distribution of applicants' success was broadly similar in Stages I and II, the 60 proposals invited to the sandpit were overwhelmingly from Northern PIs suggesting a clear correlation between country income level and success. Following this sandpit, 24 outline proposals were invited for peer review, with 12 led by UK researchers, and six led by developing country researchers. 12 projects have been funded, all with UK administrative PIs, as stipulated by the funders. For this reason it is difficult to compare success at this stage with previous stages, despite strong Southern academic involvement.

Figure 8 - Early stage USES applications by OECD DAC country category

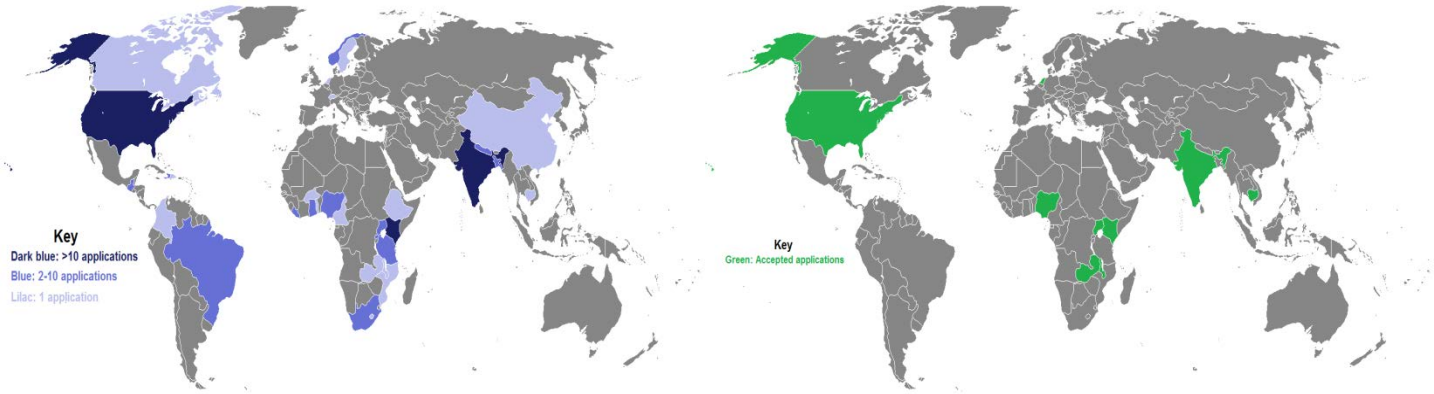


Within energy sub-sectors, the UK has significant expertise in **bioenergy**, in which there is an incipient DFID research programme. Centres of excellence include the EPSRC funded SUPERGEN Bioenergy Hub hosted by Manchester's Tyndall Centre for Climate Change Research; Imperial College; Aberdeen; and Loughborough. Outside the UK, important institutes include the International Rice Research Institute (IRRI) (Philippines); University of Stellenbosch (South Africa);

University of the West Indies; and the Centre for Agriculture and Forestry Development (CEDAF) (Dominican Republic).

Cookstoves are a cornerstone of energy research. Activity is coordinated by the US-based Global Alliance for Clean Cookstoves (GACC). In the UK, the universities in the SCORE consortium (Nottingham, Manchester, Queen Mary University of London and City University) are at the forefront. Internationally, Berkeley, the University of Colorado at Boulder and the Asian Institute of Technology (Klongluang, Thailand) are also active in this field.

Figure 9 – Global distribution of applicants and awardees for cookstove research funding



In Round II of the GACC's Pilot Innovation Fund and the Spark Fund, with applications mapped above, 79% of the 118 applications (left) came from Southern institutes/enterprises and eight of the eventual 10 grantees (right) are based in the global South.

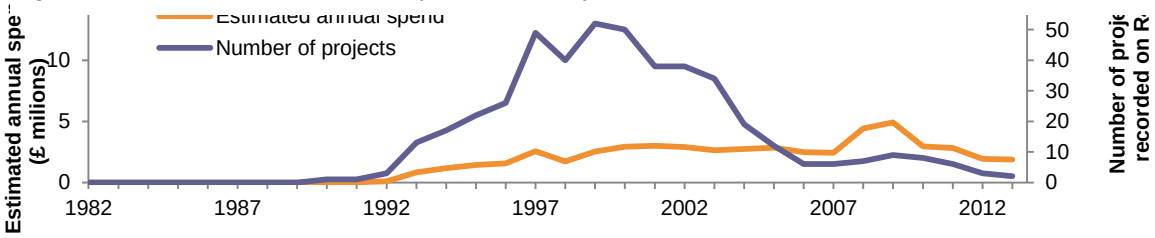
An increasing proportion of energy research is moving towards fostering innovation and trialling of **new technologies and business models to deliver energy services**. £10m of innovation prizes over five years are aiming to use a payment by results model to incentivise new researchers and technology developers beyond habitual DFID grantees in the Mobile Enabled Community Services (MECS) scheme. Important developing country centres include many of the (often expat led) social enterprises operating in solar energy in East Africa, such as M-KOPA (Kenya) which was funded under MECS and also under the New Energy Applications and Delivery Models programme.

Energy research was one particular area where survey respondents saw significant potential for extending UK expertise to developing countries. For example, substantial research exists in the UK on small-scale bioenergy systems developed to use dispersed rural resources, and this has potential applications in poor countries. In addition, electrical engineering research on minigrids, smart grids, distributed energy, the scale up of renewables including solar, and energy efficiency has clear relevance to developing countries, as well as scope for engaging UK expertise.

Transport research for development

Transport research for development remains vitally important since improving connectivity in rural areas can promote economic growth and reduce poverty[xxvi]. There is growing awareness that while rapid motorisation can bring short-term gains, poorly planned transport systems can lead to setbacks in growth due to congestion, road accidents, air pollution and climate change[xxvii]. DFID's transport research portfolio is currently focussed on rural low volume roads. DFID is planning to extend research into high volume, low carbon, urban, and road safety. It will go beyond engineering, geoscience and spatial analysis to economic and social science research into connections between transport and economic growth, gender, governance and the mobility of poor people in cities. The transport research is intensely focussed on practical applicability and uptake of evidence and thus blurs the boundaries between formal academic research and the production of technical standards or guidelines.

Figure 10 - Estimated DFID RED spend on transport



While core support to research institutions has declined over recent years, spend by DFID increased to an estimated £5m per annum in 2009. The largest recent programmes have researched rural low volume roads and transport services, through the South East Asia and Africa Community Access Programmes (SEACAP and AFCAP). The chart above does not include forthcoming programmes, such as AFCAP Phase II, and a new programme extending the principles of AFCAP to Asia (together totalling £24m); and a pre-pipeline programme on High Volume Engineering and Transport Services Research. Research elements also exist within policy programmes, such as the Nigeria Infrastructure Advisory Facility which has potential for technology transfer to other Southern contexts.

Globally, DFID has been the main funder of the World Bank's transport research over the last 10 years. One of the seven themes within DFID and the World Bank's recently agreed strategic research partnership on economic development is focussed on transport[xxviii].

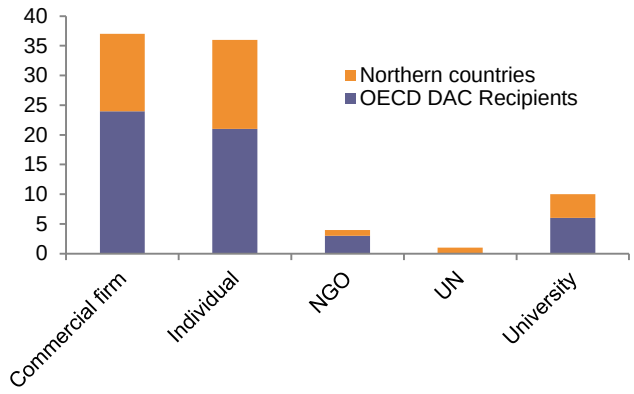
The principal institutions in transport, in contrast to other sectors, are advisories or consultancies such as the Transport Research Laboratory rather than universities. Other noteworthy private sector organisations are IT Transport, Roughton, OTB Engineering, Intech Associates, IMC Worldwide, Mott Macdonald and ARRB (Australia).

Leading Northern academic institutions include the Universities of: Birmingham; Reading; Durham; Strathclyde; UCL; IDS at Sussex; Leeds; LSE; Southampton; Oxford; Cambridge; Imperial College London; Cranfield; and MIT (USA).

Birmingham, along with Durham and Plymouth were the only three UK universities (out of a total eight universities) sub-contracted under AFCAP. The other Northern university involved was the University of Alabama (USA).

Notable African institutions for roads include the Council for Scientific and Industrial Research (CSIR) in South Africa, which has been sub-contracted under the AFCAP programme; the Building and Road Research Institute (BRRI) in Ghana; Makerere University, Uganda; and the Ethiopian Road Research Centre. Rail research capacity is limited in Africa. Asian transport research capacity is concentrated in India including the Centre of Excellence in Urban Transport at CEPT, Ahmedabad; Teri University; the Central Road Research Institute (CRRI), Delhi; and Bangalore's Institute of Science. In South East Asia, the Institute of Transport Science and Technology (ITST); the Transport Development and Strategy Institute (TDSI); the Asian Institute of Technology (AIT) Bangkok; and the Institute of Technology and the Institute of Road Engineering, both in Bandung (Indonesia) were highlighted as strong institutions which participated in SEACAP.

Figure 11 - AFCAP service providers



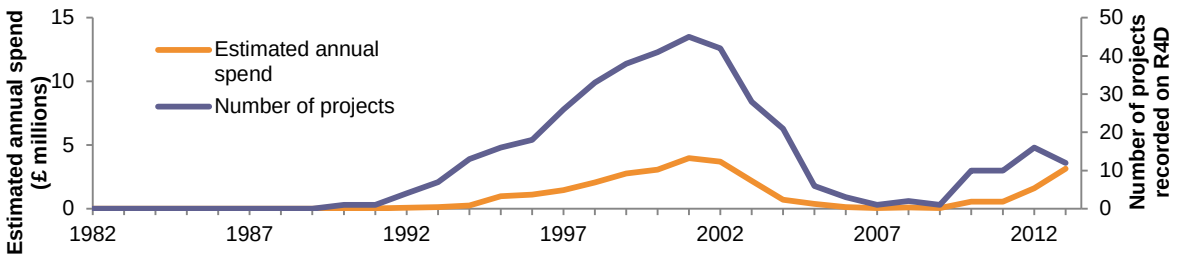
Within the AFCAP programme, substantial efforts have been made to strengthen research capacity through involvement of African institutions, although most of these are commercial firms (24) and individual consultants (21) rather than universities. The six Southern (African) academic institutions involved were CSIR (South Africa); the University of Pretoria (South Africa); the Kwame Nkrumah University of Science and Technology (Ghana); Pan-Atlantic University (Nigeria); University of Eduardo Mondlane (Mozambique); and the International Institute for Water and Environmental Engineering (Burkina Faso)[xxix].

Overall, research into transport increasingly integrates cross-cutting issues such as urbanisation, health or climate change. Potential future directions for DFID's transport research might include high volume transport, urban transport, low carbon, mass transit, primary networks, rail and road safety in addition to the existing low volume rural transport applied research and World Bank research. This is currently being scoped by DFID. There may also be a research opportunity regarding harmonisation of international standards on sustainable and resilient transport, supported by improved data collection[xxx]. DFID and seven multilateral development banks are exploring the possibility of developing a mechanism for aligning transport research and uptake agendas.

Urban infrastructure research for development

Urbanisation in developing countries can constitute a vehicle for poverty reduction through economic growth and increased productivity[xxxi], but only through targeted investment in infrastructure improvements[xxxii]. 'Urban' infrastructure intersects heavily with energy, water, transport, health and other areas. However, particularly with post-2015 discussions, it is an area rising up the agenda, with world leaders stating that the battle for sustainable development and resilience in the face of climate change will be won or lost in cities[xxxiii].

Figure 12 - Estimated DFID RED spend on urban infrastructure research



The chart above shows the research investment and number of urban infrastructure projects DFID has funded. It shows DFID spends significantly less on urban infrastructure than other sectors (notwithstanding the point made above on overlap). The peak in the early 2000s can be explained by significant contributions to UN-Habitat's Urban Management Programme and to the World Bank/UN Habitat Cities Alliance, and smaller projects managed by a broad range of NGOs, consultancies and universities. The disbanding of DFID's urban team in 2007 may partially explain the drop in urban research at the end of the 2000s, although urban development programme work continued, particularly in India. Engagement with cities as tiers of government has been underrepresented in DFID research, although many programmes outside of RED such as the Community Led Infrastructure Finance Facility will have had research elements.

The recent upsurge in funding can be attributed to two incipient programmes: Future Proofing Cities (Phase I) and Growth and Urbanisation in Low Income Countries, as well as the recently launched Safe and Inclusive Cities Programme. There are also urban elements included in other programmes, such as the City-Wide Sanitation Project on WASH in cities within the Sanitation and Hygiene Applied Research for Equity (SHARE) programme.

Few of the research projects included above constitute solely 'hard' engineering research for infrastructure, and the last 20 years have seen a shift away from pure technical research as in other sectors. Important social science programmes include Phase 3 of the DFID-ESRC Poverty Alleviation scheme, which allocated £5.3m of a total £7.3m for research into urban poverty and urban resilience building[xxxiv]; and the Safe and Inclusive Cities Programme managed by the DFID RED Governance, Conflict and Social Development team.

Notable UK institutions for technical urban infrastructure research in developing countries include first and foremost the Development Planning Unit (DPU), part of the Bartlett School at UCL. Institutions such as LSE Cities and the UCL/Imperial College Intel Collaborative Research Institute for Sustainable Connected Cities are not solely development focussed but have a global research angle. Prominent non-academic institutions include Dalberg, GHK and Overseas Development Institute, with the latter currently scaling up its infrastructure and growth research. EPSRC is also

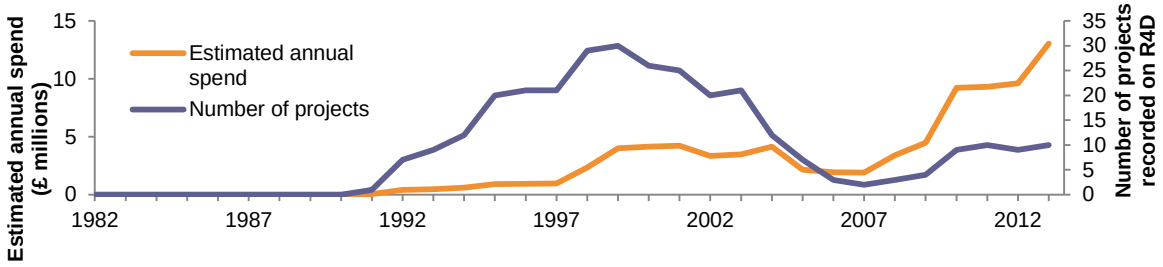
funding research networks into ecocities with Arup[xxxv]. Beyond the UK, the Cities Alliance in Brussels (founded but no longer funded by DFID) conducts research across the whole of Africa.

In developing countries, the African Centre for Cities (ACC) based at the University of Cape Town is unparalleled in the quality of its interdisciplinary research, and heads the urbanisation stream of the DFID Infrastructure Knowledge Programme. The Indian Institute for Human Settlements in Bangalore, which partners with the ACC, can be seen as its South Asian counterpart.

Other fields of engineering research relevant to development

The applications of engineering to development go beyond those featured under the more established infrastructure sectors profiled so far, to include biomedical engineering, agritech, information and communication technologies (ICTs) and arguably manifold forms of “frugal innovation” more broadly.

Figure 13 - "Other" DFID engineering research - including agricultural innovation, geoscience, infrastructure financing...



The graph above, showing miscellaneous infrastructure research beyond the categories considered so far, is not particularly indicative of the breadth of engineering research which falls outside the traditional fields. The figures are overwhelmingly composed of projects under the R4D “Agricultural Innovation” research theme.

DFID spent an estimated £13m on **agricultural innovation** in 2013, including infrastructure-relevant projects such as sustainable intensification and mAgriculture/mNutrition. This spend is higher than WASH infrastructure research. Projects under this theme in particular lie at the boundaries of traditional engineering and infrastructure research, hence they have not been profiled as a separate sector. In UK agritech and agricultural engineering research, the Royal Agricultural University, Harper Adams and Cranfield are notable institutions. A lot of agricultural engineering research (though not necessarily development focused) is funded by industry, such as the e-Agri Sensors Centre at Manchester University. The Institution of Mechanical Engineers compiled its own research into engineering’s potential contributions to ensuring food security through agricultural technologies and reduction of food waste[xxxvi].

This category also includes research recorded under the **geoscience** theme, such as mine clearance and landslide risk assessment, infrastructure in its broadest sense. Beyond the British Geological Survey, consultancies such as Wardell Armstrong, Knight Piésold and Reynolds International Ltd have managed some of the larger projects.

In **biomedical engineering**, there are pockets of UK engineering expertise unpacking the opportunities for their work in development. For example, UCL researchers have secured funding from the Gates Foundation to develop brain imaging technology for use in sub-Saharan Africa, bringing this particular type of imaging to the continent for the first time.

Architectural engineering has significant development relevance. Oxford Brookes was highlighted as an important institution: their Centre for Development and Emergency Practice (CENDEP), within the School of Architecture, researches post-disaster shelter. In addition, Coventry’s Faculty of Engineering and the Martin Centre for Architectural and Urban Studies at Cambridge are undertaking research into bamboo construction and housing. Overseas, leaders in bamboo engineering include the Universidad Nacional de Colombia and the Universidad de Los Andes.

The role of **ICTs in development** has long been recognised, but the boundaries between [academic] research and software development or scale up of services are particularly blurry. Canada's International Development Research Centre has been at the forefront of applied ICT research for developing countries. More specifically on engineering, the potential of new digital technologies for development, including 3D printing and digital fabrication are increasingly being explored, with a lot of activity coordinated through open-source platforms and forums such as Cambridge's OpenLabTools initiative[xxxvii].

Just as climate scientists at institutions like the Grantham Institute are involved in infrastructure research[xxxviii], so aspects of **climate adaptation and resilience** also involve engineers. One of the four consortia under the Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA) programme is being led by coastal engineers at the University of Southampton. Of the developing country partners, the Institute of Water and Flood Management at Bangladesh's University of Engineering and Technology has the clearest engineering focus, involving academics from the fields of water management, hydrology and river/coastal hydraulics.

In terms of **infrastructure and growth** (a cross-cutting area rather than purely thematic area)**,** DFID has several important programmes with research elements such as the Private Infrastructure Development Group (PIDG), as well as research components in the Trademark East Africa Programme. Leading institutes beyond LSE include the Centre for the Study of African Economies at Oxford University, the Université Libre de Bruxelles, the University of Toulouse, Berkeley University, Princeton University and Kyoto University.

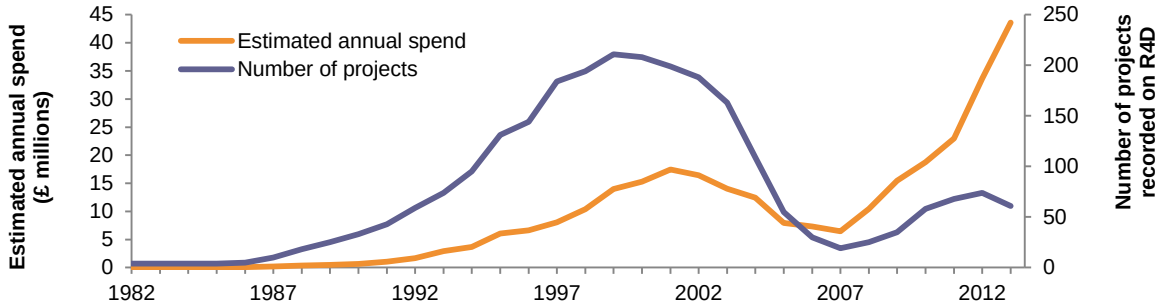
Finally, it is worth noting that research into infrastructure governance, improving data, the translation of research into policy, and strengthening local capacity to maintain and extend existing infrastructure is undertaken to support the enabling environment for infrastructure. Academic institutions such as IDS, SPRU and LSE, and think tanks such as ODI and the International Institute for Environment and Development are active in this field. Overseas, the Centre for Global Development in Washington, D.C. and the Christian Michelsen Institute in Norway are respected institutions for their research on corruption and transparency in the context of infrastructure. The Engineers Against Poverty group carries out significant action research into systemic issues such as procurement, risk management and transparency in the extractive industries, understanding of which remains essential for delivering infrastructure improvements.

Discussion

How much is DFID funding?

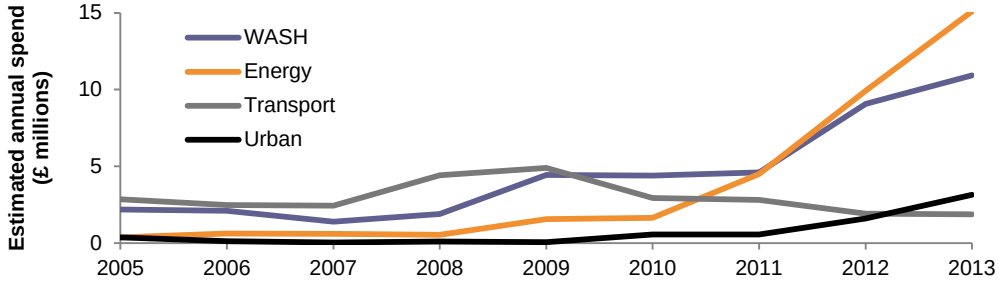
Overall DFID funding for infrastructure research rose gradually from the early 1990's to a peak of around £17.5m a year in 2001. Funding then declined through the 2000's, dropping to £6.5m in 2007. In the last 6 years it has grown very rapidly again, showing seven-fold growth to reach £45m a year in 2013[xxxix]. This dramatic aggregation of the sectoral spending profiled over the proceeding pages is shown in the figure below.

Figure 1/14 - Estimated DFID RED spend on infrastructure research



As such, infrastructure research currently receives about 15% of DFID's research budget, which totalled £305m in 2013-14. In comparison, around £75m a year is disbursed in health research (around 25% of DFID's research budget). Within infrastructure, energy, WASH, and agricultural engineering research all receive over £10m a year. Transport spend is currently lower (almost £2m), but will rise a little from 2014 with a six year £24m programme launching in 2014. Urban infrastructure is currently at a similar level to transport, at around £3m a year, but is not expected to see as significant a rise in the coming year.

Figure 2/15 - Changes to research spend across sectors since 2005



DFID is by far the biggest UK funder of engineering for development research. EPSRC does support a small amount of engineering research for development (total – *not per annum* – portfolio of almost £18m[xl]), and a larger amount of engineering research with potential applications in development. Internationally, a significant proportion of the Gates Foundation's $600m annual spend on global health R&D[xli] is engineering relevant to health and sanitation.

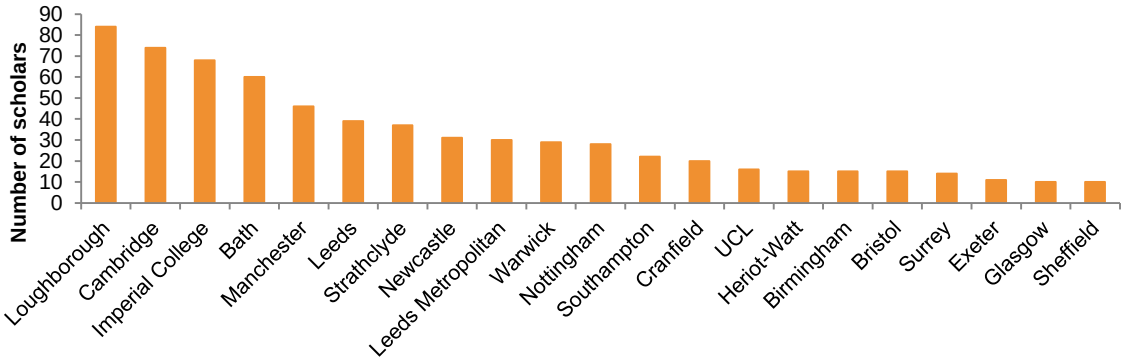
The type of infrastructure research DFID funds is changing. Scoping has revealed projects are becoming more interdisciplinary, particularly with more social science involved. This reflects a growing consensus that international development challenges cannot be solved through technology

development alone, but also require effective implementation of technology in a holistic, context-appropriate manner. This context includes business models, supply chains, and strengthening local capacity. Interviews with senior engineering researchers indicated that the key challenge is not always the engineering *per se* but rather making technology cheaper, more amenable and accessible. The average size of a DFID engineering for development research project has also increased significantly[14], though this may reflect changes in reporting processes and around what counts as a 'project'.

Who is doing this research?

In the UK, a number of institutions are consistently recognised as focusing on engineering research for development, among them the Universities of Loughborough, Cranfield, Imperial College, UCL, Cambridge, Manchester, Durham and Strathclyde. Data from analysis of DFID and EPSRC funding calls, and qualitative scoping, have been moderately consistent. A proxy measure – the institutional choices of Commonwealth Scholars studying engineering – also confirms these universities as some of the key UK centres[15].

Figure 16 - Number of Commonwealth Scholars in engineering by institution since 2000



These institutions are not necessarily the 'usual suspects' – the research intensive UK universities who receive most of the HEFCE and/or Research Councils funding. Some, like Leeds Metropolitan on sustainable engineering in Africa[xlii], and Coventry on humanitarian engineering and computing, have made strategic decisions to focus in this area. Beyond a small number of key institutions, scoping in advance of this meeting and other UKCDS work on engineering for development suggests that the research base is fragmented across four dimensions:

[14] In 2000, 208 projects were running spending just over £15m. In 2013, 61 projects were taking place with an estimated value of almost £45m.

[15] Commonwealth Scholars study in the UK under 7 different categories of award, and are then expected to return home. 52 Commonwealth countries and territories are classed as "developing" (http://cscuk.dfid.gov.uk/apply/developing-cw-countries/). Scholars do not have to study a course relevant to their country, or to development more broadly, but the data above suggests that a number of institutions are providing research training in engineering relevant to the concerns of students from poorer countries.

- Spatially, in that it often involves individuals rather than institutions
- Temporally, in that academics may undertake one-off projects related to development in what is generally a UK-centric research area in light of funding available
- Institutionally, in that many of the most experienced engineering for development researchers are freelance, and work for NGOs or consultancies as well as universities and research centres
- In terms of publication, with research published across a wide variety of journals and in grey literature.

There are encouraging signs that professional institutions such as Royal Academy of Engineering, and the Institutes of Civil and Mechanical Engineering are increasingly focusing on development. NGOs like Practical Action have long been significant contributors.

Sectoral differences

Whilst the sectors of engineering research for development show similar funding trends over the last ten years, tentative conclusions from this scoping suggest they do vary subtly:

- Consultants/consultancies play a greater role in transport research than other sectors. Individuals and commercial firms made up 73 of the 88 service providers in the African Community Access Programme (AFCAP), with only ten universities providing research.
- UK WASH research capacity has declined over time, with a small number of key researchers focusing on development remaining in wider departments
- Energy seems to be the sector with the most UK capacity and momentum at the moment.

The international research base

The sectoral summaries provide a number of examples of international research institutions working on engineering for development. Analysis of funding data across sub-sectors shows interest in DFID funding from India, China, and a number of countries in West Africa, and a band of countries running from Ethiopia to South Africa. However, following selection processes, African involvement often retrenches to Ghana, Kenya and South Africa, suggesting that these are the countries with highest quality research capacity in sub-Saharan Africa.

However, the way funding data is recorded[16] and the short time frame or this mapping (four weeks) has made it impossible to do anything more than scratch the surface of understanding international capacity.

[16] Only the lead institute is listed on R4D – mapping consortia funding by DFID would have to be done manually.

Questions for discussion

Given the findings and discussion above, the RAG members may wish to discuss:

1. Does the funding accorded to infrastructure research align with the priority of infrastructure within DFID? Within infrastructure, does the relative funding accorded to the various sectors align with policy and research priorities?
2. The UK research base seems relatively fragmented. Are proactive measures needed from funders to change this? How can greater ‘residual’ or institutional knowledge be retained as project funding comes and goes?
3. How can UK infrastructure capability which is currently untapped be exploited for its development potential? How can UK engineering researchers be better incentivised by funding and policy levers?
4. What is the role of capacity building within infrastructure research at DFID? Should more be done to build Southern capacity for infrastructure research, and if so, how?

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This paper was largely written by Jamie Enoch, with input from Ian Thornton and Andrée Carter, all UKCDS.

Annex 1 – Further details and caveats on the methodology

A. Spend calculation using R4D

1. The way programme spend was averaged out over the programme duration produced relatively crude estimates of DFID's infrastructure research spend. A programme of £10m over 5 years will generally see much larger spending in Year 3 than Year 1 or 5, although in the method used here, each year would be recorded as £2m. To obtain more accurate figures would require further time and access to spend/budget figures for each project as recorded on DFID's internal Aries system.
2. The usefulness of the information on R4D was limited for this exercise by:
    i. The failure to record research elements of DFID policy division programmes (e.g. the Infrastructure Knowledge Programme) or contributions to global knowledge platforms such as the Energy Sector Management Assistance Program (ESMAP).
    ii. The recent migration of data from R4D to DevTracker - lots of research programmes which would have been recorded discretely on R4D are amalgamated on DevTracker or included within non-RED programmes.
    iii. Failure to record the costs of research projects under larger schemes managed by ESRC and the World Bank. These were estimated by looking on the ESRC and World Bank websites and using the proportion of DFID's contribution to estimate the cost to DFID. E.g. for DFID-ESRC Growth Research projects (90% DFID: 10% ESRC), the total project cost was obtained from the ESRC database and multiplied by 0.9 to calculate the cost to DFID.
3. UKCDS aimed to offset limitations with R4D through use of internal project lists provided by the Climate & Environment and Growth Research teams. However the project lists are for ongoing rather than historic projects, so there is potential underestimation of the spend in previous years.
4. Only for projects over £400,000, UKCDS has manually gone through projects on R4D to ascertain how much is "infrastructure" "research" by using DevTracker's sector classification based on the DAC aid classification system. For example, RED contributions to CDKN are listed on R4D under the "Low carbon development" theme. DevTracker says 20% of DFID's contribution to CDKN is "scientific research" and this has been counted as a proxy for the partial infrastructure element - however this may be an overestimate. Using a similar method, 75% of SHARE was judged to be infrastructure (since 25% was recorded as "medical research" and therefore excluded); this may subjectively be an underestimate.
5. The drop in the number of projects on every graph in recent years is likely linked more to changes in how projects are commissioned/managed/recorded than changes in levels of infrastructure activity. It could be attributed to an increasing tendency to pool several smaller research projects under one larger programme, with each project having greater value. E.g. Sustainable Energy, Access and Gender (SEAG) includes three project strands under one umbrella.

B. Lists of leading institutions

Face-to-face or telephone interviews were conducted with key UKCDS engineering for development stakeholders, DFID advisers/officers on infrastructure programmes and their partner institutes. The objective was to receive and triangulate their feedback on the institutions which they perceive to be strongest in engineering for development overall and in the specific sector of the respondent's expertise.

To obtain as many responses as possible, the survey was sent out to UKCDS' engineering community of practice and to the Engineers Without Borders community. The email outlined the exercise and set out three questions, shown below:

- In your view, which are the leading research institutions in engineering for international development and poverty alleviation, in the UK and/or overseas (particularly in developing countries)?
- On a related note, which are the leading institutions for your sectoral field(s) of engineering/infrastructure research (e.g. WASH, energy, transport, urban planning) in the UK and/or overseas?
- Lastly, do you have specific examples of UK engineering research which may not have been conducted with international development in mind but which could be logically extended to, or taken up in, developing country contexts?

24 responses were received over two weeks, and the small sample size in light of time limitations should be borne in mind. Desk-based web research was used to confirm or expand on interview and survey responses regarding the foremost institutions. If a respondent listed their own institution as notable but this was not corroborated by other interviewees/respondents, this was not included.

C. Analysis of funding calls data.

For the WASH, energy and transport sections, data was obtained from DFID programme managers on submissions of expressions of interests/outlines and grantees within specific funding calls. Data analysis of which countries and institutions were submitting bids, and successful proposals, has been used to provide proxy measures for research quality.

Using data from these calls to illustrate broader general trends is problematic, since submissions represent a snapshot of currently available researchers, which may fluctuate depending on researcher numbers, workloads and time allocation. Moreover, submission by researchers depends on awareness of the call, which may reflect existing networks, prior engagement with UK funders or unequal distribution of publicity, institutional knowledge or resources. There is also a potential Anglophone bias as documentation is in English and processed and peer reviewed by Anglophone funders and academics.

At the final stages of funding decisions, UK researchers are often more successful, based on greater familiarity with the system and/or stipulation from funding agencies that there is a UK (administrative) lead. This is an additional limitation for this proxy in inferring the balance of 'Northern' and 'Southern' scientific research capacity.

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