UK Water-Energy Nexus Workshop 2015

24th & 25th September




UK Water-Energy Nexus under climate change:

Key issues and priorities for modelling and research

LR4, Department of Engineering, Cambridge University

About the Whole Systems Energy Modelling Consortium (wholeSEM)

The whole systems energy modelling consortium (wholeSEM) is a ground breaking, multi-institution initiative to develop, integrate and apply state-of-the-art energy models.
Our aim is to employ extensive integration mechanisms to link and apply interdisciplinary models to key energy policy problems, with substantive bilateral engagement with stakeholders in academia, government and industry. Funded by EPSRC, the consortium is led by University College London and consists of Imperial College London, the University of Cambridge and the University of Surrey.

Energy models provide essential quantitative insights into the 21st Century challenges of decarbonisation, energy security, energy equity, and cost-effectiveness. Models provide the integrating language and framework that assists energy policy makers – focusing at different scales and time periods – to make improved decisions and trade-offs in conditions of pervasive uncertainty. Whole systems energy modelling also has a central role in helping energy supply companies to make technical and economic decisions with regard to future energy technologies and infrastructure, as well as in the assessment of the potential role of societal and behavioural change.

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Engineering and Physical Sciences
Research Council

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EPSRC is the main UK government agency for funding research and training in engineering and the physical sciences, investing more than £800 million a year in a broad range of subjects - from mathematics to materials science, and from information technology to structural engineering.

Abstract

The UK's transition to a highly decarbonised energy regime that is in consonance with GHG emission reduction targets would require significant changes to the energy system. In turn, this will change demand for natural resource use for energy provision - in particular water. In parallel, the impact of climate uncertainties on water resources, coupled with potential future increased demand for water by other sectors of the UK economy may result in water scarcity in some regions of the UK. Meeting the water demand for all sectors of the economy under these circumstances could result in significant changes in the water industry including trans-regional bulk water transfers and building of more desalination plants, which are both energy and GHG intensive. However, within the water industry, energy use remains the highest operational cost, thus a further increase in energy intensity of water provision would be an additional burden.

In addition to these coupling between the water and energy systems, opportunities also exist for innovative approaches to recovering energy from water, aside from conventional hydropower. These include scaling up of anaerobic digestion from wastewater treatment, water-based heat-pumps and thermal heat recovery from wastewater – all of which could be harnessed to augment other low-carbon energy systems.

Addressing the above issues and harnessing the opportunities associated with water and energy interactions require concerted collaborative effort from all stakeholders in the water and energy industry. Such efforts must, however, focus on an integrated, multidisciplinary approach to addressing and framing policies on water and energy systems that reflect the interdependencies and the potential consequential challenges of future risks, and uncertainties, as well as opportunities. The aim of this workshop therefore, is to provide a platform for identifying and discussing pathways to building resilience into integrated energy-water systems in the UK, as well as to explore opportunities in harnessing low-carbon energy from water systems. This will be accomplished under three main objectives;

- Identify the main issues associated with the "Geography of water" in the UK and assess the tendencies of potential competition for scarce resources under future stress;
- Identify the critical interdependencies of water and energy, technological efficiencies and low-carbon futures for the water and energy industry;
- Explore the innovative opportunities/technologies in harnessing energy from water systems.

The outcome of the workshop will be a report based on presentations and discussions at the meeting. A particular focus of the report will be to provide advice to the developers of whole system energy models on the interactions between energy pathways and the water system.

Thursday 24th September 2015

Chair: Professor Keith Richards

9:30 – 10:00 Registration and Coffee

10:10 – 10:40 Introduction of wholeSEM— *Professor Neil Strachan, Professor Julian Allwood*

Session 1: Geography of water (10:20 – 12:40)

10:20 – 10:40 Climate Change effect on water services: *Sarah Mukherjee, UK Water*

10:40 – 11:00 Abstraction licensing and regulation: *Andrew Mason, Environment Agency*

11:00 Coffee break

11:20 – 11:40 Extreme weather events and its impact on water services: *Professor Chris Kilsby, Newcastle University*

11:40 – 12.00 UKCIP futures and risk to business: *Roger Street, UKCIP*

12.00 – 12:40 Discussion – Facilitator (Professor Keith Richards)

12:40 – 14:00 Lunch

Session 2: Water for energy (13:40 - 17:00)

14:00 – 14:20 Environmental flows and power generation: Andrew Mason: Environment Agency

14:20 – 14:40 Uncertainty in Future Water Demand of UK Thermal Power Plant : *Ugo Gasparino: RWE Generation UK*

14:40 – 15:00 UK shale gas – water resource demands and impacts: *Professor Rob Ward, BGS*

15:00 Coffee break

15:20 – 15:40 Urban energy and water systems interactions: *Simon De Stercke, Imperial College*

15:40 – 16:00 Risks and opportunities related to the water energy nexus: *Prof Simon Spooner, Atkins Global*

16:00 – 16:40 Discussion – Facilitator (Professor Keith Richards)

16:40 – 17:00 Chair's summary: next steps

1900 -2200 Dinner at Trinity Hall, Cambridge

Friday 25th September 2015

Chair: Dr Dick Fenner

Session 3: Keynote session (09:00-10:30)

09:00 – 09:10 Introduction: Dr Dick Fenner

09:10 – 09:40 Professor Jim Hall, ECI, Oxford University and ITRC

National infrastructure systems of systems: energy, water and other interdependencies

09:40 – 10:10 Professor David Butler, Exeter University and EPSRC Fellow

Recent advances in water, energy & GHG research

10:10 – 10:30 Discussion

10:30 - 11:00 Coffee

Session 4: Energy for water (11:00-13:00)

11:00 – 11:20 Energy for Water - Some observations from the North of England: *Michael Osborne, Arup*

11:20 – 11:40 Energy usage of desalination: *Dr Philip Davies, Aston University*

11:40 – 12:00 GHG emissions from the water industry: *Adrian Johnson, MWH Global*

12:00 – 12:20 Carbon reduction in the water industry: *David Riley, Anglian Water*

12:20 – 12.40 Energy and water resource efficiency: *Dr Keith Colquhoun, Thames Water (TBC)*

12:40 – 13:00 Discussion - Facilitator (Dr Dennis Konadu)

13:00-14:00 Lunch

Session 5: Energy from water (14:00-15:50)

14:00 – 14:20 Energy recovery from anaerobic digestion: *Dr Raffaella Villa, Cranfield University*

14:20 – 14:40 Thermal heat recovery from wastewater: *Dr Dick Fenner, Cambridge University*

14.40 – 15:10 Capturing energy locally from water distribution: *Susan Pridy, Lucid Energy, Portland USA (via Skype)*

15.10 – 15:40 Discussion – Facilitator (Dr Zenaida Sobral Mourao)

15:40 – 15:50 Closing remarks (Professor Julian Allwood / Professor Neil Strachan)

Session 1

Climate Change effect on water services, *Sarah Mukherjee, UK Water*

Good water management is about balance - the balance between too much water and too little, between water for health and water for farming and the environment, between the water we use and the water we re-use. But climate change, population growth and the other many demands on our limited resources are making that balance difficult to achieve. How do we ensure that there's enough water for everyone, whilst making sure that this precious and finite resource is affordable?

Flood risk and water infrastructure, Professor Chris Kilsby, Newcastle University

The analysis of flood risk to infrastructure demands attention to several issues which can dominate the problem. This talk will address these issues by considering simulation approaches to their analysis using examples from current research projects including the EPSRC ITRC and Blue Green Cities projects and the EU RAMSES programme. They include: the spatial dependence of rainfall and flood extremes for large scale (e.g. national) infrastructure network risk, the topographic drivers of urban flood risk, the role of the stormwater (sewer) network itself and the perennial issue of climate change.

Abstraction licensing and regulation, *Andrew Mason, Environment Agency*

The current licensing system for the abstraction and impoundment of water was introduced in the mid-1960s to protect the environment and the rights of abstractors and other water users. The system has evolved over time but is still follows the same basic principles. Subject to exemptions, most abstraction and impoundment activities require a licence from the Environment Agency. The Environment Agency must follow a prescribed process to make a decision on a licence application, which may involve public consultation. Typically, the Environment Agency needs to take into account: the environment impact; the reasonable needs of the applicant and socio-economic considerations. Applicants have a right appeal if they do not agree with the Environment Agency's decision on their application. There are currently around 20000 licences in force. Around one-quarter of these are time limited and will have to be re-assessed as they come up for renewal. The Environment Agency is currently taking action to resolve unsustainable levels of abstraction. The government is planning to reform the abstraction licensing system in the early to mid-2020s.

Session 1

UKCIP futures and risk to business, ***Roger Street, UKCIP***

Geographic dimensions of water are characteristics of our natural and human landscapes and changes we are and are projected to experience, including as a result of our changing and variable climate, will affect that geography. As such, these changes have implications for the risks and opportunities society and business experience and thereby the measures that they will put in place. This presentation will explore these projected changes in the geography of water. In doing so the intention is to also explore that knowledge and evidence relative to that needed to support effective decision-making under change. This includes identifying the challenges associated with consideration of the adaptation planning process – risks in an interdependent world, identifying potential responses, and assessing the risk and opportunities associated with those options and their implementation.

Session 2

Environmental flows and power generation, ***Andrew Mason, Environment Agency***

Defining the environmental flow requirements for rivers is an essential part of managing water resources and identifying abstraction and flow pressures on the environment. The United Kingdom Technical Advisory Group (UKTAG) on flows advises the UK administrations on technical matters relating to the implementation of the Water Framework Directive. Accordingly, UKTAG has produced flow standards on the environmental flow requirements for rivers. These standards are implemented by the Environment Agency through the 'Environmental Flow Indicator' (EFI). The Environment Agency uses EFI to work out how much water is available for abstraction. Information about water availability is published in the Environment Agency's Abstraction Licensing Strategies. EFI has also been used as a starting point to investigate existing abstraction and flow issues with a view to taking action on these through the River Basin Planning process.

Uncertainty in Future Water Demand of UK Thermal Power Plant, ***Ugo Gasparino, RWE Generation UK***

As a backdrop to development of various strands of environmental regulation and policy, and in particular water resource allocation reform, Defra and the Environment Agency have been working with a number of Sectors to forecast their future water demand. To inform and support its participation in this work programme, a model was developed by the Joint Environmental Programme (JEP, a programme of research into the environmental impacts of electricity generation funded by nine of the leading producers in the UK) to estimate the uncertainty and 'central case' development of future water 'gross usage' (water intake, mainly for cooling purposes) and 'consumption' (difference between the water intake and water discharge) by thermal Power Stations, under DECC 2050 pathways. The model shows that, due to the variability of the water gross use and consumption rates associated with different cooling technologies and uncertainty in timing of closure, opening and placement of thermal Power Stations, the future water requirements by the Power Sector can only be assessed with very substantial uncertainties. These should be taken into account in a wide range of water policy contexts including the design, performance and robustness of reformed regimes.

UK shale gas – water resource demands and impacts, ***Professor Rob Ward, BGS***

The UK may possess considerable reserves of shale gas but as yet there has been very little exploratory drilling. The areas likely to be exploited are overlain by aquifers used for drinking water supply. The risks to groundwater and the wider water environment must therefore be taken seriously. There are a number of potential pollutants including those used in the drilling operations, the hydraulic fracturing (fracking) fluids, the constituents of shale gas and the produced (formation) water. Pathways to the environment include spillages and leaks at the surface, natural geological features, induced fracturing widening/interconnecting natural fractures and well integrity failure. Multiple pathways may be created and interact. A further pressure on the water environment is the industry's demand for water to enable drilling and hydraulic fracturing. A Strategic Environmental Assessment undertaken by DECC suggests a total water demand per year of up to 144 million m^3 based on their high development scenario (2880 wells). This is a very optimistic development scenario and a more realistic situation might be 100 wells being drilled per year. This would require around 2.5 million m^3. This represents only 0.02% of overall current licenced freshwater abstraction in England and Wales (0.5% if the water is sourced from groundwater alone). The challenge isn't significant at the national scale but as the water will need to be sourced locally this is where the pressures will arise. This will particular be the case in areas of the South East of England where water resource availability is already exceeded.

Session 2

UK shale gas – water resource demands and impacts, *Professor Rob Ward, BGS*

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Urban energy and water systems interactions, *Simon De Stercke, Imperial College*

Cities are centres of human capital and economic activity, in which energy, food and water consumption are highly concentrated. Those systems are linked to each other in a myriad of ways and at all stages: in design, operation, maintenance, end-use, etc. With increasing urbanization worldwide, cities play a critical role in the water-energy nexus. Research in the framework of the Urban Energy Systems project at Imperial College London led to an energy optimization model for urban development, which has been expanded to include more resources such as water. Current research aims at improving understanding of the socio-economic and physical system in its complexity and in relation to its environment. It uses a system dynamics approach to map the interactions, including decision-making in its social and economic context. Various feedback loops between and within the water and energy systems, both reinforcing and balancing, are identified, with different intensities and time scales. Demand is modelled endogenously, and the importance of end-use in the system is reflected in the model.

Session 4

Energy for Water – Some observations from the North of England on Energy, Water and Resilience, ***Michael Osborne, Arup***

The Northern Powerhouse is a growing concept that is underpinned by improved transport infrastructure which is essential for modern efficient economies. Energy and water are abundant in the north and also have a role to play in the Northern Powerhouse. Our drive for resilience in water supply and the application of new treatment technology has created a water sector that is power hungry. The water grid is more resilient but perhaps more dependent than ever before on the power grid - which perhaps makes it less resilient.

Energy usage of desalination, ***Dr Philip Davies, Aston University***

Desalination plants produce 80 m^3/day of freshwater and this global capacity could double in the next 7 years resulting in additional 45 Mt/yr of CO_2 emissions. Most new plants use electrically-powered reverse osmosis (RO) technology which is replacing thermal technologies. The specific energy consumption (SEC) of desalination is subject to a lower limit of about 1 kWh/m^3 (the exact value depends on the salinity of the seawater, recovery ratio etc). In comparison, the SEC of modern RO desalination is somewhat greater at 2-4 kWh/m^3. A main cause of this difference is the high pressure needed to drive water through the RO membranes. Theoretically 26 bar would be enough but in practice at least twice this pressure is used. To avoid this energy wastage, membranes having both high permeability and good selectivity would be required. The SEC also depends on the configuration of the desalination plant. Advances across several areas are resulting in gradual reduction of SEC so that 2 kWh/m^3 is now possible, as shown the case studies presented. Desalination could also provide benefits when incorporated in energy-water systems; for example, the magnesium ions in desalination reject brine could be used to absorb CO_2.

GHG emissions from the water industry, ***Adrian Johnson, MWH***

The water industry in England and Wales has been required to provide information on its emissions of greenhouse gases (GHG) since 2005, prompted in part by Ofwat's duty to contribute to the achievement of sustainable development. Since 2005 the water industry, through its research agency UKWIR, has progressively developed an approach to reporting operational GHG emissions consistent with Defra's guidance. The industry has also developed an approach for assessing the GHG emissions arising from Investment in new or improved assets as an aid to decision-making. These approaches have variously been used by water companies to help manage and reduce their emissions.

This presentation will start by outlining this journey, including a 'whole life' approach for forecasting the emissions arising from capital investment. With the aid of some examples, the presentation will go on to illustrate how this practical approach to assessment is being used in support of management strategies as well as initiatives to develop and apply low carbon approaches to service delivery. Significant progress has been made but it is recognised that there remain various issues, such as: forecasting emissions vs. actual emissions; relative vs. absolute measurement; materiality vs. accuracy; emissions from on-site construction vs. emissions from the manufacture of mechanical and electrical equipment; GHG emissions performance vs. cost and other performance measures. Addressing these issues in ways that are both practical and credible is fundamental to ongoing efforts by water companies to achieve reductions in their GHG emissions.

Carbon reduction in the water industry, ***David Riley, Anglian Water***

Energy and water resource efficiency, ***Dr Keith Colquhoun, Thames Water***

Session 5

Benefits of adding exogenous CO2 into ADs as a means to increase energy recovery from waste
Dr Yadira Bajón Fernández, Cranfield University

Thermal heat recovery from wastewater, ***Dr Dick Fenner, Cambridge University***

Options for recovering thermal energy from wastewater will be reviewed, including within buildings, from the sewer network and at wastewater treatment plants. Examples of current research in Europe will be reviewed and the results from a study examining the feasibility of thermal heat recovery at four sewage treatment plants in Southern England will be presented. Issues that will be raised include how the environmental conditions in receiving waters can influence the allowable temperature reduction in effluents, and opportunities for utilising the heat recovered will be discussed.

Capturing energy locally from water distribution, ***Susan Pridy, Lucid Energy, Portland USA (via Skype)***

Participants

Name		Affiliation
Charles	Ainger (Prof)	CSD, Cambridge University
Julian	Allwood (Prof)	University of Cambridge
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