

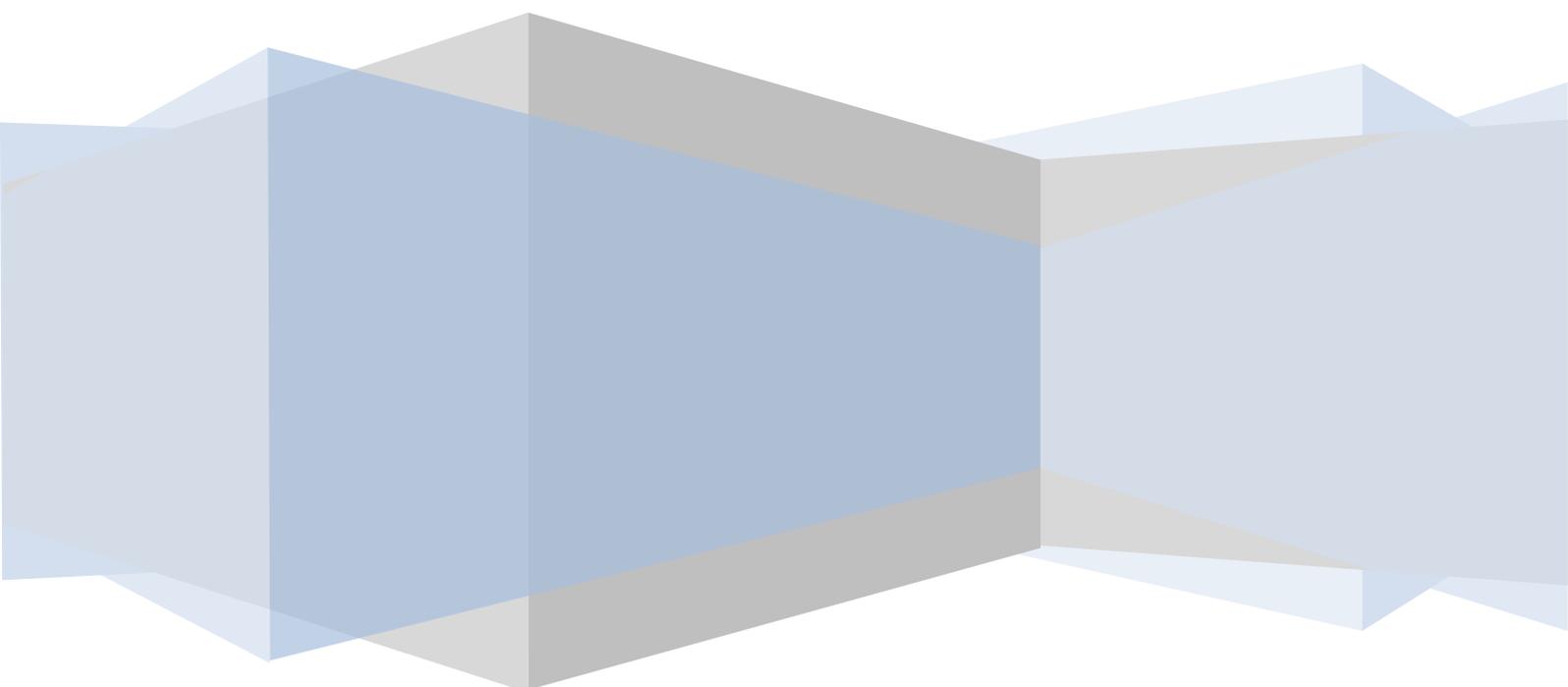
Rustat Conferences - Jesus College Cambridge

Infrastructure & the Future of Society

Energy, Cities and Water

Proceedings of the third
Rustat Conference
Jesus College, Cambridge
10 June 2010

Dr Ruchi Choudhary
Lecturer in Engineering
University of Cambridge



For more information please contact:

Rustat Conferences
Jesus College
Cambridge
CB5 8BL

Tel 01223 328316
info@rustat.org
www.rustat.org

Infrastructure and the Future of Society Energy, Cities & Water

Rustat Conference - Jesus College, Cambridge
10 June, 2010



Roundtable discussion at the Rustat Conference



Rustat Conference registration in the Prioress's Room, Jesus College, Cambridge

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Infrastructure and the Future of Society

Managing Energy, Water and the Cities of the Future The Scientific, Social and Economic Challenges

Jesus College, Cambridge - Thursday, 10 June, 2010



Jesus College
Cambridge

Session 1 **10.00-11.00**

What are the Critical Infrastructure Challenges Facing Society over the Next Half-Century?

Robert Mair CBE FREng FRS Master, Jesus College

Professor of Geotechnical Engineering and Head of Civil & Environmental Engineering, Cambridge University

Lord Watson of Richmond CBE - Chair

High Steward of Cambridge University, Chairman of the Cambridge Foundation, and Chairman, CTN Communications

Break - Tea and Coffee **11.00-11.20**

Session 2 **11.20-12.20**

Infrastructure for Energy Security – Nuclear, Low Carbon, and Renewables

Chris Hope - Chair

Judge Business School, Cambridge University, Lead Author of Third Assessment Report of the Intergovernmental Panel on Climate Change, Advisor to HM Treasury and DEFRA

Julian Allwood - **Infrastructure for a Low Carbon Future Economy**

Senior Lecturer in Engineering, Cambridge University, Fellow of Gonville & Caius College, Cambridge

William J. Nuttall - **Is Nuclear Power Inevitable?**

Senior Lecturer, Technology Policy, Judge Business School and Engineering Department, Cambridge University

Lunch - Master's Lodge and Gardens **12.20-1.30**

Session 3 **1.30 - 2.30**

Infrastructure for Cities and the Built Environment of the Future

Ian Liddell CBE FREng - Chair

Royal Academy Visiting Professor of Engineering Design, Cambridge University, and founding partner Buro Happold

Marcial Echenique OBE

Professor of Land Use and Transport Studies, Department of Architecture, Cambridge University

Randall Thomas

RAE Visiting Professor in Building Physics, Cambridge University, and Professor of Sustainable Environmental Design at Kingston University

Session 4 **2.30 - 3.30**

Financing the Infrastructure of the Future

Nick Butler - Chair

Chairman, Cambridge Centre for Energy Studies, Fellow, Judge Business School, Faculty Member, World Economic Forum

James Stewart

CEO, Infrastructure UK

James Wardlaw

Goldman Sachs, and Adviser to the Homes and Communities Agency

Break - Tea and Coffee **3.30-3.45**

Session 5 **3.45-4.45**

Infrastructure for the Secure Supply of Water

Peter Guthrie OBE FREng - Chair

Professor of Engineering for Sustainable Development, Cambridge University

Dr Jean Venables OBE FREng FICE

Chairman, Crane Environmental Ltd

Michael Norton MBE - **The Challenges of Achieving Global Water Security**

Managing Director, Water and Power, The Halcrow Group



Rustat Conferences Jesus College, Cambridge

The Rustat Conferences are an initiative of Jesus College, Cambridge, chaired by Professor Robert Mair CBE FREng FRS, Master of Jesus College, and directed by John Cornwell. The Rustat Conferences provide an opportunity for decision-makers from the frontlines of politics, the civil service, business, the professions, the media, and education to exchange views on the vital issues of the day with leading academics. They were founded in 2009 and the first two conferences covered *The Economic Crisis* and *The Future of Democracy*. This third Rustat Conference took as its theme *Infrastructure and the Future of Society: Energy, Cities and Water*, allowing us to discuss and debate this vital issue while drawing on Cambridge University's excellence in engineering, architecture, energy studies and sustainability.

The Rustat Conferences format is a round-table discussion: expert speakers set the framework for each session by a brief exposition of points followed by a moderated discussion among all invited participants. The meetings are limited to around fifty participants.

Previous participants include: Lord Eatwell, *Professor of Financial Policy, Cambridge University*; Sir Terry Leahy, *CEO, Tesco*; Lord Turnbull, *former Cabinet Secretary and Head of UK Civil Service*; Dr John Jenkins, *HM Ambassador to Iraq*; Sir Samuel Brittan, *Financial Times*; Sally Keeble MP, *Treasury Select Committee*; Baroness O'Neill, *former President, British Academy*; Dominic Casserley, *Managing Partner, McKinsey & Co. UK & EMEA*; Simon Hayes, *Chief Economist, Barclays Capital*; Chris Saul, *Senior Partner, Slaughter and May*; David Strachan, *Director, Financial Stability, FSA*; Peter Horrocks, *Director of BBC World Service*; Lord Wilson, *former Cabinet Secretary and Master, Emmanuel College, Cambridge*; John Harley, *Head of Private Equity, Ernst & Young*; Will Hutton, *The Work Foundation*; Tony Wright MP; John Naughton, *Professor of Public Understand of Technology, OU*; Peter Kellner, *President, YouGov*; Matthew Taylor, *CEO, RSA, former Chief Adviser on Strategy to the Prime Minister*; Sam Younger, *former Chair, The Electoral Commission*; Patricia Hewitt MP; Robert Chote, *Director of Institute for Fiscal Studies*; Adrian Frost, *Fund Manager, Artemis*; Martin Clarke, *Partner, Permira*.

In addition to acting as a forum for the exchange of views on a range of major and global concerns, the Rustat Conferences provide outreach to a wider professional, academic and student audience through the publication of reports in a variety of media – ebook, video and audio. See www.rustat.org for more information. The conferences are held at Jesus College, Cambridge, one of the colleges of the University of Cambridge, and are named after Tobias Rustat (d.1694), an important benefactor of Jesus College and the University. Tobias Rustat is best remembered for creating the first fund for the purchase of books for the Cambridge University Library.

Acknowledgements

This third Rustat Conference on *Infrastructure and the Future of Society* was a success thanks to the advice, encouragement and assistance of a number of people. The Master of Jesus College, Professor Robert Mair, and Professor Peter Guthrie generously helped to identify the key topics for discussion as well as the main speakers, moderators and respondents, to whom we are also most grateful. We would like to thank all the speakers and chairs, especially Jesus College Honorary Fellow and chair of the opening session, Lord Watson of Richmond CBE. A list of the speakers and participants appears on the next three pages, with more detailed participant profiles in the Appendix.

Rustat Conferences are round-table events and so rely for their success on the active participation of all those who attend and add value to the discussion. The conference was chaired by the Master of Jesus College, Professor Robert Mair, whom with Margaret Mair, kindly hosted the conference lunch in the Master's Lodge at Jesus College. The role of conference rapporteur was generously taken on by Dr Ruchi Choudhary, University Lecturer in Engineering at Cambridge. Her expert handling of the subject matter allows the critical ideas and round-table discussions to be communicated very clearly in this report. Jonathan Cornwell co-produced the conference and published this report. Dr Tudor Jenkins of Wide Eyed Vision continues to maintain a photographic record of the events for the Rustat Conferences website. I also thank Richard Dennis, Development Director and Alison White, Development Office, Jesus College, Cambridge for their time and assistance. Finally, I would like to thank the Master and Fellows of Jesus College for their continued support and participation.

John Cornwell
Director
Rustat Conferences
Jesus College
Cambridge

Infrastructure and the Future of Society

Managing Energy, Water and the Cities of the Future

Jesus College, Cambridge - Thursday, 10 June, 2010

Conference Participants

Robert Mair CBE FREng FRS - *Master, Jesus College, Professor of Geotechnical Engineering and Head of Civil & Environmental Engineering, University of Cambridge*

Peter Guthrie OBE FREng - *Professor of Engineering for Sustainable Development, University of Cambridge*

Ray O'Rourke - *Chairman and Chief Executive, Laing O'Rourke Group*

Paul Skinner - *Chairman, Infrastructure UK, former Chairman, Rio Tinto*

Lord Watson of Richmond CBE - *High Steward of Cambridge University, Chairman of the Cambridge Foundation, and Chairman CTN Communications*

Lord Macdonald of Tradeston CBE PC - *Adviser, Macquarie Capital Europe, former Minister for Transport and Minister for the Cabinet Office*

Gordon Edge - *Director of Policy, Renewable UK*

Peter Bishop - *Group Director, Design, Development and Environment and Deputy CEO, London Development Agency*

Chris Hope - *Judge Business School, Cambridge University, Lead Author of Third Assessment Report of the Intergovernmental Panel on Climate Change, Advisor to HM Treasury and DEFRA*

Alistair Buchanan - *Chief Executive, Ofgem - Office of Gas and Electricity Markets*

Sean Hanafin - *Managing Director, Power and Energy, Citibank*

Warren Pimm - *Director, Sustainable Development Capital LLC*

Paul Westbury - *Managing Director Europe, Buro Happold*

Andrew Comer - *Director of Environment and Infrastructure, Buro Happold*

Miles Parker - *Director of Science, DEFRA, and Deputy Chief Scientific Adviser*

James Wardlaw - *Goldman Sachs, and Adviser to the Homes and Communities Agency*

Colin Harris - *Deputy Chairman, Infrastructure, Arup*

Ian Liddell CBE FREng - *Royal Academy Visiting Professor of Engineering Design, Cambridge University, founding partner and consultant, Buro Happold*

Alan Sutherland - *Chief Executive, Water Industry Commission, Scotland*

Michael Norton MBE - *Managing Director, Water and Power, The Halcrow Group*

Dr Jean Venables OBE FREng FICE - *Chairman, Crane Environmental Ltd*

Nick Chism - *Partner and Head of Global Infrastructure, KPMG*

Philid Guildford - *Director of Research, Engineering Department, Cambridge University*

James Stewart - *Chief Executive, Infrastructure UK (HM Treasury)*

Nick Butler - *Chairman, Cambridge Centre for Energy Studies, Faculty Member, World Economic Forum*

Ruchi Choudhary – *Lecturer in Engineering, University of Cambridge and Rustat Conference Rapporteur*

Julian Allwood - *Senior Lecturer in Engineering, Cambridge University, Fellow Gonville & Caius College, Cambridge*

William J. Nuttall - *Senior Lecturer, Technology Policy, Judge Business School & Engineering Dept, Cambridge University*

Marcial Echenique OBE - *Professor of Land Use and Transport Studies, Cambridge University*

Wendy Pullan – *Senior Lecturer, History and Philosophy of Architecture, Cambridge University*

Randall Thomas - *RAE Visiting Professor in Building Physics, Cambridge University, and Professor of Sustainable Environmental Design at Kingston University*

Ying Jin - *Cambridge University Lecturer in Architecture, Coordinating Committee, Energy Efficient Cities Initiative*

Nick Ray - *Fellow in Architecture, Jesus College, Cambridge*

Shailaja Fennell - *Lecturer in Development Studies, Cambridge University, Fellow, Jesus College*

John Cornwell - *Director, Science & Human Dimension Project, Jesus College, Cambridge*

Teri Willey - *Chief Executive, Cambridge Enterprise*

Stuart Shilson - *Partner, McKinsey & Company*

Jon Hutton – *Director, United Nations Environment Programme - World Conservation Monitoring Centre*

Dougal Goodman – *Chief Executive, Foundation for Science and Technology*

Colin Taylor - *Professor of Earthquake Engineering, Bristol University*

Terry Macalister - *Energy Editor, The Guardian*

Hugh Cripps – *Chief Executive, Peterborough Environment City Trust*

John Constable – *Director of Research and Policy, Renewable Energy Foundation*

Tim Appenzeller – *Chief Magazine Editor, Nature*

Ben Piper - *Technical Director, Atkins Environmental and Water Management*

Cam Middleton - *Senior Lecturer in Structural Engineering at Cambridge University*

Portia Walker - *Producer, Al Jazeera*

Richard Owers – *Partner, NRAP Architects*

He Yadong – *Economic Section, Embassy of the People's Republic of China, UK*

Prajakti Kalra – *Cambridge University Central Asia Forum*

Session I: What are the critical infrastructure challenges facing society over the next half century?

Speaker: Robert Mair CBE FREng FRS Master, Jesus College

Professor of Geotechnical Engineering & Head of Civil & Environmental Engineering, Cambridge University

Chair: Lord Watson of Richmond CBE

High Steward, Cambridge University, Chairman, Cambridge Foundation, & Chairman, CTN Communications

Lord Watson opened the session and the conference, commenting that in the context where the UK faces the challenge of recalibrating its economy, this is indeed a timely conference.

Professor Robert Mair set the ground by defining the purpose of infrastructure as that of supporting economic growth and productivity, attracting globally-mobile businesses to the UK, and promoting social well-being. Citing a report on National Infrastructure by the Council for Science and Technology, Professor Mair said that a modern national infrastructure needs to be optimised in terms of cost, low carbon footprint and service quality. It needs to be robust, resilient and adaptable to changing patterns, as well as innovative across all sectors – driven by business in partnership with government. Water, Waste, Transport, Energy, and Communications were highlighted as the five significant sectors of infrastructures.

Professor Mair presented the audience with the critical infrastructure challenges facing society. Investments in infrastructure are fragmented, or in other words, without an overall vision or national strategy – both in terms of delivery and governance. With increased social and economic pressures, a lot of the infrastructure is nearing maximum capacity or ageing, especially in the energy, transport, and water sectors. The last investment peak in UK infrastructure was in 1965. Water was emphasized as one of the prime examples of UK's ageing infrastructure (burst water mains, floods, etc.). Furthermore, there is greater complexity and interconnectivity between different infrastructure sectors, leading to cascading effects of failure. We have to remember that infrastructure is a network of networks. Resilience against systemic failures is significantly weakening.

Climate change will require radical changes to infrastructure in the coming years. Low carbon solutions are urgently needed to meet the 80% target for reducing greenhouse gas emissions by 2050. Infrastructure also has to be future-proofed against extreme natural events such as droughts, heat-waves, rising sea levels, and flooding.

At the same time, infrastructure needs have been increasing and changing over the years. The social aspects and particularly social inclusion were highlighted – excellent infrastructure underpins advanced society. Pointing to the subtitle of the conference, Professor Mair emphasized the social challenges, asserting that new infrastructure will need to address long term needs, which imply catering to changing demographics.

Predicting future demand of services, future-proofing against disasters, and preventing failures are big engineering challenges and here Professor Mair cited current research on new techniques for real-time detection of infrastructure performance which will revolutionize the infrastructure industry. At the same time, he stressed the need to engage the wider public to address these challenges.

In the discussion that followed Robert Mair's talk, Lord Watson proposed that participants address priorities, fragmentation, and social adaptation of infrastructure.

It was commented that perhaps the engineering profession is backing current trends in its research and questioned whether it will have a long term impact on the future of infrastructure. The fact the old infrastructure is still in use is in fact hopeful. We need to look at a long term timeline to incubate technological advancements effectively. In terms of priorities, the current financial situation is a favourable time to address problems in infrastructure. China has shown that sweeping infrastructure changes in developing countries are do-able. We can think of the example as globally applicable. In terms of priorities, the question is, who sets them and on what basis? The private sector in Germany tends to think long term because of their close ties with the government and manufacturing base. We have to stop thinking about assets and instead consider long term decisions, with greater trust in government. The role of the government is changing significantly in this context. Businesses are also struggling. We have all the data, but no real method to understand which actions (priorities) will yield greater benefits.

Ben Piper, Technical Director of Atkins Environmental and Water Management, commented that fragmentation is related to balance of risk and time-scale. Would risk be covered by regulators? How do we balance attitude of regulators in strategic decisions of industry? Professor Colin Taylor commented that infrastructure shapes human behaviour, and this fact should help us understand where real priorities should be and how we define the purpose of infrastructure. Lord Watson, quoting Churchill, responded "*First we shape our buildings, then they shape us*"—decisions about society are generally taken politically. Gordon Edge, Director of Policy at Renewable UK mentioned that the UK electricity network is progressive, but new and good ideas often have to deal with regulation problems – such as for implementing smart grids. Paul Westbury, Managing Director of Buro Happold applauded Colin Taylor's call to confront how we want our future society to be as a basis of prioritizing infrastructure changes, and said here is the opportunity to rethink infrastructure, start afresh, and give a resounding response to climate change – which indeed requires a radical change. Climate will define the state of our infrastructure. We need bold and new moves. We need to invest more and worrying about incentivizing investment is a side issue. We need brave new leadership.

Paul Skinner, Chair of Infrastructure UK commented that there is a clear process of engagement by the new government. The two issues of real significance are: energy (supply, but also demand), and how can we make more private capital to flow into infrastructure. About 70% of UK infrastructure is developed by the private sector, and the government's role is mainly regulatory. Lord Watson citing Germany said that no investment in alternative technologies would have been possible without a stable approach given by government subsidies. Paul Skinner agreed that challenges in the Energy sector go well beyond the balance sheets of the private sector. Regulations and policies should be designed to allow private investments with confidence.

Terry Macalister, Energy Editor of the Guardian, agreed with Paul Skinner. He remarked that discussions with government have been circular thus far. Politicians have to take the lead. Referring to the new budget, he said this is a good time to take on big issues and open up about them – especially since the wider public is quite unaware of most. We cannot railroad through large investments unless people are on board. Agreeing with Paul Skinner and Terry Macalister's remarks, Lord Macdonald said that we have to get the arguments across to the new government. Energy security is an important issue. We need to debate on how to regulate and how to get the customers to

pay more. We also need to discuss where the money comes from – should government be investing in the most high-risk projects?

Jean Venables commented that resilience of London infrastructure all boils down to continuous electricity supply. We do need to change the remit of regulators to include climate and accordingly realign the government departments, including the treasury who should clarify how they account/evaluate new projects. We also need a long term strategy from the government that gives confidence to private investments. Prajakti Kalra of the Cambridge Central Asia Forum responded that our governments are short term. Do they have control or leeway to prioritize for 30-40 years? Is there any solution to reconcile short term governments with long term plans? Referring to Professor Mackay's work, she asserted that the right discussions are already out there. We now need to move forward.

On social adaptation there was a degree of optimism within the audience, but many agreed that the public needs to be led into change.



Lord Watson of Richmond (left) and Professor Robert Mair, Master, Jesus College

Session II: Infrastructure for Energy Security – Nuclear, Low Carbon, and Renewables

Chair: Chris Hope

Judge Business School, Cambridge University, Lead Author of Third Assessment Report of the Intergovernmental Panel on Climate Change, Advisor to HM Treasury and DEFRA

Speakers: Julian Allwood - Infrastructure for a Low Carbon Future Economy

Senior Lecturer in Engineering, Cambridge University, Fellow of Gonville & Caius College, Cambridge

William J. Nuttall - Is Nuclear Power Inevitable?

Senior Lecturer, Technology Policy, Judge Business School and Engineering Department, Cambridge University

Chris Hope began the second session by talking about the influence of climate change tax on infrastructure and growth. He asserted that climate change is one of the most critical challenges facing us, with far reaching consequences on food, water, ecosystems, and extreme weather. Referring to the Copenhagen Climate Change Summit 2009, he said that it is now evident that beating global warming will require a radically different model of politics than the one on display in Copenhagen. He then quantified the role of a climate change tax, putting it in the context of UK deficit reduction: according to his estimates, a climate change tax of £75 per tonne of CO₂ would potentially yield revenue of £53 billion in the first year and £50 billion in 2020 (accounting for tax rate increases and emission reduction). Linking the tax tangibly to economic growth, he proposed a breakdown for reinvesting this revenue to reduce deficit, protect poor and elderly from price increases, reduce VAT, and support R&D. There are of course issues that need resolution. For example, is it reasonable to use social cost of CO₂ as a metric; how to extend the tax to include other greenhouse gases; and on what basis would the tax change over time?

Julian Allwood's talk focused on two questions: what is our low carbon future (both from the supply and the demand side), and what infrastructure is required to enable this? Showing a map of how global energy is transformed into energy services to provide basis for change, he addressed three supply options for the future: Carbon Sequestration (CCS), renewables, and curbing demand. He rejected CCS as a valid step forward for reasons that it would cost a fortune and it does not really address the fact that generating excess emissions is a problem. Moreover, any accident (such as leakage) can be potentially dangerous. Citing a recent book by David Mackay's book *Sustainable Energy: without the hot air*, he said that relying on renewables will only work if we reduce UK's energy demand substantially; there are theoretical efficiency limits on energy conversion devices and there is simply not enough land within the UK to cover all our energy needs with renewable technologies. The main questions for curbing demand are: what is the limit of how much less energy we can use, and what are the practical efficiency limits using known technologies? Taking the example of cars – low mass is a priority. We have a practical charge (from the government) to lower 80% of emissions. There is much more room on the demand side than looking for a 'crazy' rescue on supply side. As a vision for 2050, he proposed that we use half the current volumes of fossil fuel, with half current electricity supplied by current technologies.

The next question addressed the implication of halving the UK's use of fossil fuels on infrastructure. For buildings, Julian Allwood argued for passive systems, elimination of all hot water tanks, less lighting, and high efficiency appliances. In the manufacturing industry, he proposed that material

efficiency is the last option before demand constraint. We must also double the life of what we use and not over-consume in the industrial sector; he proposed and suggested improvements in processes. For transport, he re-asserted lightweight cars, and also proposed better distribution systems to increase the efficiency of transport of goods. In conclusion, Allwood asserted that if we want to make a big difference we need to make big changes.



William J. Nuttall (left) and Julian Allwood

The second speaker in this session, William J. Nuttall, addressed nuclear energy's role in the context of UK's energy security. His key point was that the real nuclear renaissance for the UK is not here yet. Showing worldwide nuclear capacity as it currently stands through observations and projections from EIA (US) and IEA, he said that a nuclear renaissance is there, but not very big. Whatever little exists, is driven by energy policies. The path of continuing our current policies is a dangerous one. Nuclear renaissance, as it stands, in the OECD is little more than replacing a low CO₂ energy source with another, or replacing nuclear with nuclear. Energy policies are based on a triangular relationship between economics, security of supply, and environment. Integration of these three aspects is difficult and will always remain difficult; however relative importance of issues facing us changes over time. As it stands, the energy policy triangle is driving the nuclear renaissance, but nevertheless nuclear power is special. The International Energy Agency (IEA) and Sustainable Development Commission (SDC) of UK agree that nuclear power is a low carbon option. Indeed, there is a revived interest in nuclear within the UK – especially in the context of energy security. However, energy security is best assured by those energy systems that make use of a wide diversity of fuel types drawn from a range of different sources via diverse transit routes and open to a diverse set of trading opportunities. Moreover, balance of payment issues associated with nuclear energy is difficult, and he pointed out

several economic risks. He said that the day he hears that Britain is to build seven large new nuclear power plants is the day he knows that cheap British electricity will not return in his lifetime. Other issues covered in Nuttall's talk were as follows: nuclear power is low carbon, but it is not 'renewable'; there are problems of public acceptance, especially over waste management; nuclear power is associated with technocracy and authoritarianism, with the challenges of nuclear weapons proliferation and with radiological terrorism. He concluded that while the challenges of climate change and energy security suggest that there could be benefit in a major global expansion of nuclear power, for now this possibility remained far from inevitable.

Chris Hope, as chair of this session, initiated the discussion by asking whether we can internalize the cost of new infrastructure in the context of a looming budget deficit (with special reference to Nuttall's comments on economic risks associated with increasing nuclear capacity). He said that the key issue is climate change, with projected temperature rises in 2100 as a key metric of impact. He reiterated his proposal for a climate change tax, saying that this can be straightforward to implement. It will be effective, because regardless of efficiency measures adopted by sectors/consumers, we collect tax when gas and electricity are bought because we know that's what creates emissions. Once implemented, business as usual (BAU) will not be viable and consumers will be forced to invest in energy efficiency.



Left to right: Paul Westbury, Nick Chism, and Jean Venables

John Hutton, Director of UN Environment Programme, commented on the issue of energy supply, saying that there is an encouraging growth of biofuels in Europe and this is going to have huge implications on land use in the near future. He said that the biosphere is a very important consideration, but is not discussed sufficiently in engineering circles. We have a global obsession with climate change because of impacts on the ecosystem. The crux of the issue is stability of the biosphere. Responding to Hutton's remark on biofuels, Julian Allwood said that biofuels are a red herring, especially because of their low energy density. In response to comments on the importance of biosphere, he said that demand reduction is the only radical approach as an alternative to unsustainable consumption. Paul Westbury commented that he agreed with Allwood's arguments for the transport sector and domestic scale renewable. He also supported a carbon taxation plan to help change individual behaviour. Hugh Cripps proposed increasing UK's micro and medium size generation capacity as a way to deal with transmission losses.

In response to the talk on nuclear energy, Lord Watson said that there is a connection between energy and autocracy. The willingness of the Germany to say 'no nuclear bill' is a reflection on their democracy. Nuttall responded that indeed the first phase of nuclear development was indeed during

the cold war years and with the Euratom Treaty (1957). He asserted that nuclear represents a less authoritarian future. Responding to Lord Watson's comment on Germany, he said that Germany is a potential leader of pragmatists and nuclear renaissance in Europe will not go anywhere without it. Dougal Goodman, Chief Executive of Foundation of Science and Technology, said that one of the critical questions we have to ask was: how much was this generation ready to forego for future generations? He commented that taxes and costs are already there. Alternative technologies (citing offshore wind) are expensive and uneconomical. They will not expand by taxes or costs, but by subsidies from the state. Allwood commented that we do not know the implications of many changes, for example what will be the rebound effect of increasing material efficiency in the manufacturing sector? We need to hence supplement by having regulations to constrain supply. He further re-asserted his view that renewables are not the solution. Efficiency of macro-generation is far better and worth paying for distribution losses. Moreover, the renewable plan will be cut back significantly once the cost becomes apparent.

Paul Skinner asked Chris hope if his quantification of benefits of the carbon tax has been extended to evaluate UK's comparative advantage with other cities in Europe and/or Australia. He aligned himself with Nuttall's views on nuclear energy, and further commented that any large changes in UK's infrastructure will also require enabling skills. We have to create a skill base that can serve as a big opportunity. In response, Nuttall said that if we talk about replacing coal with nuclear, then the question of an appropriate skill base becomes very relevant. He also said that UK has a better skills base than what may be apparent at a first inspection. However, a future where UK will have a combination of high capacity of renewable by 2020 and very low efficiency fossil fuels is worrisome, and not the step towards a low carbon future. Chris Hope responded by saying that taxation does not mean that UK suffers in the competitive world. In fact, it will benefit because other taxes can be reduced. Subsidies etc. are not the same – CO₂ and other GHG gases have to be priced appropriately.



Paul Skinner, Infrastructure UK, and Lord Macdonald of Tradeston, Macquarie Capital

Session III: Infrastructure for Cities and the Built Environment of the Future

Chair: Ian Liddell CBE FREng

RA Visiting Professor of Engineering Design, Cambridge University, founding partner Buro Happold

Speakers: Marcial Echenique OBE

Professor of Land Use and Transport Studies, Department of Architecture, Cambridge University

Randall Thomas

RAE Visiting Professor in Building Physics, Cambridge University, and Professor of Sustainable Environmental Design at Kingston University

Marcial Echenique began the session, arguing for increasing transport capacity to maintain economic growth. He said that efficient transport is a necessary but not sufficient condition for economic growth. In addition, transport systems need to be well connected and offer a reasonable level of service. He criticized the low level of service provided by the UK transport sector. He also argued that while we understand the direct cost of commuting well (such as time and resources), the wider economic costs of mobility are less understood. In fact, there exists a clear relationship between income and mobility. Passenger mobility has increased by use of cars, and freight mobility increased by the use of lorries and water transport. He further said that all increase in mobility is due to increased trip length and that the time cost of mobility is increasing due to congestion; we thus need to increase capacity. He rejected the option of reducing car travel, arguing that to do so would be to accept reduction in standards of living. He pointed to the following as misconceptions: that rail is a more efficient alternative; that public transport can be a viable alternative; and expanding road travel will have a material effect in climate change. His key point was that we should expand road capacity in conjunction with pricing. Citing examples from infrastructure developments in Chile, he proposed inter-urban corridors with link roads and urban networks with tunnels as tangible infrastructure solutions in combination with congestion pricing. Greenhouse emissions should be addressed by increasing efficiency of the vehicles and engines rather than reducing car travel.

Randall Thomas, the second speaker of the session, talked about low carbon buildings. He argued that the government is right to promote zero-carbon new homes by 2016 and zero-carbon non-domestic buildings by 2019 but that is only a start. We need to reduce the CO₂ emissions of all of the buildings existing now that we will still be using in 2050 by about 60%. The main questions that we have to ask are: Is it feasible to achieve these 60% reductions in the existing building stock? How do we make the transition to a low-carbon economy and what types of infrastructure might correspond to a building sector composed of 30% new build at zero carbon and 70 % refurbished existing with 60% reductions? Randall Thomas proposed that we reduce CO₂ emissions through the design of zero and very low-carbon buildings, the characteristics of which must be: optimal orientation to take advantage of the Sun, well insulated and sealed, high efficiency appliances, robust controls, and user-friendly systems. He promoted extensive use of renewables for all new-build so they are zero carbon, and significant upgrades to refurbish the existing building stock. He also said that we will need a new scale of renewable infrastructure to meet the residual energy demand, even if all buildings were highly efficient. Building the infrastructure to meet residual demand through renewables will require an investment of approximately £30 billion/year, which is about 2% of the UK GDP. This, he said, is consistent with recommendations made by the *Stern Report* that recommends spending 2% of GDP per annum to combat global warming. He also estimated that it will cost £11 billion/year over the next

40 years to reduce the CO₂ production of two thirds of the existing building stock by 60%. He concluded by remarking that meeting our energy targets will not be cheap, but time is an important constraint.



Nick Ray of Jesus College, and Ray O'Rourke of Laing O'Rourke

Responding to the first talk of the session, Michael Norton, Managing Director of the Water and Power group at the Halcrow Group, asked to what extent GDP growth is driven by increased capacity of infrastructure. Marcial Echenique responded that the relationship is gigantic for developing countries. UK already has good infrastructure. His concern is that any further growth (in road capacity) we constrain will cost us (he estimated that one extra mile of passenger mobility corresponds to one extra £ of income). He asserted that more traffic going to more places is more beneficial. Lord Watson commented that we cannot build ourselves out of congestion. There are constraints on government investments on roads. Moreover, the number of deaths in railways is little compared to roads. Counter-intuitively, it is the poor who need the car most. He asked Echenique if he proposed that the government put money on road instead of rail. Echenique agreed that, indeed, he supports greater investment on roads. Hugh Cripps, CEO of the Peterborough Environment City Trust, commented that assuming a relationship between road travel and GDP growth is in fact a dangerous interpretation of cause and effects. He also said that the economic argument proposed herein is 'dodgy'. We need to look at quality of life, especially since motorways bisect life. We should not look towards increasing consumption, but instead, towards increasing quality of life. Colin Harris, Deputy Chairman of Infrastructure at Arup, applauded the Chilean example as a way to increase road capacity. He further commented that the future challenge is not just to solve the problems in front but to also address other interconnected problems.

Responding to Cripps's comments on looking at overall quality of life rather than growth, Echenique said that people have indeed chosen what gives them a better a quality of life – they have chosen a way of life that includes a house, a garden, and a shopping centre. He agreed that road transport

comparatively causes more deaths, but that is a matter of design. He once again cited the roadways in Chile, that there are no motorways above ground. He asserted that the big technological issue is to reduce CO₂ rather than reduce capacity. Chris Hope reminded the audience that there is also an economic cost/impact of CO₂ emissions, as he had shown earlier (£75/CO₂). Echenique responded that there are other external effects of constraining capacity and questioned this figure and their accuracy. Others in the audience expressed concern about social exclusion effects of increasing road travel. Colin Taylor commented that we also needed to benchmark how much energy we need per person before discussing relative merits of different alternatives.

Paul Westbury questioned why we did not hear more on combined heat and power (CHP) from any of the speakers? He commented that CHP will potentially have a big impact on any city related investments. Randall Thomas responded that his approach focuses on demand reduction. CHP is problematic to compare, because the benefits depend on the fuel you use. Moreover, CHP is often used where heat may not even be needed, or in some cases, heating demand is in fact increased to make the CHP viable. Gordon Edge, Director of Policy at Renewable UK, responded in defence of CHP, saying that CHP as a technology gives us the opportunities to integrate heat with other energy systems and sources. Randall Thomas responded that indeed design of a technical system is important and perhaps the key to its useful implementation.



Left to right: Portia Walker, Tim Appenzeller, Warren Pimm and Colin Harris

Session IV: Financing the Infrastructure of the Future

Chair: Nick Butler

Chairman, Cambridge Centre for Energy Studies, Fellow, Judge Business School, Faculty Member, World Economic Forum

Speakers: James Stewart

CEO, Infrastructure UK

James Wardlaw

Goldman Sachs, and Adviser to the Homes and Communities Agency

Nick Butler began the fourth session by remarking that there is a delay in getting an institution together for dealing with the future of infrastructure. As a result, there are limited debates on priorities, sequencing, and social choices. There are trade-offs between various paths – for example the choice between increasing rail capacity versus roads. Thus, we now have a concentration of investment requirements at a time when both private and public finances are constrained (we are expecting the private companies to invest and also pay short term dividends). The concentration of investment requirements also comes at a time of huge international competition for capital. By the time we finish the session today, there will be 60,000 more citizens of the world who will have infrastructure needs. The challenge is to match demand for all forms of infrastructure. To do so, will investment have to be given more rewards than what investors are currently used to?

James Stewart, Chief Executive, Infrastructure UK and the first speaker, defined economic infrastructure as spending within five specific sectors (energy, transport, water, waste and communications). Spending in the last five years has been an estimated £150 billion, mostly from the private sector. Looking ahead, the demand for investment in economic infrastructure in the UK is expected to be in the range of £40-50 billion per annum until 2030 and possibly beyond. This is significantly above historic levels, driven by demands such as population growth and the need to cut greenhouse gas emissions. New energy and transport projects will form a major part of this spending. In planning a step change in how the nation plans, prioritises, finances and delivers infrastructure, *Infrastructure UK* has three main objectives: enabling long term investment; developing effective long term plans and priorities and; improving delivery. Infrastructure UK has already identified that there is a significant risk of a gap emerging in the provision of equity capital to large complex infrastructure projects within the next few years. To bridge this gap, a Green Investment Bank (GIB) is to be established which will operate on a commercial basis and will involve both public and private sector capital.

James Stewart also identified additional challenges such as the need for resilience to natural disasters, interdependence among various sectors of infrastructure, and need to expand into new areas, for example, off-shore wind ports and electric charging stations for cars. At the time, the environment is fiscally constrained. The burden of funding will tend to fall on the consumer. Who will think about affordability and value-for-money for the consumer? *Infrastructure UK* has been set up to respond to these challenges. It is formed in recognition of the need for an organized centre. James Stewart discussed three main issues in relation to infrastructure of the future: long term planning, financing, and effective delivery. For long term planning, he said that we have to prioritize attracting investment in the UK, give clarity to the planning process, and move away from 'stop-start' approach.

When planning the UK national infrastructure, we need to look short-term at affordability and address other social and economic issues as part of long term goals. For example, how will infrastructure influence the behaviour of people in the long term? How will we balance the cost of infrastructure in the future? We also have to create enablers for investment and make sure that markets are attractive for private sector investments. Regulatory frameworks, being under strain, work less well for large projects. Moreover, environmental issues, such as carbon emissions, are not accounted. Planning is certainly always among the top three disincentives for bringing investments into the UK. The main questions when estimating financing is: is there enough capacity and at appropriate pace? What are the mechanisms to fill the gaps? He proposed that we attract new sources of finance into the infrastructure market (it is a good asset), and create channels for investment. For the issue of effective delivery, do we have the right skills base? Are we investing in enough R&D? Why is the cost of infrastructure twice in the UK that of other European countries?



James Wardlaw of Goldman Sachs spoke second. He argued that the Green Investment Bank (GIB) as a state sponsored development bank ought to be a priority, otherwise it will be difficult to attract private/public investments in energy infrastructure. He then posed key questions and points related to the financing of infrastructure: (1) The green investment bank should operate commercially. How do you form a bank that operates similar to private banks but withstands in case of market failure? (2) In the context of scarce funds, we need a framework for evaluating projects across different technologies. How do we define priorities, and how do we avoid placing bets on certain technologies? This is extremely important because there is no magic money to fund mistakes. (3) How do we create an institution that has low cost of capital (because it is close to the government)? (4) How do we get more private funds into infrastructure investments, for example, pension funds? (5) How can we marry savings and investments, which is especially difficult at early stages of infrastructure investments? The community is not geared to analyse investment risks. The private banks simply cannot buy unlimited investment debt. The Green Investment Bank will have an important role to play in the risk-prone period from conception to operation of new infrastructure. (6) The bank should finance green deals, such as the retro-fitting of homes. There is no innovation by the banks so far for these. In general, the retail banks are disconnected with these issues and with investment banks.

In the discussion that followed, Ying Jin, Lecturer in Architecture Department, commented that energy is perhaps an important issue in the room today. However, profit is the priority for commercial banks. What would be the indices for a Green Investment Bank assessing different projects? Dougal Goodman followed up and asked about the financial regulation of a Green Investment Bank. Commenting on James Stewart's talk, Gordon Edge questioned about the tension between stability and risk in infrastructure investment.



Left to right: Terry Macalister, John Hutton, Marcial Echenique, Nick Ray and Ray O'Rourke

James Stewart responded that people do cost-benefit studies in the project context, but not to compare different projects. We need to change this. We want to be able to put the right numbers with good supporting data to analyze decisions. Wardlaw responded to the comments on the Green Investment Bank. He said that regulations have to deal with tensions between stability and change. A strong regulatory base has been a huge asset to the UK. The challenge is to tweak this mechanism so that it is effective for long term investments. Colin Harris commented on regulation of utilities, particularly water, saying that regulations have caused water companies to put huge amounts of energy on processes. It is ironic that we are using a lot more energy because of regulation. He argued that we need to do more than simply tweak regulation. He also remarked that the UK infrastructure is more expensive because the brief at starting point of a project answers the wrong questions. Responding to Wardlaw's proposal of directing pension funds towards long term infrastructure investments, Lord Macdonald questioned whether this would be beneficial. Chris Hope commented that he is sceptical about UK's ability to choose the right infrastructure at the government or institutional level. We should remove market failures rather than come up with a Green Investment Bank. James Stewart agreed, saying this solution does not really focus on the real problems. We have to structure the market properly and minimize the need to fill gaps. Nick Butler remarked that infrastructure investments are long term whereas politics is not. At this, Paul Skinner commented that it would be good to see infrastructure de-politicized as much as possible. However, such an idea is only inspirational, and we do need to find best practice solutions. We can find examples in the world where longer views have yielded better results. Effectiveness of infrastructure delivery is what we want to focus on.

Referring to earlier discussions on curbing demand, Prajakti Kalra asked the audience if there should similarly some thrust on constraining supply. Should the government not do something about it? Citing the example of public debate that led the government to redirect London's overflowing sewage away from the River Thames, James Stewart remarked that the future will hold more active discussions between consumers and government. James Wardlaw closed the session by commenting that financing issues are yet not worked through to any great degree and will require further discussions.

Session V: Infrastructure for the Secure Supply of Water

Chair: Peter Guthrie OBE FREng

Professor of Engineering for Sustainable Development, Cambridge University

Speakers: Dr Jean Venables OBE FREng FICE

Chairman, Crane Environmental Ltd

Michael Norton MBE

Managing Director, Water and Power, The Halcrow Group

This session focused on issues associated with setting limits of growth in infrastructure using the example of the water sector. Jean Venables gave the first talk of this session. She said that we cannot take water for granted and that the UK is largely in a semi-arid condition. There is plenty of water, but very little in usable state or in the right place. Should we consider non-potable water coming out of the taps for certain uses? She also argued for increasing the efficiency of the delivery systems (such as using wind pumps), better management of catchments, and effective re-use through desalination plants. Over 10% of the country is under managed drainage. We worry about managing water levels because it gives us more land, and to avoid flooding and logging. We need to keep the water levels high enough in the summer to avoid clay shrinkage and for irrigation. Venables said that we have too many legislations and political boundaries that have led to too much energy being consumed in supplying water. Management among different organizations is complex and we need to simplify these. We need to change the culture and attitude towards water use and its management.

Mike Norton of the Halcrow Group spoke about the challenges of achieving global water security. Citing various reports published over the last 12 months, he said water crises are creeping up on us and it will get worse. If we overlay the projected scenarios with population growth, water scarcity increases even further. He commented that we have forgotten the importance of the natural water cycle. Mike Norton showed that most withdrawals are for irrigation and drinking water. Showing virtual flows of water globally, he said countries are exporting water (embedded in their produce). He argued for looking at embedded water demand per country including green water, and so doing



Left to right: Mike Norton, Cam Middleton, and Ben Piper

suggested that the 150L/day/person needs to be re-assessed. Two-thirds of UK water is thus imported, and this is another reason why the water sector is so important. He concluded by saying that water, food, and energy are linked. We cannot address one without influencing others.

Commenting on Jean Venables's talk, Gordon Edge said that the pricing and regulatory process has worked well but it has not encouraged innovation. Regulations are indeed valued by investors, but not understood very well. Changing the regulatory framework can thus be counter-productive. The key question is: how can private companies get the right incentives to make the right choices? Dougal Goodman remarked that we first need to clarify what is needed to change the regulatory framework. Colin Harris proposed that water companies set more long term frameworks. He also commented that issues pertaining to water are not single utility issues and we have to account for interdependencies with other utilities. Colin Taylor remarked that climate change is not as much of a challenge in the water sector as is the structure of the industry. Organization is so fragmented and driven by corporate culture that any common understanding is impossible. James Stewart asked if we should be building more reservoirs, or instead, should we be focusing more on networks? What do the regulations support? Peter Guthrie remarked that hopefully the idea of a water grid is long dead. Jean Venables responded that security of supply is extremely important. Michael Norton added that biofuels is in fact in the middle of the nexus. Using water to grow food is better than using it to grow biofuels. He also added that two-thirds of the UK daily water consumption (150L/day/person) is for sanitary treatment. We should not build more reservoirs but think of a 22nd century paradigm for using water. Also, we should be using water to grow our own food, instead of importing it.



Terry Macalister, Energy Editor, *The Guardian*



Dr Shailaja Fennell, Jesus College, Cambridge

Infrastructure and the Future of Society
Rustat Conference - Jesus College, Cambridge
10 June, 2010
Rustat Conference Participants

Professor Robert Mair CBE FEng FRS - Master of Jesus College and Rustat Conferences Chair

Professor Robert Mair is the Master of Jesus College, Cambridge, Professor of Geotechnical Engineering and Head of Civil and Environmental Engineering at the University of Cambridge. He was a Fellow of St John's College from 1998 to 2001. He is co-founder of the Geotechnical Consulting Group, an international consulting firm based in London, started in 1983. He is a Fellow of the Institution of Civil Engineers, a Fellow of the Royal Academy of Engineering and its Senior Vice-President, and a Fellow of the Royal Society. Throughout his career he has specialised principally in underground construction, providing advice on numerous projects involving soft ground tunnelling, retaining structures, deep excavations and foundations. Recent projects have included railway tunnels in Amsterdam, Barcelona, Bologna, Florence, Rome and Warsaw, and motorway tunnels in Turkey. In the UK he has been closely involved with the design and construction of the Jubilee Line Extension for London Underground, and with the Channel Tunnel Rail Link and Crossrail projects. He was responsible for the introduction of compensation grouting in the UK as a novel technique for controlling settlement of structures during tunnel construction - on the Waterloo Escalator Tunnel Project. The technique was widely used on the Jubilee Line Extension Project for the protection of many historic buildings, including the Big Ben Clock Tower at the Palace of Westminster.

John Cornwell - Director Rustat Conferences

John Cornwell is an author, journalist and Fellow Commoner of Jesus College, Cambridge where he directs the Science and Human Dimension Project, a public understanding of science programme, and the Rustat Conferences. He has written for many well known publications including The Sunday Times, Vanity Fair, Nature, Financial Times, Prospect, New Statesman, Spectator, TLS, The Tablet, New York Times and The Observer, where he was on the staff as a senior manager. He is author of twenty books including *Hitler's Pope*, *The Secret History of Pius XII*; *A Thief in the Night*; *Power to Harm*; *Earth to Earth*; and a biography of Samuel Taylor Coleridge. He is editor of *Nature's Imagination: The Frontiers of Scientific Vision*; *Consciousness and Human Identity*; and *Explanations: Styles of Explanation in Science* (all published by Oxford University Press), and with Michael McGhee, of *Philosophers and God*, Continuum (2009). His biography of Cardinal Newman, *Newman's Unquiet Grave*, Continuum (2010), has just been published. He studied at Oxford and Cambridge Universities.

Julian Allwood

Julian Allwood leads the Low Carbon and Materials Processing research group in the Department of Engineering at the University of Cambridge (lcmp.eng.cam.ac.uk). His work spans innovative materials processing technologies and low carbon manufacturing. The first 10 years of his career were funded by contracts with the Alcoa Technical Centre in Pittsburgh. In 1996 he was appointed as a lecturer in mechanical engineering at Imperial College, and moved to Cambridge in 2000. His research group focuses on the technologies and systems of material and energy efficiency, largely related to metals. Projects include development of second generation incremental sheet forming processes with Ford, Novelis, Metal Spinners and Cummins, technologies for toner print removal to allow paper-reuse with Xerox, identification and evaluation of options for future carbon emissions reductions with Unilever, and a global study of energy efficiency options. He is secretary to the scientific technical committee on metal forming of the CIRP, and since 2007 he has been joint editor-in-chief of the Journal of Materials Processing Technology. In 2008 he was awarded a 5-year, £1.5m EPSRC Leadership Fellowship to lead a major project on the global carbon emissions targets for steel and aluminium in collaboration with a consortium of 20 global companies spanning the metals

supply chain (www.wellmet2050.com). In 2009, Julian was appointed the Cambridge Director of the Low Carbon and Energy Alliance between the Universities of Cambridge, Tsinghua and MIT, and he is currently acting as co-ordinator for energy research across the University of Cambridge. Julian has been appointed as a Lead Author for the chapter on mitigation in industry in the IPCC's 5th Assessment Report, to be published in 2014.

Tim Appenzeller

Tim Appenzeller is Chief Magazine Editor at Nature, overseeing the publication's journalism and opinion sections. Before starting at Nature in 2009, he spent more than 25 years as an editor and writer in the U.S., on magazines including Scientific American, Science, U.S. News & World Report and, most recently National Geographic. His National Geographic article on the global carbon cycle, "The Case of the Missing Carbon," won the American Geophysical Union's Walter Sullivan award for excellence in science journalism in 2005, and his June 2007 cover story on glacier retreat, "The Big Thaw," was recognized for best explanatory reporting by the Society for Environmental Journalists. He has an undergraduate degree in literature from Harvard College.

Peter Bishop

Peter trained in town planning at Manchester University and has spent his entire career working in London. Over the past 20 years he has been a Planning director in four different Central London Boroughs and has worked in major projects including Canary Wharf, the development of the BBC's campus at White City and the Kings Cross developments, one of the largest and most complex sites in London. He was appointed as the first Director of Design for London, the Mayor's architecture and design studio, in 2006. In 2008 he was appointed Group Director at the London Development Agency. In this role he combined Design for London with the Agency's land development, environmental, housing and public space programmes. Peter lectures and teaches extensively, is a visiting professor at the faculty of Architecture and the Built Environment at the Nottingham Trent University, is an advisor to the City of Bucharest and an honorary fellow of University College London.

Alistair Buchanan

Alistair Buchanan has been Chief Executive of Ofgem since 2003. He is also a member of the Business Energy Forum and the UK Energy Research Partnership (UKERP) and previously a Non Executive Director for the state-owned company Scottish Water. He was appointed CBE in December 2008. He began his career as a Chartered Accountant at KPMG and is a Fellow of the Institute of Chartered Accountants. Since then, his working career has been in the financial sector, but closely aligned to energy and utilities. An award winning analyst at Smith New Court (now Merrill Lynch) he was one of the central analysts to the privatisations of the electricity industry in the early 1990s. From 1995 to 2000, Alistair had a break from UK utilities, and was firstly Head of Research at BZW, and then moved to New York to run the American Utilities research team for Salomon Smith Barney. He returned to London with DLJ, where he was head of European Utilities, as he was at ABN Amro.

Nick Butler

Nick Butler is Chairman of the Cambridge Centre for Energy Studies. He was a special adviser to the former British Prime Minister Gordon Brown at the end of his term in office from 2009-2010. He also served as non executive Chairman of the energy technology business Agni Inc from 2008 until February 2009. Butler graduated in economics from Cambridge University before joining BP, ultimately becoming Group vice-president for strategy and policy development. Currently he is chairman of the Centre for European Reform, a member of the International Advisory Board at Yale University, and a member of the Faculty of the World Economic Forum. In 2007 he joined the Judge Business School, Cambridge University, as Chairman of the Cambridge Centre for Energy Studies. He is a Vice-President of the Hay Festival.

Nick Chism

Nick Chism is global head of infrastructure at KPMG. He has worked in the transport and infrastructure sectors for more than 20 years. Nick is responsible for a network of 3000 professionals

active in the infrastructure sector worldwide, advising on strategy, financing, delivery and investment, across a range of sectors. Nick travels regularly and widely to meet clients and gain insight into the global challenge of infrastructure development.

Ruchi Choudhary

Dr Ruchi Choudhary specializes in building simulation with a particular interest in multi-criteria modelling of energy demand and environmental characteristics of the built environment. Her research is on simulation-based optimization methodologies for energy management of buildings; ventilation design strategies; integration of novel building technologies and renewable energy supply systems during design phases; and performance assessment of buildings. She is a lecturer in Engineering at the University of Cambridge and is the rapporteur for this Rustat Conference. Prior to joining Cambridge, Dr Choudhary was assistant professor of building technologies in the College of Architecture at Georgia Institute of Technology in Atlanta, USA (2004-08). She has also taught in the Sustainable and Environmental Design Unit at the Architecture Association in London (2007-09). She received her PhD in Architecture from the University of Michigan in 2004.

Andrew Comer

Andrew Comer is Director of Environment and Infrastructure at Buro Happold. Andrew has over 30 years' experience in the field of civil engineering covering public and private sector consultancy work. He has been involved in an extensive range of projects, both in scale and type, from transportation and highway engineering through airport, port, river and marina work to urban regeneration and infrastructure schemes. He is responsible for Buro Happold's Infrastructure, Transport and Environment Groups and for the co-ordination and management of multi-disciplinary project teams. In addition, he is responsible for ensuring provision of expert and cost effective advice on planning and site development issues to clients and our other design teams. He has a keen interest in developing and promoting improved development and delivery of projects, and has been involved in the development of PFI, PPP and DTI 'pathfinder' initiatives.

John Constable

Dr John Constable is the Director of Policy and Research for the Renewable Energy Foundation (www.ref.org.uk), an independent charity which publishes data and research relating to renewable energy technologies and their place in the wider energy sector. Dr Constable read English at Cambridge, taking his PhD in 1993. He has subsequently taught at both Kyoto University, Japan, and at Cambridge, where he was in 2005 a Senior Research Fellow of Magdalene College. In that field he is best known as the co-discoverer, with the Japanese particle physicist and economist, Hideaki Aoyama, of the mathematical distinction between verse and prose in English. He has been working in energy policy since 2004, and is currently responsible for co-ordinating the Foundation's large circle of practical and academic engineers, and for the direction of policy. He is also the principal author of the Foundation's publications and consultation submissions.

Jonathan Cornwell

Jonathan's background is in academic and educational publishing. He has managed government and UNESCO backed online education projects in the Middle East, China, Africa and Latin America. He worked for Routledge, Chapman & Hall, O'Reilly Media, the Thomson Corporation; headed the international division of elearning business ThirdForce plc; and was Chief Operating Officer of YUDU Media. He is on the Rustat Conferences advisory board which directs the conferences and publishes the reports. He studied at UCL, Trinity Hall, Cambridge, and Imperial College, London.

Hugh Cripps

Hugh Cripps is Chief Executive, Peterborough Environment City Trust. A geologist by training, he started his working life exploring for oil and minerals around the world; from the jungles and deserts of Brazil to the northern forests of Sweden. He returned to the UK to take up a new career in countryside management and post graduate research. In 1989 he moved to Peterborough to work with the local authority delivering their Local Agenda 21 commitments. In 1992 he co-founded

Peterborough Environment City Trust (PECT) in response to Peterborough becoming one of the UK's 4 Environment Cities. In 2005 he took over as Chief Executive and since then has been driving the city's ambition to become the UK's Environment Capital. He is also the Managing Director of PECT Consultancy Ltd.

Marcial Echenique OBE

Professor Marcial Echenique OBE, MA DArch RIBA RTPI, is Professor of Land Use and Transport Studies and former Head of Architecture at the University of Cambridge. He is accredited, in particular, with early work on the integration of land use and transport planning, and for both theoretical and practical advances in the development and application of computer models. He has also acted as a consultant to numerous government and local authorities and has directed a number of major planning studies financed by international institutions such as The World Bank and The United Nations. Recently, He directed the influential study of *Cambridge Futures* (RTPI award for planning innovation), co-directed the joint urban design studio of the Cambridge -MIT Institute and is the Principal Investigator for the EPSRC research on sustainable urban environment (SOLUTIONS and ReVISIONS). In 2009 he was awarded an OBE for services to Urban and Regional Planning.

Gordon Edge

Dr Gordon Edge is Director of Policy at RenewableUK, the trade and professional body for the UK wind and marine renewables industries. He has had a varied career in energy, initially in academia, followed by journalism, and now advocacy for the renewable energy industry. At the start of 2004 he joined BWEA (now RenewableUK), initially as Head of Offshore. In all his roles, he has had a strong interest in the economic and business aspects of energy, which made his move to being RenewableUK's Director of Economics and Markets a natural one. He was recently promoted to Director of Policy, with overall responsibility for all policy issues relating to all aspects of planning, economics and delivery of all the technologies that the association champions.

Shailaja Fennell

Dr Shailaja Fennell is Lecturer in Development Studies at Cambridge University and a Fellow of Jesus College. Her research interests include institutional economics, agricultural reform, gender and household dynamics, kinship and ethnicity, comparative economic development, educational provision and partnerships. She has a BA, MA and MPhil from Delhi University and an MPhil and PhD from Cambridge University.

Dougal Goodman FREng

Dr Dougal Goodman is Chief Executive of The Foundation for Science and Technology a charity set up over thirty years ago by a group of members of the House of Lords. The Foundation works while remaining neutral to facilitate debate between both Houses of Parliament, Whitehall, industry, the Research Councils, universities and academics on policy issues that have an engineering, science, medical or technology element (www.foundation.org.uk). Prior to joining the Foundation Dr Goodman was a Deputy Director of the British Antarctic Survey, a senior manager for BP and a research fellow at the Cavendish Laboratory in the University of Cambridge. He is also Chairman of the Lighthill Risk Network, Vice-Chairman of the Hazards Forum, serves on a number of government committees and works as a consultant on risk strategy mainly for companies in the London insurance market.

Philip Guildford

Philip Guildford is the Director of Research at the Cambridge University Engineering Department (CUED). A graduate in Natural Sciences from Jesus College, Cambridge, specialising in Materials Science, Philip spent a number of years in industry. Having begun his working life in R&D, working with building products, he then moved into the aerospace sector, and then into industries taking a lead in 'green', environmentally friendly projects related to energy efficiency and renewable energy. A strong interest, and ability, in project management and technology strategy then led him into the

realms of business consultancy, and back to Cambridge, working for PA Consulting Group. He then moved into telecoms, working as Principal Consultant for Analysys, when the market entered the greatest boom in history. Following international consulting work, he moved back into the University and joined the newly formed Corporate Liaison Office, which has been set up to act as an interface between the University and the business world. Having spent a year leading the development of the Office's strategy, implementing a project management system, building regional links and facilitating relationships with companies, the move to CUED seemed a natural step.

Peter Guthrie OBE FREng

Peter Guthrie is Professor of Engineering for Sustainable Development at the University of Cambridge. Professor Guthrie's research is focused on the assessment of the sustainability of large-scale projects like housing, mining enterprises, and educational buildings. He also pursues research in the sustainable development of infrastructure in developing countries, including challenging the appropriateness of technical standards, waste management, the potential for waste materials to be used in construction, and the engineering of earth roads. Peter is Vice-Chair of DEFRA's Scientific Advisory Council and leads the Waste Sub Group. He is also on the DECC Project Board for the Severn Tidal Power scheme. Professor Guthrie was also involved in the founding of RedR, an international charity which improves disaster relief through training and recruiting relief workers worldwide.

Colin Harris

Colin Harris is a Fellow of the Institution of Civil Engineers with 37 years experience of Infrastructure projects and programmes in the UK, Middle East, Far East and Africa. His experience includes large capital projects such as Dubai Dry Dock (UAE), Lantau Fixed Crossing (HK), New Multi Product Pipeline (SA), and New Forth Crossing (UK); procurement advice and technical due diligence including Northumbrian Water, and Regional Gas Distribution Networks transactions; and engineering and environmental Capital Programme delivery including 3 successive AMP (5 year) periods for Yorkshire Water, and for the Environment Agency. Colin established a new office in Leeds in 1989 which grew to circa 300 people under his leadership. He is now a member of the Arup UK-ME board with responsibility for Infrastructure in the UK-ME Region and is a member of the Global Infrastructure Practice Executive.

Chris Hope

Dr Chris Hope is Reader in Policy Modelling at Judge Business School, University of Cambridge. He was a Lead Author and Review Editor for the Third and Fourth Assessment Reports of the Intergovernmental Panel on Climate Change, which was awarded a half share of the Nobel Peace Prize in 2007. He was the specialist advisor to the House of Lords Select Committee on Economic Affairs Inquiry into aspects of the economics of climate change, and an advisor on the PAGE model to the Stern review on the Economics of Climate Change. In 2007, he was awarded the Faculty Lifetime Achievement Award from the European Academy of Business in Society and the Aspen Institute. His research interests involve numerical information in public policy and the integrated assessment modelling of climate change, and he has published extensively in books and peer-reviewed journals. He has recently completed the latest version of the PAGE integrated assessment model, PAGE09.

Jon Hutton

Professor Jon Hutton is Director of the Cambridge-based United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC), specialist centre for the assessment of biodiversity and ecosystems. He has a background in biodiversity science, rural development and international policy, as well as over 20 years experience working as a conservationist in Africa. He is an alumnus of Jesus College, Cambridge and received his doctorate on crocodile ecology from the University of Zimbabwe in 1984. He has held a number of senior management positions in that country, encompassing the government, NGO and private sectors. In 1999 he moved to Europe where for several years he was concurrently the Executive Director of *ResourceAfrica*, an NGO supporting community development in southern Africa, and Director for the Africa Programme of Fauna & Flora

International (FFI). In 2005 he joined UNEP with a mission to reinstate WCMC as a global leader in biodiversity information, synthesis and assessment. He is currently responsible for the work of 80 scientific staff and projects such as the 2010 Biodiversity Indicators Partnership which is tasked with measuring global progress towards the 2010 target. He is a Senior Member of Hughes Hall College, Cambridge and Honorary Professor of Sustainable Resource Management at the University of Kent.

Ying Jin

Dr Ying Jin lectures on city planning and design at Cambridge University. An architect by training, he is particularly interested in understanding how technology, policy and human behaviour affect the development of cities, and in using this knowledge in architectural and urban design. His main research interests are computer models of cities. He has directed multi-disciplinary teams in building and using computer models as experimental platforms to appraise policy scenarios that involve investment, regulation, pricing, and promotional campaigns. Key projects include strategic planning of London and surrounding regions, sub-regional and local planning in the English Midlands, transport and energy scenarios for the European Union, and long term city region and transport plans in China and South America. He is currently leading research to create a new generation of conceptual and practical city models under Cambridge University's Energy Efficient Cities Initiative.

Prajakti Kalra

Prajakti Kalra is a Research Associate with the Cambridge Central Asia Forum. She holds an MPhil in Oriental Studies from the University of Cambridge and an MA in International Relations from the University of Chicago. She trained as a historian, political scientist and a psychologist. Her interests are in the areas of Central Asian history and politics, energy security, international relations, international organisations, immigration and identity. She has conducted research on international relations in post Soviet Central Asia and political analysis of regional and international organisations like the Shanghai Cooperation Organisation and the OSCE (Organisation for Security and Cooperation in Europe). Her work on the Shanghai Cooperation Organisation focused on energy needs and security for China, Russia and India in Central Asia. She has worked on issues of identity and immigration, specifically the history of Uzbeks in Saudi Arabia (since 1917) and future prospects of interaction between the Gulf Cooperation Council and the Central Asian region.

Ian Liddell CBE

Professor Ian Liddell CBE FEng is graduate of Cambridge University and has worked in the construction industry for about 50 years, mainly in a design capacity and on a wide range of building types and functions, mostly high profile buildings. For a period he became an expert of the engineering of flexible cable and fabric structures and was notably responsible for the design of the Millennium Dome for which Buro Happold won the MacRobert award. He has also worked on structures for energy which is a current interest. He is currently a Visiting Professor in engineering design at Cambridge. He has also been awarded the Gold medal of the Institution of Structural engineers and the Award of Merit from the International Association of Bridge and structural Engineers.

Rt Hon Lord Macdonald of Tradeston, CBE

Lord Gus Macdonald is Senior Adviser to Macquarie Capital in Europe which provides corporate advisory, equity underwriting, funds and asset management services, including infrastructure and utilities. Following a successful business career in industry, the media and publishing, Lord Macdonald served five years as a UK Government Minister for Business and Industry, Transport, and the Cabinet Office. He joined Macquarie in 2004 and is also a Director of Scottish Power Ltd.

Terry Macalister

Terry Macalister is the Energy Editor of the Guardian and the Observer. He has been employed at the paper and website for ten years in a variety of roles including Deputy Business Editor and Industrial Correspondent. Terry previously worked at The Independent, London Evening Standard and has freelanced for the BBC, Daily Mail and Sydney Morning Herald. He specialises in international

business, politics and the environment and has reported on these subjects from all over the world. He has also spoken on these subjects at conferences in London, Stockholm and Shanghai. He has helped to establish and writes for two independent energy publications, Upstream and Recharge. Terry is a law graduate and will undertake a Journalism Fellowship at Wolfson College, Cambridge, this autumn. He lives with his wife and children in Cambridge.

Campbell Middleton

Dr Campbell Middleton is a Senior Lecturer in Structural Engineering at Cambridge University and Director of Studies in Engineering, King's College, and previously worked for nearly 10 years in bridge and highway construction and design in Australia and with Arup in London. He is Chairman of the UK Bridge Owners Forum (www.bridgeforum.org), established in 2000 by representatives of the major bridge owning organisations in the UK to identify research needs and priorities for the bridge infrastructure. He was elected Fellow of the Transport Research Foundation in 2005, is involved in the development of codes of practice and acts as a specialist bridge consultant to clients in the UK and abroad. The main areas of interest for his research group in Cambridge are computational collapse analysis, risk and reliability analysis, computer vision for structural evaluation, non-destructive testing & inspection, wireless sensor networks for structural health monitoring and sustainability evaluation of constructed facilities.

Michael Norton MBE

Michael Norton MBE is Managing Director of Halcrow's water and power business. He graduated in Civil Engineering from Leeds University. After working with water authorities and companies in Yorkshire, Scotland and Merseyside, Michael joined Halcrow in 1985. Michael has been responsible for projects including Portsmouth and Havant Wastewater Treatment; Barcelona Water Projects in Venezuela; Cusco, Abancay and Sicuani Water Studies in Peru; Aconcagua Valley Wastewater Treatment Plants in Chile; Puerto Cortes Wastewater Treatment Plant in Honduras; the design review of Guangzhou Wastewater Project in China; and a number of specialist roles on projects in Latin America, Middle East and China. Today, Michael is responsible for around 1,500 employees and a turnover in excess of £100 million. Michael represents Halcrow and British interests throughout the globe. In 2007, he was appointed chair of the UK Trade and Investment (UKTI) India Water Working Group; whilst in 2008 he joined the UKTI's Water Sector Advisory Group. He is a visiting lecturer for Oxford University's MSc in Water Science and Policy and former Chair of the Water Programme Advisory Committee at Cranfield University. In November 2008, Michael joined the Institution of Civil Engineers' (ICE) Water Panel.

William J. Nuttall

Dr William J. Nuttall is a University Senior Lecturer in Technology Policy at Cambridge Judge Business School. In 1987 he won a Fulbright Post-Graduate Student Award to the Massachusetts Institute of Technology to study for a PhD in physics. He received his PhD in 1993 and returned to the UK where he took two post doctoral research positions in large-facility physics. In 1997 Dr Nuttall shifted his career to reflect his long-standing interest in science and technology policy. He moved to the London headquarters of the Institute of Physics where he later became Manager, Policy. At the IOP he worked on a wide range of physics-based policy issues including energy. In early 2002 he moved to Cambridge University to be founding Course Director for a new Cambridge-MIT Institute (CMI) sponsored master's degree in Technology Policy. Dr Nuttall has a leading role in the ESRC Electricity Policy Research Group. He is a Fellow of Hughes Hall Cambridge.

Ray O'Rourke

Ray O'Rourke is Chairman, Chief Executive, and founder of the Laing O'Rourke Group. As chairman of the executive board, he leads the strategic direction and operational management of the Group. His early career included roles at Kier plc and J Murphy & Sons. In 1977 he founded R O'Rourke & Son, which commenced trading the following year. Through organic growth and acquisition the company became a major force in UK construction. The business acquired the construction arm of John Laing plc in 2001, creating today's extended international construction solutions group. Ray is the recipient of honorary doctorates from a number of universities in the UK and Ireland. Among its many

landmark projects, Laing O'Rourke was principal construction delivery partner on BAA's new Terminal Five at Heathrow, was part of the joint venture that designed and built the St Pancras Station end of the Channel Tunnel Rail Link, and has completed the delivery of the New Terminal at Dubai International Airport. Other high profile projects include the Ministry of Defence GCHQ facility, the Bluewater Retail Centre, reconstruction of the Royal Opera House, the erection of three tower blocks at Canary Wharf, the Museum of Scotland and the transformation of central Liverpool, completing the Liverpool One Development to coincide with the City's status as the European City of Culture in 2008. Laing O'Rourke is currently programme managing the construction of the 2012 Olympic and Paralympic Park as part of the CLM consortium. It is also delivering, as part of the Aldar Laing O'Rourke joint venture, the extraordinary US\$20bn Al Raha Beach project, creating the world's premier coastal city along 11km of Gulf Coast in Abu Dhabi, UAE.

Richard Owers

Richard Owers MA(Hons) Dip Arch RIBA founded *Plastik* Architects in London in 2002, was shortlisted for the Young Architect of the Year Award 2007 and has recently joined forces with Nicholas Ray Associates to create NRAP Architects, of which he is a Director. He studied at the University of Edinburgh and trained at Edward Cullinan Architects. From 1992 he worked in Berlin on two competition-winning schemes: Weimar City Hall and Meiningen Town Hall. He joined Penoyre and Prasad Architects in 1997, where he was an associate responsible for arts, education, health care and sustainable housing projects. Richard has acted as an independent consultant for Kent Architecture Centre, as a judge for RIBA Eastern Region design panel, and as a tutor, critic, and examiner at the University of Wales. He has taught on the "IDBE" masters programme at Cambridge University, and his contributions to professional publications include articles on urban design and sustainable architecture for "EcoTech" magazine and the "Cambridge Architecture Gazette".

Miles Parker

Dr Parker graduated in zoology, with a PhD in marine ecology, from Trinity College, Dublin. He managed marine the pollution unit and undertook research on marine environmental issues at the Department of Agriculture and Fisheries in Dublin, 1975-83. He was Head of research and operations on marine pollution from waste disposal at sea at MAFF's Directorate of Fisheries Research (now CEFAS) 1983-7. While in Dublin and at DFR, he was chairman of several of the marine environmental working groups of the International Council for the Exploration of the Sea (ICES) and at the Oslo and Paris Commissions (OSPAR). He was Head of the MAFF food contamination and biotechnology policy in 1987; Head of the Agri-Environment Unit at MAFF Chief Scientist's Group (CSG) in 1988; and Cabinet Office Science Secretariat 1991; Head of the MAFF CSG Science Division, managing agriculture and fisheries research programmes until 1997; acting Director of Food Science at MAFF's Central Science Laboratories (CSL) and managing ownership of MAFF's Laboratory Agencies in 1998. He was Director for International Science at the Office of Science and Technology 1998-2001, mainly on negotiations of EU Framework Programme 6. He has been Director of Defra's Evidence Programme since 2002 (managing Defra's policy and investment programme for science), Deputy Chief Scientific Adviser and internal Head of Profession for Science and Engineering.

L. Warren Pimm

Warren Pimm is a Director of Sustainable Development Capital (SDCL). He joined SDCL with a focus on financial advisory and capital markets. Prior to SDCL, he worked with the corporate finance group of an international investment bank in London, UK, where he focused on global capital markets and mergers and acquisitions across the diversified and sustainable sectors. He is a former principal and co-founder of Berkshire Securities Inc. where he established and led its Capital Markets Group, and was responsible for leading the development of the firm into a leading independent Canadian investment bank, growing the organization from start-up to over 2,200 professionals, \$12.5 billion in client assets, and 200 offices. Warren has completed on over 80 separate underwriting transactions collectively raising over \$9.8 billion in total equity capital. Warren is a CFA Charterholder and a Member of the CFA Institute, and the CFA UK. He completed a MBA from the Segal Graduate School of Business, and BA (Economics) from the University of Calgary.

Ben Piper

Ben Piper is Technical Director, Atkins Environmental and Water Management and a chartered civil engineer with over 35 years experience of hydrology and water resource planning in the UK and overseas. His experience of strategic water resource planning ranges from drought and water supply planning in South East England, to water demand forecasts in China, and a water resource investment strategy in Africa. His work has included research on the potential impacts of climate change on water resources, and how to include uncertainties and risks in long-term planning. His work on major river systems includes the Mekong, Lake Victoria and the Nile, the Zambezi, the Mahaweli Ganga and Lake Malawi. Prior to joining Atkins, he was water resource specialist for the UK water companies within the Compagnie Générale des Eaux group (now Veolia). Before that he was at the then Institute of Hydrology (now CEH) in Wallingford.

Wendy Pullan

Dr Wendy Pullan is Senior Lecturer in the History and Philosophy of Architecture at the University of Cambridge. She is Principal Investigator for 'Conflict in Cities and the Contested State, an international and multidisciplinary research project funded by the ESRC's Large Grants Programme. In 2006, she received the Royal Institute of British Architects' inaugural President's Award for University Led Research for work on Conflict in Cities. Dr Pullan has published widely on Mediterranean and Middle Eastern architecture and cities, especially Jerusalem, and has advised on issues to do with urban uncertainty and security. She is a Fellow of Clare College, Cambridge.

Nicholas Ray

Nicholas Ray is Reader Emeritus in Architecture at the University of Cambridge and a Fellow of Jesus College. After qualification at Cambridge and University College, London he worked in London for the Shankland Cox Partnership and for Colin St John Wilson and Partners. On returning to Cambridge in 1973 he practised within Hughes and Bicknell Architects, where he became Partner, before founding Nicholas Ray Associates in 1989. His most prominent building in Cambridge is the Quayside Development, on the banks of the Cam. He has been responsible for new and refurbishment projects for numerous Colleges and universities. He is founder of the Cambridge Historic Buildings Group and author of numerous papers.

Stuart Shilson

Stuart Shilson is a partner in the management consulting firm McKinsey & Company where he leads its UK Infrastructure work and focuses in particular on strategic infrastructure (i.e. road, rail, ports, airports, and major projects in energy, extractive industries, water and waste and communications). Stuart joined McKinsey in 1997; in 1999 he spent a year as a Senior Civil Servant for the UK Government in what is now its central Strategy Unit; in 2001 he left McKinsey again to work as one of The Queen's Private Secretaries, returning to McKinsey at the start of 2005. Before joining McKinsey, Stuart worked for five years as a commercial barrister, specialising in major contracts and public law. His law qualifications are from Cambridge University (MPhil) and the Inns of Court School of Law in London. Stuart also has a BA (First Class) in Mathematics and Philosophy and an MSc in Computing, both from Oxford University.

Paul Skinner

Paul Skinner is Chairman of Infrastructure UK, a division of HM Treasury, which has responsibility for providing a strategic focus in government for planning, prioritisation, financing and delivery across all infrastructure sectors. He is also a non-executive director of Standard Chartered plc; of Air Liquide S.A., the industrial and medical gases company; and of the Tetra Laval Group, the privately owned global foods packaging company. He is a non-executive member of the Board of INSEAD, the European/Asian business school. Paul read law at Cambridge University and later studied at the Manchester Business School. He joined Royal Dutch Shell as a student in 1963 and worked in all Shell's main businesses, including senior appointments in the UK, Greece, Nigeria, New Zealand and Norway. From 1999 he was CEO of the Group's global Oil Products business and was Managing Director of The "Shell" Transport and Trading Company plc, and a Group Managing Director, from

2000-2003. In 2001 he became a non-executive director of Rio Tinto plc, and was Chairman over the period 2003-9. Paul was President of the UK Chamber of Shipping in 1997/8, Chairman of the governing body of ICC UK 2004-8, a member of the Defence Board of the MoD 2006-9, and Chairman of the Commonwealth Business Council 2007-9. In October 2008 he was invited by the Prime Minister to join other business and university leaders as a Business Ambassador, supporting UK business interests in global markets.

James Stewart

James is the Chief Executive of Infrastructure UK, a new body announced in the Pre-Budget Report of December 2009, which will act as the focal point for the UK's infrastructure strategy, financing, development and delivery. He is on secondment from Partnerships UK, where he was Chief Executive for the previous nine years. He is also a Non-Executive Director of Partnerships for Schools and Sport England and he acts as an independent member of the Crossrail Sponsor Board. Previously, James was Head of Newcourt Capital's project finance team in London. Prior to joining Newcourt Capital, he was Managing Director of Project Finance and the Global Head of Infrastructure and Environment with Société Générale (SG) in London.

Alan Sutherland

Alan has been the Chief Executive of the Water Industry Commission Scotland since its establishment in July 2005. Prior to this he was the Water Industry Commissioner. He was appointed by the Scottish Ministers to that role in November 1999. He has extensive experience in management consultancy and in the investment banking industry, being a former management consultant with Bain and Company and before that a Manager with Robert Fleming and Company. More recently he was a Managing Director of Wolverine CIS Ltd, a division of Wolverine World Wide. Alan has a MBA and MA from the University of Pennsylvania and a MA (Hons) from the University of St Andrews.

Colin Taylor

Professor Colin Taylor BSc PhD CEng FICE is Professor of Earthquake Engineering and Head of the Department of Civil Engineering at Bristol University. He is Chairman of the SW Region of the Institution of Civil Engineers and a member of the Steering Group of the Severn Tidal Power SEA study. He has a particular interest in the systems performance of complex infrastructures subject to natural hazards such as earthquakes, wind and climate change. His research interests range across dams, long span bridges, nuclear, offshore energy, water and electricity supply systems, buildings, foundations, non-linear dynamics, and advanced experimental facilities. His current work is engaging with the social sciences, in particular viewing engineering as primarily a social learning process.

Randall Thomas

Randall Thomas spent over 25 years with Max Fordham LLP and is currently a consultant to the practice. His experience includes both individual buildings such as the Environmental Building at the Building Research Establishment and larger innovative urban regeneration schemes. His most recent books are *Environmental Design, Sustainable Urban Design* and *The Environments of Architecture* which he co-authored. He is currently a Royal Academy of Engineering Visiting Professor in the Department of Engineering at the University of Cambridge, Professor of Sustainable Environmental Design at Kingston University and Course Organiser for Sustainable Urban Design at the Architectural Association. He also teaches in schools of architecture in France.

Portia Walker

Portia Walker is Producer for *Frost Over The World*, Al Jazeera English's flagship current affairs programme presented by Sir David Frost. She has worked at Al Jazeera English since 2007 where she focuses on the Middle East and Asia. She has made television news programmes from Israel, India, Germany and the United States. She studied at the Arabic Language Institute in Fez and Magdalen College, Oxford.

James Wardlaw

James Wardlaw is a Managing Director at Goldman Sachs, where he is responsible for GS' business with the public sector in the UK. He was formerly an HM Treasury official from mid 2002-2005. James co-authored with Professor Dieter Helm, a paper for the Policy Exchange called 'Delivering a 21st Century Infrastructure for Britain', published last September. He is also currently supporting the *Green Investment Bank Commission* looking into the feasibility of a financing institution for the UK's low carbon priorities. He has been closely involved in a number of the UK's largest infrastructure projects over the last decade, and has also recently been closely involved with the Home and Communities Agency (HCA), the Government's housing and regeneration arm, in an initiative to encourage institutional investors to set up funds to invest in private rental housing.

Lord Watson of Richmond, CBE

Alan Watson is Chairman of CTN Communications and was European Chairman of Burson Marsteller for more than ten years. He advises major companies on their communication strategies and is Chairman of the Advisory Board of Havas Media UK. In broadcasting Alan was a regular presenter with "The Money Programme" on BBC2 and "Panorama" on BBC1. He also reported on LWT, Radio 4 and the BBC World Service, and wrote and presented many award winning documentaries. He is a Fellow and former Chairman of the Royal Television Society. From 1976 to 1980 he was responsible for Media at the European Commission. In politics, he was elected President of the Liberal Party in 1984. He was appointed CBE in 1985 and created a Life Peer in 1999. He has served twice as a Member of the House of Lords Select Committee on the European Union and as a Front Bench Spokesman on Higher Education. He holds a range of visiting and honorary posts at British Universities including Honorary Fellow of Jesus College, Cambridge. He chairs the Cambridge University Chemistry Advisory Board and advises the Cambridge University Engineering Department. He is a Life Patron of The Churchill Archives held at Churchill College. He is Chairman of The Cambridge Foundation, and is High Steward of the University. He is the recipient of five honorary doctorates and holds honorary professorships and posts in a number of foreign Universities.

Paul Westbury

Paul Westbury MA (Cantab), CEng, FEng, FStructE, FICEI, is Managing Director Europe, and Principal Engineer of Buro Happold. He joined Buro Happold in 1991 and early on was instrumental in establishing the Buro Happold Special Structures Group. Initially working with Ian Liddell, this group was involved in a number of distinctive fabric and cable structures and a secondment to FTL-Happold in New York in 1996 saw him pursue an interest in demountable buildings. Following his return to the UK, Paul continued to explore the boundaries of structural engineering on a wide variety of international projects, culminating in his work as the Project Engineer for the Millennium Dome in London for which the team was awarded the 1999 Royal Academy of Engineering MacRobert Award for Innovation, the first time that a construction related project had won in some 30 years. Over the past ten years, Paul has specialised in the engineering design of sports and entertainment buildings and has led the teams on a number of innovative and award winning projects including a stadium for Arsenal FC, the new Oval speed skating arena for the 2006 Turin Winter Olympics, the early masterplan for the 2012 London Olympic Games, the Ascot Racecourse Redevelopment and the redevelopment of the Millennium Dome into the O2 Arena. Paul is currently working as the engineering principal for the new Aviva Stadium at Lansdowne Road in Dublin, the new stadium for Tottenham Hotspur FC and the new Olympic Stadium for the London 2012 Games.

Teri Willey

Teri Willey joined Cambridge Enterprise (CE) as Chief Executive in 2006. Cambridge Enterprise exists to help University of Cambridge inventors, innovators and entrepreneurs make their ideas and concepts more commercially successful for the benefit of society, the UK economy, the inventors and the University. Prior to CE, Teri was a Managing Partner of ARCH Development Partners (ADP), a seed and early stage venture fund focused on university and corporate spin-outs. Teri, a founder of ADP, participated as a Director on portfolio company, community and venture capital Boards of

Directors and Advisory Boards, as a University of Notre Dame Business School Adjunct Professor and continues as an Advisor to ADP. Prior to the start of ADP, Teri was Vice President of Start-ups at ARCH Development Corporation, a subsidiary of the University of Chicago, which commercialised technology from the University and Argonne National Laboratory. Her experience includes technology transfer roles at Northwestern University, Purdue University and in industry. Teri has been an advisor to policy makers, universities and companies and is a past President of the Association of University Technology Managers (AUTM). Teri is a Bye-Fellow of Christ's College and a Senior Member of Hughes Hall.

Jean Venables OBE

Jean Venables OBE FREng CEng CEnv FICE MCIWEM is Chairman of Crane Environmental Ltd, Chief Executive of the Association of Drainage Authorities, Chairman of the Thames Estuary Partnership and Immediate Past President of the Institution of Civil Engineers. As Chief Executive of ADA, she represents organisations involved with water level management and flood risk management, including Internal Drainage Boards, Flood Defence Committees, Environment Agency, Local Authorities and a wide range of Associate Members. Jean has wide experience of flood risk assessment, facilitation and chairmanship, and works with colleagues to assist the construction industry, its clients and suppliers to reduce environmental risk. Jean was awarded the MBE for services to civil engineering and the OBE for services to flood defence. She holds Visiting Professorships at Southampton University, University of Strathclyde and Imperial College. She has been appointed to the ICE Water Panel, the ICE Professional Conduct Panel and is a Trustee of the Hazards Forum and a member of the RNLI Technical Committee.

He Yadong

Dr. He Yadong is a Second Secretary of Chinese Embassy to UK. He graduated from Peking University with BA degree in 1996. Afterwards, He worked in the Management Committee of Economic and Technological Development Zone in TianJin. After this he did his PhD in Peking University, and joined ministry of commerce (MOFCOM) as a researcher in the policy research department. In 2010, He went to UK as a diplomatic official. He has been engaged in research on various aspects of Chinese economy. He is the author of numerous papers including 'Twin Surpluses -A Unique Product of China's Participation in Globalisation', 'Reflection and Reconstruction of China's Model of Globalisation'.





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