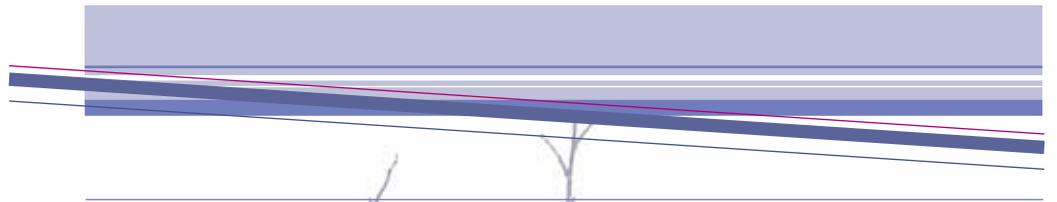


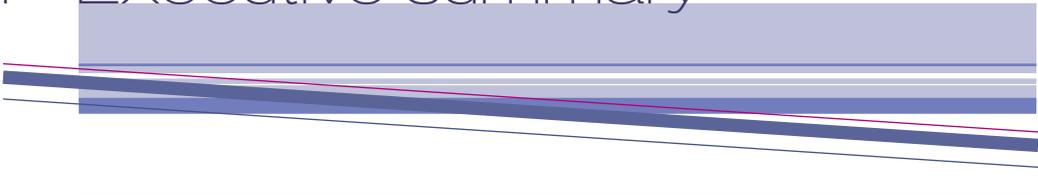
ARCC Coordination Network UKCIP annual report 2011



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1 Executive summary



The Adaptation and Resilience to a Changing Climate Coordination Network (ARCC CN) has now evolved into a mature network of researchers and stakeholders focussing on the built environment and infrastructure sectors. There is active participation from 18 multi-disciplinary research teams involving 35 academic institutions, over 200 researchers and a wide variety of stakeholders from central and local government, business and industry. Working together through network activities, this community is providing evidence to enable the design of urban systems that are more resilient to climate change thus benefitting national economic stability and well-being.

Key achievements across the network in 2011 included:

- input to the Climate Change Risk Assessment (CCRA). The network was instrumental in engaging researchers and stakeholders in the CCRA process and results from the research informed the Buildings and Infrastructure chapter;
- support to the Chartered Institution of Building Services Engineers. Future weather data and information was provided on which to base thermal and energy performance assessments for buildings and to inform best practice guidance on climate change adaptation issues;
- an improved understanding of overheating in the urban environment. Network events brought together researchers and central policy makers to consider the evidence available and how it could be focussed further to inform policy;
- broadening engagement through a two-day open conference: *Adapting our Built Environment – ARCC Contributions and Challenges*, attended by over 140 decision-makers, researchers and international colleagues;
- on-going development of a pool of skilled researchers capable of engaging effectively with end-users to facilitate the cooperative provision of evidence to inform policies and practices.

During 2011, two research projects finished (CREW, COPSE) with on-going work concentrating on final dissemination activities. Following network activities to identify priority research gaps and policy requirements, four new projects (ITRC, ARCoES, ARIES and RESNET) started in 2011 which have broadened the research base to include the adaptation and resilience to climate change of national infrastructure, and in particular the energy sector.

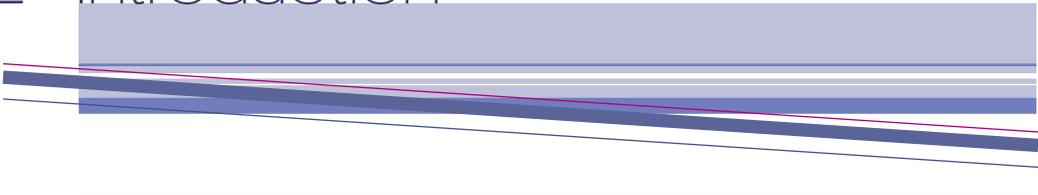
UKCIP provides the management and coordination role for the network and aims to enhance overall cooperation and knowledge exchange activities to promote benefits to all participants. With research timelines now stretching out to 2016, the work of UKCIP within the ARCC CN has evolved into a rolling programme of activities aimed at facilitating coordination between and beyond the projects and promoting the effective dissemination and use of outputs from across the network.

Further information on both the network and individual research projects can be found on the ARCC CN website: www.ukcip-arcc.org.uk.

Project acronyms

ARCADIA:	Adaptation and resilience in cities: analysis and decision-making using integrated assessment
ARCC-Water:	Water system resilience
ARCoES:	Adaptation and resilience of coastal energy supply
ARIES:	Adaptation and resilience in energy systems
BIOPICCC:	Built infrastructure for older people In conditions of climate change
COPSE:	Coincident probabilistic climate change weather data for a sustainable built environment
CREW:	Community resilience to extreme weather
DeDeRHECC:	Design and delivery of robust hospital environments in a changing climate
DOWNPIPE:	The use of probabilistic climate scenarios in decision-making for adaptation of building and property drainage
FUTURENET:	Future resilient transport networks
ITRC:	UK infrastructure transitions research consortium
LCF:	Decision support for building adaptation in a low carbon climate change future
LUCID:	The development of a local urban climate model and its application to the intelligent development of cities
PROCLIMATION:	The use of probabilistic climate scenarios in building environmental performance simulation
PROMETHEUS:	The use of probabilistic climate data to future proof design decisions in the buildings sector
RESNET:	Resilient electricity networks for Great Britain
SCORCHIO:	Sustainable cities: options for responding to climate change impacts and outcomes
SNACC:	Suburban neighbourhood adaptation for a changing climate

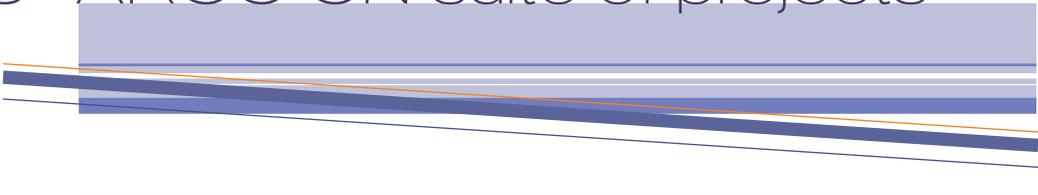
2 Introduction



The ARCC CN was established in 2009 and comprises a suite of research projects focussing on adaptation and resilience to a changing climate in the built environment and infrastructure sectors, their end-users and a central coordination unit to facilitate collaboration and to promote knowledge exchange activities both between and beyond the individual research projects. The overall programme is funded by the Engineering and Physical Sciences Research Council (EPSRC) as part of the Living with Environmental Change (LWEC) partnership, and in particular as a contribution to the LWEC Infrastructure Challenge which aims to make infrastructure, the built environment and transport systems resilient to environmental change, less carbon intensive and more socially acceptable.

This annual report focuses on describing the impact of coordination and dissemination activities across the network and the role of UKCIP in managing these cross-project activities. Summaries of individual ARCC CN research projects and website links for further information are given in Section 9.

3 ARCC CN suite of projects



To date, 18 research projects with a total funding of £19.3m have been involved in the ARCC CN, plus the coordination role provided by UKCIP (£0.53m).

Fourteen research projects formed the original network when it was established in 2009. These included six projects; ARCADIA, ARCC-Water, BIOPICCC, DeDeRHECC, FUTURENET and SNACC, funded under the EPSRC Adaptation and Resilience to Changing Climate call within the LWEC programme and several on-going related projects:

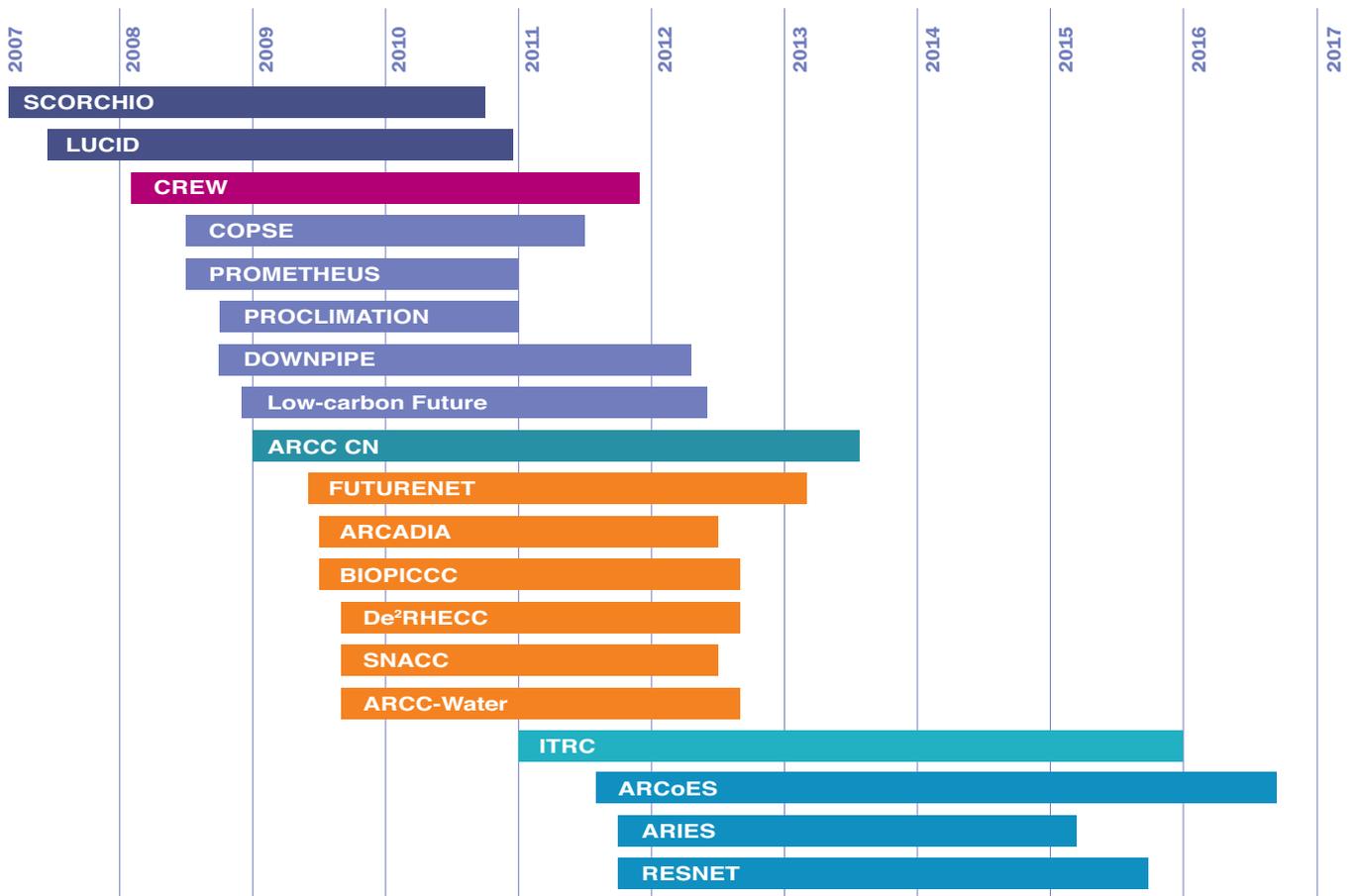
- SCORCHIO and LUCID both started in 2007 in response to a call for climate change research into urban environments. Both projects finished in late 2010 but have remained actively involved in coordinated dissemination and policy advisory activities throughout 2011.
- The CREW project started in 2008 as a result of an IDEAS factory call on coping with extreme weather events. The project has just held its final general assembly meeting (November 2011) at which nearly 100 participants heard presentations summarising outputs from the programme and discussed next steps and implications for users. The focus is now on working with the research team to help disseminate key findings effectively to a range of targeted audiences.
- Also in 2008, five projects were funded to study the use of probabilistic climate change projections in adaptation decisions within the built environment. PROMETHEUS and PROCLIMATION are now complete. COPSE finished in 2011 whilst DOWNPIPE and Low Carbon Futures continue into 2012. The challenge now is to promote the use of such information based on probabilistic climate projections in risk-based policy and decision-making.

During 2011, four new projects focussing on national infrastructure and in particular on the energy sector were incorporated into the ARCC CN: ITRC, ARCoES, ARIES and RESNET (see Section 4). This represented a fundamental change in the strategic role of the ARCC CN which has now developed from a discrete set of projects (2009 - 2013) to a rolling programme of climate change adaptation research through to 2016 with associated and coordinated cross-project activities.

In addition, the ARCC CN coordination unit is managed and supported by UKCIP at the University of Oxford. The work started in January 2009 and the current programme runs to July 2013. The aims and objectives are to:

- facilitate collaboration by establishing an integrating network;
- promote stakeholder and researcher participation within the portfolio of projects;
- maximise the potential benefits of the research to all end-users through broadening engagements and targeted dissemination of outputs;
- facilitate the further exploration of related knowledge and research gaps.

During 2011, activities organised by UKCIP within the network have sought to build on and expand the general engagement and interaction processes established in earlier years. Priority has been given to enhancing opportunities for further coordination both between projects and between researchers and stakeholders, with initiatives focussing on general adaptation issues of relevance to all projects or specific technical issues relevant to smaller sub-sets of projects. Work has also continued on further improving communication and dissemination opportunities, particularly with respect to the first suite of research projects as they come to completion.



4 Expanding the network: infrastructure projects

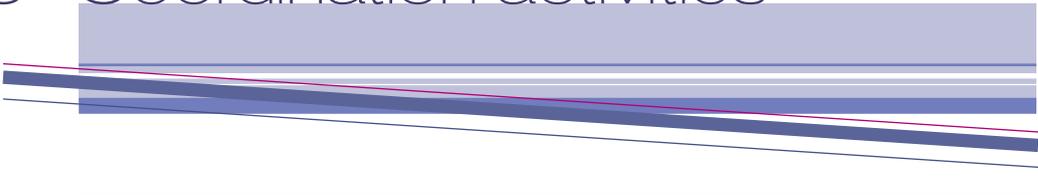


Recognising the need to provide decision-makers with further evidence on climate change adaptation within the UK infrastructure sector, the EPSRC funded four new research projects in 2011:

- The 5-year Infrastructure Transitions Research Consortium (ITRC) project started in January 2011 and is funded by a platform grant from the EPSRC with additional support from universities, industry and government departments. The aim is to develop and demonstrate a new generation of system simulation models and tools to inform the future design of national infrastructure, including water, energy, waste, transport and information technology systems.
- Building on recommendations developed by the network in 2010 on research gaps and priority requirements for information on adaptation in the UK energy sector, the EPSRC sought proposals from multidisciplinary consortia concerned with the adaptation and resilience of energy generation and transmission systems in the context of climate variability and change. Three projects were subsequently funded by the EPSRC within the Research Councils UK Energy (RCUK) programme and the LWEC Infrastructure Challenge. Research started in autumn 2011 for:
 - » Resilient Electricity Networks for Great Britain (RESNET)
 - » Adaptation and Resilience in Energy Systems (ARIES)
 - » Adaptation and Resilience of Coastal Energy Supply (ARCoES)

The challenge this past year has been to integrate these new projects into the ARCC CN. Following an initial meeting of project representatives in summer 2011, a first meeting of researchers has been scheduled for February 2012 to develop a shared understanding of the individual project work programmes, to identify where links and synergies can be established and promoted and to initiate discussions on possible coordinated stakeholder and knowledge exchange activities.

5 Coordination activities



Experience gained in previous years has highlighted the importance of effective on-going coordination and communication both between researchers and between researchers and a range of stakeholders and other end-users. Engagement through networks such as the ARCC CN helps ensure researchers are fully aware of end-user requirements and can develop their research accordingly, and that stakeholders are well informed and therefore better able to contribute to the research and benefit from the outcomes.

Whilst all projects have their own stakeholder advisory groups, the ARCC CN seeks to enhance wider researcher – stakeholder interaction. During 2011, this involved a range of activities from organising an open conference to highlight adaptation issues across the built environment aimed at a general audience and smaller, dedicated cross-project themed meetings seeking to address specific end-user requirements.

5a. ARCC CN conference: Adapting our Built Environment - ARCC Contributions and Challenges

This major ARCC CN conference (6–7 April 2011, Oxford) provided a first opportunity to highlight outputs from across the portfolio of research projects and to discuss policy implications. Open to everyone with an interest in adaptation in buildings and infrastructure, over 140 participants including stakeholders, decision-makers, researchers and international colleagues took the opportunity to explore the ARCC CN research completed, underway and outstanding.

Presentations and posters from all the network projects were grouped to provide overviews of specific cross-sector themes including the urban heat island and overheating, building design for a low carbon future, working at the community level and with vulnerable populations, water management and related extreme events, and infrastructure and large-scale networks. Projects were encouraged to work with key stakeholders to highlight potential uses for the research and these joint researcher - stakeholder presentations successfully emphasised the implications of the research from an end-user perspective.

Informal feedback highlighted the value of such broad-based information-sharing and networking opportunities.

To accompany the conference, and to provide a single reference document available to all, a brochure was produced (Adaptation and Resilience to a Changing Climate, Research Update, 2011; www.ukcip-arcc.org.uk/images/stories/pdfs/ACN_conference_brochure.pdf) aimed at informing end-users of progress to date across the ARCC CN and providing links and contact details for further information.

5b. Cross-project themed activities

(i) Climate change, risk and resilience: lessons for health and social care

Climate change presents significant challenges for human health and well-being but little attention has been given to the impact of climate change on the delivery of health and social care and how the risks associated with adapting to climate change are managed. This theme was explored during a symposium (21 October 2011, London) organised as a joint venture between the ARCC CN, the Social Care Institute for Excellence and two ARCC CN projects: BIOPICCC and DeDeRHECC. Taking the central theme of risk, its impact and meaning for service provision, and the care of people in vulnerable circumstances, over 50 invited experts from health, social care, planning, security, transport and the insurance industry explored responses to risk in general and to climate change in particular. A report of the meeting and key messages are available on the BIOPICCC website (www.dur.ac.uk/geography/research/researchprojects/biopiccc/)

(ii) Evidence for policy: overheating in cities and neighbourhoods

One issue facing policy makers and other end-users is the need to assess evidence from various academic sources particularly when the research seems to provide conflicting messages. To help ensure that coherent advice on overheating in cities and neighbourhoods is emerging from across the network, a meeting was convened to help identify, explore and resolve potential inconsistencies to better understand the advice and information being made available to end-users. This meeting (6 October 2011, London) involved both central policy makers (Defra, DCLG, GLA) and relevant ARCC CN projects (SNACC, ARCADIA, LUCID, SCORCHIO, COPSE, CREW) and a summary report is available: (www.ukcip-arcc.org.uk/content/view/596/9/). Discussions also spanned the implications of the Green Deal, input to the London Adaptation Strategy and revision of the building regulations and results are now being used to inform on-going DCLG consultancy work.

(iii) Support to the Chartered Institution of Building Services Engineers (CIBSE)

The ARCC CN has worked closely with CIBSE to provide information and research outputs to inform the development of guidance and resources to assist the building services industry in addressing climate change adaptation. Knowledge and expertise from the network has been used to:

- support the provision of hourly weather data and associated advice to inform building thermal and energy performance assessments through the CIBSE Climate Task Force;
- contribute to the steering group responsible for the revision of CIBSE Guide A on environmental design aiming to incorporate best practice advice on climate change adaptation into core industry activities; and
- support joint events to contribute to and present the latest in industry practices and research.

(iv) Meeting with the Scottish Government climate change adaptation team

Building on their involvement at the ARCC CN Conference in April 2011, the climate change adaptation team within the Scottish Government expressed an interest in hearing more about network projects of particular relevance to Scotland. A meeting with representatives from ten projects with links to Scotland was held (24 June 2011, Edinburgh) to raise awareness and to provide updates on research progress and outputs thereby assisting policy leads in expanding their understanding of the evidence available and likely future developments.

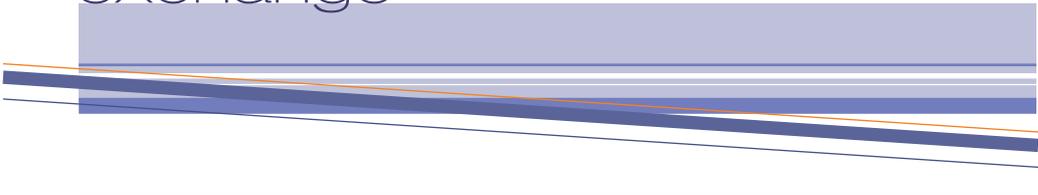
5c. Future research priorities

To help identify future short- and long-term research priorities, the ARCC CN has been undertaking a process to map knowledge gaps and further research opportunities within and beyond the current portfolio of research projects. By defining existing and emerging knowledge gaps and challenges based on policy and practice perspectives, research priorities can be identified and further investment targeted to build on and expand the current programme to meet EPSRC and LWEC strategic objectives.

As a first step in this process, the 2011 ARCC CN conference included a facilitated discussion on future research and research delivery priorities, taking account of the need to address the balance between information required to address policy issues and research required to enhance the evidence base. Focussed presentations at the conference by EPSRC, DCLG, Defra and UKCIP highlighted key areas of interest from their perspective and participants were then asked to consider the specific priority research gaps, policy or practice questions that should be addressed, and how the research-policy and research-practice links could be strengthened. Information was sought across the range of current challenges, possible solutions and perceived opportunities and barriers.

The responses are being merged with outcomes from discussions at other ARCC CN meetings and knowledge of current policy processes to highlight where further targeted research can help inform the decision-making process.

6 Effective knowledge exchange



Effective and timely knowledge exchange across the portfolio of ARCC CN projects is necessary to better engage both the broad research community and the full range of potential end-users. This is necessary at all stages of a project and strengthens the interaction among network participants. The overall aim, as outlined in the ARCC CN communication and dissemination Strategy (updated September 2011) is to enhance the impact of the research by improving the visibility, awareness and understanding of the research, and by promoting the usefulness of the outputs to the widest possible audience.

The ARCC CN strategy remains flexible to be able to benefit from additional communication and dissemination opportunities as they arise and to take account of lessons learnt both within the ARCC CN and from other programmes and networks as appropriate.

Recognising that projects are responsible for their own individual pathways to impacts, the ARCC CN strategy focuses on two complementary strands which build on existing achievements of individual research groups in publishing and promoting their results:

- Facilitating the promotion of outputs from individual ARCC CN projects to a wider audience than would otherwise have been possible;
- Working across projects to assimilate information that addresses specific themes or policy areas of relevance to stakeholders with the intention of further informing targeted end-users and practitioners.

6a. Publications

1. ARCC CN website and newsletters

A key outward-facing focus for all ARCC CN activities, the website provides an up-to-date summary of activities within the network aimed at both other researchers and the end-user community (www.ukcip-arcc.org.uk/). Links to project websites and other relevant external sites are included for further information.

Three ARCC CN newsletters have been issued in 2011 (March, July and December) to an increasing list of over 450 national and international recipients including researchers, project stakeholders, other end-users, funding agencies and decision-makers (www.ukcip-arcc.org.uk/content/view/600/542/). These newsletters update readers on research progress within the ARCC CN portfolio, promote forthcoming network events and include news from related programmes.

As requested, contributions are also made to newsletters from other organisations such as LWEC, Adaptation Scotland and CIBSE both to inform different audiences of progress within the ARCC CN and to highlight future events of interest to all.

ii. BSER&T journal special issue

To inform their technical audience of professional engineers, CIBSE and the ARCC CN worked together to explore possible dissemination options. The outcome was a special issue of the Building Services Engineering Research & Technology (BSER&T) journal on the adaptation of buildings and services to climate change based on the UKCP09 climate projections and focussing exclusively on ARCC CN outputs. With a growing international impact and 20,000 registered CIBSE members, a journal issue on this subject has significant impact with key engineers and technologists responsible for the design of buildings and heating, ventilation and air-conditioning services within the urban environment both in the UK and beyond. Six papers from DeDeRHECC, DOWNPIPE, COPSE (2 papers), Low Carbon Futures and PROCLIMATION were published in January 2012 together with a synthesis paper from the ARCC CN evaluating the potential methodologies for using UKCP09 projections to produce weather files for building simulations, as investigated by four ARCC CN projects.

Reference: Building Services Engineering Research and Technology, February 2012; 33 (1) Special Issue. Adaptation and resilience to a changing climate: Supporting adaptation decision-making. Abstracts available at: <http://bse.sagepub.com/content/current>

iii. UKCIP Climate Digest

The UKCIP Climate Digest is a monthly compilation of climate change research from academic literature covering the science of climate change, impacts, adaptation and decision-making across a broad range of sectors and regions. It is available on the UKCIP website and is publicised through the UKCIP e-newsletter which is sent electronically to over 8000 recipients. To broaden the reach of ARCC CN outputs, the April 2011 Digest focused exclusively on scientific papers from the LUCID, PROMETHEUS and PROCLIMATION projects covering issues such as the implications of London's urban heat island and exploring the understanding and perceived need for adaptation in the building industry.

Scientific papers from several other network projects have been included in Climate Digests throughout the year.

6b. Access to data and outputs

The aim is to maintain the ARCC CN website as a central depository of research outputs from across the network including, importantly, for a realistic period of time after completion of an individual project. Given that many of the current projects have their own websites, there is a need to balance and coordinate efforts by ARCC CN and the individual projects in this respect.

Work continues to make interim and final research outputs more accessible to end-users. Efforts during 2011 have concentrated on helping the earlier projects which have now finished but which did not have the dedicated 'pathways to impacts' embedded in their work plans: PROCLIMATION, PROMETHEUS, LUCID and SCORCHIO. To capture key messages, final summary reports have been written by the ARCC CN in discussion with the researchers. These two-page documents are available on the network website and summarise the research aims and achievements, give links for further scientific information and include contributions from project 'so-what?' documents which provide a stakeholder view of the value of the research and potential applications.

6c. Working with LWEC

As an EPSRC-funded LWEC-accredited activity, the ARCC CN works closely with the LWEC partnership at all levels from invited participation in LWEC Business Advisory Board meetings through to maintaining up-to-date information and links on the LWEC website. A key area during 2011 has been participation in the on-going development of the LWEC/NERC/RELU principles, guidelines and resources bank and tool kit for knowledge exchange practitioners and champions, through attendance at workshops in July and December.

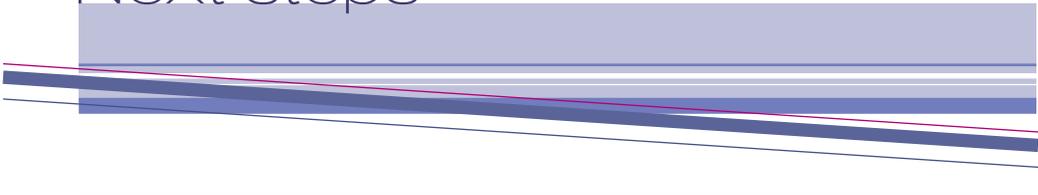
6d. Establishing international links

To promote the ARCC CN to an international audience and to help initiate links with other European networks, a poster was presented during the Adaptation Strategies session at the European Meteorological Society conference (September 2011, Berlin). The poster focussed on lessons learnt from cooperative efforts by the ARCC CN to enhance the value of research to inform adaptation planning and policy and identified both achievements and challenges.

As a direct result of contacts made at the conference, summaries of all the network projects have now been added to the Climate Adaptation Infobase. This searchable database of national climate change adaptation projects is maintained by CIRCLE-2, a European network of 34 institutions from 23 countries committed to fund research and share knowledge on climate adaptation and the promotion of long-term cooperation among national and regional climate change programmes. Inclusion in the database will enhance the reach of the UK-based ARCC CN research within a wider European audience.

Discussions have also been initiated with several international networks to promote wider links and coordination to help ensure the development of sustainable future systems based on the best available national and international evidence. In particular, links have been established with the US NSF Resilient and Sustainable Infrastructure (RESIN) programme which supports cross-disciplinary research to improve understanding and innovation for resilient and sustainable civil infrastructure and distributed infrastructure networks. The National Science Foundation (NSF) has indicated its potential support for collaborative work and funded the participation of RESIN's Dr John McGrath at the ARCC CN 2011 mid-term conference both as a keynote speaker and to initiate discussions.

7 Next steps



Building on existing achievements, the ARCC CN will continue to liaise with all projects to enhance the overall coordination and knowledge exchange processes within the network. Flexibility within the outline programme allows the ARCC CN to respond to requests for additional activities from both projects and stakeholders as the need for further evidence on climate change adaptation in the built environment and infrastructure sectors develops.

7a. Final project dissemination activities

CREW finished towards the end 2011 and seven more projects will come to completion in 2012: ARCADIA, ARCC-Water, BIOPICCC, DeDeRHECC, DOWNPIPE, Low Carbon Futures and SNACC. Individual meetings will be held with each project to discuss final dissemination issues, key messages etc. based on the ARCC CN communication and dissemination strategy. Specific activities include working with the CREW team to help finalise outputs from their last national assembly, with the ARCC-Water project to help plan and facilitate their forthcoming stakeholder engagement workshops and with the BIOPICCC project to continue their feedback events with local authorities to enhance the value of their prototype project toolkit.

A major 1 or 2 day conference is tentatively scheduled for early September 2012 to present final outcomes from these projects. This will be an open conference aimed at a broad audience of local and national decision-makers, researchers and other end-users.

7b. Dissemination of cross-sectoral issues

To enable the enhanced dissemination of cross-sectoral, cross-project issues of particular relevance to local and national decision-makers, the ARCC CN was successful in securing additional funds from the EPSRC Pathways to Impact Award to Oxford University (£9874 for January–June 2012). This funding will be used to appoint a senior science communications specialist to help respond to emerging end-user requests for evidence that addresses specific policy and practice questions in particular at the local level given recent changes in the political landscape and the emerging localism agenda. Initial work will focus on two areas: overheating and extreme events, and will also provide a framework to guide the development of future topics.

Transferring lessons learnt

As the ARCC CN is now established and projects have gained valuable experience in the climate change adaptation arena, work will start to identify and capture transferable messages on processes and methodologies used by projects which are of interest to the wider climate change community and to sectors beyond the built environment. Lessons that will be explored include approaches to communicating complex climate science and uncertainty, approaches to understanding vulnerability and methods for making the case for adaptation.

International links

Further progress will be made in developing links with the US NSF RESIN programme, the EU CIRCLE-2 project and others as appropriate. Early contact has been made with the Australian National Climate Change Adaptation Research Facility (NCCARF) with the aim of forging links with their adaptation research network on settlements and infrastructure, and with OURANOS, a Canadian consortium focussing on climate sciences, impacts and adaptation.

Future research activities

Recently, the EPSRC announced that it will be evaluating the ARCC CN during 2012 with the aim of understanding the extent to which EPSRC investments achieve their aims, to obtain information about scientific achievements and highlights and to generate evidence-based input to the overall EPSRC/LWEC planning process. The ARCC CN will work with the EPSRC to facilitate this evaluation and to learn from its findings. Further development of the existing work programme and any future projects will be guided by recommendations from this evaluation.

Now that the network has become established, there is an opportunity to build on existing expertise to broaden the value and reach of the network and to further integrate and focus research efforts to respond to emerging policy questions. Taking into account requirements from business and government and building on recent ARCC CN events to scope research priorities and evidence gaps, UKCIP will work with stakeholders and researchers to identify innovative and creative methods to provide the highest-quality scientific evidence to meet these needs.

With respect to coordination activities, the contract with UKCIP (to July 2013) was established to provide a discrete work programme taking into account the fact that the majority of projects finished by end 2012 with subsequent time allowed for final dissemination and forward-looking activities. More recently, policy requirements have driven the establishment of new projects with work programmes extending out to 2016 and the rolling programme of coordination and dissemination activities has evolved accordingly. UKCIP will work with the EPSRC to explore mechanisms to expand current coordination and knowledge exchange activities to include, for example, specialist science communication expertise and the development of specific delivery mechanisms to meet the requirements of the localism agenda and the government aim of co-production and co-delivery.

8 Project management

The ARCC CN is overseen by a project management advisory group consisting of the Principal Investigator (Richard Washington, University of Oxford) and two co-managers (Roger Street and Chris West, UKCIP) with responsibility to monitor and evaluate progress relative to contract milestones and objectives and to oversee plans for the future work programme.

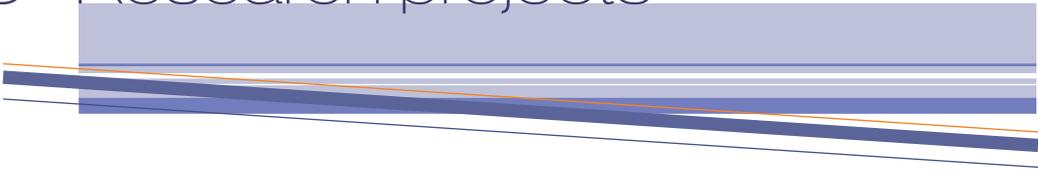
At the annual project management advisory group meeting, the future location of the ARCC CN coordination unit was discussed which, since its inception in 2009, has been based at UKCIP as part of the University of Oxford's Environmental Change Institute (ECI). This relationship has proven beneficial in developing and promoting synergies between the ARCC CN activities focussed specifically on aspects of adaptation to climate change within the UK built environment and its infrastructure and the wider adaptation landscape considered by UKCIP. The Environment Agency (EA) has now taken over responsibility for delivering Defra's work on adaptation and some UKCIP activities are being transferred to the EA. However, UKCIP is continuing to build on its strong reputation as a leader in understanding adaptation processes and the ARCC CN will remain at UKCIP within the ECI as a key focus for coordinating and sharing information on adaptation within the UK built environment.

Overall, expenditure is tracking the profile anticipated in the work programme with sufficient funds available to support planned activities through 2012 and 2013. On-going negotiations with EPSRC may provide further funding to broaden activities particularly on responding to the localism agenda through specialist science communication and on securing the legacy of outputs from across the network.

Financial statement, 31 December 2011:

Expenditure category	Budget	Expenditure	Available
Staff costs	£178,579	£108,019	£70,560
Travel & subsistence	£99,969	£16,572	£83,397
Consumables, conference, publications	£106,383	£47,549	£58,834
Overheads	£149,373	£66,730	£82,643
RPLJ0 Award Total	£534,304	£238,870	£295,434

9 Research projects



Summaries of recent progress for each research project are given below together with links to individual project websites where applicable. Further information can also be found on the ARCC CN website (www.ukcip-arcc.org.uk).

The ARCC CN is now an established network of researchers and stakeholders with active participation from 18 multi-disciplinary research teams based in various departments within 35 academic institutions. Over 200 researchers are involved together with a similar number of directly-involved stakeholders representing a wide range of central and local government, business and industry organisations. Beyond this is a much broader audience of end-users interested in high-quality scientific evidence on climate change resilience and adaptation issues in the built environment and infrastructure sectors.

During 2011, over 37 presentations were given by ARCC CN researchers to specialist and non-specialist audiences and 35 scientific papers were published in peer-reviewed journals. Significant contributions have been made to major national policy reports, in particular the Climate Change Risk Assessment and the London Adaptation Strategy. Further engagement of key end-users in specific sectors, e.g. in the health and social care sector and the energy sector, has also advanced significantly. At the sub-national level, and in a timely manner given the emerging localism agenda, several projects are working closely with specific local authorities, city councils and neighbourhood groups to test and refine their research outputs before considering implications on a wider scale.

On capacity building, an expanding pool of skilled researchers capable of engaging effectively with end-users is gaining expertise that can be applied in the future and across disciplines. Building on this, at least 20 PhD students are being trained through the network with positive implications for the quality and validity of future research projects. Importantly, stakeholders are also gaining experience of working with the research community to help meet on-going requirements for evidence and of incorporating this into their own policies and practices.

On-going projects

Adaptation and Resilience in Cities: Analysis and Decision-making using Integrated Assessment (ARCADIA)

Jim Hall, Newcastle University (now at Oxford University)

July 2009–August 2012

Aim: To provide system-scale understanding of the inter-relationships between climate impacts, the urban economy, land use, transport and the built environment and to use this understanding to design cities that are more resilient and adaptable.

The ARCADIA project is progressing well and on schedule. As the project enters its final 6 months it is at a pivotal stage as the various components of the framework are being completed and are brought together in the overarching methodological framework. Outputs to date include:

- An analysis of governance of climate change adaptation in London.
- A series of elicitation with stakeholders on use of climate models in adaptation decision-making.
- Gap analysis of London Adaptation Strategy.
- Qualitative systems analysis of urban function, climate impacts and adaptation.
- Analysis of regional climate models results providing new insights into regional climate change in London from urbanisation and energy use.
- Assessing probabilistic climate projections for London.
- Development of a spatial urban weather generator which can provide time-series of fields of weather variables at a 5 km and 1 hour resolution.
- Initial development of methodology for dynamic spatial simulation of cities, climate impacts and adaptation.

Stakeholder steering groups are held twice a year and newsletters are circulated to provide interim updates. As the project methodology comes together in the final year there will be more opportunity for engagement with a wider stakeholder group.

Water System Resilience (ARCC-Water)

Mark New, University of Oxford

September 2009–October 2012

www.arcc-water.org.uk/

Aim: To develop an integrated ‘whole system’ approach to water resource planning in SE England under multiple uncertainties, in which portfolios of infrastructure and demand management options are considered to maintain secure supplies and enhance the environment.

Through 2011, the ARCC-Water project has been mainly focussed on developing the Regional Water Resources Systems model (RWSM), organising and rolling out the water demands survey and holding briefings with stakeholders. The RWSM has been designed using IRAS-2010, a new open source software built by UCL, to represent the South-East of the UK. This work is now near completion and the first set of runs representing the current and planned future system will be conducted in early 2012. Spatially coherent future climate scenarios have also been generated to drive hydrological and groundwater models for input into the RWSM.

Lancaster University and Essex University have been working with BMG Research to construct the 'water demand' survey at the beginning of 2011. The survey was piloted and BMG launched the full field collection period in June. The data collection was completed in September 2011, with survey results expected to be released in the Spring of 2012. Planning for the future water demand scenario workshops is underway, and they will be held in early 2012. ARCC-Water's sister project, the ESRC-funded Sustainable Practices Research Group (SPRG) 'Patterns of Water' project, is now live.

Throughout 2011, we have visited many of our key stakeholders in a set of project briefings. The aim of the 2-hour sessions was to discuss the ARCC-Water approach to (i) using the UK Climate Impacts Programme's UKCP09 probabilistic climate projections (ii) regional surface/groundwater modelling and (iii) regional water resources systems modelling. Members of the research team are also currently contributing to and editing a special issue of Water Resources Management on Adaptation and Resilience of Water Systems to an Uncertain Climate.

Adaptation and Resilience of Coastal Energy Supply (ARCoES).

Andy Plater, University of Liverpool
November 2011–October 2016

Aim: To evaluate the implications of climate change impacts for coastal energy production and distribution, with a focus on the NW region and to identify the practical steps necessary to achieve effective adaptation and to enhance resilience to climate change for (i) the nuclear sector and (ii) coastal energy supply in the NW region.

With commencement of the project in November 2011, the main progress to year end has been in the appointment of the Integrated Framework post-doctoral research assistant and the storm survey studentship at Plymouth. Stakeholder engagement has been developed with EDF Energy and CEFAS with the main focus being on data gathering and obtaining permissions to access sites. This has also led to engagement with Sellafield Sites and the Nuclear Decommissioning Authority. Work on the coastal modelling has commenced and tests are being undertaken on the FV-COM modelling platform: comparing model runs with those of POLCOMS to assess computational efficiency and accuracy. Development of the mobile storm survey facility at Plymouth by currently testing the different instruments and exploring the capacity for installing X-band RADAR.

Adaptation and Resilience in Energy Systems (ARIES)

Gareth Harrison, University of Edinburgh
September 2011–February 2015

Aim: To deliver a comprehensive risk framework for assessing and managing UK energy system resilience to climate change. In pursuit of this aim, the following objectives have been defined to develop an effective risk management framework for decision makers:

- To model physical and economic impacts of climate changes on current and new generation technologies;
- To capture the climate-driven changes in gas and electricity demand in domestic and non-domestic buildings and their response to changes in building design, behaviour and micro-generation;
- To examine future regional and national balance of supply and demand for gas and electricity, its implications for a resilient energy system, and interaction with other infrastructure sectors;

- To define and appraise potential energy system adaptation, articulate the implications of these changes to decision-makers, and to inform the 2012 and later UK Climate Change Risk Assessments;
- To deliver the above through an enhanced set of future energy systems and climate scenarios with new modelling that preserves the spatial and temporal coherence that defines national energy resilience;

ARIES started formally in September 2011 and is in its inception phase. The original objectives have been confirmed as being appropriate and the project has proceeded to recruit one of four research staff and a PhD student. Project partners presented at an ARCC CN event for the Scottish Government as well as conducting initial meetings with key stakeholders.

Built Infrastructure for Older People In Conditions of Climate Change (BIOPICCC)

Sarah Curtis, Durham University
November 2009–October 2012

www.dur.ac.uk/geography/research/researchprojects/biopiccc/

Aim: To develop a methodology for selecting locally sensitive, efficient adaptation strategies during the period up to 2050 to ensure that the infrastructures and health and social care systems supporting older people will be sufficiently resilient to withstand harmful impacts of climate change.

During 2010, we had conducted modelling work drawing on the UKCP09 weather generator to identify variations across England in projected risk in the 2030s of heatwave and coldwave events (defined in ways relevant to care of older people). We also mapped local flooding projections for the 2050s using Foresight 2004 Flood and Coastal Defence Project (Environment Agency). These were mapped against the projected distribution of older people in local authorities by the 2030s and the results have been published. Based on this mapping exercise and after consideration of a number of additional local factors, relevant for this project, we identified two English local authorities (LAs) as case studies where, during 2011 we carried out a series of local consultations and enquiries in these two areas. The LAs are located in southern and northern England in semi-rural areas (thus complementing some of the other ARCC CN projects based in major urban centres). These included strategic level consultations with a range of partners responsible for, or representing key parts of the health and social care system for older people and the built infrastructures that support them. The consultation process scoped the key aspects of built infrastructure, facilitated by development of toolkits which we developed for this project. Through the strategic level consultations we identified smaller localities where it seemed especially important to focus on adaptation of infrastructure for older people's care and risks of extreme weather events. Here we have been carrying out local discussion groups and interviews with older people, their carers and local service providers to draw a rich picture of the important aspects of the infrastructure system. Findings from these local consultations have been reported at an international conference and will be submitted for publication. Technical details relating to local infrastructure systems in these localities have also been collated. We have also begun modelling of the infrastructure interdependencies and the hazard loadings on different parts of key infrastructures in order to identify different design and management solutions to make these systems more resilient to extreme weather related events.

Coincident Probabilistic climate change weather data for a Sustainable built Environment (COPSE)

Geoffrey Levermore, University of Manchester
July 2008–June 2011

www.copse.manchester.ac.uk/index.htm

Aim: To develop a methodology for deriving weather data for building designers etc. that is based on future data rather than observational records from the last 20 years or so.

This research finished in 2011. A final report will be available soon.

Community Resilience to Extreme Weather (CREW)

Steve Hallett, Cranfield University
February 2008–November 2011

www.extreme-weather-impacts.net/twiki/bin/view

Aim: To gain a better understanding of the effects of extreme weather events and to develop a set of tools for improving the resilience of local communities.

This research finished in 2011. A final report will be available soon.

Design and Delivery of Robust Hospital Environments in a Changing Climate (DeDeRHECC)

Alan Short, University of Cambridge
September 2009–October 2012

www-edc.eng.cam.ac.uk/robusthospitals/

Aim: To investigate the design and delivery of economical and practical strategies for the adaptation of the NHS Retained Estate to increase its resilience to climate change whilst meeting the challenging carbon reduction goals and performance requirements of the NHS.

Data collection in representative spaces in type buildings on the four partner NHS Trust sites took place throughout the year, generating rich datasets of current internal conditions. The data for the Addenbrooke's Ward Tower (a classic 'matchbox on a muffin' type of 1972) and the Bradford Royal Infirmary Nightingale Wards (the quintessential pre-1948 form of hospital) and the Rosie Maternity Hospital have been analysed. The future performance of all three has been predicted. Refurbishment options for the Addenbrooke's tower and Nightingale wards have been devised and tested, and have been accepted for publication in Building and Environment and BSERT respectively. Papers examining the Rosie Hospital and the internal reconfiguration of Nightingale wards are in progress. The Engineering Design Centre and Open University teams continue to refine their models, including much work on an agent-based model of the Rosie Hospital. The OU and Architecture teams have investigated recent refurbishment projects in Leicester and Watford. Sessions for the project film, a key output for stakeholder impact, have taken place throughout the year, capturing interviews with staff at Leicester, Bradford, the NHS Sustainable Design Unit, PFI contractors, and Paul Morrell, the Government's Chief Construction Advisor.

The research has demonstrated that, for the Addenbrooke's Tower and Bradford Nightingale wards, resilient refurbishment strategies can be devised that deliver safe environments and reduced energy use to 2080. These strategies use the physical 'stuff' of the building; they are not created by tacking on 'green' devices. In other

words, the buildings need not be made redundant in a changing climate: relatively minor interventions, indeed, can ensure that they will perform well in the medium term. The team is now testing this hypothesis on the other case studies. The team has demonstrated the value of an adaptive comfort model, which may well be more appropriate than the fixed thresholds of the existing guidance. Examination of recent refurbishments on partner Trust sites reveals a wholly understandable concern with patient safety, and the quality of the patient and staff experience, but relatively little if anything about the future climates in which buildings may have to operate or real measures to save energy. A risk-averse sector and its procurement mechanisms tend to treat the Department of Health guidance as immutable, but derogations are possible and may be desirable in some settings.

The use of probabilistic climate scenarios in decision-making for adaptation of building and property drainage (DOWNPIPE)

Lynne Jack, Heriot-Watt University
October 2008–September 2011

Aim: To realise potential benefits to property drainage design and adaption by using probabilistic data from UKCP09. The location and extent of any under-capacity will be identified and adaptation solutions proposed, thus impacting positively on the mitigation of flood risk.

This project finishes in early 2012. A final report will be available shortly.

Future Resilient Transport Networks (FUTURENET)

Chris Baker, University of Birmingham
June 2009–February 2013

www.arcc-futurenet.org

Aim: To determine the nature of the UK transport system in 2050 both in terms of its physical characteristics and its usage, and to assess resilience to climate change.

FUTURENET is just over half way through the research period and progress to date has been excellent. A key element of the project is bringing together the social and engineering aspects of future transport systems in assessing resilience and progress has been made in both of these areas in 2011. The second Social Network Analysis workshop and a Future Scenarios workshop have helped develop interactions between transport stakeholders, engineers and sociologists. A major travel behaviour survey has been undertaken in order to understand the response of the way long-distance travellers react to transport network performance modifications (on the London – Glasgow transport corridor) due to weather-related uncertainty. An overarching engineering model of the transport system has been developed and the various sub-models are in development. Significant progress has been made on the analysis of journey delays along the route corridor as well as physical asset modelling of the various infrastructures. A major challenge remains the description of ‘resilience’ for the many different types of stakeholder and various scales involved in a national network, e.g. the journey delay of individual users against the overall network capacity. This is an area of current activity and the current models include both ‘operational’ service assessment (e.g. individual delays) and ‘ultimate’ service assessments (e.g. network failure).

Although it is still early in the project a significant number of noteworthy developments have been made and reported at conferences. The analysis of the travel behaviour survey and associated social behaviour findings has generated particular interest both nationally and internationally and this is reflected in the publications list. Within the engineering modelling the analysis of delay data from historical events has

yielded important information about the propagation and recovery profiles of delays through the complex interconnected systems of road and rail as well as the nature of the trigger weather events. This work has led to interactions with EU FP7 projects EVENT and EU-WEATHER and the co-creation of 3 new EU proposals for joint research combining event and economic impact analysis as well as proposals for improving inter-modal support in times of disruption.

UK Infrastructure Transitions Research Consortium (ITRC)

Jim Hall, University of Oxford
January 2011–December 2015

www.itrc.org.uk/

Aim: To develop and demonstrate a new generation of system simulation models and tools to inform analysis, planning and design of national infrastructure (energy, water, waste and information and communication technologies systems).

By December 2011 the first major output from the project, a Fast Track Analysis (FTA) of strategies for infrastructure provision in Great Britain, was complete. The FTA was the first co-production cycle with stakeholders and scopes possible futures for infrastructure, the drivers for change and the sources of uncertainty through:

- development of a new conceptual framework for long term strategic analysis of national infrastructure systems
- provision of a cross-sectoral overview of UK infrastructure sectors (energy, transport, water, waste, ICT), future prospects, risks and opportunities
- a review of governance (policy, regulatory, funding) arrangements and future challenges for national infrastructure provision
- identification of high level drivers of change within the UK's infrastructure systems, including the demands of a changing population, economic growth and increasing energy costs
- presentation of preliminary results from analysis of future infrastructure demand
- presentation of cross-sectoral strategies for national infrastructure provision and preliminary assessment of these strategies.

Aside from the FTA, progress was also made on all of the four remaining parallel workstreams. Good progress was made in development of an integrated modelling framework under workstream 1. Scenario generation progress was hindered by WS5 FTA resource requirements, however this activity is now benefitting from insights gained from the FTA process. Demographic projections provided by Leeds University researchers were used in the FTA report and further work is underway to develop household-level simulations and associated projection model. Cambridge Econometrics provided economic projections for use in the FTA and further work is underway to translate DECC 2050 pathways analysis figures into modelling inputs. Work also got underway to study the empirical relationship between infrastructure and economic growth. Workstream 2, which is studying the future risks of infrastructure failure, kicked off with a workshop in November 2011 with the involvement of researchers from other ARCC projects FUTURENET and RESNET, and a planned approach was agreed including a "first pass" looking solely at flooding hazards that is planned for completion by June 2012. Scoping began for workstream 3, which will study the management of infrastructure as a complex adaptive system. Workstream 4 has progressed well in development of enabling tools including preliminary configuration of a spatial database comprising 160+ spatial data layers with representation of all major infrastructure networks and both administrative and population geodemographic zones.

Work also commenced to develop initial exemplar input and output enabling tools for use by project co-investigators and ultimately project partners.

Decision support for building adaptation in a low-carbon climate change future (LCF)

Phil Banfill, Heriot-Watt University
December 2008–May 2012

Aim: To produce a general, deterministic and computationally efficient methodology for adequately sizing Low Carbon Future heating, ventilating, and air-conditioning plant and equipment in buildings.

In line with the objective of producing a decision support tool for building designers, work has continued on several fronts. In-depth interviews were carried out with building professionals including building services engineers, architects, facilities managers, and housing association and local authority directors in order to tailor user-focussed design outcomes. Based on the analysis of the feedback obtained, an additional simpler form of probabilistic output has been developed. This is to ensure that the risks of overheating in buildings are easily communicated to a client or non-technical personnel. Results of this work were communicated through several journal and conference papers in 2011. The group is also contributing to Chapter 2 of CIBSE Guide A, using the above findings to suggest methods of incorporating probabilistic climate change into building design.

A robust regression methodology, the LCFTool, has been developed in R (a user friendly software environment for statistical computing and graphics). To assess performance of a given building type the proposed LCFTool can easily simulate building performance over thousands of climates and generates outputs in the form of simple probabilistic plots and csv files. During development, different versions of the regression model were thoroughly analysed to accommodate a wide range of design conditions and to incorporate the influence of important building related input variables, in particular 'Internal Heat Gain' and 'Air Change', in conjunction with hourly climate information. The key feature of the tool is that it performs Principal Component Analysis to simplify hourly probabilistic climate information. The LCFTool has also been used successfully to assess the effect of heatwaves.

In order to show the relationship between climate information and building simulation output, a number of building templates have been used to demonstrate the LCFTool. Two domestic buildings and two non-domestic buildings have been simulated in depth, with several versions of each building assessed (to allow for multiple adaptation scenarios). The different versions of each building have allowed a rigorous test of the developed regression involving 2000 building simulations using ESPr and IES dynamic building software. Therefore, across all buildings and climate scenarios, the number of simulations runs into the tens of thousands. For each simulation, the hourly internal temperatures and (if relevant) cooling loads have been assessed and used to calibrate the tool.

At this stage in the project we are confident of producing by the end of the project a validated methodology which could be incorporated into a user-friendly decision support tool.

Resilient Electricity Networks for Great Britain (RESNET)

Kevin Anderson, University of Manchester
September 2011–August 2015

Aim: To develop and demonstrate a comprehensive approach to analyse, at a national scale, climate-related changes in the reliability of the UK's electricity system, and to develop tools for quantifying the value of adaptations that would enhance its resilience.

The RESNET Project commenced on 1 September 2011. A project kick-off meeting was held in Manchester on the 19 October 2011 and was attended by members of the Manchester and Newcastle teams. Discussions took place regarding the various work packages and project deliverables and work scheduling. Work on developing scenarios is now underway with delivery of the first scenarios expected in autumn 2012.

A meeting with National Grid, a key stakeholder, took place on 13th December 2011. Discussions took place regarding the possible overlaps between work being undertaken by the National Grid and the RESNET project. A follow up meeting is scheduled to take place in March 2012.

Suburban Neighbourhood Adaptation for a Changing Climate (SNACC)

Katie Williams, University of the West of England
September 2009–August 2012

www.snacc-research.org

Aim: To answer the question: how can existing suburban neighbourhoods be best adapted to reduce further impacts of climate change and withstand ongoing changes?

Climate change scenarios for the case study cities (Oxford, Bristol and Stockport) have been developed as have socio-cultural and governance scenarios for suburban adaptation and a typology of 6 types of UK suburb: Inner historic suburb; pre-war garden suburb; interwar period suburb; social housing suburb; car suburb; and medium-high density suburb. A master list of over 60 climate change adaptation (and mitigation) measures for use in suburbs has been produced at the home, garden and neighbourhood scales. Case studies have been selected in the three cities to represent the 6 types of suburb. Baseline data has been collected to inform the modelling. Household surveys have been undertaken in each suburb in Bristol and Oxford and the physical conditions have been surveyed for the visualisations. The Bristol case study is complete, Oxford is ongoing, and Stockport will be done by May 2012.

The modelling found that overheating in homes is strongly attributed to built form, home age and glazing characteristics, e.g. a mid-terraced home is more likely to overheat before a detached home with similar characteristics and occupant profiles. In addition, the location of insulation has an impact on overheating hours. In terms of adaptation, shading glazing is by far the most effective adaptation option although increasing the albedo for both roof and walls was also found to be effective. Because higher insulation standards will still be necessary for reducing heating demand in the future, the added risk of overheating as a result must be balanced with other adaptation options. Ultimately, adaptation packages are being tested that include higher insulation standards to both simultaneously consider mitigation and adaptation and to project the impact of policy measures such as the Green Deal on future comfort conditions.

Adaptations that perform well technically are now being tested with residents and other stakeholders. Early findings are that in inner historic suburbs people are most likely to implement roof insulation, triple or double glazing, wall greenery, solar

film or inter-pane glazing, rainwater harvesting systems, trickle vents, drought resistant planting. They are far less likely to implement external shading, green roofs, flood skirting, flood gates or doors, or waterproof window seals. On the whole, residents are far more positive about neighbourhood scale adaptations than changes to their homes. The reasons people gave for not implementing various adaptation measures include: high costs, inconvenience, practicality in relation to their home, lack of authority to make the change, lack of knowledge of options, negative perception of options, suggestion of behavioural alternatives, lack of responsibility for risk and lack of perception of risk.

Completed projects

The Development of a Local Urban Climate Model and its Application to the Intelligent Development of Cities (LUCID)

Michael Davies, University College London
June 2007–December 2010

www.lucid-project.org.uk/

Aim: To develop, test and apply state-of-the-art methods for calculating local climate in the urban environment. The impact on the internal built environment, energy use and the consequences for health will then be explored and the implications for urban planning considered. A final summary report is available at: www.ukcip-arcc.org.uk/images/stories/Summaries/LUCID-summary-final.pdf

The use of probabilistic climate scenarios in building environmental performance simulation (PROCLIMATION)

Vic Hanby, De Montfort University
October 2008–September 2010

Aim: To develop and implement methodologies for using probabilistic climate scenarios (UKCP09) in building simulation and other related analytical procedures. Final summary report available at: www.ukcip-arcc.org.uk/images/stories/Summaries/PROCLIMATION-summary-final.pdf

The use of probabilistic climate data to future proof design decisions in the buildings sector (PROMETHEUS)

David Coley, University of Exeter
July 2008–December 2010

emps.exeter.ac.uk/research/energy-environment/cee/projects/prometheus/

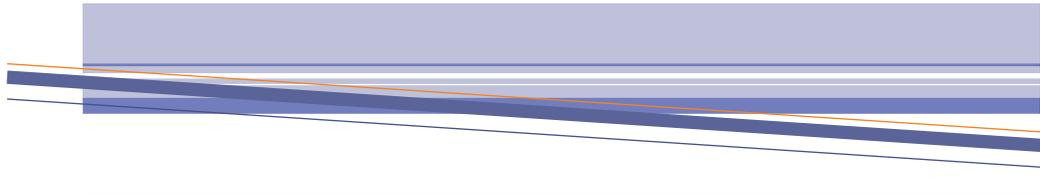
Aim: To develop a new set of probabilistic reference years that can be understood and used by building designers. A final summary report is available at: www.ukcip-arcc.org.uk/images/stories/Summaries/PROMETHEUS-summary-final.pdf

Sustainable Cities: Options for Responding to Climate Change Impacts and Outcomes (SCORCHIO)

Geoffrey Levermore, University of Manchester
March 2007–September 2010

www.sed.manchester.ac.uk/research/cure/research/scorchio/background/

Aim: To develop tools for analysis of adaptation options in urban areas, with a particular emphasis on heat and human comfort in the built environment. A final summary report is available at: www.ukcip-arcc.org.uk/images/stories/Summaries/SCORCHIO-summary-final.pdf



The Adaptation and Resilience in a Changing Climate (ARCC) Coordination Network brings together a range of research projects funded by the Engineering and Physical Sciences Research Council (EPSRC). These look at the impacts of climate change and possible adaptation options in the built environment and its infrastructure including water resources, transport systems, telecommunications, energy and waste. The overall programme contributes to the Living with Environmental Change (LWEC) Infrastructure Challenge which aims to make infrastructure, the built environment and transport systems resilient to environmental change, less carbon intensive and more socially acceptable.

UKCIP provides the management and support role for the network which aims to enhance the cooperative development of the programme and help promote benefits to all participants.

www.ukcip-arcc.org.uk