Climate Change, Extreme Events, and Coastal Cities

A joint Houston-London Conference at The Shell Oil Auditorium
Jesse H. Jones Graduate School of Management
Rice University, Houston, Texas
February 9, 2005

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Conference Agenda

8:45 – 9:15 **Introduction of Conference and Key Questions**
Mark Wiesner, *Director, Environmental & Energy Systems Institute (E.E.S.I.)*
Chris Holmes, *Executive Director, Shell Center for Sustainability*

9:30 – 10.30 **Opening Remarks**
Neal Lane, *Rice University*
Judith Slater, *Her Majesty's Consul General, Houston*

9:30 – 10.30 **Review of climate change with special reference to coastal cities**
Tim Killeen, *Director of National Center for Atmospheric Research (NCAR)*
Geoff Jenkins, *Chief Coordinator, Hadley Centre, UK Meteorological Office*

10:30 – 10:50 **Break**

10:50 – 12:00 **Panel: Specific impacts of climate change on Houston and London**

Flood Prediction in Urban Areas
Phil Bedient, *Rice University*

Health in Urban Areas
Paul Wilkinson, *London School of Hygiene and Tropical Medicine*

Ecology of Coastal Urban areas
Jim Lester, *Houston Advance Research Center (HARC)*

Insurance and Climate Change
David Crichton, *Benfield Hazard Research Center at UCL*

12:00 – 1:00 **Lunch**

1:00 – 2:00 **Keynote speakers**
Elena Marks, *on behalf of the Mayor of Houston, Bill White*
Lord Julian Hunt (UCL), *on behalf of the Deputy Mayor of London, Nicky Gavron*

2:00 – 3:00 **How coastal cities can respond in a sustainable fashion to the current and future impacts of climate change**
H. J. Fernando, *ASU, NASA 100 Cities Program (and comments on the tsunami in Sri Lanka)*
David Goode, *Head of Environment of Greater London Authority (Ret'd), University College London*

3:00 - 3:30 **Break**

3:30 – 4:30 **Panel: Specific ways in which Houston and London can and are responding to current and future impacts of climate change through mitigation and adaptation**

Improving Air Quality
Daewon Byun, *University of Houston*

Architecture & Planning
Lars Lerup, *Dean of Architecture, Rice University*

Environmental Protection/Design
Chris Jofeh, *Arup Consultants*

Renewable Energy/Energy Efficiency Technologies
David Fisk, *Imperial College London, UK*

Emergency Response in Urban Areas: flooding, social systems, etc.
Dennis Parker, *University of Middlesex, UK*

4:30- 5:30 **Plenary Summaries and Discussion**
Lord Julian Hunt, *University College London*
Mark Wiesner, *Director, E.E.S.I.*

CITY OF HOUSTON
Office of the Mayor

Bill White
Mayor
P.O. Box 1562
Houston, Texas 77251
901 Bagby, 3rd Floor
Houston, TX 77002

Greetings and welcome to all those attending the joint Houston-London conference on global climate change at Rice University.

As one of the world's leading seaport cities, a capital of the energy industry and a center for excellence in many areas of scientific research, Houston understands well the importance of the discussion. We also understand our obligation to educate citizens, business and political leaders about the impacts and implications of climate change for our global city, our coastal region and beyond.

Bringing to bear the best and brightest minds from here and the U.K., we hope to highlight the need for international collaboration in determining what exactly is happening to the Earth's climate, and how we might best respond to it.

Having the most accurate and up-to-date thinking and science is the best way to shape prudent public policy.

Houston is a great city of opportunity and we want to take this opportunity to help shape a prudent response to the challenges ahead.

I commend the efforts of the conference organizers and participants to broaden and focus our understanding of our world. While you are here, I also hope you will take a measure of the essence of our city as a great and dynamic place to live, to work and to prepare for a brighter global future.

Sincerely,

Bill White
Mayor

GREATERLONDONAUTHORITY

City Hall
The Queen's Walk
London SE1 2AA

Greetings from London to all participants in the first Climate Change, Extreme Events and Coastal Cities: London-Houston Conference!

I want to underscore to you my deep commitment to tackling the dangers posed by climate change by addressing its fundamental causes. In addition, I am committed to doing everything possible to protect London from serious flooding and other problems to which climate change is a clear contributory factor.

London is a great city with world-class scientific and technological know-how, and I am glad to see that so many of our experts are with you at the Conference. One city, or even one nation alone, cannot face up to the challenges climate change poses. It requires a concerted effort by a global coalition. That is why the British Prime Minister, Tony Blair has made climate change one of his top priorities for this year, when the United Kingdom holds the Presidency of the G8.

I am delighted that Houston, another great city and the energy capital of the world, is joining with us this week to discuss and publicize the causes of climate change and to seek means of co-operating with us to address the behaviors which are contributing to the problem. I hope this will lead to the forging of many links that will last well into the future.

Best wishes for a productive Conference,

Nicky Gavron

Nicky Gavron
Deputy Mayor of London

The UK S&T Network: Strengthening Relationships with North America

Who We Are

The UK is committed to scientific growth and advancement. As part of this commitment, the UK Government established a network of Science and Technology Attachés around the world to support the Government's science and innovation agenda. Headed by the Foreign & Commonwealth Office's Science and Innovation Group (SIG) in London, the S&T Network has a variety of overarching objectives including:

- **Science Policy** — The Network inputs into UK science policy development by monitoring and reporting on policy in other countries, benchmarking UK S&T performance against other nations and emphasizing collaboration and innovative policy development worldwide.
- **S&T Collaboration** — The Network promotes the UK as a partner of choice and attracts overseas expertise in areas that will match or complement existing or potential UK strengths.
- **Wealth Creation** — The Network facilitates trade and inward investment and enhances the UK knowledge economy by promoting science and high-tech collaboration.
- **Public Diplomacy** — The Network promotes the UK as a modern, dynamic and technologically advanced nation committed to scientific advancement.

Where to Find Us

The S&T Network is always interested in building new and enhancing existing relationships. For information on how you can be involved in the Network's activities or how the Network can support your S&T objectives with the UK, look to www.uksciencetech.com. There you will find contact information for the S&T Network Attachés in your area, as well as details on upcoming events and initiatives.

UK S&T Attaché in Houston:

Dr. May Akrawi
Vice Consul, Science & Technology
British Consulate-General
may.akrawi@fco.gov.uk
713.659.6270 x 2134

Catherine Santamaria
Assistant to Vice Consul, S&T
713.659.6270 x 2135
catherine.santamaria@fco.gov.uk
713.659.6270 x 2135

British Consulate-General
1000 Louisiana, Suite 1900
Houston, TX 77002

Working With You

In meeting our objectives, the North American S&T Network undertakes a wide variety of activities that benefit the local, regional and national S&T communities in both North America and the UK. For example:

- Identifying key contacts and bringing together opinion formers and experts
- Helping to arrange missions and visits for specific technology sectors
- Analysis and reporting on S&T developments in the host country
- Raising awareness of UK S&T policy and achievements

About University College London

www.ucl.ac.uk

Founded in 1826, UCL is the Sunday Times University of the Year 2004 and the fourth-ranked UK university in the top 500 world universities for 2004 league table produced by the Shanghai Jiao Tong University. In the government's most recent Research Assessment Exercise, 59 UCL departments achieved top ratings of 5* and 5, indicating research quality of international excellence.

UCL's centers of excellence include: the Slade School of Fine Art; the Bartlett School of Architecture; Benfield Hazard Research Centre; Institute of Child Health; Institute of Ophthalmology (Moorfields); Institute of Neurology; Royal Free and University College Medical School.

UCL was the first English university established after Oxford and Cambridge, the first to admit students regardless of race, class, religion or gender, and the first to provide systematic teaching of law, architecture and medicine. UCL alumni include Mahatma Gandhi, Chaim Herzog, Junichiro Koizumi, Lord Woolf and members of the band Coldplay.

In October 2004 UCL launched Advancing London's Global University – the Campaign for UCL, a strategic plan to provide the university with the resources to develop a range of ground-breaking new projects, while reinforcing London's status as one of the world's great centers of knowledge. The Campaign seeks to raise £300 million ($500 million) over the coming decade.

About Rice University

www.rice.edu

Rice University is consistently ranked one of America's best teaching and research universities. It is distinguished by its: size — 2,850 undergraduates and 1,950 graduate students; selectivity — 10 applicants for each place in the freshman class; resources — an undergraduate student-to-faculty ratio of 6-to-1, and the fifth largest endowment per student among American universities; residential college system, which builds communities that are both close-knit and diverse; and collaborative culture, which crosses disciplines, integrates teaching and research, and intermingles undergraduate and graduate work. Rice's wooded campus is located in the nation's fourth largest city and on America's South Coast.

Today, more than one third of the world's population lives within 60 miles of a shoreline. Thirteen of the world's twenty largest cities are located on a coast. Because of their precarious location and unique meteorology, these cities are particularly vulnerable to the effects of global warming. As industrial and commercial centers, many are also net contributors of greenhouse gas emissions. Houston and London, prosperous, low-lying estuary metropolises both rapidly expanding and at risk from extreme weather events, are two such cities.

The prospect of coastal urbanization and climate change accelerating in tandem provided the impetus for an international conference held February 9th 2005 at Rice University, "Climate Change, Extreme Events, and Coastal Cities." Co-sponsored by the Shell Centre for Sustainability at Rice University, UK Science & Technology at the British Consulate-General in Houston, and University College London (UCL), the day brought together academics, policy advisers, urban designers, business people (particularly from the oil and petrochemical industries), NGOs, national and regional journalists, and the public. The ambition was to see how the differing technology and policy approaches developed in Houston and London — together with their underlying science - could profitably be exchanged and potentially applied to similarly sited cities. Not least in cities of the developing world that are encountering more acute consequences of climate change but often lacking the infrastructure and expertise to manage accordingly.

Given the reality of global warming, the question facing policy makers is both how to adapt cities to cope with the expected changes in temperatures and extreme weather systems as well as work to mitigate future greenhouse gas emissions. With urbanization set to increase across the world, it was widely agreed that, in the words of Deputy Mayor of London Nicky Gavron, "sustainable development as an idea won't succeed without sustainable cities."

Conference Themes

A range of leading environmental scientists, meteorologists, government advisers, architects, business people and practitioners addressed an array of policy and science challenges presented by climate change for coastal cities. Among the major themes stressed over the course of the two days were:

1. A broad acceptance of the reality of climate change for cities and, especially, the fact that the earth is now "committed" to 30-40 years of global warming based on existing levels of greenhouse gases.

2. The susceptibility of coastal cities to climate change. Moreover, the growing global trend towards urbanization ("the brown revolution") and, in particular, coastal urbanization made the search for policy solutions even more acute.

3. The necessity for international collaboration on climate change. In particular, the synergy which can arise from the complementary political and scientific connections already existing between the United Kingdom and United States.

4. The need for academics and technicians to assumed the role of "civic scientists" in order to engage in public debate on global warming and educate political opinion.

5. A free-market, entrepreneurial approach offered the most effective route towards adaptation to and mitigation of climate change. This necessitated well co-ordinated public / private partnerships.

6. Benefits of recent advances in modeling and data collection. But also a realization of the need for better systems of information management.

7. Need to understand the city as a living metabolism with its own impact on the environment (its "ecological footprint") and total emission levels.

8. Importance of architecture, planning and urban design in helping cities adapt to climate change and curb emissions.

9. Importance of political vision and strong civic leadership in coping with climate change and marshalling public opinion. Due to personal, political, and business connections, a realization that cities can play a unique role in encouraging the private sector to take the lead in addressing global climate change issues.

10. Because of their global dominance in the vital sectors of oil and financial services, the weight of influence Houston and London could bring to bear on this issue. Taking a lead on climate change should be regarded as an opportunity in terms of urban identity and competitive advantage.

Summary of Key Findings and Recommendations

The following summarizes key findings and recommendations delivered by the keynote and plenary sessions speakers.

1. Generating a broad a public acceptance of the scientific consensus concerning human contributions to climate change was essential to any further debate about adaptation and amelioration. This needed to be directed both at the elite level of opinion formers and elected politicians, but also amongst the general public. Participants pointed to the UK's National Environment Research Council (NERC)/Hadley Centre website (www.climateprediction.net) which simulates climate change models for postcode areas as a tool for greater public understanding. Climate and urban scale modeling along with demonstrations of energy saving and renewable energy systems might be rolled out to local and national museums (making use of US examples, such as the Museum of Science and Industry in Florida).

2. Thanks to the growth of such satellite technology as Geographical Information Systems (GIS) and Digital Ground modeling (DGM), there now exists a mass of data on climate, air quality, heat islands, flood plains, and the urban terrain. However, individual universities and research organizations frequently lack the computational capacity to analyze this amount of information effectively. There was widespread agreement on the need to co-ordinate computer workloads (e.g. NERC and the UK Hadley Centre for Climate Prediction working together with both the National Centre for Atmospheric Research (NCAR) and Environmental Protection Agency in the US). London universities attending the conference and workshops decided to co-ordinate their climate change activities by forming a London Climate Change consortium. This was set to include UCL, Imperial College, Middlesex University, University of Reading, and the Environment Agency amongst others.

3. Despite the growth in information sources, there was much to be learned about the differing constituent parts of floodwater within an urban setting. In what appeared to present an excellent opportunity for Houston-London collaboration, participants focused on the need to create a flood risk compendium which combined rainfall models, above ground flow models, and below ground pipe models.

4. In addition, there was also room for knowledge-sharing on systems which assisted in the transfer of flood-risk information to knowledge end-users. Here the discussion focused on risk management and the relationship between scientific predictability and policy. In the short term, better systems needed to be in place to ensure forecasts of extreme weather were speedily delivered to authorities and the public. Given increased knowledge of how flooding and heat affects particular population groups — the elderly, infirm, and very young - policies and publicity should be better tailored. Even a few hours warning can mitigate the impact of extreme weather. The terrible legacy of the south Asian tsunami on coastal settlements only underscored the need for effective and timely information management.

5. The tradition of entrepreneurialism in Houston and London, combined with the US and UK's free-market approach to climate change, offered new avenues for public-private partnerships. Scientists and policy officials stressed the commercial opportunities presented by climate change and the need for creating the correct regulatory environment for private sector involvement. Given the earth is "committed" to rises in temperature over the next 30-40 years, it was only rational these futures be built into business models. But reducing emissions did not need to be at the expense of competitiveness: in fact, carbon trading, clean technologies, and sustainable energy generation all promised new opportunities for skilled jobs and economic growth.

6. Business also has a broader, civic role to play in the climate change debate. Many of the UK delegation highlighted the influential role of the London business consortium, "London First", in laying the ground-work for some of the Mayor of London's sustainability policies. Engaging the vocal support of the business community, especially the oil and petrochemical industries in Houston (one of the largest contributors to the city's greenhouse gas emissions) was vital to the political task of "selling" sometimes expensive and unpopular climate change policies.

7. While there is little room for credible scientific doubt about the human contribution to climate change, there is need for greater research on some aspects of global warming. There were areas of uncertainty which remained in climate modeling — precise levels of rain-fall and sea-levels rises — and this was considered to be an area of prospective future research between NERC (especially their Flood Risk from Extreme Events Programme — FREE), and the US National Science Foundation (NSF). Nonetheless, what imprecision remained could no longer be used as an excuse for inaction. In any model, costs associated with prevarication would be far greater than potential mis-expenditure on under utilized infrastructure.

8. Similarly, while it was generally agreed that in urban areas the epidemiological consequences of climate change were likely to be highly damaging, more research was needed into the relationship between long-term air pollution, climate change and chronic health outcomes. It was suggested that this policy could be pursued in collaboration with the World Health Organization.

9. Transparent and credible information available to the public, city authorities and Non-Governmental Organizations (NGOs) was essential to developing climate change policies. Without a realization both of global warming scenarios for the city (temperature rises, storm frequencies, flooding risks, sea-level rises) and the city's own contribution to climate change (its energy consumption, ecological footprint, and greenhouse gas emissions), there was little prospect of generating the informed public debate necessary to move forward on policy.

10. The important role of the insurance industry in adapting to climate change was repeatedly emphasized. Variability of insurance provision played a key part in the planning of flood-prone areas: the United States blanket coverage of flood damage encouraged ill-advised development, whereas in England the growing refusal of insurance companies to underwrite properties at risk was leading to informal zoning. This stood in contrast to the transparency of the Scottish system of insurance agencies working with local authorities to inform planning decisions. There was a need for a more open debate about the function of insurance in climate change policy provision.

11. With both London and Houston experiencing more frequent and more powerful storms and rain fall, the capacity of the urban fabric to mitigate the effects of global warming was addressed by a number of contributors. In terms of flooding, some of the old structural solutions — the concreted bayous of Houston; the Thames Barrier in London — need additional measures for large city areas in the future. The concreting and channeling of surface water has, during extreme weather events, tended to exacerbate run-off and flooding. Instead, speakers highlighted the need for greater research into non-structural flood alleviation strategies: reviving natural systems of water ecology, updating building regulations, managing floodplains more effectively.

12. In the context of urban design, architects should plan for future climate change by factoring in shade and space into the cityscape. Parks remained an essential tool for cooling temperatures and countering "heat islands." Both for air quality and public health, cities needed to turn back the dominance of the car and revive pedestrian spaces. Holistic design will be needed so that we consider the environment of whole districts, not just individual buildings. The achievement of the London Congestion Charge — and the resulting fall in emissions — was seen as particularly encouraging. In Houston and other low density US cities, the emphasis needed to be placed on curbing the 80% of non-work automobile trips.

13. While there existed a political and rhetorical difference between the UK and US when it came to global warming and its place in international diplomatic priorities, that did not mean that innovative developments were not taking place within the US. There were many cutting-edge examples of sustainable development — in terms of housing design, co-generation energy systems, and transport technology — occurring outside federal jurisdiction at state and city level. Moreover, there was a step-change occurring in Houston public opinion. And, while climate change was not part of Texan political discourse, debates about air quality inevitably pushed global warming issues up the agenda. At the same time, climate change was surreptitiously informing design changes as planners factored in heavier rainfalls and rising temperatures. All of which offered multiple opportunities for future research and collaboration.

The US-UK Policy Background

Former Science Advisor to President Clinton and Director of the National Science Foundation, Professor Neal Lane opened the conference by emphasizing how the international nature of climate change demanded an international response. In particular, the historic warmth of UK-US relations could be mobilized to encourage British scientists and policy makers to help explain to the American people and selected representatives the seriousness of global warming and climate change. This was all the more essential given the many instances in which the present Administration has ignored scientific opinion in making important decisions and misled the public on such matters as climate change. Professor Lane explained how he felt the voice of the scientific community was being ignored or marginalized and the American people "misled." It was now clear that a scientific consensus exists on the human contribution to global climate change and the consensus is growing stronger. Federal government should be honest about the science while national political leaders need to understand their responsibility to explain climate change to the broader public and take appropriate policy actions. Unfortunately, the strength of corporate special interests in Washington is having a deleterious effect on rational, science-based policy making. The danger is that if special interests are allowed to manipulate government on matters of science, then the American people, who have always been supportive of science, could lose faith in its value. That would be a huge blow to the country and its future. In turn, this was having a direct impact on climate science funding levels. To counter such damaging influences, academics needed to assume the role of civic scientists and engage with public and politicians alike so that the scientific voice is heard amidst the welter of anti-scientific messages. US and UK scientists could usefully join forces in such an effort.

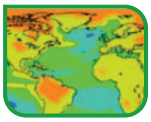
By contrast, the UK Consul-General in Houston, Judith Slater, stressed that climate change is a key issue for the British government, one of two priorities for the 2005 British presidency of the G8 group. "We believe that climate change is one of the most pressing issues confronting our cities, and are keen to raise its profile and seek solutions," she told the conference. The UK was committed to cutting its 1990 carbon emission levels by 60% by 2050. Its current strategies included a levy on intensive users of energy; an economy wide emissions trading scheme; an obligation on energy suppliers to generate 10% of electricity from renewables by 2010 rising to 20% by 2020.

The UK also ratified the Kyoto Treaty. Initiatives such as the EU carbon emissions trading scheme which followed from Kyoto were valuable. It would be good to see the US taking emissions trading forward, it had after all, been their idea. We now need to look "beyond Kyoto", in the words of Tony Blair, British Prime Minister. The US has to decide whether it wants to sit at the table and help shape the future solutions, or whether to risk marginalizing itself by not participating in the process.

In terms of urban policy, Slater underlined recent decisions in London to improve air quality and counter greenhouse gas emissions. The policy of Congestion Charging for cars entering the centre of the city had resulted in qualitative public health improvements without harming the capital's economy. And the alignment of emission curbing policies with economic growth reflected a broader policy goal. The UK government firmly believed in an entrepreneurial approach toward climate change and encouraging a regulatory environment that allowed innovation to thrive. The success of this policy was reflected in the fact that while UK emissions were down 14% on 1990 levels, the economy had at the same time grown by 30%. Such an approach offered great potential for US-UK and, in particular, Houston-London commercial collaboration. There are numerous opportunities for joint research and investment in technologies, clean energy, and climate change oriented business models.

Slater concluded, "Now is the time to move forward, and to do it together, in order to achieve first-to-market advantages; to build workable, free-market based systems that can be applied around the world to any coastal city."

Climate Change: The Current Science



Timothy Killeen, Director of the National Center for Atmospheric Research (NCAR), began by commenting on the improvements in the predictability of forecasting. The recent tracking of hurricane Ivan highlighted the success of the new United States operational weather system in modeling extreme meteorological events. This computational and analytical capacity was now being applied to climate change. In this context, Killeen was keen to emphasize that when it came to human contributions to global warming, "the jury is now in." It was impossible to understand the climate of the 20th century, according to Killeen, without appreciating man made emissions. A computer climate model of the last 1,000 years, based on coral and tree-ring evidence, pointed to a substantial leap in temperature in the late 20th century due to human impact.

Increasingly, scientists and policy makers were focusing on the built-in temperature rises which look set to occur over the next 30-40 years based on existing emissions. In a report for the International Panel on Climate Change (IPCC), NCAR has stressed the earth's commitment to rising temperatures and rising sea-levels independent of any curbing of greenhouse gases. The Centre has forecast sea-level rises of 40-60 centimeters by 2100. Forecasters were also focusing on uncertainty in the models: how mean global temperatures rises will impact in different regions and geographies. In particular, the kind of extreme weather events — flooding, heat waves, storms — which appear to be on the increase. Coastal cities were particularly vulnerable both to change in mean temperatures (with knock-on effects for sea-levels) and extreme weather events.

Killeen stressed the need for the swift transmission of this growing volume of information to end users: city managers, planners, emergency services. There needed to be greater communication with stakeholders and, when it came to extreme events, for decision tools to be tailored more effectively to societal need. Climate information had to be effectively integrated into urban planning and management. But it also needed to be taken into account by the private sector. The prospect of 40 years of rising temperatures should be factored into all forward looking business plans and approached as a commercial opportunity. There were companies to be built and jobs to be had.

Geoff Jenkins, of the UK Hadley Centre for Climate Prediction and Research, echoed Killeen's comments with a detailed analysis of 20th century climate change. Jenkins concurred that there was little room for doubt that recent changes in global temperatures were due to human activities. In specific terms, for example, "We estimate with a high probability that half the blame for the European summer 2003 heat wave can be assigned to human activities."

Similarly, when it came to future predictions, Jenkins stressed the existing commitment to global temperature rises over the next 30-40 years. Following that period, there existed a number of different potential scenarios for climate change based on emission policies. The lowest scenario pointed to a rise in land temperatures of 3 degree Celsius by 2100; the highest to 7 degrees Celsius. By 2040, the summer heat wave of 2003 as well as far heavier rates of rainfall could well be the norm for Europe. At the same time, sea levels would rise due to thermal expansion and the melting of land glaciers as well as the Antarctic and Greenland. Indeed, recent research by British Antarctic Survey glaciologists has indicated the Antarctic ice sheet is melting more rapidly than thought with knock-on effects for sea-level rises. On the lowest emission scenario and with the least sensitive model sea levels are predicted to rise by 10cm by 2100; on the highest emission scenario and most sensitive model, by 90 cm. However, Jenkins expressed skepticism about the effects of global warming in diverting the North Atlantic Current and "switching off" the Gulf Stream. Any potential reductions in temperature were more than off-set by prospective rises due to the increase in greenhouse gases.

While there existed near unanimous scientific consensus about the broader impact of climate change in terms of temperatures, sea levels and storm frequency, the magnitude and distribution of these trends was still uncertain. Much of this uncertainty was due to difficulties involved in the modeling of cloud formation. For climatologists, the challenge was to move to a probabilistic form of climate prediction explaining the likelihood of different scenarios. Probabilistic predictions will allow planners to cope with uncertainties in the predictions. "Planning for a high scenario could waste money if it doesn't come about; planning for lowest predictions could jeopardize infrastructure integrity and safety, with greater costs," concluded Jenkins.

Specific Impacts of Climate Change on Houston and London

Flooding and Coastal Ecology

Focusing on the unique ecology of coastal cities, Jim Lester, Director of the Environmental Group at the Houston Advanced Research Centre, explored their particular vulnerability to climate change. Cities such as London and Houston, which existed at a critical interface between air, land and water, were particularly susceptible to pollution and contamination from transported ecologies. In addition, their low lying, estuary sites made them highly susceptible to any rises in sea levels.

Unfortunately, according to Professor Lester, Houston's development pattern had made such weaknesses more acute. The city represented "classic urban sprawl over coastal ecology." With its large, low density population and high density roads and impervious surfaces the city was highly vulnerable to flooding. Before the development arrived, the natural ecology of the Houston delta would have managed increases in rain fall and flooding. But the constructed environment had pushed back forest and wetland ecologies and undermined natural flood alleviation mechanisms.

Philip Bedient, Professor of Engineering at Rice University, supported the thesis by listing the major causes of flooding in the Houston basin as: a highly developed area; the intensity and duration of Texas rainfall; flat topography with little storage; poor building practices in floodplains; and modern methods used to replace storage with local and regional level detention ponds. These conditions led to Houston suffering heavily at the hands of flooding — most recently, the $5bn price tag after the inundations accompanying Tropical Storm Allison. The flooding heavily damaged the urban infrastructure and, because of the release of human waste from sewers and medical waste from hospitals, posed a severe public health risk.

Bedient concurred with Lester's ecological approach by suggesting that the traditional structural solutions to flooding might no longer provide the entire solution. The strategy of channeling the water by concreting the historic bayous took little account of future climate predictions of larger storms and greater rain-fall. In such circumstances, the concreting and channeling of surface water tended to exacerbate run-off and flooding. Instead, Bedient outlined an approach based on a more overarching understanding of Houston as an hydrological area and underpinned by new technologies enabling better analysis of topography and water flows. Such data pointed to the necessity for non-structural strategies to alleviate flooding. Property buyouts, flood proofing, floodplain management zoning, public education, and regional detention ponds offered solutions more in line with the natural ecology of the city. The hydrology infrastructure in the Woodlands planned community north of Houston was a successful example of a non-structural approach.

In line with Tim Killeen's comments, Bedient stressed the necessity for the swift transmission of weather information to end-users. For example, the development of a real-time flood alert system in Houston was allowing the frequently flooded Texas Medical Centre to effect appropriate contingencies. A new real-time precipitation measurement system, NEXRAD, (was achieving 85-90% accuracy of rain levels and providing vital lead times of 2-3 hours in advance of inundation. Given the predicted frequency of storms and high levels of rain-fall in the coming decades, it was essential that investment continued in such warning systems. But, accompanying it, there needed to be far greater respect for the city's natural flood plain.

Later in the day, the question of information management was pursued further by Dennis Parker, Professor of Environmental Management at Middlesex University, in an analysis of British flood warning systems. Professor Parker focused on the issue of public understanding of risk. One of the more unfortunate consequences of the success of the London Thames Barrier in preventing sea-level rises inundating the capital was a low level of public expectation about flooding. Over the last twenty years, Londoners had not tended to think about the risks and were generally unprepared. This stood in contrast to Holland where a programme of education had kept residual flood-risk in the mind of public and politicians alike. In the wake of increased flooding across the UK and government funded awareness campaigns, British public's attention to this issue is on the rise.

At the same time, warning systems were becoming more sophisticated across the UK. In addition to traditional methods — such as door to door announcements; telephone calls and radio segments — emergency authorities were also beginning to use television, mobile phones (and WAP phones), email, and real time web data. From such usage, there was emerging increasing clarity about the domestic recipients of flood warnings. According to data from Middlesex University, 54% of residents were female, 36% of residents were aged 55 yrs and over, 8% were from an ethnic minority with various first non-English languages, some 18.2% had a long-term illness, health problem or disability which limited daily activities, and 14% or more suffered mild or moderate deafness. All of which was allowing city leaders to draw up far more tailored programs of emergency information management. However, what was still lacking was a comprehensive system of post-flood care for the numerous physical and mental after effects of flooding.

Health in Urban Areas

Indeed, the health impacts of climate change in urban areas were widely regarded as a field requiring much greater consideration. Paul Wilkinson, Professor at the Centre on Global Change and Health at the London School of Hygiene and Tropical Medicine, began by suggesting that the health effects of global warming would be felt far heavier in the cities of developing nations rather than London or Houston. The global poor would face the most chronic health consequences with notable increases in diarrhea and malnutrition.

Nonetheless, first world cities would not be unaffected. One of the most tangible consequences of global warming would be a rapid increase in temperature in urban areas with knock-on effects for mortality. The August 2003 heat wave in Europe was a taste of things to come. According to Professor Wilkinson's analysis, the cumulative rise in temperatures resulted in 2045 excess deaths in England and Wales (a 16% hike). In Paris, the average rate of 50 deaths per day shot up to 315 per day. Nationally, 15,000 deaths occurred in France because of the heat wave; across Europe, the figure was 25,000 lives. Part of the impact was related to air pollution — especially ozone — but the direct effects of temperature far outweighed those of air pollution.

Turning to flooding, Professor Wilkinson drew on historical data drawn from the great storm of 1953 which claimed 307 lives along the Eastern seaboard of England. While most of the deaths occurred amongst the elderly, a far broader section of the population was affected by the flooding. The long-term health consequences of flooding were not fully appreciated. In the context of 1953, a comparative study of the flooded area and non-flooded during the following year pointed to a 50% increase in mortality amongst the flooded; over 100% increase in hospital admissions and referral; and a 53% increase in General Practitioner attendance. Because of the disruption and trauma, there was also a substantial increase in Common Mental Defects — especially amongst women. Wilkinson suggested that health impacts were rarely taken into account during planning for flooding.

Many climate models pointed to the growth of vector-born diseases — such a malaria or Nile fever — in previously disease free areas due to the rise in temperature. However, Wilkinson was skeptical of an obvious link between rises in temperature, the emergence of more suitable climates for mosquitoes, and the growth of disease. Other factors were equally as important to the flourishing of vector-born disease as temperature — not least such indicators of socio-economic development as healthcare, windows, environmental services, etc.

While cities such as London and Houston faced difficult challenges from global warming, they were also net contributors to greenhouse gas emissions the full effects of which would be more severely felt in other, less developed cities. Houston and London had a duty to adopt policies aimed at curbing emissions. Domestic energy efficiency in the UK was an area which required improvement. But the fabric of cities themselves needed to change. Both for air quality and public health, cities needed to turn back the dominance of the car and revive pedestrian spaces.

The issue of air quality was pursued in greater detail later in the day. HJ Fernando, Professor of Mechanical Engineering at Arizona State University, outlined the contribution which the NASA 100 Cities programme was making to the modeling of urban environmental phenomena. By examining 100 rapidly developing urban areas, satellite technology was allowing the precise monitoring of air pollution, heat islands, energy use, urban surface materials, soil properties, and regional climate systems. Such a range of data offered city leaders new opportunities for fostering debate and making informed policy decisions about public health in urban areas.

It was precisely such satellite imagery which Daewon Byun, Professor of Geosciences at the University of Houston, used in his discussion of land use and air quality in the Houston-Galveston area. As Jim Lester had earlier suggested, the siting of coastal cities made them particularly vulnerable to climate change. Byun developed the idea by exploring how shifts in land use and land cover affected local heat islands, land-sea breezes, and air temperatures. In the case of Houston, extensive and ongoing deforestation was leading to significant rises in ozone concentration with potential knock-on effects for public health. Meanwhile, any improvements in car emissions was more than off-set by growth in traffic and further changes in land cover thanks to the construction of extra road surfaces. Only very reluctantly was a comprehensive assessment of land use and land cover being factored into policy making. And, echoing Professor Wilkinson, Daewon Byun suggested far more work needed to be done in assessing the health effects of regional climate change and air quality.

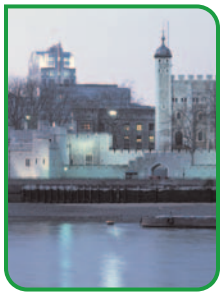
Insurance and Climate Change

The UK and European insurance industry was waking up to the implication of climate change. David Crichton, Visiting Professor at the Benfield Hazard Research Centre at University College London, outlined how together with leading financial institutions they have begun to co-ordinate a major lobbying exercise to highlight the environmental and commercial risks of global warming. Under the auspices of the United Nations Environment Programme, 200 major banks and insurance companies have made a commitment to the environment and to lobby governments at climate change conferences for ameliorative policies. Under the Carbon Disclosure Project, 95 institutional investment companies with assets of $10 trillion are demanding carbon emission information. Currently, some 300 of the top 500 companies in the world now feel obliged to disclose details of their carbon emissions. In addition, the Investor Network on Climate Risk is a consortium of institutional investors putting direct pressure on individual oil companies and other investors.

Professor Crichton was adamant that architecture and urban design were at the heart of any comprehensive response to climate change in cities. But variability of insurance provision was often an undermining factor when it came to the planning of cities for such extreme events as storms and flooding. In the United States blanket coverage of flood damage encouraged ill-advised development, whereas in England the growing refusal of insurance companies to underwrite properties at risk was leading to informal zoning. Local authorities were continuing to build in unsuitable areas (in 2003, 600 new housing subdivisions were developed despite objections on grounds of flood risk), but insurance companies were often unwilling to provide cover. This situation marked the end of a tacit contract between the English insurance industry and the government: the former would provide cover for all if the latter controlled flood plain development and invested in flood defenses. The failure to provide such investment had led to the collapse of the accord. By contrast, Professor Crichton highlighted the transparency of the Scottish system whereby insurance agencies informed local authority planning decisions by declaring their intention to underwrite new developments.

In conclusion, the presentation also highlighted some projected areas of concern for the insurance sector. On a global scale, the impact of Chinese urbanization and industrialization — together with vast growth in car use and manufacture of consumer durables — threatened to accelerate global warming trends markedly. By 2010, China's energy consumption is projected to have doubled. More immediately, Professor Crichton pointed to a recent increase in dam failures — a source of potential disaster given their frequent location near urban centers. Meteorological research also suggested that the power and trajectory of winter storms over France and Britain were set to head inland with greater force. This offered the prospect of extensive future insurance claims.

Climate Change and City Hall



London

"Climate change and sustainability are climbing the political agenda. In the UK, there is a growing consensus about the need for more urgent action and that with increasing urbanization, the role and function of cities to act positively is central," was how Deputy Mayor of London, Nicky Gavron, opened her comments to the conference, presented by Lord Julian Hunt. She went on to position London within the broader UK political environment of focusing on climate change as a national priority.

In terms of urban policy, Gavron outlined the "London Plan": the framework which the Greater London Authority (GLA) had adopted with regard to transport, energy, waste and air quality strategies. The most tangible policy development was the implementation of a Congestion Charge for vehicles entering central London between 7am – 6.30pm Monday to Friday. As a result, there had been a 30 per cent drop in congestion and 30 per cent reduction in cars usage, leading to improved journey times and reliability. This had spurred a substantial shift to public transport, especially buses. Initial monitoring showed a 19% drop in CO2 emissions from traffic inside the zone. Building on the policy, the ambition was now to extend the congestion charge further and, by 2007, to make London a Low Emission Zone with only low emission trucks, buses, coaches and taxis operating in the entire Greater London area.

However, transport was only one part of the agenda. Some 70% of London's CO2 emissions came from buildings. To curb the release of greenhouse gases, the Mayor was establishing the London Climate Change Agency to engage with the private sector to promote sustainable design and construction for all corporate, institutional and domestic buildings. This will supplement work with developers and seek to achieve new standards in sustainable design and construction. Equally important were sustainable and secure energy infrastructure projects. A key element to this strategy was locally distributed combined heat, power and cooling (trigeneration) for large new developments, where possible extended to serve existing communities. The aim was for an increasing proportion of power to come from renewable sources. Transitional use of natural gas will be replaced with renewable energy and hydrogen as they become more cost effective.

Deputy Mayor Gavron concluded by emphasizing that, "Successful models and real-world solutions developed either singularly or collaboratively by Houston and London have application in cities around the world. The lessons we are learning will lead to a healthier environment for ourselves and our children."

Some of the more detailed thinking behind the Mayor's policy framework was provided by David Goode, Visiting Professor at UCL and former Head of Environment at the Greater London Authority. First, there was the probability and costs of global warming. The capital was at risk both from increased flooding due to rising sea levels and severe rain fall incidents as well as high summer temperatures. Extended heat waves, exacerbated by the city's heat island effect, could prove highly detrimental to air quality and increase demand for energy for cooling in both buildings and transport systems. The costs associated with climate change were extensive. Solely in terms of flooding, 500,000 properties (with an estimated value of $150 Billion), 1.25 million residents, 400 schools, 16 hospitals and 8 power stations were at risk in the Thames Estuary. It was such a financially disastrous prospect which had helped to generate the support of the city business community through the "London First" consortium.

The GLA was interested in more than just structural adaptations to global warming. The underlying philosophy guiding their approach to climate change was an appreciation of the city as an urban metabolism. And this, in turn, could only be understood by realizing the extent of the city's ecological footprint — i.e., the amount of natural resources it required to function. Through an analysis of energy consumption, waste management, carbon emissions, etc., Professor Goode had concluded that London had a footprint 293 times its own size — i.e., about the size of Spain. The environmental ambition underpinning the Mayor's climate change policy was thus to reduce the city's ecological impact. The vision of London's City Hall was both to adapt to global warming and move the city towards a model of sustainable development in energy, transport, construction, resource use and food supply. "The challenge is to move from an unsustainable, linear urban ecosystem to a sustainable, natural ecosystem with cyclical processes," explained Professor Goode.

Houston

Speaking on behalf of Houston Mayor Bill White, his senior environmental adviser Elena Marks outlined how the challenge for urban areas seeking to confront climate change was daunting. Indeed, it was all too tempting for city leaders to dismiss the issue as too big and best left alone. However, there was a tangible need to translate to the average citizen the impact of their life choices.

The statutory limitations constraining the Mayoral office in terms of environmental policy was an issue repeatedly addressed. For example, the Mayor was determined to improve Houston's air quality and curb industrial pollution. Yet a truly coherent policy demanded action at state and federal level. In turn, this required a more regional than city approach and a multi-agency deployment of resources. Indeed, the very monitoring of industrial pollution — an absolutely crucial step toward identifying and alleviating the problem — required close collaboration with the federal Environmental Protection Agency. When it came to automobile pollution, the city was similarly limited in its powers. While the Mayor was committed to converting the municipal fleet to hybrid and incentivizing contractors to use clean equipment, there was not much the city could do in terms of emission levels.

However, the Mayor's Office was committed to working with the business sector to address greenhouse gas emissions and reduce Houston's contribution to global warming. This was not easy in a petro-chemical capital. While the threat of legal action was a necessary last resort, the administration was keen not to get bogged down in legal wrangles. The way to effect change was to work within an accountability system with clear emission goals including operational change. But Houston was also an intellectual capital with a vast wealth of scientific knowledge. In the past, this had not always been mobilized for the more immediate advantage of the metropolitan area. The Mayor was now hoping to establish an expert advisory panel of scientists.

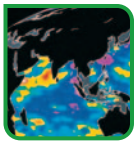
Finally, during questions, Ms Marks noted the different rhetorical conventions adopted in Houston and London. In Texas, they did not talk of "climate change." It was, she explained, a form of language "which puts people off." While the same ambition existed of reducing greenhouse gases and industrial pollution, to ensure public support it was best to talk in terms of "sustainable development."

Amelioration and Adaptation: Design and Technology

"As designers we have contributed to the problem, now we need to reduce it," was how Chris Jofeh, a director of Ove Arup & Partners, began his discussion of engineering/architectural responses to climate change. The structural and interior design of new buildings had much to contribute both in terms of reducing energy demands and creating liveable urban environments. Ove Arup had itself pioneered a sustainable development scoring system — known as SpeAR (Sustainable Project Appraisal Routine) — which established a framework for understanding the impact of new builds in terms of the Environment (air quality; land use; water; ecology and cultural heritage; design and operation; transport); Natural Resources (materials; water; energy; land utilization; waste hierarchy); Economy (social benefits and costs; transport; employment / skills; competition effects; viability); and Society (health and welfare; user comfort and satisfaction; form and space; access; amenity; inclusion). As such, it was a tool for encouraging the right questions to be asked. The firm was now using this approach in two major new developments in coastal cities: Stratford City in East London and Dongtan Eco-City on the Chinese coast. There is no point, Jofeh, emphasized at which either development will have "arrived" at sustainability. But by deploying renewable materials, drawing on green energy, and — in the case of Stratford — using excess ground water so alleviating the London water-table, each project will be part of a sustainable process.

Yet differences could also be achieved at a more micro level. Renewable energy could be built into residential developments. Indeed, Ove Arup's own BedZED housing project in London had shown one possible future: relative to a house built to 1995 Building Regulations it required 10% of heat demand, 40% of power demand, and 2/3 water demand. All its energy demands were met by on-site renewable energy (Solar PV and Biomass CHP) and the development was entirely carbon neutral. In terms of the cityscape, imaginative use of shade, open space, and manipulation of wind could all turn stifling downtown districts into pleasant, open air environments. As Jofeh put it, "World cities have always needed engineers and architects with imagination to make them live."

This tradition of innovation was underscored by the presentation from David Fisk, Professor of Engineering at Imperial College and Chief Scientific Advisor to the Office of the Deputy Prime Minister in the UK. Cities had historically been at the forefront of innovation and technology and the current age was no different. The most sophisticated marketing and publicity campaigns now focus not on nations, but world cities. Contrasting two potential futures of a Bladerunner nightmare scenario and an urban model inspired by the sophistication of the International Space Station, Fisk challenged Houston and London to marshal their innovative cultures towards creating sustainable cities. One such avenue for research was the 5-Volt office. Aligning himself with earlier suggestions that climate change be regarded as a commercial opportunity, Fisk suggested how economic rather than ecological incentives would inspire businesses to hone down costs with intelligent design, green energy, and high technology products. The challenge for policy makers was to create the framework in which such an "innovative city" might emerge.



Conclusion

Lord Julian Hunt, Professor of Climate Modeling at UCL and member of the House of Lords, concluded the day's discussion by returning to Houston and London's similarities: their estuary geography, their vulnerability to extreme weather, and their rapid rate of urbanization. As the conference had shown, they also shared a belief in scientific research and commercial enterprise as essential tools in approaching climate change.

The range of data and timescales discussed had pointed to an overarching theme of the day: the mass of information available and the opportunity it presented for a quantifiable, methodological approach to sustainable development. What was more, the growth in visual data from space and the physical tracking of the city might herald a more sophisticated public engagement with urban policy. There was now the opportunity to unite the hard sciences with social and political problems in a transparent framework. Vital to that process was a more sophisticated understanding of risk. This would entail a more transparent explanation of the connections between scientific predictability and policy. And in this context, Professor Hunt concurred with Geoff Jenkins assertions: making the assumption that climate change is here and happening for the foreseeable future was by far the least risky option for planners and politicians alike.

Education and rational discussion was essential to this process. As David Fisk had suggested, cities had certainly been drivers of technological innovation across history, but they had also provided a public domain: arenas for rational debate and public discourse about the compelling issues of the day. In terms of generating an approach to adapting to and mitigating climate change, their civic duty in this regard was just as vital as their progress in science and technology.

Workshop Reports

Climate Change

Chairs: Ron Sass *(Rice University)*, Alan J. Thorpe *Natural Environment Research Council (NERC)*
Focus: Interplay between climate change science and public policy

The workshop felt there was a widespread need to promote the visibility and public understanding of information about climate change. Participants pointed to the UK's NERC / Hadley Centre website (www.climateprediction.net) which simulates climate change models for postcode areas as a tool for greater public understanding. Climate and urban scale modeling along with demonstrations of energy saving and renewable energy systems might be rolled out to local and national museums as well as retail and civic spaces. A good example of engaging public audiences about climate change was taken to be The Museum of Science and Industry (MOSI) in Tampa, Florida's exhibit "Disasterville", on Natural Disasters, (funded by a $1.58 million NSF grant).

One potential research area which could be developed as a UK-US joint initiative was the basic science about future flood risk based on climate change. In Britain, the NERC have initiated funding of a Flood Risk from Extreme Events (FREE) Programme. This could be a project that the US National Science Foundation might be interested in joining up to since the two bodies already co-operated on the science of rapid climate change. There existed other scientific areas demanding broader international co-operation — not least in terms of computer capacity — such as the carbon cycle; the frequency / intensity of weather systems; adaptive grids; linked statistical and dynamical predictive methods.

Finally, participants agreed on the need for extra research on the dispersal of chemical and waste pollutants by flooding and short-term weather prediction.

Planning and Transportation

Chairs: Jeff Taebel *(Houston-Galveston Area Council)*, Phil Steadman *(University College London)*
Focus: Relationship between land-use, urban transportation and mobility, and demographic and economic forecasts in the context of London and Houston.

The workshop focused on opportunities within land use and transport for adapting to and mitigating climate change within Houston and London. A large part of the discussion centered around density and the capacity for changes in modes of transport. Obviously, the startling differences in density levels between the cities — with Houston housing 2,500 per square mile as opposed to London's 15,000 per square mile - had significant implications for transport and planning. And while there were some differences about the very desirability of density, there was agreement that shifts in transport provision (such as light rail) offered a chance for changes in density levels (with clustering around transport nodes). The question the group addressed was what reductions in vehicle miles and carbon emissions might feasibly be achieved within an auto-centred metropolis.

Traditionally, transport and urban planning models had tended to focus on the drive-to-work commute. But in Houston only 16% of all car trips are work oriented. And while this might account for 30% of all vehicle miles, the myriad journeys to school, shops, and friends etc. account for a much greater proportion of shorter car journeys. These non-work trips might represent the low hanging fruit for emission reduction. Curtailing them would require changes in planning to foster the type of liveable, walkable communities that can avoid excessive car usage. However, within the Houston planning scheme many decisions on land use have already been taken looking twenty years down the line. There existed a severe disjuncture between land use timetables and the more urgent demands required by climate change.

A potential Houston-London research programme would entail a comparison of the two cities in terms of patterns of land use and energy use as well as comparisons in terms of planning controls and governance. Part of that process would be an investigation using simulation models to look at modal shifts in terms of transport hubs, urban density, and non-work journeys.

Alternative Energy

Chairs: Jacqueline Weaver *(University of Houston Law Center)*, John Murlis *(University College London)*
Focus: Design of energy systems more resilient and capable of coping with the effect of extreme events caused by global climate change

The ambition of this workshop was to develop a research strategy focused on reducing the energy intensity of the economy; reducing the pollution burden; and resilience (to natural hazards) in coastal cities. The question was, how can an intelligent infrastructure enable clean and secure energy for our cities?

The hope was to learn from each other's academic and policy communities in building research networks and exploiting case studies with common protocols. London, for example, had much to learn from Houston's focus on air quality as part of a broader climate change agenda. Alternatively, Houston's flood subsidy system could benefit from a study of the London insurance market and its use for land planning. Other areas for collaboration included:

- IT Support and Pricing signals for managing traffic congestion
- Smart housing designs such as that pioneered by Energy Star (which runs 30,000 homes with 15-20% more energy efficiency)
- Distributed generation and best practice in net metering — ensuring the supply to network is charged properly
- Energy alternatives — including the full cycle of Hydrogen
- Power supply and David Fisk's concept of the 5 Volt office
- Co-generation of heat and power — such as that carried out by Shell Chemicals in Houston combined heat and power operations with a doubling of efficiencies

Public, Private Partnerships

Chairs: Victor Flatt *(University of Houston Law Center)*, Richard Munton *(University College London)*
Focus: Partnerships and their role in coastal cities given climate change

Under current trends, we are increasingly dependent on the private sector to accomplish climate change goals and, in the future, we will depend on them even more. As we move to more private sector funding, we are also going to give them more control. If corporations seek to deal with adaptation and mitigation, they will do so with their own commercial benefit in mind. But how will these costs fall on others? When the government addresses such issues there is an assumption that it will be dealt with within the body politic. However, such assumptions no longer hold when private sector firms are setting the pace. There is the additional problem of having information controlled by the private sector.

In future, it seems the government role will be different but not wholly absent. It must seek to act as the guardian of any private sector take-over: overseeing the regulatory environment and securing open information. Local government, in particular, has the chance to become more influential. It can make a difference by educating both public opinion and business leaders. Because of their global dominance in the vital sectors of oil and financial services, the city leaders of Houston and London could bring especial weight to bear on this issue. Taking a lead on climate change should be regarded as an opportunity in terms of urban identity and competitive advantage. Local government has the chance to make a global impact.

Potential areas of research were identified as:

- Enforcement strategies: what is going to happen if the private sector increasingly assumes control of climate change policy and how can government seek to regulate and enforce control?
- How can local government achieve more results from local education strategies on climate change?
- How can government facilitate subsidies for losers in new energy systems: if one sector is harmed by adaptation, how can they set up incentives? Alternatively, can the public buy into wind farm profits?
- The powers local government has to incentivize, educate, and regulate
- Can we establish a Houston Climate Change Partnership modeled on London?

Environmental/Air Quality

Chairs: Jim Lester *(Houston Advanced Research Council)*, Jan Peter Muller *(University College London)*
Focus: Health and environmental effects compounded by climate change

The workshop identified the key areas of research in health policy to be:

- Filling knowledge gaps in the link between long-term air pollution exposure and chronic health outcome
- Follow-up studies on impacts of extreme weather events (e.g. flood) which could be applied to industrial accidents and an evaluation of the impact of future events
- Understanding why there is a greater vulnerability to extreme heat in London cf. Houston
- Understanding the impacts of intervention (e.g. notification of poor air quality; expansion of the Metroline; congestion charge zoning) in health improvements

In terms of environmental effects of climate change, the most encouraging avenues of investigation were:

- How much air pollution is caused locally and how much comes from other locations (e.g. forest fires; Toxic tracers) and if so, from where?
- Linkage of disease tracers and aerosol transport and how these affect Houston and London
- How climate and global emissions change affect air pollution levels (and hence health) and how this impacts plans on determining or attaining regulatory limits
- Release of legacy chemicals (Stockholm Treaty "dirty dozen") as a result of global warming in Houston and London
- Mapping biogenic emissions (oil rapeseed around London and forests around Houston) and its relationship to respiratory diseases
- Ecological footprint production for Houston (leveraging off the one developed for London) and how this is changing as a result of the population increase

Based around this agenda, practical steps forward might include:

- Developing specific research proposals around extreme thermal events; exploitation of data assimilation, satellite and *in situ*; quantifying the ecological footprint of Houston
- Technology collaboration between London and Houston in terms of night-time lights and the use of MISR (and MODIS) for mapping aerosols at the local scale.

Flooding and Emergency Response

Chairs: Phil Bedient *(Rice University)*, David Butler *(Imperial College London)*
Focus: Adequacy of predictability and response capabilities

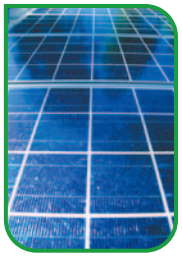
The workshop concurred that there existed strong similarities between flooding issues in Houston and London, but most research remained focused on fluvial flooding rather than pluvial flooding from sewers. Moreover, we are extremely data rich, but need better ways of handling and exploiting the mass of information we have. For example, in terms of flood risk mapping: more needed to be done in identifying flood probabilities and linking that with flood consequences. We know that storms are now of higher magnitude than previously, but we have yet to explain properly that flood risk is therefore much greater.

Among the potential research topics mooted were:

1. There was more to be learned about the differing constituent parts of flood water within an urban setting. In what appeared to present an excellent opportunity for Houston-London collaboration, participants focused on the need to create a flood risk compendium which combined rainfall models, above ground flow models, and below ground pipe models.

2. Model application and comparison case studies: modeling the hydrology and hydraulics of London using the Houston model and compare with the existing Thames Water model. There was also room for comparing and contrasting radar rainfall data available in both cities and sharing experience of benefits and problems.

3. Bilateral seminars on flooding issues in US and UK addressing leading edge developments; technology transfer; state of the art reviews; practical implementation strategies; and academic-industry-government networking.

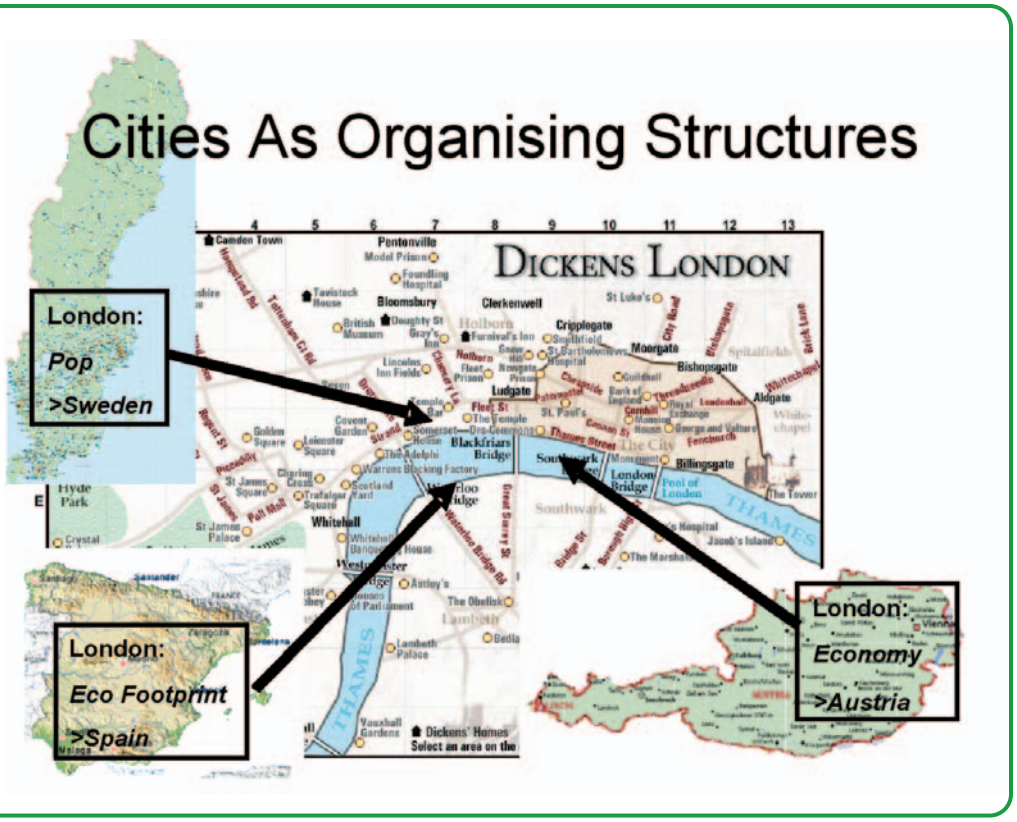


Additional Reports

Renewable/Energy Efficient Technologies — Cities, Networks & Energy Integration

David Fisk, *BP RaEng Professor Engineering for Sustainable Development Imperial College London*

The city of the 21st century whether in the developed or developing world is of a size comparable with a nation state at the beginning of the 19th century. London has an economy larger than Austria, a population larger than Sweden and an eco-footprint on the planet larger than the area of Spain. The importance of the city as a structure is almost taken for granted by the private sector. For example the private sector will know within the city where are the stores that need to be stocked with the innovative product and than those that will follow. "City" here is meant not just the public services, important though they are, but the whole social and industrial mix that defines what is meant by being "in" "London" or "Paris" or "Houston".



Speaker Bios

Dr. Philip B. Bedient is the Herman Brown Professor of Engineering in the Dept of Civil and Environmental Engineering at Rice University. He teaches and performs research in surface and ground water hydrology and flood prediction systems. He served as Chair of Environmental Engineering from 1992 to 1999. He has directed 50 research projects over the past 28 years, has written over 120 articles in journals and conference proceedings. He is lead author on a text on Groundwater Contamination (Prentice Hall, 1999) and his textbook on "Hydrology and Floodplain Analysis" (Prentice Hall, 3rd ed., 2002) is used in over 70 universities across the U.S. Dr. Bedient received the Shell Distinguished Chair in Environmental Science (1988 to 1993), and recently received the Herman Brown endowed Chair of Engineering at Rice University.

Daewon Byun is Professor of Geosciences and Chemistry at the University of Houston and Director of the Institute for Multidimensional Air Quality studies. He was technical leader of the EPA Models-3 Community Multiscale Air Quality project and is a committee member for NCAR, NOAA, Community Modeling and Analysis System, TCEQ, Houston Advanced Research Center.

Professor David Crichton, MA, FCII, is a Chartered Insurance Practitioner and visiting Professor at the Benfield Hazard Research Centre at University College London (the leading hazard research centre in Europe) and at Middlesex University Flood Hazard Research Centre (the leading flood research centre in the UK). He also is a Research Fellow at the University of Dundee, (the home of the UK National Flood Insurance Claims Database, and the British Hydrological Society flood events database); member of government and academic boards, including the Research Committee on Building Standards in Scotland; and member of the UK Advisory Committee on Natural Disaster Reduction, part of the United Nations ISDR initiative.

David has many years' experience in the insurance industry at senior management level. He has held senior underwriting and claims management positions in both property and casualty business, and has won a number of insurance industry awards. He advises insurance companies on strategic issues such as climate change impacts and was a contributing author for the Greater London Authority report on climate impacts on London and also a report on climate change and flooding for the Scottish Executive.

Dr. Harindra Joseph Shermal Fernando is Professor, Department of Mechanical and Aerospace Engineering and Director, Environmental Fluid Dynamics Program at Arizona State University. He is the recipient of numerous national and international research awards, and has had academic appointments at the California Institute of Technology and the University of Cambridge, among others. Dr. Fernando received his undergraduate training at the University of Sri Lanka, and obtained his Ph.D. from The Johns Hopkins University.

Professor David Fisk is holder of the Royal Academy of Engineering Chair at Imperial College London in Engineering for Sustainable Development. At Imperial he leads the cross campus advanced energy in buildings program. He is currently Chief Scientific Adviser to the Office of the Deputy Prime Minister in the UK. He is a member of the Council of the Royal Academy of Engineering. Until 2001 he was Director Central Strategy in the Department of Environment Transport and the Regions. He was responsible for the Department's policy towards the European Union, sponsorship of the Health & Safety Commission and Executive, and the handling of DETR cross-cutting issues including "futures" studies and risk. He was previously responsible for the development of UK Climate Change Policy, including negotiating the Framework Convention on Climate Change and its Kyoto Protocol: the UK's first National Air Quality Strategy; policy on the safe release of genetically modified organisms and chemicals into the environment, and policy on the disposal of radioactive and other wastes. He is a Fellow of the Royal Academy of Engineering, a Fellow of the Institute of Physics and an Honorary Fellow of the Chartered Institute of Building Services Engineers. He received a CB in the 1999 New Years Honours List for services in the Department of Environment.

Professor David Goode is a Visiting Professor at University College London and was recently Head of Environment at the Greater London Authority. He has worked for many years as a professional ecologist in both central and local government. His work has ranged from the conservation of threatened habitats to the complexities of urban sustainability. Prof Goode has written extensively on environmental issues including an essay on Cities as the Key to Sustainability in a recent book on Human Futures. For many years he was Director of the London Ecology Unit where he developed a major program for biodiversity conservation within the urban environment and for implementation of sustainable development projects.

At the Greater London Authority Prof Goode was responsible for developing the Mayor's Environmental Strategies, including Waste Management, Air Quality, Biodiversity Conservation, Noise and Energy. This required an overarching approach to ensure that these policies for sustainable development were contained in the overall London Plan. As an ecologist he has argued for a radical approach to the management of cities based on ecological principles. His role at the GLA was to ensure that the strategies for London provide a framework for achieving environmentally sustainable solutions.

Christian Holmes serves as Executive Director of both the Rice University Shell Center for Sustainability and the Environmental and Energy Systems Institute (EESI). He has held a number of senior executive positions including Vice President for Environment, Safety and Health at Tenneco Energy; Chief Financial and Administrative Officer for the U.S. Environmental Protection Agency; Director of the U.S. Trade and Development Agency; and Executive Director of the President's Task Force on International Private Enterprise.

Professor Lord Julian Hunt, CB, MA, PhD, FIMA, FRS, has been Professor of Climate Modeling in the Department of Space & Climate Physics, and Earth Sciences, and Honorary Professor of Mathematics at University College London, since 1999. Formerly he was at the University of Cambridge where he was Professor of Fluid Mechanics. He is still a Fellow of Trinity College. He is also a J.M. Burgers visiting professor at the Delft University of Technology. He is a Fellow of the Royal Society. He has honorary degrees from Salford, Bath, East Anglia, Warwick, Grenoble, and Uppsala. In 2001 he has been awarded the L.F. Richardson medal for non-linear geophysics by the European Geophysical Society. He was Director-General and Chief Executive of the Meteorological Office from 1992-1997, and was created a Baron in the House of Lords (with the title Lord Hunt of Chesterton) in May 2000. He is chairman of Cambridge Environmental Research Consultants Ltd., which is working world wide on air pollution modeling and forecasting; he helped found it in 1986. In his research, he has developed new approaches to modeling turbulence, atmospheric flows around buildings and over mountains, and the dispersion of environmental pollution.

Geoff Jenkins is at the Hadley Centre for Climate Prediction and Research, part of the Met Office based in Exeter, UK. He managed the first scientific assessment for Working Group 1 of the Intergovernmental Panel on Climate Change in 1988-1990, under Sir John Houghton. After a spell at the Meteorological Research Flight, he returned to the Hadley Centre in 1995 and managed the Climate Prediction Programme there. He has been co-author of "Scenarios of Climate Change for the UK", published in 1998 and 2002, and is currently planning the next update. Close liaison with the UK Department of the Environment is an important aspect of the job, including frequent briefing for planners, policymakers and ministers.

Chris Jofeh is a civil and structural engineer and a director of Ove Arup & Partners, based in Arup's Cardiff Bay office since 1991, following three years as structural principal in Los Angeles, where he gained his California professional qualification. Chris is the author of the UK Institution of Structural Engineers design guide on the structural use of glass in buildings and is a member of the Institution of Structural Engineers' Journal Advisory Panel. His research interests are focused on climate change and the environmental physics of large volume enclosures in hot arid regions. Chris has also worked in Saudi Arabia, Qatar and Kuwait and has taught and lectured in the USA, Hong Kong and Australia. Chris has been responsible for leading multidisciplinary design teams on a wide range of major building projects in the US and the UK.

Timothy L. Killeen is the Director of the National Center for Atmospheric Research (NCAR). In that role he has overall responsibility for the scientific, technical, and educational activities of the Center, which has an annual budget of over $130M and is home to over 800 permanent scientific and technical staff. Dr. Killeen is also a senior scientist at the High Altitude Observatory (HAO) where he leads an experimental and theoretical program in upper atmosphere research. Dr. Killeen received a BSc in Physics in 1972 and a Ph.D. in Atomic and Molecular Physics from University College London in 1975. He is a U.S. citizen.

Neal Lane is the Malcolm Gillis University Professor at Rice University. He also holds appointments as a Senior Fellow of the James A. Baker III Institute for Public Policy, where he is engaged in matters of science and technology policy, and in the Department of Physics and Astronomy.Prior to returning to Rice University, Prof. Lane served in the Federal government as Assistant to the President for Science and Technology and Director of the White House Office of Science and Technology Policy, from August 1998 to January 2001, and as Director of the National Science Foundation (NSF) and member (ex officio) of the National Science Board, from October 1993 to August 1998.

Through his work with scientific and professional organizations and his participation on review and advisory committees for Federal and state agencies, Dr. Lane has contributed to public service throughout his career. He is a fellow of the American Physical Society, the American Academy of Arts and Sciences, the American Association for Advancement of Science, the Association for Women in Science and a member of the American Association of Physics Teachers. He serves on several boards and advisory committees.

Lars Lerup is Dean and William Ward Watkins Professor in the School of Architecture at Rice University. Educated in both the United States and Sweden, Professor Lerup has served on the architectural boards in numerous countries and was, in 2004, the recipient of the Swedish American of the Year award. Lars Lerup is author of Planned Assault: The Nofamily House, After the City, and other books.

Jim Lester holds a Ph.D. in Zoology from the University of Texas at Austin and is currently the Director of the Environmental Group at the Houston Advanced Research Center. As Director, he is responsible for development and implementation of projects to improve the sustainable management of water, air and biological resources. He is Past President of the Texas Environmental Education Partnership and is a member of the executive committee of the Galveston Bay Foundation. His scientific work is grounded in ecological and population genetics, which he has applied to projects dealing with biodiversity and development of new species for sustainable aquaculture.

Dennis J. Parker is Professor of Environmental Management and is currently Pro Vice-Chancellor of Middlesex University in London, and Dean of Middlesex University Business School — one of Britain's largest business schools. A specialist in research on flood management, hazard management, disaster management and project appraisal methodologies in the flood mitigation field, he has completed a series of research projects on the economic effects of floods for the British government, and has worked closely with the UK's flood defense agency, the Environment Agency and its forerunners on flood warning systems and flood defense emergency response. He and his colleagues have developed innovative project appraisal methods and data and have undertaken numerous project appraisals of flood management projects across Britain. He has been consultant to the Government of Hong Kong on flood proofing and flood warning systems, to the United Nations on hydro-meteorological warning systems, to the Government of Mauritius on tropical cyclone warning systems, to French government agencies on flood mitigation for the Paris region of France, and more recently to the World Meteorological Organization in Geneva on integrated flood management. During the 1990s he was a leading member of the EUROflood research project for the European Commission which involved researchers and practitioners from six European countries, and he has undertaken research for the Organization for Economic Cooperation and Development on the management of coastal zones. His current research is on the design of flood warning systems, and flood hazard management in London and the Thames estuary. He has written six books and over one hundred and twenty published papers. His most recent book is edited by him and is entitled "Floods" (published by Routledge, London in 2000), and incorporates chapters from over 50 flood experts from many regions of the world. Dennis Parker is one of the two founders of the Flood Hazard Research Centre at Middlesex University. The Centre specializes in flood hazard management and hazard management generally, and employs a socio-economic and organizational approach. This Centre was awarded a Queen's Anniversary Prize in 2000 — a Prize awarded for world-class enterprise.

Mark Wiesner is Director, the Environmental and Energy Systems Institute, and Professor, Civil and Environmental Engineering/Chemical Engineering. His principal interests are in membrane processes, nanotechnology, environmental transport and the uses of colloidal and nanostructured materials. In 2004 he was the recipient of a Pierre de Fermat Laureate and the Frontier Award from the Association of Environmental Engineering and Science Professors.

Paul Wilkinson is a Professor at the Centre on Global Change and Health at the London School of Hygiene and Tropical Medicine, a cross-departmental initiative that brings together staff and students from a wide range of disciplines to contribute to the School's rapidly growing body of research on globalization, environmental change and health. His main research interests are the health impacts of climate change and environmental pollution. He is a member of a research group on Climate Change, ozone depletion and health (in collaboration with researchers at the Tyndall Centre for Climate Change Research, University of East Anglia) and a member of the Centre on Global Change and Health. He is organizer of Environmental Epidemiology Study Unit; lecturer and Chairman of Examiners for the Environmental Epidemiology & Policy MSc; and a course tutor for the Public Health MSc. His most recent research project is "Outdoor air pollution, infant mortality and adverse birth outcomes: a geographical and time-series study" conducted in collaboration with the University of Ulster, IARC, UCL.

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1000 Louisiana, Suite 1900
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713.659.6270 x 2134
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