Tyndall°Centre
for Climate Change Research

truly Useful

… doing climate change research that is useful for both theory and practice

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Truly Useful to whom?

This publication is a series of personal reflections from several key Tyndall people about the execution, lessons learned and motivations of doing interdisciplinary and solutions-focused climate change research over the past five years. It is not about our research highlights - all these you can find at our website and elsewhere - and it is neither a five year report nor an academic paper. ***Truly Useful*** is about the approaches that we have applied towards realising the Tyndall vision of excellence in interdisciplinary research that is meaningful to stakeholders and informing to policymakers, engaging with and motivating society, and reducing our own impact on the environment.

Given that Tyndall has caught a wave of rising interest in climate change over the past five years (and I like to think it may have played a small part here - Ed.), an alternative strategy in writing ***Truly Useful*** might have been to consider how Tyndall could have had more of an impact. We could have asked has Tyndall done enough. What would need to have been different to have had a bigger impact? Hopefully we go some way to answering these questions, but here we are avoiding the creation of 'what if?' scenarios.

The international panel that reviewed the operation of Tyndall Phase 1 recommended that we document our institutional learning in some way, and we hope that ***Truly Useful*** helps with this. We intend it for people interested in the practicalities and challenges of what research can and cannot bring to better understanding and managing socio-scientific issues. We hope that you find it both interesting and useful and that we, other interdisciplinary ventures in the UK and abroad, and the research investment community can listen to and act on our learning from the first five years of the Tyndall Centre adventure.

Foreword

Bill Clark Harvard University

The Tyndall Centre for Climate Change Research is a breathtaking experiment. Even from the other side of the Atlantic, it was clear in the opening years of this Millennium that while other countries were talking about new approaches for bringing intelligence to bear on the unprecedented challenge of climate change, the UK was actually doing something about it. Rumours of what was that precise "something", fuelled by a growing number of working papers and press releases, drifted across the waters during the Centre's formative years, leaving many of us over here alternately excited, envious and confused. It was therefore with something of the enthusiasm of a zoologist given a chance to examine an exotic new species that I received and accepted the invitation of the Research Councils to chair the first external review of the Centre in 2004.

What the review team found was a grand experiment indeed that seemed to be grappling with four central questions: How can science and technology communities on the one hand, and stakeholder communities on the other, be brought together for the collaborative production of useful knowledge about climate change? How can purposive efforts to shape such knowledge draw on the best scientists and engineers throughout the UK and beyond? How can the knowledge of multiple disciplines mobilized through such collaborative processes be integrated to provide the robust and powerful insights on possible responses to climate change? How can a new generation of scientists, engineers and integrators be nurtured for careers that pursue the novel approaches being pioneered by the Centre?

We concluded then, and I believe today, that the Centre has created and implemented a unique vision of a solution-driven, virtual institute for climate change systems analysis that is internationally recognized for its innovative character and is increasingly being emulated. It has produced research output of international calibre quality and impressively high quantity. Decision makers at the regional, national, and global scale increasingly seek it out as a source of authoritative and useful knowledge regarding response options. Finally, it has assembled an impressive collection of senior researchers, fellows and doctoral students who are enthusiastic about being members of the Tyndall community, who are learning – even as they help to invent – the Tyndall approach, and who will surely constitute a uniquely valuable resource for the nation and the world in the years to come.

The Tyndall Centre is maturing as an extraordinarily ambitious effort to tackle an extraordinarily important problem. Experience suggests that under the best of circumstances it will require a decade or more of active learning-by-doing and capacity building before a venture of this magnitude and difficulty can be reliably judged to have succeeded. But I do not know of any comparable programme that in its initial years has come further, faster, or produced more exciting results. I am therefore particularly pleased for the opportunity to help introduce a wider audience to the evolving but already truly useful Tyndall Centre.

William C. Clark
Professor of International Studies, Public Policy and Human Development
Harvard University

by John Schellnhuber

Introduction

climate strategies for a warming planet

John Schellnhuber Director

Ali Colls Ecology

The present geological era – the "Anthropocene", as Nobel laureate Paul Crutzen has called it – is characterized by humanity's dominance over the planetary environment. And the most conspicuous – although inadvertent – expression of that dominance is global warming, a process that will affect the well-being, if not survival, of almost every ecological or social system on Earth. Science has convincingly demonstrated that anthropogenic climate change is already happening and will accelerate through well-understood mechanisms under business-as-usual scenarios of further worldwide industrial development. By way of contrast, science has not yet worked out a robust strategy for coping with the resulting challenges. This strategy needs – above all – to aim to *avoid dangerous climate change*[1].

A perfect "solution" of the global warming problem evidently does not exist: even if all greenhouse gas emissions were stopped instantaneously worldwide, the multiple inertiae of the Earth System would nevertheless enforce significant environmental echoes of previous human interference with the atmosphere. These echoes would persist for many centuries or even millennia – like sea-level rise, land-cover change and lifestyle transformation. On the other hand, humankind still has the option to contain global warming to a sub-dangerous level ("mitigation") and to deal with the residual excursion of the climate system in the most appropriate way ("adaptation"). In simple terms any climate change strategy needs to *avoid the unmanageable* and to *manage the unavoidable.*

But this is a gigantic task. The strategy has to work for different regions and sectors of our planet and has to combine the efforts of actors at all scales, ranging from individual behaviour changes to international agreements as solicited by the United Nations. In other words, a sophisticated, geographically explicit portfolio strategy is required that blends the pertinent options available in climate solutions space. Designing this strategy, and underpinning it by the best evidence, can be seen as the most important of all conceivable contributions to the emerging field of sustainability science[2].

Some seven years ago in 1999, the UK Research Councils decided to spearhead this field by creating a national centre for strategic climate change research. This vision eventually materialized as the Tyndall Centre in 2000. It was clear from the outset that any institution conducting integrated climate solutions research had to do this in a radically interdisciplinary and interactive manner – combining first-rate expertise from all relevant disciplines for generating novel scientific approaches, whilst engaging in structured dialogues with all relevant stakeholders for generating novel operational approaches. Addressing this challenge by creating an entirely new stand-alone institute – something like a Hadley-type Centre for climate protection analysis – would have required enormous resources that were not available. The alternative option (which was probably the better one anyway, given the nature of the task) was to form a distributed – or virtual – centre composed of leading research groups in UK universities and research institutes; these groups were to operate within a single management framework to pursue a common scientific agenda.

The Tyndall Centre was designed precisely along these lines and has demonstrated the potential to become a role model for organizing sustainability research, as an eminent international review panel confirmed in 2004. This potential was one of the main reasons why I joined the Centre some five years ago, and I still believe that doing climate solutions analysis and appraisal "the Tyndall way" is simply the best choice we as researchers can make.

[1] Schellnhuber, H.J. et al. (eds.) (2006) *Avoiding Dangerous Climate Change*. Cambridge University Press, Cambridge, UK

[2] Kates, R.W. et al. (2001) Sustainability science *Science* 292, 641

by Mike Hulme

Identifying and mobilising the UK's academic capacity

Matching supply with demand

The research structure and capacity of the UK's higher education institutions has been subject to various drivers and incentives over the decades. Classically, of course, university research was organised around the traditions of the great academic disciplines – physics, biology, history, literature, geography. This structure, a legacy in large part of the nineteenth century, still provides the organisational spine for many twenty-first century universities. But the last 50 years has also seen a different coalescing of research expertise into inter-disciplinary departments or schools, most notably in the clutch of UK universities created from scratch in the 1960s. The School of Environmental Sciences at UEA, for example, was a child of this era; the extent of its intellectual reach strongly shaped by Solly Zuckerman's[3] desire to see physical and social sciences, and economics, combine to provide more powerful insights into some of the world's emerging and pressing problems. The expansion of UK higher education in the 1990s provided another shaping influence on research capacity, with new undergraduate courses designed to attract new cohorts of students stimulating *inter alia* the emergence of new organisationally-shaped research expertise, for example in media studies, sports psychology, or environmental economics.

Up to a point, climate change research in UK universities rather struggled in this setting, with geography departments and a small handful of meteorological or environmental science departments providing the main institutional capacity (outside the Met Office and the research council institutes) to engage with climate change. The Climatic Research Unit was a rare exception to this pattern, having been established by the late Hubert Lamb[4] in 1971 as a satellite to the UEA's School of Environmental Sciences.

Yet the nature of climate change as the subject for legitimate, indeed essential, academic research was changing more rapidly than the higher education landscape was altering. Rooted in the natural sciences, and often posed as a problem of prediction, it was clear that during the 1990s climate change had evolved into a phenomenon that had political, technological, economic and social dimensions just as real and powerful as those found in nature. As one of the top five environmental policy issues there was a need to start understanding climate change in a different and more holistic manner.

The opportunity emerged in 1999 when the Treasury approved a ring-fenced allocation of £10m to be invested in a new research capacity in the UK higher education sector, an investment that would not only transcend the Research Council funding structure[5], but would also transcend the organisational structures in higher education. The remit for this new investment was explicitly inter-disciplinary and also was to require the mobilisation of academic expertise across higher education institutions.

The character of the Tyndall Centre

The Tyndall Centre was therefore designed both to respond to a new (type of) funding opportunity and to reflect a new understanding of the nature of climate change research. The climate change problematique wasn't posed as a meteorological problem, nor as one for the natural sciences alone. Neither improved climate monitoring nor climate change prediction were its goal. Rather, both the Research Council call of opportunity and the design of the (eventually) successful consortium recognised that innovation in UK's research capacity in climate change was needed in three dimensions: the Centre must undertake research that was *scientifically integrative, solutions oriented, and socially interactive*. These three characteristics are fundamental to understanding the design, operation and role adopted by the Tyndall Centre since 2000; indeed, much of this short publication is structured to provide insights into how far the Centre has been successful against these three criteria.

Before reflecting on the significance of these three defining characteristics for the Centre, it is worth elaborating in a few words what we mean by each of these couplets. *Scientifically integrative* research fosters the sharing and learning across academic disciplines of theories, methods and tools. Such deployment in an inter-disciplinary framework will lead to new insights about a problem that could not be gained by any *post hoc* synthesis of disciplinary results. For example, our work on integrated

Mike Hulme Director

[3] Zuckerman was the first UK Government chief scientist, a champion for joined-up thinking and a great supporter in the early 1960s for the new University of East Anglia.

[4] Hubert Lamb left the UK Met Office precisely because his vision of climate research did not match the rather narrow meteorological view prevailing at that time in the Met Office.

[5] Funding was channelled through three Research Councils – NERC (50%), EPSRC (35%) and ESRC (15%).

Sarah Mander Decarbonisation

assessment modelling has indicated that the costs of stabilising greenhouse gas concentrations at a given level are lower than previously thought. *Solutions oriented* research is driven by the desire to interact with, and inform, the world of decision-making. This requires a particular way of framing research questions and also influences the way research is conducted and the types of research outputs generated. For example, the success of our work on Domestic Tradable Quotas (DTQs) cannot be measured narrowly in terms of academic papers, but in terms of Parliamentary hearings, media exposure and policy workshops. *Socially interactive* research recognises that individuals, institutions and cultures exert powerful influences on the process and interpretation of research and that these influences need to be identified and understood. As researchers we are embedded in this social context and can never fully escape; our role is to expose assumptions, mediate conflicts of interest, and translate knowledge and the limits of knowledge to wider audiences. For example, in our work on sustainable coastal management in Norfolk we have worked with many different interest groups – Defra, the Environment Agency, conservation bodies, local authorities, local residents – and helped mediate a process of listening and thinking about future options, injecting scientific knowledge into this process as appropriate.

Alex Haxeltine Policy assessment

What challenges and tensions have been created by the Centre adopting this particular stance and profile? None of them on their own may appear particularly surprising or counter-intuitive, yet taken together they become significant. Put in the context of a five-year operational programme, the Tyndall Centre has acted as an experimental laboratory where researchers, funders and external stakeholders have all been forced to learn lessons about the nature of this new research process and what it can (and cannot) deliver.

What are the lessons for academic researchers?

Geographical proximity of the individuals in a research team has a valuable premium, especially when doing inter-disciplinary research. Virtual (or distributed) centres have some attractions as an organisational structure for tackling complex research challenges, yet creative interaction between researchers in such a setting is often limited. Overcoming this limitation through travel has a high overhead in time, cost and carbon emissions; overcoming this limitation through use of technology (phone, email, Access Grid) can only ever be partial. We have struggled to resolve this tension.

Our experience also reveals that some researchers thrive in such an inter-disciplinary and interactive environment and adapt their research methods and working habits, while others just dig a little deeper and continue to do things the same way. This does not seem in any obvious way related to seniority, nor to disciplinary area; senior engineers may or may not be just as adaptive to an inter-disciplinary setting as social science PhD students. This raises two interesting questions – what are the determinants of inter-disciplinary researchers (are they born or are they made?) and what mix of disciplinarians and inter-disciplinarians is best to do truly creative and useful research?

Working in an inter-disciplinary, interactive and solutions-oriented centre has exposed real tensions between different measures of success. This is as true for the Centre as a whole (see below), as it is for the individuals working within it. A research paper in *Nature* or *Science* brings a very different set of rewards to the individual than being invited to give oral evidence in front of a Parliamentary Select Committee. Within the narrow confines of the academic establishment, the former is much more likely to bring career rewards than the latter. Yet in terms of impact or personal reputation within a wider society or for influencing decisions the latter may be much more significant. For the individuals working within the Tyndall Centre this tension is not easily resolved; nor is the setting of priorities always easy.

The Tyndall Centre experience has also revealed difficult tensions arising from the solutions-oriented and socially interactive approaches to research ('co-production'[6]) being pursued. One can think of this in terms of a continuum between curiousity-driven research at one end and call-down consultancy at the other. Co-produced research clearly sits somewhere in the middle of this spectrum, perhaps slightly more towards the consultancy end if the engagement process and the influence of stakeholders are taken seriously. Yet at what point on this continuum does research become consultancy? At what point does research that 'meets the needs of business and government' cease being research that can be defended in front of critical peer review? What is the balance of power in the negotiation between researcher and stakeholder in setting the research agenda, in selecting the methods, or in interpreting the results? The Centre has encountered these difficult questions in several areas of its work and it remains a further tension within the work programme and ethos of the organisation.

[6] 'Co-production of knowledge' is a term used to define a research process which engages both ends of the knowledge-to-action spectrum through a dialogue, out of which emerges a negotiated view of what is both feasible and desirable.

The solutions-orientation of much of Tyndall's work also creates a further dilemma in the research process. Responses to climate change inevitably lead to the exposing of underlying positions on matters of ethics (e.g. social justice), politics (e.g. the role of the state) and value systems (e.g. the value of a human life). Yet in this research process how is it possible not to step over the line from analysis to advocacy? The Centre has been very clear from its foundation that it is not an advocate for specific climate change actions, yet many of the Centre's researchers are advocates (of a range of different climate change responses) in their role as citizens and play an active, even exemplary, role in public climate change debates and action. It is very difficult to compartmentalise these roles, the danger being that both roles – the professional researcher and the private citizen – are compromised to some extent. Critical self-reflection – individual, collective and organisational – on this and on the other tensions mentioned above becomes an ever more highly valued activity.

What are the lessons for research funders?

We need to be cautious in reaching conclusions on behalf of others, but having observed the funding system interact with the Tyndall Centre over several years it is legitimate to make some comments. There are three important observations to make here. First, the review and decision processes within each of the Research Councils remain instinctively disciplinary, or at best grudgingly multi-disciplinary. This is not to say that no individuals inside the Councils, or enlisted as external experts by the Councils, appreciate inter-disciplinarity; clearly this is not the case. Yet the processes, structures and implicit cultures of these funding organisations will tend to revert to favouring more conventional disciplinary research. There is clearly a need for more rapid organisational learning in this respect by the Research Councils.

Second, I think the Tyndall Centre exposes some real conflicts between measuring the success of research investments using measures of 'quality' versus measures of 'impact'. Translated simply this equates to whether performance criteria should revolve around the generic and conventional Output Performance Measures (OPMs) or around issues concerning what is broadly termed knowledge transfer (KT). Both OPMs and KT are part of the culture of research performance inside OST, yet when operationalised in specific settings they are not always commensurable. There is also the problem that the weightings given to quality and impact measures vary from Council-to-Council and vary over time. This lack of consistency and commensurability presents real problems for funders and researchers alike.

Third, is the exposing of the tension between research investments aimed at developing a sustainable research capacity, and those aimed at securing competitive, but short-term, scientific excellence. These two objectives are not inherently incompatible, yet they do imply rather different approaches and boundary conditions for investment strategies and for performance review. The Tyndall Centre experience demonstrates that it is essential to be clear about what is being sought for. Ambiguity and woolly thinking, as often is the case, is the enemy of any type of achievement – and this should be a lesson to be taken to heart inside our funding agencies.

Ruth Wood Emissions assessment

What are the lessons for external stakeholders?

Again caution needs to be exercised here, but from our experience over several years of interacting with a wide variety of external organisations about climate change, three observations seem important to make. First, it is easier for organisations to pose questions about climate change than it is for a research process to answer them. Or put another way, any "solutions" to climate change are multi-faceted, conditional and always framed in terms of political and social acceptability. Thus, ultimately, no disembodied research process can discover a solution for climate change since it is through other agents in society that "solutions" are implemented. Climate change research, no matter how well connected and engaged with any set of external stakeholders, will not be able to answer the question of 'what is dangerous climate change' or 'what is the right carbon tax'. Solutions to climate change are in the end political and stakeholders must not, openly or tacitly, endow science with greater power or authority than it has.

Second, serious and sustained engagement and interaction with a research process will cost a stakeholder organisation a substantial amount in time and effort (just as it will require commensurate commitments from the research team). Developing a truly interactive relationship between stakeholder and researcher whereby there is real learning occurring on both sides is costly. This is true at each stage of the relationship – framing the problem, selecting the methods, interpreting the results. It is easy for both sides in the relationship to use the rhetoric of stakeholder interaction, or 'co-production of knowledge'. In practise it is much harder to deliver

Neil Jennings Discourse analysis

when competing priorities for rare staff time and effort abound. More positively, however, is the experience that where a sustained commitment is forthcoming from both sides, there can be a genuinely fruitful and creative process that adds unique value to the research process.

Finally, it is worth noting that in some cases the above relationship between stakeholder and researcher may yield surprising benefits for stakeholder organisations. In a number of cases Tyndall Centre researchers have found themselves acting as translators – sometimes between different expert groups who speak different languages, sometimes between an organisation and its public where conflicts of interest emerge. This role as independent translator, with all of the power and responsibility that flows from this, was in none of these cases designed or sought out, but it emerged from a genuine dialogue between stakeholder and researcher and is one of the most important legacies of an inter-disciplinary research organisation such as the Tyndall Centre.

The true role of the Tyndall Centre

There are ultimately no solutions to climate change. Society will always be tensioned against climate and its variability, and occasionally be buffeted by it, whether or not humans are altering the global climate. Yet there are real political choices to be made and individual and corporate self-interests to pursue, however self-interest is defined. The most a research centre like Tyndall can hope to achieve is first to mobilise and then to facilitate society in opening up and shaping its choices. At the same time, we have a responsibility to ensure that the consequences of those choices are fully explored to the best of our knowledge and communicated. If the Tyndall Centre, and other organisations like it are doing their job well, society should be better informed about the consequences of different choices relating to future climate than would be the case for governments, organisations and individuals left on their own. This is the new pact between science and society. This is what climate change teaches us. This is the real lesson of the Tyndall Centre … by limiting the authority of science we actually give science a more valuable role shaping a sustainable society.

"And amongst our particular strengths are the environmental sciences, lead by the world-renowned Hadley and Tyndall centres for climate change research"

Rt Hon Tony Blair, 14th September 2004

"The Tyndall Centre has ... provided high quality scientific information on climate change .... I have been impressed by their depth of knowledge and the quality of their research. The work of the Centre is also held in very high regard internationally."

Professor Sir David King, the UK Government's Chief Scientific Advisor, written evidence to NERC, 19 January 2004

by Andrew Watkinson

A journey in inter-disciplinarity

The value of inter-disciplinary research

In the original proposal for the Tyndall Centre, the consortium of applicants stated that Tyndall Centre activities would have three key elements, one of which was *"an integrated, inter-disciplinary research programme"* and that the execution of inter-disciplinary research would be achieved by *"pioneering new integrated approaches drawn from the natural, social and engineering sciences that will deliver new insights into climate change."* So, how successful has the Tyndall Centre been in reaching across the disciplines and facilitating and delivering interdisciplinary research? There are undoubtedly Tyndall researchers who remain wedded to their individual subject disciplines and others who have ventured far outside their traditional comfort zone into the inter-disciplinary world (Figure 1). A range of approaches have been tried to deliver integrated and inter-disciplinary research, some more successful than others. The aim of this article is to explore some of the lessons that have been learnt from the collective Tyndall Centre in the delivery of inter-disciplinary research.

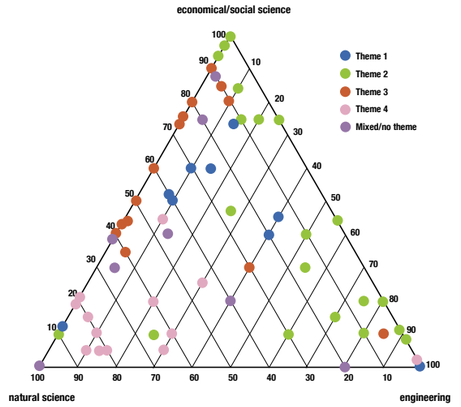


Figure 1. A self-assessment of Tyndall researchers into how they perceived themselves in terms of three component disciplines (2003 survey).

As a starting point it is probably helpful to be clearer about what we mean by inter-disciplinary research. *Disciplines* are established domains of knowledge that share a common set of theories, methodology and research tools. *Inter-disciplinary* research is designed to embrace a number of different disciplines in an organised programme of activity, but where the distinct theories, methods and tools in each discipline are shared and used in some combinatorial way to yield new insights *through the research process* that could not be gleaned from a post-hoc synthesis of disciplinary insights. That does not mean that we require everybody within the Tyndall Centre to feel that their academic home is at the centre of the triangle in Figure 1; all such scientists would inevitably end up being generalists. A successful inter-disciplinary programme will require a mix of both generalists and specialists. What is important is that those scientists engaging on an inter-disciplinary programme can communicate with each other, whatever their background, and can reach across the disciplines.

Inter-disciplinarity is a response to the recognition that many problem-driven research challenges in our globalising world need to understand the complexity and inter-dependency of the real world of nature and humanity … in other words, the need to adopt a 'whole-systems' approach to framing and hence analysing particular problems. Traditional disciplines – physics, chemistry, economics, psychology – are not well suited to this task. Taking climate change as an example, what society needs from publicly-funded research to help it address the challenges of climate change is not simply better meteorological predictions or economic analyses of the environment cost of carbon. While such knowledge may be valuable and indeed essential, society also needs research that – using this example – is able to draw upon meteorology and economics, together with an understanding of, say, behavioural psychology and policy analysis to evaluate the effectiveness of a given set of climate policies which minimise the risks associated with future climate change.

The 'whole-systems' approach involving the natural, physical and social sciences is seen as key by the Tyndall Centre in addressing the problem of climate change. From the outset it promoted an inter-disciplinary approach to the question of climate change by addressing problems that cut across the borders of a range of disciplines. This was true at the individual project level, but is best exemplified by the *Flagship projects* of the four research themes.

Andrew Watkinson Coasts

Carly Mclachlan Energy

These were the *modular multi-purpose integrated assessment system* in Research Theme 1, *the transition to a decarbonised UK* in Research Theme 2, *a theory of adaptive capacity* in Research Theme 3, and *the coastal simulator* in Research Theme 4.

Promoting inter-disciplinary research within the Tyndall Centre

In promoting inter-disciplinary research, through activities such as the *Flagship projects*, it has been recognised that there are a number of methods that encourage the development of inter-disciplinarity[7]. How successful have these been?

Encouraging and supporting research groups to form and self-organise

The initial Tyndall consortium essentially self-organised, identifying partners that could potentially collaborate in the fields of the natural, social and engineering sciences. Most of the people had not worked together, but the Tyndall Centre then allowed the groups to self-organise through the development of the original proposal and the initial project grant round. This had many benefits, but the development of an integrated programme also requires vision and planning. Inevitably, individual researchers want to make sure that they or their institutions achieve a slice of the research cake. On the other hand, the delivery of a complex integrated programme requires that all of the key elements are in place. There are inevitably tensions between these top-down and bottom-up approaches, and also between institutions vying for limited research funds.

Allowing time and space to learn about other disciplines

Time is at a premium in the contemporary research environment, but it is clearly essential to put aside time to learn about the other disciplines, whether this is through reading or discussions. I well remember at some of the initial meetings feeling cut off at times from discussions because I was not sufficiently familiar with all the disciplinary jargon and acronyms. It is important that everyone feels comfortable to express their ignorance of other disciplines and uses language that facilitates communication. Respect for your colleagues and their disciplines is essential, even when you find some of their theories and methodologies perverse from your own disciplinary standpoint. Throughout Phase 1 of the Tyndall Centre, face-to-face meetings at the beginning of projects, and then during the projects, were the primary method used to allow individual researchers to learn about the other disciplines and their approaches.

Training disciplinary staff in inter-disciplinary learning

For younger researchers, discussion groups were organised to promote inter-disciplinary learning. However, relatively little effort went into specific training for established disciplinary staff. It was essentially 'learning on the job' and 'sink or swim'!

Facilitating communication flows between people

The Tyndall Centre has facilitated communication, through a range of mechanisms, not only within the organisation, but outside to a range of stakeholder groups. Meetings within the organisation range from individual project meetings, through research theme meetings, to the annual Tyndall Assembly where all members of the core and extended Tyndall network (researchers from other research institutions involved in Tyndall projects) meet to share their work, review their progress and discuss future activities.

We have also created a PhD research network to provide identity to Tyndall PhD researchers and a coherent framework for learning. Individual sites within the Tyndall Centre have also promoted annual 'away days' when researchers gather at a location outside their institute and are encouraged to think about the centre objectives. These are then followed by 'action plans'. Apart from meetings, other important initiatives to encourage communication include the development of the web site, working papers to circulate research findings before publication, use of the Access Grid, mobility grants for people to move between sites and fellowship awards to bring overseas visitors to the Tyndall Centre.

Applying for problem-based research grants

Research in the Tyndall Centre means being involved with projects that address the problem of climate change and looking for sustainable responses, whether in terms of adaptation or mitigation. The Tyndall Centre had three research project grant rounds focused around its four research themes.

At all stages, project grant applications were required that involved more than one discipline and that involved more than one site. This strategy was undoubtedly successful in bringing together inter-disciplinary teams. The review process also allowed for modification of proposals to bring in other partners and disciplines to further the programme objectives. While this was successful in promoting inter-disciplinary objectives, the sizes of the grants often meant that some of the more expensive natural and engineering research was selected against.

Inevitably, research skills were not always available within the Tyndall Centre to tackle some of problems we wished to address. Consequently, the second open call for project grants allowed researchers from outside the Centre to apply for funding. This was undoubtedly important in furthering the research capability of the Tyndall Centre and the consequences of this can be seen in the adjustments that the Tyndall Centre has now made to its structure[8]. The downside was that insufficient attention was perhaps given to the deliverables that would be obtained from these new project teams and also an underinvestment in internal grants to deliver the *Flagship projects*.

To address this latter deficiency, the third round of project grant applications was again an internal round, designed primarily to 'plug the gaps' and ensure delivery of the *Flagship projects*. With our Phase 2 programme there has already been a much greater focus on the deliverables to be obtained from the seven inter-disciplinary programmes, especially as there is a more restricted time horizon – three years, rather than five.

Novel approaches such as digital libraries or artists in residence

Inter-disciplinary research requires approaching and communicating problems and their potential solutions in a different way. Early on we established a library of Powerpoint slides and have freely exchanged these, and similar types of information, to facilitate outreach. Personally, I have learnt a lot from the sharing of such resources and communicating those ideas to others from the business, government and the education sectors. An extension of this approach has been the appointment of two artists-in-residence who organised an art exhibition entitled 'Home Climate Gardens', allowing gallery visitors and school pupils to explore science and art. This has now appeared in the Tate Britain in London, and also in New York.

More slime mould than honeycomb?

Space

The promotion of collaboration can also depend on the physical environment in which researchers work. Within individual institutions of the Tyndall Centre there have been developments in the physical environments that have had both positive and negative impacts on researchers and their ability to carry out inter-disciplinary research. However, the essence of the Tyndall Centre is that it is virtual institute, engaged in the exploitation of inter-disciplinary research. As we move into a new phase of work there are two issues that I would highlight.

First, there have been considerable developments in electronic communications, which are making it increasingly easy for researchers from the different institutes to collaborate on a daily basis.

Second, the virtual nature of the Tyndall Centre means that it can reinvent itself as the scientific landscape around it changes and as the nature of the problems to be talked changes. Consequently as we have moved from Phase 1 to Phase 2 there has been a change in the partner organisations. Although some of the original partners remain (UEA, Manchester, Southampton, Sussex) we are now joined by Oxford and Newcastle. John Schellnhuber has used the analogy of a honeycomb to describe the structural nature of the Tyndall Centre. In some sense, although my analogy is not so attractive, I see the Tyndall Centre more like a slime mould, a group of organisms in which the dynamic replacement of components serves maintenance and facilitates structural reorganisation. Such incremental and organic reorganisation is key to the successful delivery of inter-disciplinary research bringing new disciplines and epistemologies into the inter-disciplinary mix.

Budget

Flexibility is not only required in the physical configuration of an inter-disciplinary research centre, but also in its budget. If you are going to allow time and space for self-organisation, training, communication and project development in a complex inter-disciplinary programme, it is almost impossible to cover all eventualities – that missing data set or gap in the original programme formulation. By allocating funds through three project grant rounds within Phase 1 of the Tyndall Centre and through, for example, the strategic use of workshop funding and reserves, it was possible to meet the changing needs of developing research themes in a highly successful manner. Unfortunately, the same level of flexibility is not now available in Phase 2. We hope that loss can be compensated for, at least in part, by the experience we have developed in programme planning through the last five years.

Coda

On a personal note the Tyndall Centre has changed my outlook of science and the way that research problems should be tackled. I have travelled a long way from the comfort zone of my traditional subject discipline, ecology, towards the centre of the inter-disciplinary triangle (Figure 1). It has been a rewarding journey.

Helena Amundsen Researcher

Seb Carney Emissions inventories

[7] Committee on Science, Engineering, and Public Policy (2004) *Facilitating inter-disciplinary research*. National Academies Press, Washington DC. and Tompkins, E. (2005) *Review of inter-disciplinary environmental science centres of excellence*. Report to MISTRA – Swedish Foundation for Strategic Environmental Research.

[8] The Tyndall Consortium in Phase 2 has lost five institutional partners from Phase 1 and added two new institutional partners.

Santiago Santos Programmer

Approaches to integrated research

The Tyndall Centre's research programme over the first five years was organised around four integrating themes: integrated frameworks, mitigation, adaptation and sustainable coasts. Although we toyed with the idea of a meta-integration of all of our research, discussions within the Centre – between themes and across disciplines – led us to accept and to respect that integration approaches (methodologies might be rather too grand a term) would vary between these four research endeavours.

The following four contributions by the leaders of the four research themes reflect on these different approaches to integration, how easy it was to achieve and what the eventual benefits were for both research and practise.

Terry Barker Economics

Integrated modelling for interactive assessments

by Jonathan Kohler

Capacity

One of the strategic goals of the *integrating frameworks* research theme was to undertake inter-disciplinary analysis of climate change policy. Climate change policy debates often throw up quantitative questions such as – How much will a specific climate policy cost? What policy combinations are required to stabilise greenhouse gas concentrations at a particular level? What are the avoided damages of a particular policy target? Such questions require quantitative analytical tools to be able to explore a range of answers and how different assumptions affect those answers. Within this particular realm of knowledge, integrated assessment models (IAMs) are the primary means to address such policy-relevant questions in a comprehensive fashion.

The Centre made a strategic decision very early on that it would develop such an integrated analytical tool (the UK did not then possess such a substantive tool), but with two very important caveats … we would use pre-existing models and modules where relevant rather than developing them from scratch, and that the deployment of the tool should be embedded in an interactive stakeholder engagement process.

The former condition led to the development of a Community Integrated Assessment System (CIAS), a next generation integrated assessment model relying on the development of open software protocols to allow module sharing between institutions and countries. The two model components which the Centre has invested most in is an economic component with emphasis on long run technical change – the E3MG Energy-Environment-Economy global model – and an intermediate complexity earth system model exploiting NERC's GENIE programme. For other modules and components the CIAS is drawing upon capacities elsewhere in Europe, or at least adapt such capacities. In concept and design, therefore, the CIAS is a shared community integrated assessment tool that can be run by different people in different institutions.

With respect to the deployment of the CIAS, Defra Global Atmosphere division was identified as the main policy stakeholder and so a process of engagement was initiated. The strategy was to offer to discuss scenario specifications, so as to ensure that the CIAS was deployed to answer (global) policy questions that were relevant to the policy process. This process was facilitated through staff secondments from the Tyndall Centre to Defra.

Experiences

The main challenge of the engagement process was to convince the Global Atmosphere division of Defra that the Tyndall CIAS could be useful for the climate policy questions they were concerned with. This had to demonstrate some new quality viz-a-viz their funding of the Hadley Centre models and also to overcome a degree of scepticism towards the economic theories used in integrated assessment models. Over a period of time we were able to show that the Tyndall CIAS performed a different function than that of the coupled ocean-atmosphere models of the Hadley Centre and also that our approach to economic modelling was more plausible that the conventional (general equilibrium/optimal growth) economic models of other assessment models. Defra Global Atmosphere has taken a keen interest in the results from the Tyndall CIAS, with a paper presented at the Defra-organised Exeter conference and a chapter in the subsequent conference book. Defra also provided considerable funding during 2004 and 2005 for the Tyndall Centre to co-organise the Innovation Modelling Comparison Project (IMCP) and to run the CIAS as a contributing model in this project. The success, nevertheless, has only been partial and further development work and sustained interaction with Defra will be necessary to build on the Centre's achievements.

The Community Integrated Assessment System has also contributed to the wider engagement of the Tyndall Centre with Defra. Ideas about the economics of technical change provided the basis for a joint side-event at COP 9 in Milan in 2003 and scoping work for the CIAS on impact damage functions has also proved valuable to Defra. The Centre's integrated modelling platform and expertise opened up new international research collaborations, especially through the IMCP and a CIAS workshop funded by the European Science Foundation. Tyndall Centre resources have enhanced the pre-existing reputation of the Cambridge macroeconomic group (especially through the new global model E3MG), whilst at the same time the Cambridge reputation in economic modelling has enabled the Centre to offer credibility in climate change economics, and together with the Cambridge Centre for Climate Change Mitigation Research (4CMR) execute joints events on climate economics.

There remain challenges for the Tyndall Centre CIAS in the years ahead. Will CIAS take its place amongst other widely cited integrated assessment models and will it make a contribution to policy development in future climate negotiations? Will CIAS become a genuine *community* model with shared software, modules and Grid-based operability? There are partners who are interested in contributing modules to CIAS, in particular in the Netherlands and in Germany. There is also a risk of overemphasising the economics within the CIAS, at the expense of simulating physical and social impacts and representing climate system feedbacks. Feedbacks are still missing in CIAS, as in nearly all integrated assessment models.

The formal integration of knowledge domains through the development of a coherent quantitative analytical tool has perhaps been the most demanding approach to integration adopted in the Tyndall Centre. We have progressed beyond the prototyping stage, however, and have demonstrated the usefulness of this integration modelling for insights into policy questions. Will the Centre be able to invest sufficiently in the years ahead to make sure that the CIAS is at the leading edge of integrated assessment modelling and climate policy analysis? New external funding from the European Commission suggests the prospects for obtaining resources are good.

Integrating decarbonisation research for system-level analyses

by Kevin Anderson

Kevin Anderson Decarbonisation

The early steps

The Tyndall Centre was expressly established to conduct inter-disciplinary research, yet the silo mentality of academic disciplines, allied with the numerous structural divisions *within* all universities and the strong sense of competition *between* universities, seriously hampered the execution of this vision. This clash between the ubiquitous disciplinary culture of universities and the inter-disciplinary principle informing the Tyndall agenda was clearly evident within the Centre's energy and climate change research theme – *decarbonising modern societies*.

In retrospect, mistakes were made very early on in defining and allocating the research for this theme. The desire for Tyndall to be a geographically distributed centre where resources were, in large part, allocated through an internal competitive process, combined with various political sensibilities and personal relationships, acted to dilute the vision of a coordinated inter-disciplinary research programme. This occurred despite the considerable efforts of several individual champions committed to the principle of inter-disciplinary research.

In many respects, Tyndall's early and stumbling steps towards establishing an inter-disciplinary centre mirrored the reluctance of the Research Councils to shed many of the shackles of 'traditional' *knowledge* generation and genuinely support the development of inter-disciplinary *understanding*. However, whilst it is easy to criticise the formative years of Tyndall, the eventual outcomes from the *decarbonising modern societies* theme is evidence that the Centre has matured over five years. Whilst the transition from a fledgling to a mature inter-disciplinary Centre was a process of evolution, it would not have proved successful if it were not for a small number of Tyndall champions battling against the disciplinary structure of universities and some colleagues, as well as the conservatism of the Research Councils. A practical demonstration of the ultimate success of Tyndall in providing an integrated vision of the big picture, is evidenced by both the enthusiasm with which the Centre's *'Decarbonising the UK'* report has been received and by the substantial and ongoing requests for the Centre to provide guidance to other organisations in their drafting submissions to the DTI's 2006 energy review.

More specific failures, successes and subsequent lessons

Some of the institutions successful in attracting Tyndall funding were initially reluctant to contribute to the inter-disciplinary focus of the *decarbonising modern societies* research theme. Such institutions, having viewed Tyndall simply as another funding stream, only half-heartedly engaged either with other projects or with the explicit project charged with integrating Tyndall research (from which the *'Decarbonising the UK'* report came). In the future it is essential that both the individual researchers and their immediate managerial structure are fully committed to the concept of integrated inter-disciplinary research and value it as highly as they do their own disciplinary research domains.

Whilst the first few years of the Tyndall Centre have demonstrated that geographical separation is a real obstacle to integrated inter-disciplinary research, it has also become apparent that provided there is sufficient belief in the value of developing a big-picture vision, distance between researchers is an obstacle that, to some extent, can be overcome. Inter-disciplinary research, by its very nature, is time consuming. We have also discovered that for such research to be really fruitful often requires some duplication of effort as different contributors, often with different perspectives, skills and experiences, are brought up to speed with each others research, methods, results and interpretations. This can be frustrating for all involved, and whilst good management can minimise such duplication, it is an unavoidable facet of such research and must be recognised, and on occasions even encouraged.

The development of the Flagship decarbonisation scenarios project demanded an expressly 'systems' vision of UK energy; this in turn required an inter-disciplinary approach, embracing and synthesising academic contributions ranging from the highly technical (e.g. thermodynamic efficiency implications of post combustion amine scrubbers installed on integrated gasification combined cycle plant) through to the philosophical (e.g. different interpretations of equity within the 'distributive justice' literature). It is difficult to envisage such an approach being either funded or facilitated through the conventional research funding channels. It is to the Tyndall Centre's credit that it recognised the value of such a systems level analysis.

The final and, in many respects, most important lesson from the past few years, is that unless the Research Councils undergo a fundamental sea change in their appreciation of inter-disciplinary research, it is unlikely that the success of Tyndall will be replicated in relation to other important issues with which society is faced. The mindset and internal machinery within the Research Councils is simply not appropriate to fund or facilitate inter-disciplinary research. Consequently, if such research is to flourish in the UK, it will be necessary either to establish an independent inter-disciplinary funding council or to have a proportion of the individual Research Council budgets allotted to inter-disciplinary research, and distributed by an *independent* panel, fit-for-purpose. Either way, current experience suggests that unless more incentives are introduced for the academic community to embrace inter-disciplinary research, alongside disciplinary, the longer-term spill-over benefits of the Tyndall experiment will be few.

Integrating adaptation research through inductive and deductive learning

by Emma Tompkins and Neil Adger

Adaptation research in the Tyndall Centre integrated diverse disciplines by using, in parallel, both deductive and inductive approaches focussed on seven pertinent questions: Who adapts and to what? What determines adaptive capacity? What are the thresholds? What are the justice and equity implications of adaptation? What tools and scenarios do we need? What are the costs and benefits of adaptation? How do we manage adaptation in natural systems? Each of these seven questions was explored in different levels of detail in order to develop a body of knowledge upon which a greater understanding of adaptation could be drawn.

The overall approach, summarised in Figure 2, was to understand the mechanisms and processes, as well as the outcomes, of adaptation to climate change. The demand for such research comes from diverse stakeholders in government and in civil society. They recognise that existing knowledge, primarily focussed on simply the risks and impacts of climate change, are insufficient to plan strategically for adaptation. The theoretical building blocks for understanding adaptation come from economics, theories of collective action and of individual cognition of risk, technology assessment, organisational theories, the natural sciences of climate change, and understanding the justice and equity issues associated with climate change.

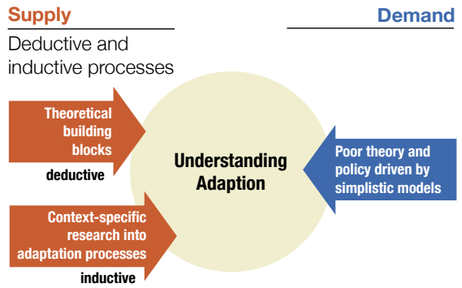


Figure 2: Theory and context-specific observation together build an understanding of adaptation processes.

But adaptation can also be observed in the real world. Inductive research therefore focussed on context and place-specific instances of adaptation. Such work took examples of the UK insurance, water and house-building sectors, subsistence farming in southern Africa, flooding and health, planning for extreme events in small island states and many others to describe and test theories of planned and autonomous adaptation.

The adaptation research theme sought in effect to derive useful and replicable models and theories of adaptation using theory-building and empirical testing. Such a design has worked well in the past. One precedent is the development of now well-established theories of common property resource management. Insufficient and simplistic assumptions (captured in Hardin's thesis on the 'tragedy of the commons' in 1968) were overturned by political scientists, ecologists and anthropologists based on 20 years of theory building and empirical observations of how commons actually worked. If the Tyndall Centre has assisted in the evolution of new theories of adaptation to the risks posed by climate change, this will constitute a major contribution to knowledge in the climate change arena.

We believe this research theme has succeeded in producing high quality published research (over 100 peer reviewed book chapters and journal articles), has influenced international scientific agendas on adaptation, for example through participation in the Fourth Assessment Report of the IPCC, and has influenced policy and practice in adaptation in government, business, and civil society in the UK and beyond. The next step in adaptation research is to describe the pathways towards resilient and sustainable adaptation into the future.

Integration through coastal simulation

by Andrew Watkinson and Robert Nicholls

The Tyndall research theme *Sustaining the coastal zone* managed the process of integration primarily through the development of a coastal simulator. The other relatively minor project within our theme centred around small islands and provided a focus for collaboration with the adaptation research theme and its interests around adaptive capacity and small islands.

With its over-arching objective of identifying 'Flexible adaptation to and mitigation of sea level rise in the coastal zone', we concentrated activities on the identification of the problems (through vulnerability assessment) and on the exploration of adaptation and mitigation options (through a regional simulator). The basic idea was to consider a vulnerable UK coastal zone – the East Anglian coastline – and to mimic its structure and dynamics using a geographically-explicit integrated model that took into account the relevant natural and anthropogenic features and processes.

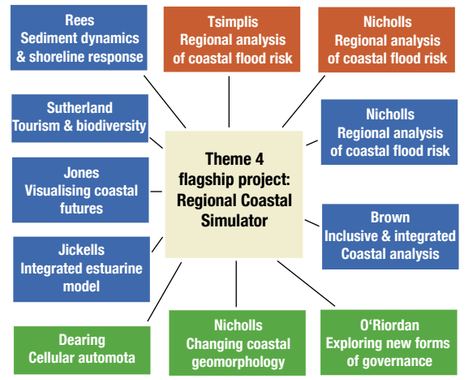


Figure 3. Projects contributing to the coastal simulator from the three rounds of Tyndall funding.

Marisa Goulden Adaptation

Robert Nicholls Coasts

Paul Upham Aviation

The initial stage was to scope what would be involved. Consequently the two projects supported during the first round of funding were centred around vulnerability assessment and the methodology for developing the simulator (Figure 3). The second round provided resources for bringing together various elements that would contribute to the development of the simulator, while the third funding round explored some novel approaches that might contribute to the model in the future and also how the model framework could be used in a more interactive mode with stakeholders.

This approach has undoubtedly been a success in integrating research from a range of institutions and disciplines. This is illustrated below, demonstrating how the British Geological Survey, and the Universities of Manchester, Newcastle, Southampton and UEA have been collaborating closely across a range of natural, physical, engineering and social science disciplines. En route there were undoubtedly some false starts and blind alleys. However, encouraging and supporting research groups to form and self-organise and allowing time and space to learn about other disciplines has in the end brought success.

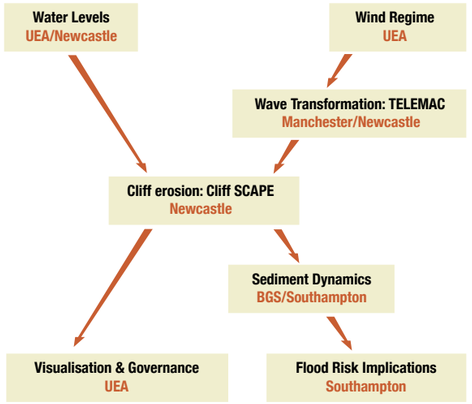


Figure 4. An illustration of some of the component elements of the coastal simulator.

During these first years, there was unfortunately insufficient resource to bring together all of the elements of the model under one framework. Nevertheless the concept of the simulator has been successful in integrating diverse areas of knowledge and demonstrating how a coastline area of Norfolk (which comprises areas of cliffed coastline and downdrift low-lying areas vulnerable to flooding) might evolve with climate change and different management regimes in the future. The SCAPEGIS tool provided a library of these simulations allowing further analysis of erosion risk and in principle disseminating the results more widely. We have explored some of the biodiversity and socio-economic impacts of the changing coastline and provided visualisations of these futures which have been tested in a number of different stakeholder fora.

“ … the Tyndall Centre seeks to break new ground in innovative research on several themes connected with policy responses, including mitigation and adaptation … it reflects an innovative institutional experiment by the UK to confront complex interdisciplinary issues that face climate research and policy.”

United Nation’s Framework Convention on Climate Change (UNFCCC), Review of the 3rd UK National Communication, May 2003, p.26

Influencing policy

The Tyndall Centre’s second strategic objective is to develop and evaluate sustainable responses to climate change. Of necessity this brings the Centre and its researchers close to the process of policy development, advocacy and implementation. In this section, we select four case studies of ways in which Tyndall Centre research has engaged and then influenced the climate policy process. We are not claiming responsibility for policy implementation and nor are we presenting necessarily universal principles for successful science-into-policy. We simply present four different learning experiences taken from our larger portfolio of science-policy engagements.

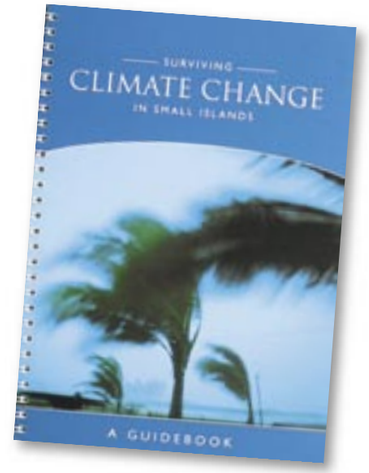
The Cayman Islands

by Emma L. Tompkins and Lisa-Ann Hurlston

Over a three year period, the Tyndall Centre worked with the Cayman Islands’ Government to identify how ready the Cayman Islands were for climate change and how they could learn from past advances that they had made in hurricane preparedness.

The project engaged different parts of Caymanian society. Interviews were undertaken with the heads of all government agencies, from environmental health to social services. This process raised the profile of the research and of the climate change issue. All interviews were transcribed and sent back to the respondents for confirmation and feedback to engage them in the process. A final report was written and then presented back to the heads of government and the media in a variety of fora. A similar process was utilised to engage the private sector and individuals and community groups on the islands.

On the back of this success the UK Government funded a capacity-building project which allowed the project team to expand the engagement to include the UK Overseas Territories in the Caribbean. The Government-funded project allowed six individuals from the UK Overseas Territories’ governments to attend a one month research fellowship within the Tyndall Centre, to participate in a three-day workshop in the Cayman Islands, and to co-author a guidebook on *‘Surviving climate change in small islands’*.



Key lessons for influencing policy from this process can be identified at each of the four phases of the project:

- the stakeholder and project identification phase;
- engagement phase (information provision, and feedback);
- support phase (availability of researchers to stakeholders);
- disengagement phase.

Identification phase

In the identification phase it is always easiest to contact only those who are known to the researcher. However, if a full engagement is desired, and conflict is to be avoided at a later stage, then all stakeholders need to be identified. Stakeholder identification proved quite challenging during all phases, often with individuals or groups notifying the project team of their desire to be considered stakeholders in the project.

Engagement phase

In the engagement phase it is necessary to share information immediately and not just assume that stakeholders will want to talk with you. Before meeting with the stakeholders the researcher needs to identify potentially interesting information that can be provided to increase stakeholder interest in the subject and in the research project. Providing information, clearly describing the project and its expected outputs, as well as managing stakeholder expectations are all important in this phase. Ensuring that stakeholders are provided with contacts for information that the researcher is unable to readily provide is vital to maintaining credibility and preserving stakeholders’ interest and cooperation in future phases of the project.

Emma Tompkins Adaptation

Support phase
Both the identification and engagement phases begin prior to the research, whilst the support phase occurs during the research. During this phase the researcher needs to make his or herself available to the individuals being engaged. As the research begins the stakeholders are likely to start to have questions about the research process and the subject matter that require answers. It is during this phase that the relationship with the stakeholders can be effectively built by providing the information and answers sought. During this phase there is an on-going two-way transfer of knowledge and information that benefit both sides of the research relationship.

Disengagement phase
The final disengagement phase enables the researchers to make final presentations back to the stakeholders and to discuss what the stakeholders may wish to do with this information. It is important to ensure that the dialogue can be continued into the future, although future time restrictions on the researchers need to be communicated.

Stakeholder relationships are not short-term time-limited relationships. These relationships are on-going and evolving and should be treated in the same way as friendships. There are times when both parties will want to invest significant time and effort in them, and other times when there will be no communication.

In the Cayman Islands, the stakeholder engagement and involvement process enabled an effective engagement because of the commitment of the researchers to the process and to the subject area. Because there was committed interest from all the stakeholders, this Tyndall Centre project has led to a rising profile of climate change issues in the Cayman Islands and to the request from the Cayman Islands Government to have the UNFCCC and the associated agreements extended to the Cayman Islands. It has also informed the guidebook *'Surviving climate change in small islands'* which was launched at COP11/MOP1 in Montreal in December 2005 and which has subsequently been distributed to and downloaded by several hundred organisations worldwide.

Alice Bows Energy

Aviation

by Alice Bows

The Tyndall Centre undertook a 12-month research project to quantify the contribution made to national greenhouse gas emissions from the UK aviation industry, to quantify this contribution under a number of future scenarios and to begin to examine possible policy measures for limiting the growth of emissions from this sector. Many people within the climate change research and policy communities were well aware of the aviation industry's growing contribution to the UK's carbon dioxide emissions. And significant numbers of the general public may also have realised that flying, rather than driving or taking a train, was probably not the most environmentally sensitive choice. I would suggest, however, that a fuller understanding and the acceptance of the scale of the problem faced by a nation striving to reduce its carbon dioxide emissions, has been substantially enhanced through the results of the Tyndall Centre's aviation research entering public and policy discourses during 2005.

The conclusion of the project was clear: if we continue to grow the UK's aviation industry at rates even half of those being seen today, the carbon dioxide emissions will soon be greater than those from all the other sectors of the UK's economy. National and international greenhouse gas inventories have not previously included emissions from the aviation sector. The project revealed the enormous disparity between the UK's position on reducing carbon dioxide emissions and the Government's failing to recognise and adequately respond to the rapidly escalating emissions from aviation. While the message from this Tyndall research was strong, disseminating it in a way that influences public discourse and policy still requires a significant amount of time and effort by all individuals involved.

The impact of this research was boosted through a consultancy the Tyndall team at Manchester University carried out for Friends of the Earth. In addition to focusing the research on the UK, Friends of the Earth wanted a broader view incorporating all of the EU nations. Publicising the conclusions of this report helped the work make a timely contribution to the debate about bringing emissions from the aviation industry into the EU's emissions trading scheme. The research report was initially launched at a major climate change event in Brussels and resulted in extensive coverage in the mainstream media in both the UK and further afield. The fact that the research had been carried out by the Tyndall Centre enhanced its credibility, enabling Friends of the Earth to present the results directly to Stavros Dimos, the EU Environment Commissioner. Further to the Brussels launch, Tyndall's research was then presented to a group of MPs in the House of Commons.

This success in gaining the attention of MPs and MEPs was followed by further media attention following an emphasis on the aviation results at the Tyndall Centre's *'Decarbonising the UK'* launch event in London at which over 150 stakeholders were present. The Tyndall analysis began to significantly influence the public discourse about aviation and climate change. But not only was the research now frequently mentioned in the media – see for example George Monbiot's piece in *The Guardian* in February 2006 – but it increasingly impacted the policy debate. The Tyndall research team has been called twice to give evidence to Government Committees, Elliot Morley (the climate change minister) has used results from the research on many occasions in arguing for the inclusion of international aviation emissions within the EU emissions trading system, and Kevin Anderson was invited to give a keynote address to a DEFRA-organised conference of EU-25 environment ministers.

Engaging with policy makers and the national media at this sustained level required a huge commitment of time and effort from those researchers involved and inevitably took time away from other academic duties. Finding additional time to publish the results in the mainstream academic literature proved exceedingly difficult when being called upon *daily* to engage with a variety of audiences about the issue. This experience raises a dilemma when it comes to priority-setting. Is it more valuable to continue engagement with policymakers and opinion-formers, or should engagement take a back seat whilst researchers publish results in peer reviewed journals? Which route in the end will make the bigger difference to climate change and society? This example illustrates the acute challenge faced by Tyndall Centre researchers seeking to 'develop sustainable solutions' whilst at the same time enhancing an academic CV for career progression.

Greenhouse East

by John Turnpenny

Our principal aim in this piece of Tyndall research[9] was to raise awareness about climate change at local and regional levels in the UK, and especially to explore the major changes necessary to reduce greenhouse gas emissions at a regional scale by 60 per cent by 2050. We strove for an interactive, integrated research process, which involved local and regional policy advisors and other senior officials in the research design and execution. We also aimed to integrate across at least five different dimensions:

- Climate change mitigation and adaptation
- National policy with regional and local scales
- Across sectors (e.g. agriculture, water, housing, etc.)
- Research results into the policy process
- Climate change with other policy domains (e.g. transport, spatial planning, etc.)

Through creating a set of illustrative scenarios for the East of England region, jointly developed with senior regional and local policy actors, we were able to influence the region's strategies on sustainable development, spatial planning and climate change. We found that the following lessons are important for interactive integrated research.

Implementing an interactive research approach requires significant resources to do properly – it cannot just be a minor appendage of modelling work. It is very important to ensure a commitment to the interaction process from users, including practical and administrative arrangements. Involving the user as co-funder should be seriously considered as a way of helping to ensure buy-in.

It is vital to have a shared conceptual framework and suitable project management structure in the research team that allows researchers from different disciplinary backgrounds and with differing priorities to work together effectively. Simpler, conceptual, models that are easier to understand quickly by busy users can aid in the research development process.

Effective communication is vital. In our case, we produced towards the end of the project a glossy brochure entitled 'Greenhouse East: social and economic scenarios for reducing and addressing climate change in the East of England', jointly funded by Renewables East and the Government Office for the East of England. This summarised the

John Turnpenny Policy

[9] This case study is based on the work carried out as part of the project, 'The creation of a pilot phase Interactive Integrated Assessment Process for managing climate futures'. Contributions to the research were made by Alex Haxeltine, John Turnpenny, Tim O'Riordan and Sebastian Carney.

scenario work in eight pages in a suitable format for policymakers and interested lay people. This has significantly increased the profile of the research and been a valuable aid in communicating with all involved in the project and is helping guide the region's sustainability strategies.

The need for research work goes well beyond the official end of the research project. Rather than a traditional linear 'academics do the work, then pass it to policymakers, then move on to something else' approach, the interactive-integrated approach seeks to develop and maintain trust and good working relationships with users, as contributors as well as receivers of research. These relationships take time to build, and researchers often have to move off to different contracts just when the research-policy interactions are becoming fruitful. This presents a challenge to traditional funding and contractual arrangements in universities.

The interactive approach forces the research process to be more realistic about real-world needs, while at the same time allowing user examination and critique of the assumptions within the scientific process.

Richard Starkey DTQs

Domestic Tradable Quotas

by Richard Starkey

Domestic Tradable Quotas (DTQs) are a "cap and trade" scheme for the reduction of greenhouse gas emissions from energy use. Under DTQs, emissions rights ("carbon units") are allocated to and surrendered by all end-purchasers of fuel and electricity i.e. adult individuals and organizations. Carbon units are allocated to adult individuals free and on an equal per capita basis whilst organizations purchase the units they require on a national market for carbon units. Individuals with surplus units can sell them on the national carbon market and individuals who require additional units can purchase them on the market.

DTQs were proposed in 1996 by David Fleming, a London-based policy analyst and in July 2003 Richard Starkey and Kevin Anderson began a Tyndall research project assessing the appropriateness and feasibility of the scheme. Since the beginning of the project, DTQs have become increasingly widely known and discussed as a potential policy option within the policy community. How did this come about?

Five months into the project, Kevin was invited to give a presentation on DTQs to the Tyndall Advisory Board. One of the board members was Roger Harrabin, environment correspondent of the Radio 4's Today programme, who was interested enough in the idea to arrange for it to be featured on the programme in January 2004. Listening to Kevin's interview was Colin Challen, Labour MP for Morley and Rothwell, who was very taken with the concept and got in touch. In March, Colin, a member of the House of Commons Environmental Audit Committee, arranged for Kevin and Richard to brief the Committee and in July Colin presented to the House a private members bill on DTQs drafted with the assistance of Richard and Kevin.

One consequence of the bill was that it led to substantial funding of further work into personal carbon trading. The meeting to launch the bill was attended by Peter Jones, a director of Biffa Waste Services Ltd, and a member of the environment committee of the Royal Society for the Encouragement of Arts, Manufactures & Commerce (RSA). Peter invited Richard to present DTQs to the environment committee and as a result, and to cut a long story short, in August 2005 the RSA launched a half-a-million pound project to further develop and promote the DTQs idea.

Not content to stop at his private members bill, Colin arranged for Richard and Kevin to present the DTQs idea to Elliot Morley, Minister of State for Climate Change and the Environment, a meeting which took place in the Minister's private office in January 2005. And, in addition, Colin organized a meeting on DTQs at the House of Commons in November 2004, at which Richard spoke alongside Michael Meacher and which was attended by around 60 people. Through his various activities raising the profile of DTQs, Colin certainly contributed to Richard and Kevin being invited by Defra in June 2005 to submit evidence for the UK Climate Change Programme Review.

Two lessons arise from the experience of working on the DTQs project. First the experience demonstrates the benefits that can arise when research work captures the imagination of a person with a degree of political influence. Second, it demonstrates the role of the media in disseminating research work so that is has the potential to capture the imagination of such a person. And what is perhaps particularly interesting in relation to this project is that it benefited from media dissemination not as a result of a decision to actively seek out the media but as a result of Tyndall's sensible decision to include a representative of the media on its Advisory Board.

by Esteve Corbera, Marisa Goulden and Katrina Brown

Crossing borders and cultures

climate change knowledge and research in developing countries

Tyndall research in developing countries

In its first five years the Tyndall Centre has supported five research projects and seven PhD studentships involving place-based research in Asian, Latin American and African countries including Vietnam, Mexico, Brazil, Bolivia, El Salvador, Uganda, Mozambique, Tanzania and South Africa. These projects have addressed a number of issues related to climate change mitigation and adaptation, both at policy and implementation levels. They have certainly produced a number of well-informed and intellectually stimulating outputs. They have enabled Tyndall researchers to gain valuable insights and knowledge into understandings and responses to climate change in non-European cultures. In this short article, we outline what we perceive have been some of the main difficulties and opportunities encountered by Tyndall researchers when undertaking climate change research in other cultural contexts beyond the UK borders, and specifically in developing countries. We also highlight a number of lessons learned and the challenges that lie ahead to consolidate the role of the Tyndall Centre in sharing knowledge, resources and capacities with collaborators and host country partners.

Challenges and opportunities of climate change research

Tyndall researchers working in developing countries have faced a number of challenges beyond the expected logistic problems of working in often remote places, involving different languages and unfamiliar customs. Information about climate change is often scarce, like many other resources, in poor countries. Developing countries often do not have access to the same level of information and awareness about climate change as in developed countries. This has a direct effect on the way in which research partners and stakeholders are identified and engaged.

In many cases, developing country governments are represented in international negotiations by a limited number of individuals, usually from environment or energy ministries. Only a very small number of individuals participate in discussions and have access to information, and their views or perceptions may be shaped by their own ministerial portfolio. They can act as important gatekeepers, and their support is often vital to facilitate access to government departments and relevant institutions. These individuals may be sceptical about the relevance of research to their work. We have found that it takes time to build trust and make contact with the relevant people inside government to initiate research. The issue also reflects the need to think strategically about how research findings and outputs can be targeted to the policy and practical needs of the host country, and how communications strategies should be seen as part of the research process. It also underscores the importance of developing longer-term research partnerships, where collaborators have a greater say in shaping and actively participating in the research process.

Esteve Corbera Development

There are many different forms of knowledge on climate change. Information on the 'science' of climate change and the international and national policy responses may be limited to more highly (formally) educated people in the government, academic and private sectors. But it is often rural communities who directly experience the impacts of climate extremes. Farmers have a detailed knowledge of the changes in their local climate that they have experienced over the last few decades and a number of Tyndall research projects have focussed on understanding the impacts and responses to climate change on rural populations. Local knowledge and perceptions of change provide a valuable opportunity for detailed studies of adaptation to climate change, even though we have found that there are often divergent explanations for the causes of changes given within and between communities and different social groups within a country or region.

Climate change research designed in the UK by 'scientifically' trained researchers encompasses a series of assumptions or concepts which are often far from clear to citizens in developing countries. Some climate-change related terms simply do not exist in other languages or local dialects. Some concepts which we in the UK take for granted and in our professional life use frequently, are unrelated to the reality of everyday life of a poor person, a small farmer, or a slum dweller in a developing country. For example, how does one explain to rural communities what carbon trading is, who is involved in it, or what is expected from rural communities? How is the notion of carbon trading translated? How is the notion of global climate change framed so that people can relate their experience with climate variability to wider societal processes? These are

Katrina Brown Development

Jessica Milligan Governance

dilemmas faced by Tyndall researchers working in the field in developing countries.

A further challenge concerns how to deal with local peoples' views and perceptions of the role of the Tyndall researcher in the local context. For example, in fieldwork in Uganda one Tyndall researcher found that the villagers associated all outsiders with development projects. In group discussions participants gave little prominence to the impact of climate events on their lives, preferring instead to emphasize problems such as poor health and lack of infrastructure, which they perceived as likely to be addressed by development agencies (aka Tyndall researchers!). After all, by their reckoning, the rainfall and sunshine is something that is controlled by God or the spirits, not by people.

All these challenges reflect the complexity and the novelty of conducting field-based research on climate change in developing countries. They are also indicative of the importance of conducting exploratory research or pilot projects, which build up relationships and establish communication between researcher and local people, and which ultimately enable the design of the research and the techniques used to take better into account linguistic and social contexts.

Lessons learnt and some recommendations for the future

We have learnt several lessons from working in developing countries. First, research networks are essential for the implementation of Tyndall research projects. Tyndall projects have relied on existing contacts and networks and in many cases projects have built new contacts with stakeholders in developing countries. In some cases, these networks have allowed for the co-production of knowledge among distinct actors, they have legitimised our work in the host country and, more importantly, they have helped to transfer knowledge among distinct actors. Our future research will allow some strengthening of existing networks, for example in Mozambique, South Africa and Vietnam, but in some cases we will be starting to work in countries new to us and with new actors and communities.

The Tyndall Centre could play a more significant role in promoting knowledge transfer (KT) to developing countries, at both research and policy levels. Although some KT has occurred at an informal level through researcher/stakeholder interactions and also through the participation of researchers in workshops and conferences in host countries, there has been no overall strategic KT or communications strategy within developing countries, either to governments or different sectors of society. Rather it has relied on ad hoc initiatives with specific projects or spin-offs from other activities such as participation in conferences.

Another lesson learnt relates to the participation of project partners and local stakeholders in the production of reports and publications. When working with local partners in developing countries, including government and civil organisations, the production of project reports and publications can be slowed down by the relatively slow response of partners to written drafts. The process of writing-up requires resources and time, and this is a privilege that often only researchers can afford. Therefore, it is important that future projects allocate substantial time during the writing process to allow for comments by host-country partners to be incorporated. Of course of paramount importance is the dissemination of research outputs to host country research partners and other participants in the research. For local communities who have taken part and assisted in research, a return visit and a presentation is often appreciated so people understand how their knowledge was used and how it informed findings.

Tyndall researchers working in harsh environments with direct interaction with very deprived communities for relatively long periods of time have experienced some psychological strain as a result of the living and working conditions and the high and often unrealistic expectations of the people who are the subject of the research. This can lead to difficulties adjusting to life back in the UK – a phenomenon sometimes referred to as 'reverse culture shock'. The Centre needs to be sensitive to this, to recognise it and to provide necessary and appropriate support through mentoring and other services.

It is important to end this reflection by acknowledging that several Tyndall researchers have established emotional linkages which have led them to get involved in other social processes beyond the research itself, such as helping community leaders to put up proposals to obtain government funding for either agricultural or forestry schemes, writing environmental histories for local schools, and creating fund raising mechanisms or supporting local development initiatives, among others. Although these activities do not contribute directly towards formal research outputs, they are integral to the research process in developing countries both for the reputation of the Tyndall Centre abroad and the personal fulfilment of the researchers involved. They demonstrate the commitment of Tyndall researchers to the transformation of local realities towards sustainable development and highlight the ethical challenges faced by researchers of being primarily an observer rather than a participant in the development process.

by Jim Watson

Researching with stakeholders, not at them

Jim Watson Energy

At the Tyndall Centre, we spend a lot of time analysing the future. What could happen, and how do we get there? This kind of research requires free thinking and an imaginative approach. But it is not useful if it is not grounded in reality. One way to ensure this grounding is to involve 'stakeholders' – people from the non-academic world who are directly affected by or involved in the issues of interest. Involving stakeholders, both in the development of ideas, and as a reality check on the final outcomes, gives the research credibility. So how easy is it to do? In its first five years, the Tyndall Centre has amassed a good deal of experience in the process of involving non-academics in research. Together with other Tyndall institutions, SPRU (Science and Technology Policy Research) at Sussex University have incorporated inputs from industry, policy makers and regulators in three projects analysing energy and electricity networks of the future. Here, we describe the challenges of involving stakeholders effectively and look back at how we handled them.

Who to involve?

The concept of stakeholders is not well defined. It is worth thinking carefully about who to include and how you justify this at the outset. Stakeholders can be interpreted as 'anyone with an interest', and often include the general public, consumers and campaign organisations. The stakeholders we conferred with in our electricity and energy projects were from a narrower range. What we wanted from stakeholders was not a rounded view, but specialist knowledge, to check our analysis was feasible. So we approached practitioners within the electricity industry, regulators, government policy makers and trade associations. These included representatives from Defra, the Department of Trade and Industry, the National Grid Company, utilities such as Edison Mission Energy and Npower and the energy regulator Ofgem.

These stakeholders, and many others, were involved in three energy projects focusing on future possibilities for electricity and hydrogen[10]. Each of them involved the development of medium- or long-term scenarios of energy use, up to 2020 or 2050. Scenario approaches are designed to capture many of the uncertainties inherent in long-term thinking. It would be wrong to address the uncertainties without input from industry and policy makers on what is feasible, or likely. The involvement of stakeholders was therefore an essential part of the research. They also provided important data on the current situation, and the potential future.

All these projects were carried out by an interdisciplinary team of social scientists and engineers, from more than one research centre. Team members were accustomed to interacting with industry in their research. Was there a conflict, between our blue-sky thinking and their industrial realism? Actually, no. If anything, the disagreements we encountered were more within the project team than between scientists and stakeholders. We had some heated debates on the role of demand side management in a future grid with a higher proportion of intermittent renewable sources, for example. Our sticking points highlighted the challenges of interdisciplinary research. Industrial representatives did not express their views so strongly. They were more inclined to sit back and watch the academic debate with interest.

One valuable guideline is to include as broad a range of people as possible. This mitigates against any one stakeholder trying to influence the outcome and guards against accusations of industry bias. It would have been wrong, say, to include just hydrogen energy companies in a study of the future hydrogen economy, and not balance them with more independent views from other groups. You need to set out the agenda clearly and explain the advisory role. This was especially important for us since, in the electricity projects, the Tyndall Centre received small financial contributions from some of our industrial collaborators.

When to involve them?

When you involve stakeholders in the process of your research is absolutely crucial. You can involve them in the development of project plans and processes (such as scenarios), in commenting on the end result, or in discussions of how to get to the end result. Ideally perhaps, they would participate at all three stages but there are various pitfalls to avoid.

The first thing to consider is the structure you use to consult. An advisory body, or committee, that meets regularly throughout the project, is one extremely

Rudra Kapila 40% House

[10] *Integrating Renewables and CHP into the Electricity System, Security Assessment for Future UK Electricity Scenarios* and *The Hydrogen Energy Economy: its Long-term Role in Greenhouse Gas Reduction*. Full reports are available on the Tyndall Centre website www.tyndall.ac.uk

Simon Jude VR Technology

useful approach. There are huge benefits to be gained from the tacit knowledge of practitioners, knowledge that cannot necessarily be gleaned from written reports and policies. The language can be impenetrable, and it can help scientists to immerse themselves in the culture of the industry. These are particularly strong benefits for research on current or near-term issues. However, in assessing long term future possibilities, you run the risk of becoming tied up in a mindset of how complicated current energy systems are, and losing sight of the rather different future possibilities you are trying to analyse.

Another option is to organise a number of workshops, less frequent, but perhaps more focussed. Here, the timing of the workshop is all-important. It seems attractive to devise scenarios first, then consult on the outcomes of them and ask your stakeholders to suggest precise numbers for various factors. This formed part of our approach in the near-term electricity project. The biggest challenge we encountered in running the workshops can be described as 'knowledge equalisation'. In a single day, it is very difficult to get everyone up to speed on the detail within the scenarios, in order to consider their outcomes. Some people are unwilling to comment if they are unfamiliar with underlying assumptions. One way around this is to use scenarios that stakeholders are already familiar with. We used four well-versed scenarios developed by SPRU for the Technology Foresight Programme.

When the project is developing new scenarios, as our hydrogen economy project considered in its early stages, there is a good argument for including stakeholders earlier. However, if you involve them too early, you run the risk of being bogged down in deciding what the best approach is.

In the hydrogen project, we found considerable disagreement among the project team about whether the scenario approach itself was appropriate. Those from engineering disciplines were less familiar with the use of scenarios, which have been used increasingly by social scientists since the Royal Commission on Environmental Pollution (RCEP) reported on energy and climate change in 2000. Some in the team argued that the RCEP approach – of different pathways to a defined goal – would be desirable. Others pressed for the more exploratory approach that was eventually used, which has no guaranteed role for hydrogen. The disagreement happened before we began consulting our stakeholders, but it serves to illustrate the problems you might encounter if you invited industry and policy experts to take part at an early stage.

In the end, the early debate considerably delayed our stakeholder consultation process, which was through interactive workshops. We didn't involve the stakeholders in scenario development, which we had originally planned to do. Instead, we chose to focus on the pathways from the present to realise these scenarios in 2050. One problem with this was that some delegates to the workshop found the scenarios opaque and wanted to question their content before thinking about the pathways.

The advice here is do not underestimate how difficult it will be to reach agreement within a multidisciplinary team. It may be desirable to take a risk and invite stakeholders in before you have fully agreed on your approach. Perhaps you'll find their input helps your discussion.

If you involve stakeholders too late, it becomes impossible to properly analyse their comments. To incorporate their feedback into serious analyses, you need to hear from them early enough. In the *Integrating Renewables* project, for example, we successfully used expert feedback on our scenarios to analyse potential future price trends in the market for Renewables Obligation Certificates.

How to integrate them in research?

Once you have gathered experts together, how do you elicit appropriate opinions, and what do you do with the information? There is a continuum between building your research methods on the basis of expert advice and tacking a few comments from industry on at the end. In considering medium- and long-term futures, it's advisable to sit nearer the beginning of this continuum because the latter end is not very convincing. However, you need to be sure that the views you incorporate are handled in a robust and reliable manner.

If you incorporate stakeholder views in the development of scenarios, for example, how do you ensure the range of views is representative? When you're analysing the future, different experts will give different answers. If you ask how much energy will come from renewables under a certain scenario in 2020, some may say 3%, some 10%. The difference in outcome is quite large. One solution is to present the results as a range, with a degree of uncertainty, rather than providing a single answer. Another is to compare the results with similar exercises carried out elsewhere. In our near term renewables and combined heat and power (CHP) project, this was possible since the Cabinet Office was generating similar results from the same scenario set at the time.

Some experts are uncomfortable providing real estimates. Representatives from industry have been known to retort 'How should I know?' This unwillingness to pin down figures comes from a lack of familiarity with scenario thinking. Persuading people to set aside the immediate situation can be very difficult. Many are so embroiled in current policy preoccupations that if they can't see how a particular future could be realised in the short term, they don't want to spend time thinking about it.

On the other hand, we see a very positive role for advisory groups, precisely because of the opportunity for free thinking. Members benefit from the neutral space to discuss issues frankly, and there is real potential to progress towards solutions for the long- and short-term.

Stakeholders really come into their own when asked to consider more immediate mechanisms of change – how do we get from here to there? Analysing pathways is a vital final stage in the application of scenarios. Industry and policy representatives are usually more comfortable talking in these terms, because it draws on their current experience.

Overall, then, what have we learned? Involving stakeholders is an integral part of long-term futures research, but it's a fine balancing act. You need to involve stakeholders early enough to properly incorporate their views and feedback, but not so early or so much that they throw you off course. At the Tyndall Centre we view this process as absolutely essential to the success of many branches of our research. We will continue to develop our ways of doing it, learning as we go.

"I am always struck in my Tyndall interactions by the tangible sense of shared purpose, belief and commitment ... That kind of institutional capital can't really be captured in funding proposals but it is worth more than most of what does get written down, particularly when it extends across disciplinary boundaries."

John Ashton, Co-founder E3G Third Generation Environmentalism

"The Tyndall Centre has produced and continues to produce ground breaking research into climate change ... Knowing that the Tyndall Centre is seeking to delineate the problems we face is something of a relief to us politicians, even if the solutions are still very hard to grasp."

Colin Challen MP, Chair of the All Party Group on Climate Change Member of the Environmental Audit Select Committee

Brenda Boardman 40% House

Irene Lorenzoni Risk Perceptions

Emma Tompkins Adaptation

Clare Gough Decarbonisation

by Emma L. Tompkins

Facilitating inter-disciplinarity

a comparison with international experience

Introduction

This article examines the central features of inter-disciplinary research centres, and considers what might be the central elements of best practice. Meeting the Tyndall Centre mission of: advancing the science of integration; developing responses to guide policy and society; and motivating society, is challenging, not least because these three objectives require a range of activities focussing on scientific endeavour, information provision in multiple forms, outreach activities, capacity-building, training, and policy interaction. With such a wide ranging mission, multiple skills and initiatives are required. This article considers both successes and failures of the Tyndall Centre to date, what the Tyndall Centre experience can offer other comparable centres, and what can be learned by the Tyndall Centre from other centres.

The successes of the Tyndall Centre relate to its: scientific outputs; outreach and communication; time provided to allow for innovation by researchers; training for young researchers; and in the provision of policy guidance. The Centre has been less successful in facilitating communication and inter-disciplinarity between researchers and in retaining senior researchers. Some of the main challenges with regard to the future relate to: how the Centre can facilitate the creation of self-organising research groups; learning about other disciplines within the Centre; facilitating communication *within* the Tyndall Centre, specifically between Tyndall researchers; and bringing in high profile visitors on a regular basis.

International bench-marking

To achieve the three-fold Tyndall Centre mission – integrative research, informing policy responses and motivating society – the Centre has had to work in areas which are considered unusual by some academics – i.e., in policy engagement, capacity-building, outreach and dissemination – whilst at the same time maintaining scientific rigour.

The Tyndall Centre is not alone in operating as a centre of excellence in applied earth and environmental sciences. There is a clear demand from policy makers and funders for more applied research which can answer problematic real world questions, and there appears to be a parallel increase in the number of academics interested in participating in such research[11]. The Tyndall Centre has experienced many of the same challenges these other centres have experienced, and in some area of them has been able to move forward. This article draws heavily on some of the findings from a report that I produced for MISTRA, the Swedish Foundation for Strategic Environmental Research[12].

Inter-disciplinary research centres appear to work best when there are three approaches applied simultaneously to encouraging inter-disciplinarity, communication and integration. These three approaches can be broadly summarised as: academic means; social means; and physical or structural means. These three approaches are summarised in more detail in Table 1.

"… examples of where co-ordination has worked well …. The Tyndall Centre is a model of good practise for UK centres of excellence …."

Report of the Environment Funders Forum on the status of UK environmental science, August 2003

[11] Rhoten, D. and A. Parker, 2004. Risks and Rewards of an Interdisciplinary Research Path. Science, 306 2046.

[12] Tompkins, E.L. (2005) Review of interdisciplinary environmental science centres of excellence. MISTRA, Swedish Foundation for Strategic Environmental Research, Stockholm.

Table 1: Different approaches to facilitate inter-disciplinarity

Type of approach	Specific mechanism	Examples in practice
Academic	Traditional methods of information dissemination	Seminar series Colloquia
Academic	Support the creation of self-organising research groups	Research clusters 'self-organise' around specific themes (e.g. water governance)
Academic	Actively learn about other disciplines	Face-to-face meetings at the beginning of a project 'Open peer review' system whereby colleagues drop their draft papers in a public (electronic) 'drop-box' and receive feedback (and share)
Academic	Facilitate communication flows between people	Working papers Good website PhD research network Office 'away days' Annual retreats
Academic	Research programme and project structuring	External funds sought to fund specific interdisciplinary projects Structuring research into topical rather than disciplinary areas (e.g. managing the coast)
Academic	Provide research funds	Use conditions such as: funded projects cannot be with conditions single disciplinary
Academic	Regular visitors	New people bring in new ideas, new ways of thinking and new collaborations
Academic	Teaching	Develop problem-based curriculum Form interdisciplinary PhD supervisory boards
Academic	Novel approaches to inter-disciplinary thinking	Art Electronic outreach resources
Social	Formal/routine social events	Traditional 'afternoon tea' Friday coffee and cakes Beers on last Thursday of the month Subsidised lunch
Social	'Service-oriented' support staff	Providing 'emotional' support and ensuring administrative issues are handled quickly and efficiently
Physical	Office layout	Avoid open-plan offices 'Cave and commons' building design Promote openness and privacy Shared offices
Physical	Areas for informal interaction and socialising	Kitchens for preparing food Dining areas for consuming food Communal printer/fax facilities
Physical	Comfortable interactive spaces to facilitate researcher interaction	Variety of meeting rooms with different facilities (sofa's, white boards, teleconferencing) Common room with chairs/books Libraries
Physical	Technical and computing support	

Any one of these approaches to facilitate inter-disciplinarity alone does not appear sufficient to promote active inter-disciplinarity and problem-focussed research and learning. During its first phase the Tyndall Centre has pioneered some initiatives, but it also has failed to adopt some of the initiatives that could have further enhanced its success. These successes and failures are explored in more detail overleaf.

Bev Starkings Secretary

Successes and failures in the Tyndall Centre

The successes of the Tyndall Centre relate to its: scientific outputs; outreach and communication; time provided to allow for innovation by researchers; training for young researchers; and in the provision of policy guidance. In this regard, the Tyndall Centre experience can offer other centres significant insight. There are also significant lessons, however, that the Tyndall Centre can learn from other centres. Table 2 suggests the areas in which the Tyndall Centre has and has not yet achieved success.

Table 2 Areas of insight gained from the Tyndall experience

Approaches to facilitate inter-disciplinarity	Mechanism tried by Tyndall	Success (√) or failure (X)	Possible explanation
Face-to-face meetings at outset	Bi-annual theme meetings	(√)	Supported by on-going email list communication
Working papers	Working papers	(√)	Publishes whole range of institute outputs
Annual retreats	Tyndall Assembly	(√)	Well organised and carefully planned to engage all
Office 'away days'	Manchester and UEA	(√)	Good to address localised issues of communication and interaction
PhD research network	PhD researcher network	(√)	Actively managed network
Seminar series	Monthly seminars (intermittent)	(X)	Clashes with other seminar series in UEA – not special
'Self-organised' research clusters/reading groups	Governance (led by Turnpenny) Adaptation (led by Adger)	(X)	Very few have emerged, these are not supported at all
Website	Website	(X)	Not friendly for research purposes; not initially updated over time. Recent changes are a significant improvement
Research funding from Tyndall	Conditions attached to funding	(X)	No penalties associated with not meeting stated objectives
Office layout	Open-plan offices at UEA	(X)	Lack of involvement of researchers in design
Staff turnover	Accidental high rate of staff turnover	(X)	Regular staff role-over should facilitate innovation; however too rapid turnover can stymie projects
External funding sought	e.g. EU, DEFRA, ESRC, OTEP	(√)	Active promotion of this activity by Director
Structuring research into topical areas	e.g. adaptation, mitigation, coasts	(√)	Good in principle, but chosen areas may have led to a disciplinary focus in some areas.
Regular visitors	e.g. Hallie Eakin, Patricia Iturregui, Anna Lyth, Bo Kjellen, Jon Barnett	(√)	Successful for the themes that invited the visitors
Art	Artist in residence Science-artists meetings	(√)	Organised by an individual who ensured that there was active use of the outputs
Formal/routine social events	Friday coffee and cakes	(√)	Weekly reminders and encouraging an individual to take responsibility
'Service-oriented' support staff	Ensuring administrative issues are handled quickly and efficiently	(√)	Adequate resources given to administration
Areas for informal interaction and socialising	Kitchens for preparing food	(√)	Facilities included microwave, tea and coffee, cutlery, crockery provided
Communal printer/fax facilities		(√)	Fax facilities separate at present
Areas for informal discussion	Spaces to facilitate researcher interaction	(√)	3 Meeting rooms 1 Common room with chairs/books

Rachel Warren Modelling (CIAS)

There are clearly many areas in which the Tyndall Centre has already found success and can build on for the future. The areas of greatest success relate to cooperation within physical locations. For example, the Tyndall Centre HQ at UEA and Tyndall Centre North at Manchester University have both used 'away days' to develop a sense of camaraderie among staff, to develop a shared vision and to resolve issues of concern within the office. There has been significantly less cooperation outside of these individual physical locations. Some cooperation has developed through externally funded projects. It could be that the new relationships between individuals started at the outset of the Centre in 2000 are only now starting to reach the point whereby collaborative work is possible. Strong encouragement from the Director and programme leaders will be needed to encourage greater cooperation among the research teams and physical locations in the future.

The Tyndall Centre has also made significant headway in its outreach and communication activities. Tyndall has made major contributions to international science panels (e.g. the IPCC), at international policy events (e.g. UNFCCC), at international conferences (e.g. Avoiding Dangerous Climate Change in Exeter; the IHDP Conference in Bonn), in the spoken and written media, in public debates (e.g. the Royal Institution), in overseas government policy processes, with NGOs, in UK government policy development (e.g. the Stern Review) and in academic debates. However, this outreach has not been achieved in all projects and themes to the same extent. Some individuals and projects have made significant contributions and others less so. Encouraging more projects to be engaged in outreach and stakeholder engagement will be a challenge for the future.

The Centre has achieved mixed success with its office layout, although there are different concerns in the various physical locations. At UEA, while there has been appreciation of the communal spaces for informal interaction, there is still concern among the research staff in the open plan offices that their needs and concerns are not being met. Along with others in the open plan area there is the issue of staff working longer hours to cope with the noise variability that is experienced, and a high degree of staff turnover, which can be attributed in part to the open plan offices. There is a very clear message from the other centres on how best to structure a research office – offices for quiet work and shared spaces for communal work or discussion.

Future improvements and recommendations

Several of these areas could be addressed by focussing on facilitating communication and inter-disciplinarity between researchers and on retaining senior researchers. Mechanisms to achieve this objective are described in Table 3; these relate to both internal communication and outreach.

Table 3 Opportunities for better in-reach, outreach, communication and stakeholder engagement

Area of opportunity	Specific mechanism	Example of activity
In-reach	Inter-research group communication	Contract Research Staff support, e.g. CRS network (being developed)
In-reach	Electronic drop-box for all papers developed	All staff review at least one internal draft every three months
In-reach	Communication between question areas	Regular (at least bi-annual) meetings of all programme leaders, specifically to identify areas of cooperation
In-reach	Self-organising clusters	Provide administrative support in the form of emailed reminders and pre-meet agendas
Outreach	Electronic outreach resources	Develop web-based and interactive resources to engage a wider range of stakeholders
Communication	More regular face-to-face meetings for wider groups (can be through Access Grid)	Begin Phase 2 with a meeting for all participants, followed immediately by programme meetings
Stakeholder engagement	Active communication between Stakeholder Director, Communications Manager and researchers	Monthly phone calls, one-on-one meetings or group meetings to explain what is happening and who is being involved

Nigel Arnell Adaptation

Harriet Pearson Administration

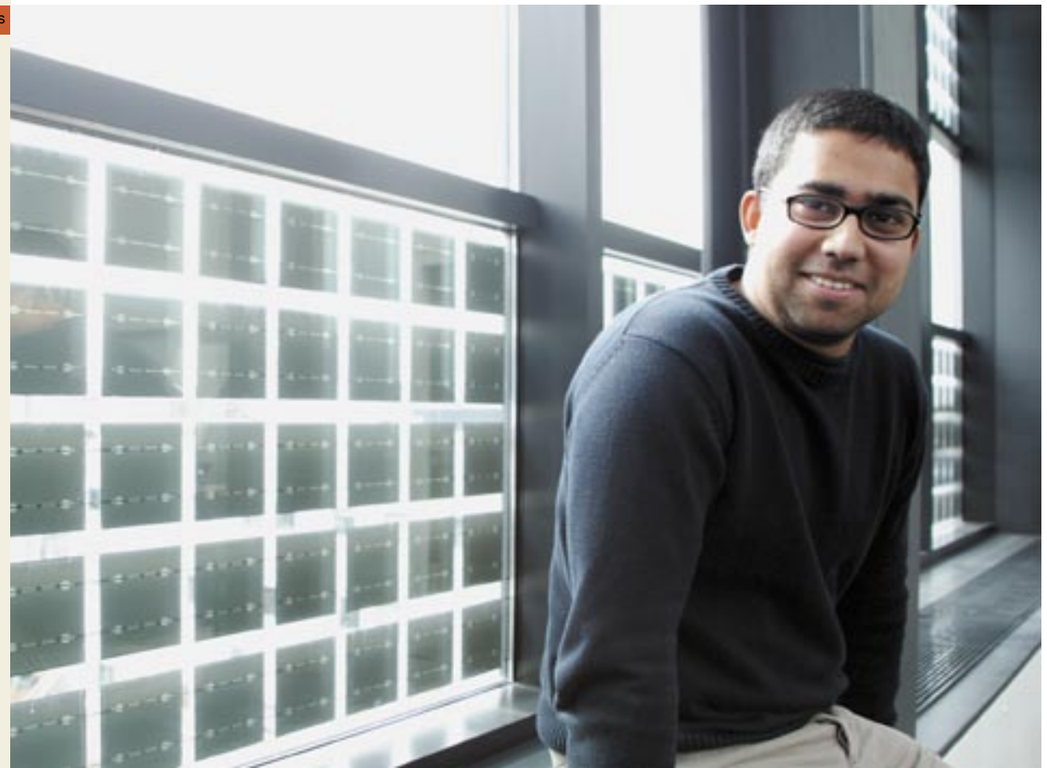
Investment in the areas described in Table 3 could lead to greater levels of inter-disciplinary interaction and to higher levels of cross-programme dialogues. It is a fine art to balance motivation, time and resources in a complex multi-site organisation so as to retain and advance successes in strategic areas whilst to also address weaknesses to ensure enhanced delivery across multiple objectives. The international review team reported in 2004 that it had every confidence that the Tyndall Centre could do so.

The resources available for Tyndall Phase 2 will not allow the Tyndall Centre to be a source of funding for external projects, nor will it allow for the same level of support for some types of external engagement and knowledge transfer as was provided in Phase 1. Nonetheless the Centre plans to achieve some significant goals and to produce some substantive outputs. To maximise the benefits from the inter-disciplinary multi-site Tyndall Centre, there has to be a greater degree of integration across programmes, locations and disciplines. To achieve this, the Centre needs strong direction, from the programme leaders, and from the directors.

"…is clearly conducting useful multidisciplinary work on climate change and energy, and is reaching out to the UK research community, as was planned, strengthening the UK's reputation in this field."

House of Commons Science & Technology Committee, March 2003.

Suraje Dessai Uncertainty analysis



by Asher Minns

Motivating society

a work in progress

Tyndall Centre Objective 3…to promote informed and effective dialogue across society about its ability and willingness to choose our future climate. Pursuing these objectives will require the Centre to engage widely with stakeholders on public and private sector organisations

From marketing and public engagement …

The Tyndall Centre's communication strategy has evolved over the Centre's first five years of operation. During its first two-and-a-half years – 2000 to 2003 – the communication strategy can best be characterised as adopting two main strands – marketing and the public engagement of science and technology. At the founding of the Tyndall Centre in 2000 it was important to establish a visible brand and reputation around the exciting and unique venture of solutions-focused inter-disciplinary climate change research in the UK. For the first time in the UK a research organisation had joined together environmental scientists, engineers, economists and social scientists. In the first phase it was important to communicate the radical objectives of the Centre, its innovative structure and the research vision that was new and getting underway.

Our public engagement initiatives included: public talks and science cafes all year round; a Christmas show for school children; two teacher's packs; two art and climate change exhibitions with Norwich School of Art (one is currently in New York Galleries and was included in Tate Britain's Summer Show); and a TV-based information campaign about renewable energy in partnership with CSV Media and Anglia TV where over 11,000 contacted our hotline for further information. More recently, we have provided significant support and input to the British Council's worldwide ZeroCarbonCity Campaign. I think it reasonable to write that we may be one of the UK's most successful research organisations for communicating issues around environmental science and policy to the public as well as stakeholders, especially with regard to the size of our communication and knowledge transfer teams (we are the full-time equivalent of 1.8 people).

In addition to marketing and public engagement, equal effort was also focussed upon disseminating the importance of climate change to policy makers, the media and the public. It is fair to consider some success with both of these communication objectives. Tyndall is now a recognised international UK-based brand in climate change research and policy circles. It has got there through proactive marketing via a significant number of ambassadors and of course because it does research that is designed to be truly useful. It is also clear that climate change is now on the policy, media and public agendas more than it was even two years ago, which is reflected by tracking the phrase 'climate change' over time in the UK press. Over the past three months (January to March 2006) there has been an average of 1380 news stories each month mentioning climate change. For the same period 2005, it was an average of 1148 stories; 2004 389 stories; 2003 18 stories and 2002 only 7[13]. Climate change has grown from an occasional nerdy science story or doomsday headline to being about politics, money and power. Clearly this rise in press interest is not solely due to the activities of the Tyndall Centre and the motivation of its staff, but I think that a little credit can also be allowed. We have actively influenced and informed public policy debate around climate change policy, showing that the Tyndall Centre has been agenda-setting in its communication as well as in our research. We have actively engaged and built lasting relationships with decision makers and journalists, whom influence each other as well as the perceptions of the public, which in turn influences policy and the media.

… through to Knowledge Transfer

Over the second two-and-half year period (2003 to 2006), our communication has strategically moved from marketing and public engagement towards knowledge transfer (KT). We have actively shifted from being less about the Tyndall Centre and the climate change issue in general, to communicating the specific outputs arising from Tyndall research projects and their informative results. In science communication terms, we have moved from science in general to science in particular. The communication strategy now has more focus upon delivering our deliverables to key target audiences through, for example, workshops, conferences,

Asher Minns Communication

[13] This is probably an underestimate as my media search engine's ability and the number of online news has significantly increased since 2002. The magnitude of the differences nevertheless suggests a strong pattern and is similar when applied to other months.

Vanessa McGregor Events/PA

targeted publications, briefings and of course occasionally routed through the media (Figure 5). Topical timing is a key to success with such events. Some specific examples of our knowledge transfer that has informed policy are detailed in the previous chapters.

My third point on the long-term development of the strategy over the whole five years is that communication is now close to a normalised part of our research activity, as I think that this document demonstrates. Many of our contract and younger researchers are motivated and trained to consider the value of communication and knowledge transfer in all of their activities, and have had significant success as science communicators. There is an age and experience cut-off though – most faculty members are less able to put in the extra effort and extra hours that are required for engagement and media activities. However, the question of 'what to do about climate change', is itself a newly formed area of research and public interest, and few people can reasonably claim to have yet had a long academic career in the subject. I hope that exposing our younger and contract researchers to communication from their early careers will continue to pay dividends when they themselves are faculty or senior researchers. Hopefully, we are spreading a communication and inter-disciplinary virus throughout UK environmental research. Perhaps the ultimate measure of a successful science communication manager is for she/he to have made themselves redundant, because the researchers eventually do all the communication themselves?

Where we have had less structured success is perhaps with international communication. Specific projects and researchers have been extraordinarily successful with their engagement from the local level of communities to the heights of UN COPs and the IPCC, but available resources and networks keep us mostly focused on UK engagement (Figure 6). This will change in Phase II due to three new international research programmes and a big new European project. Given hypothetical extra funding, there was stakeholder interest in the idea of establishing a rapid response capacity to coordinate UK research for just-in-time engagement on topical climate change issues of public-policy interest.

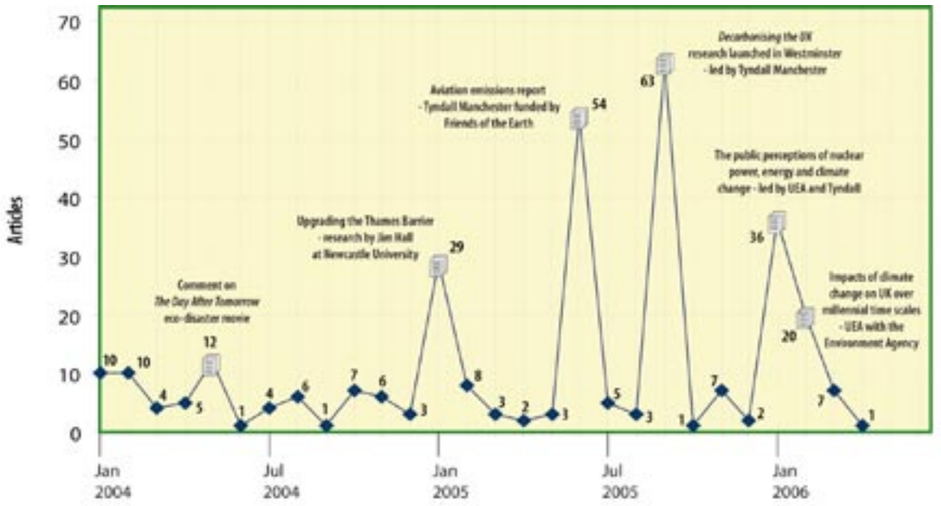


Figure 5. Tyndall Centre in the UK press 2004-2006. The major spikes are media in support of our higher profile knowledge transfer activities where we have actively sought attention

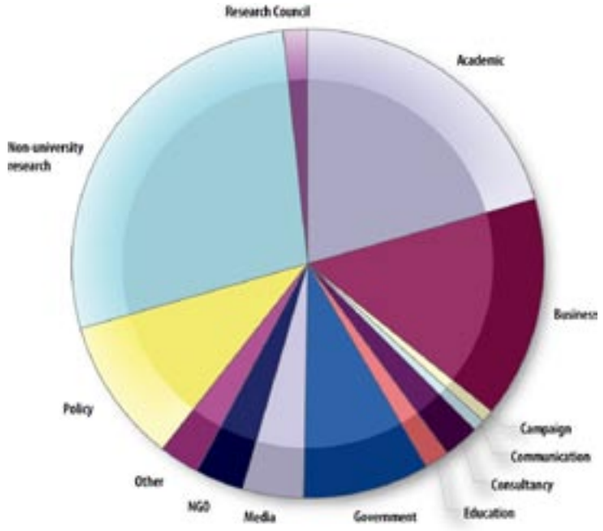


Figure 6. Our stakeholder contacts database by type of organisation, March 2006. Half of the 2976 contacts have self signed-up to our website's quarterly electronic. This data represents 3000 people from 1483 different organisations from 95 different countries. 2000 of the contacts are from the UK.

When to engage?

There is a very real conflict of time and resource around whether people should be communicating and engaging (out-of-office for a day), or productively researching in the office. Many Tyndall researchers see the need to do both in order to balance their career aspirations with their social contract and personal motivations. Unfortunately, unlike peer reviewed publications and research grants won, engagement does not step-up anyone climbing the well defined ladder of an academic career and as the communication manager, I also have a responsibility to our younger researchers to help them develop their careers. It is now the case that so many people, organisations and media companies want to hear about climate change research that I am now discouraging our researchers to accept requests so that they have more time for research and publishing. This morning while writing this piece, for example, I have received two calls and two emails asking for Tyndall to engage (pupils at the Natural History Museum, a London transport conference, a biofuels consultancy and with the citizens of Kent). Including preparation time, that is the full-time researcher equivalent of an entire week out of the office.

It is both an advantage and disadvantage that Tyndall is a victim of its own success which means that we cannot possibly respond to all the requests that we receive for engagement and knowledge transfer. While it is frustrating to me that we cannot respond to such demand, it is also a real indicator that everyone should be proud who has contributed to Tyndall. I am obviously the wrong person to ask but if I try to objectively give the Tyndall Centre an overall grading for communication and knowledge transfer, as is done with its science, then I award an 'Alpha 4' – an excellent. I am tempted to give an 'Alpha 5' – meaning outstanding and exceptional – but you the reader would then think that I might be biased. As always though, we could do better.

Jim Hall Engineering

by Samantha Jones

Seeking sustainability

approaches to reducing our carbon footprint

Cheryl Gardner Administration

The Tyndall Centre is committed to undertaking integrated research that contributes to a sustainable response to the challenge of climate change. As such it is appropriate and important for the Centre to consider the sustainability of its own operations. Initially, the Tyndall Centre undertook some ad hoc measures concerning sustainability, in particular a scheme for measuring greenhouse gas emissions from travel which has operated since 2001. In 2004 we decided to take a more comprehensive approach to these issues, by devising a sustainability strategy for the Centre.

Developing a sustainability strategy

The Centre Manager took responsibility for co-ordinating the preparation of a sustainability strategy. The first task was to decide how best to obtain input and draw on experience from across the multi-partner Tyndall Centre. As a staring point, a voluntary email interest list for sustainability issues in the Centre was created, bringing 16 people together with reasonable coverage of different Tyndall institutions and staff categories. <tyn.sustainable> was used to exchange ideas and information on making the Centre more sustainable in its operation.

List members were asked if they would like to participate in drafting a strategy, and a working group of five members was convened, co-ordinated by the Centre Manager. This comprised two researchers, a PhD student and two support staff members, based in two different Tyndall institutions. The group worked by email and had one meeting via a teleconference. Various group members drafted sections of text for the strategy, which were collated by the Centre Manager. A draft strategy was circulated to the full <*tyn.sustainable*> group for consultation. The comments received were used to produce a refined version of the strategy. Early in 2005 this was considered and approved by the Tyndall Council, the Centre's internal management committee. The strategy is available on the Tyndall web site.

A number of principles and challenges were identified which guided development of the sustainability strategy.

The Tyndall Centre's structure

The Tyndall Centre consists of a number of partners, which are hosted by UK universities and Research Council institutes. It had to be recognised that the different parts of the Centre would be influenced by the practises of their host institutions. These local practises vary in the extent to which they address sustainability and take account of other factors such as economic cost and health and safety. Our sustainability strategy therefore identified areas where the Tyndall Centre could work with its host institutions to implement and enhance sustainability measures and pool resources where possible – for example, working with institutions on establishment and maintenance of recycling schemes.

The Centre's structure also posed a challenge for co-ordinating the strategy. One of its key elements is that each partner should appoint a sustainability 'representative'. This person's job description explicitly includes time to be devoted to encouraging and monitoring sustainable practices in that part of the Centre, exchanging information with other partners, liaising with host institution staff and seeking to influence host institutional strategies. This network of representatives collectively agrees on specific, short-term objectives and targets for improving sustainability and to make recommendations to the Centre's management committee. The network also helps to ensure views across the Centre are represented in decision-making.

In a distributed research centre, sustainable travel is a demanding issue. Our strategy therefore encourages staff to actively consider whether potential travel is really necessary or whether there are other reasonable options. These include the access grid and tele-conferencing as alternatives to face-to-face meetings.

Coverage

It seemed realistic to start off small-scale, focussing on a few areas of Tyndall Centre operation. We also defined timescales for implementing objectives at three levels: long, medium and short-term related to the Centre's first and second phase of core funding. The overall goals of the sustainability strategy are identified as long-term objectives; different areas of operation are then addressed more fully, involving identification of medium and short term objectives to improve sustainability.

The areas focussed on are:

- *built environment and energy* – metering and measurement; energy efficiency/reducing environmental impact
- *procurement, consumables and waste* – including the 'reduce, re-use, recycle' hierarchy, and recognising Centre staff members' greatest influence over sustainability is likely to be in their own office environments
- *travel* – alternatives to travel; more sustainable forms of travel; developing the Centre's travel emissions scheme

Examples of objectives defined in relation to these areas:

- *energy – medium term* objective to replace existing equipment with low energy items
- *travel – short term* objective to produce a guide for Tyndall Centre staff offering practical advice on use of access grid, video/teleconferencing and low(er) carbon travel options

We also felt it was useful to employ a combination of direct and indirect sustainability measures. For instance regarding travel, a direct action is offsetting travel emissions, and an indirect measure is giving staff practical information which encourages more sustainable forms of travel such as\web services for booking train travel in Europe.

Flexibility

At the time of preparing the sustainability strategy, the Tyndall Centre was nearing the end of its first phase of core funding, with an expectation that a second phase would be granted. The strategy had to be sufficiently flexible to evolve, especially to take account of the Centre's transition from phase 1 to 2. The use of objectives with specific timescales helped. A procedure for reporting and review has been incorporated in the strategy, which should help inform its further development.

Strategy implementation

Short-term objectives have focussed on preparation and dissemination of information to share sustainable practices across the Tyndall Centre, encouraging both partner and individuals to think critically about the impact of their activities in sustainability terms. A guide to using the Access Grid and video and teleconferencing has been published, providing practical advice relevant to the Centre. This includes availability of Access Grid and conferencing facilities at partner institutions, how to book these facilities, advantages and disadvantages of use, and what kinds of meetings are best suited to these technologies. This is now being expanded into a broader sustainability 'good practice' guide. A number of these guides already exist, so this one aims to be specifically relevant to the Centre's needs, for example advice on sustainable travel and office practices. Staff have been surveyed to find out what information they would like included.

Future questions

One issue proving especially challenging is sustainable travel. Our strategy includes development of the Tyndall Centre travel emissions scheme. This monitors greenhouse gas emissions from most types of UK and overseas travel undertaken by staff at the Centre Headquarters office (normal journeys to work excluded), and staff and other individuals involved in centrally organised Tyndall events. Most (~90 per cent) of our emissions come from air travel. HQ set a target from financial year 2004-5 onwards to reduce carbon emissions from air travel by 10 per cent per year. This was based on an entirely voluntary approach and relying on individuals to take steps to reduce their emissions. The target was not met in its first year of operation and in fact aviation emissions increased from 2003-4 to 2004-5.

A purely voluntary approach may not be effective as a long-term means of emissions reduction. Staff shouldn't be made to feel guilty about travelling or that valid activities should be curtailed. Nevertheless, how does this increase in the Centre's emissions sit with our recent research on growth scenarios for EU and UK aviation and how these scenarios contradict climate policy goals?

We surveyed staff opinion on the acceptability of refusing to fund/reimburse air travel costs within the UK or under a minimum distance, but did not achieve consensus. Some staff supported this, but others did not noting that individuals would take into account and balance a number of valid factors in deciding how to travel, – for example, time taken, cost and family commitments, as well as sustainability. We are now looking at the possibility of operating carbon budgets or tax or staff pledges to decrease emissions within the Centre, which would influence individual or project decisions on whether and how to travel.

Gavin Killip 40% House

Professor Mike Hulme

Professor Andrew Watkinson

Professor Katrina Brown

Professor John Shepherd

by Mike Hulme, Andrew Watkinson, Kate Brown, John Shepherd

Into the future

a new pact between science and society?

The Tyndall Centre has five years of experience of how to (and how not to) execute and deliver inter-disciplinary climate change research in the UK. The international expert review of the Tyndall Centre in 2004, whilst praising the early achievements of the Centre, identified a number of issues about internal organisation and external engagement that needed attention. Many of these have been tackled carefully in the revised bid for Phase 2 funding submitted to the Research Councils in 2005.

But with a reduced rate of core investment from the Research Councils – almost a 20 per cent cut in real terms – and a three-year programme rather than five years, a more fundamental issue has now emerged. Creating and bringing to fruition a new type of inter-disciplinary research capacity, staffed with people who can operate effectively in such challenging territory, is no short-term venture. The Centre will not thrive in a contractual framework in which staff are hired for 2 or 3 years and then dismissed. Nor where the short-term delivery period dictates against taking risks with new inter-disciplinary methods and against developing sustainable relationships with stakeholders where mutual learning – essential for co-production of knowledge – can occur. An organisation like the Tyndall Centre needs a longer planning horizon than this for the ethos, culture and practise of the Centre to be established, embedded and sustained. This is especially true when the Centre in several important respects is counter-cultural to the prevailing higher education (dominated by the RAE paradigm) and Research Council (dominated by traditional disciplinary science outputs) environments.

The fundamental question then is whether the Tyndall Centre in Phase 2 is executing a time-limited traditional three-year research programme or whether the Centre is seeking to develop a sustainable capacity for inter-disciplinary climate change research in the UK? The Research Councils seem implicitly to believe it is the former; the Centre, the international review panel and many national and international stakeholders believe it is the latter. The long-term sustainability of the Tyndall Centre requires us to articulate, justify and fund this vision.

And our reason for proposing this future for the Tyndall Centre is simple. Climate change is in the end an intractable phenomenon; there are massive difficulties in re-directing society(ies) towards a more sustainable relationship with their prospective climates. This is not a case of one big science push to get our climate predictions 'correct' or one great engineering 'breakthrough' that will yield cheap, safe, carbon-neutral hydrogen fuel. Climate change needs to be positioned first and foremost as a geo-political problem, embedded in a heterogeneous and changing global culture. We have to recognise the appropriate and necessary contribution of research in helping the world to steer through this geo-political maze, namely:

- to articulate and quantify the risks and benefits of different climate futures, for different people at different times
- to demonstrate how effective different policy interventions, at different scales of governance, may be in delivering different climate futures
- to work with stakeholders – public or private, north or south, local or national – to help them identify their own best climate change management strategy
- to provide intellectual and public spaces for debate, learning and interaction between science and society to occur.

This is the Tyndall Centre's true role.

Research outputs

This final section summarises the more conventional research outputs of the Tyndall Centre. To date from phase 1 of Tyndall, forty-one research projects have published their final Technical Reports and have produced 251 papers in research journals, 88 Tyndall Working Papers, 106 book chapters and books and 13 topical Briefing Notes.

Below are listed the final Technical Reports, Working Papers and Briefing Notes, all of which are free to download without registering at www.tyndall.ac.uk The website also lists all journal papers.

Tyndall Technical Reports

Lenton T., Loutre M., Williamson M., Warren R., Goodess C. M., Swann M., Cameron D., Hankin R., Marsh R., Shepherd J., (2006) Climate Change on the millennial timescale: Tyndall Centre Technical Report 41

Bows A., Anderson K., Upham P., (2006) Contraction and Convergence: UK carbon emissions and the

implications for UK air traffic: Tyndall Centre Technical Report 40

Starkey R., Anderson K., (2005) Domestic Tradeable Quotas: A policy instrument for reducing greenhouse gas emissions from energy use: Tyndall Centre Technical Report 39

Pearson S, Rees J., Poulton C, Dickson M, Walkden M, Hall J, Nicholls R., Mokrech M, Koukoulas S., Spencer T., (2005) Towards an integrated coastal sediment dynamics and shoreline response simulator: Tyndall Centre Technical Report 38

Sorrell S., (2005) The contribution of energy service contracting to a low carbon economy: Tyndall Centre Technical Report 37

Tratalos J, Gill J., Jones A, Showler, D, Bateman I, Watkinson A., Sugden R, Sutherland W, (2005) Interactions between tourism, breeding birds and climate change across a regional scale: Tyndall Centre Technical Report 36

Thomas C., Osbahr H, Twyman C, Adger W. N., Hewitson B, (2005) ADAPTIVE:adaptations to climate change amongst natural resource-dependant societies in the developing world: across the Southern African climate gradient: Tyndall Centre Technical Report 35

Delaney K, Adger W. N., Tompkins E. L, Arnell N. W., (2005) Vulnerability to abrupt climate change in Europe: Tyndall Centre Technical Report 34

Anderson K., Shackley S., Mander S, Bows A., (2005) Decarbonising the UK: Energy for a climate conscious future: Tyndall Centre Technical Report 33

Halliday J, Peters M., Powell J, Ruddell A, (2005) Fuel cells: Providing heat and power in the urban environment.: Tyndall Centre Technical Report 32

Haxeltine A., Turnpenny J., O'Riordan T., Warren N, (2005) The creation of a pilot phase Interactive Integrated Assessment Process for managing climate futures: Tyndall Centre Technical Report 31

Nedic D, Shakoor A, Strbac G, Watson J, Mitchell C, Black M, (2005) Security assessment of future electricity scenarios: Tyndall Centre Technical Report 30

Shepherd J., Challenor P, Williamson M., Lenton T., Huntingford C, Ridgwell A, (2005) Planning and Prototyping a Climate Module for the Tyndall Integrated Assessment Model: Tyndall Centre Technical Report 29

Lorenzoni I., Pidgeon N., Lowe J., (2005) A strategic assessment of scientific and behavioural perspectives on 'dangerous' climate change: Tyndall Centre Technical Report 28

Boardman B, Killip G, Darby S, (2005) Lower Carbon Futures: the 40% House Project: Tyndall Centre Technical Report 27

Dearing J., Plater A., Prandle D., Richmond N., Wolf J, (2005) Towards a high resolution cellular model for coastal simulation (CEMCOS): Tyndall Centre Technical Report 26

Timms P., Kelly C., Hodgson F., (2005) World transport scenarios project: Tyndall Centre Technical Report 25

Brown K, Tsimplis M, Tompkins E. L, Few R., (2005) Responding to climate change: inclusive and integrated coastal analysis: Tyndall Centre Technical Report 24

Anderson D., Kohler J., Barker T., Pan H., Warren R., Winne S., Agnolucci P., Ekins P., Foxon T., Green K, (2005) Technology policy and technical change a dynamic global and UK approach: Tyndall Centre Technical Report 23

Abu-Sharkh S., Li B, Markvart T, Ross N, Wilson A, Steemers K, Kohler J., Arnold R, Yao R, (2005) Microgrids: distributed on-site generation: Tyndall Centre Technical Report 22

Shepherd D, Jickells T, Andrews J, Cave R, Ledoux L, Turner K., Watkinson A., Aldridge J, Malcolm S, Parker R, (2005) Integrated modelling of an estuarine environment: an assessment of managed realignment options: Tyndall Centre Technical Report 21

Dlugolecki A., Mansley M., (2005) Asset management and climate change: Tyndall Centre Technical Report 20

Shackley S., Bray D, Bleda M, (2005) Developing discourse coalitions to incorporate stakeholder perceptions and responses within the Tyndall Integrated Assessment: Tyndall Centre Technical Report 19

Dutton A, Bristow A, (2005) The Hydrogen energy economy: its long term role in greenhouse gas reduction: Tyndall Centre Technical Report 18

Few R., (2005) Health and flood risk; A strategic assessment of adaption processes and policies.: Tyndall Centre Technical Report 17

Brown K, Boyd E., Corbera E., Adger W. N., (2004) How do CDM projects contribute to sustainable development?: Tyndall Centre Technical Report 16

Bristow A, Tight M, May A, Berkhout F, Harris M, (2004) How can we reduce carbon emissions from transport?: Tyndall Centre Technical Report 15

Levermore G, Chow D, Jones P, Lister D, (2004) Accuracy of modelled extremes of temperature and climate change and its implications for the built environment in the UK: Tyndall Centre Technical Report 14

Jenkins N, Strbac G, Watson J, (2004) Connecting new and renewable energy sources to the UK electricity system: Tyndall Centre Technical Report 13

Hanson C, Holt T, Palutikof J., (2004) An Integrated Assessment of the Potential for Change in Storm Activity over Europe: Implications for Insurance and Forestry in the UK: Tyndall Centre Technical Report 12

Berkhout F, Hertin J, Arnell N. W., (2004) Business and Climate Change: Measuring and Enhancing Adaptive Capacity: Tyndall Centre Technical Report 11

Tsimplis M, (2004) Towards a vulnerability assessment for the UK coastline: Tyndall Centre Technical Report 10

Gill J., Watkinson A., Cote I, (2004) Linking sea level rise: coastal biodiversity and economic activity in Caribbean island states: towards the development of a coastal island simulator: Tyndall Centre Technical Report 9

Skinner C, Fergusson, Kroeger K., Kelly C., Bristow A, (2004) Critical Issues in Decarbonising Transport: Tyndall Centre Technical Report 8

Adger W. N., Brooks N, Kelly M., Bentham G., Eriksen S., (2004) New indicators of vulnerability and adaptive capacity: Tyndall Centre Technical Report 7

Macmillan S, Kohler J., (2004) Modelling energy use in the global building stock: a pilot survey to identify available data sources: Tyndall Centre Technical Report 6

Steemers K, (2003) Establishing research directions in sustainable building design: Tyndall Centre Technical Report 5

Goodess C. M., Osborn T, Hulme M, (2003) The identification and evaluation of suitable scenario development methods for the estimation of future probabilities of extreme weather events: Tyndall Centre Technical Report 4

Kohler J., (2002) Modelling technological change: Tyndall Centre Technical Report 3

Gough C., Shackley S., Cannell M, (2002) Evaluating the options for carbon sequestration: Tyndall Centre Technical Report 2

Warren R., (2002) A blueprint for integrated assessment of climate change: Tyndall Centre Technical Report 1

Tyndall Working Papers

Kuang C, Stansby P, (2006) Sandbanks for coastal protection: implications of sea-level rise. Part 3: wave modelling: Working Paper 88

Kuang C, Stansby P, (2006) Sandbanks for coastal protection: implications of sea-level rise. Part 2: current and morphological modelling: Working Paper 87

Stansby P, Kuang C, Laurence D, Launder B, (2006) Sandbanks for coastal protection: implications of sea-level rise. Part 1: application to East Anglia: Working Paper 86

Bentham M, (2006) An assessment of carbon sequestration potential in the UK – Southern North Sea case study: Tyndall Working Paper 85

Anderson K., Bows A., Upham P., (2006) Growth scenarios for EU UK aviation: contradictions with climate policy: Tyndall Working Paper 84

Williamson M., Lenton T., Shepherd J., Edwards N, (2006) An efficient numerical terrestrial scheme (ENTS) for fast earth system modelling: Tyndall Working Paper 83

Anderson K., Bows A., (2005) An analysis of a post-Kyoto climate policy model: Tyndall Working Paper 82

Sorrell S., (2005) The economics of energy service contracts: Tyndall Working Paper 81

Wittneben B, Haxeltine A., Kjellen B, Turnpenny J., Warren R., (2005) A framework for assessing the political economy of post-2012 global climate regime: Tyndall Working Paper 80

Ingham A., Ma J., Ulph A., (2005) Can Adaptation and Mitigation be complements?: Tyndall working paper 79

Agnolucci P., (2005) Opportunism and competition in the non-Fossil fuel obligation: Tyndall working paper 78

Barker T., Kohler J., Pan H., Warren R., Winne S., (2005) Avoiding dangerous climate change by inducing technological progress: scenarios using a large-scale econometric model: Tyndall Working paper 77

Agnolucci P., (2005) The role of political uncertainty in the Danish renewable energy market: Tyndall Working paper 76

Fu G, Lawry J, Hall J, (2005) Beyond probability: new methods for representing uncertainty in projections of future climate: Tyndall Working paper 75

Ingham A., Ma J., Ulph A., (2005) How do the costs of adaptation affect optimal mitigation when there is uncertainty irreversibility and learning?: Tyndall Working Paper 74

Walkden M, (2005) Coastal Process simulator scoping study: Tyndall Working Paper 73

Lowe D J, Brown K, Dessai S, Doria M, Haynes K, Vincent K, (2005) Does tomorrow ever come? Disaster narrative and public perceptions of climate change: Tyndall Working Paper 72

Boyd E., Gutierrez M, Chang M, (2005) Adapting small-scale CDM sinks projects to low-income communities: Tyndall Working Paper 71

Abu-Sharkh S., Li B, Markvart T, Ross N, Wilson P, Yao R, Steemers K, Kohler J., Arnold R, (2005) Can microgrids make a major Contribution to UK energy supply?: Tyndall Working Paper 70

Hurlston L, Tompkins E. L, (2005) Natural hazards and climate change: what knowledge is transferable?: Tyndall Working Paper 69

Bleda M, Shackley S., (2005) The formation of belief in climate change in business organisations: A dynamic simulation model: Tyndall Working Paper 68

Turnpenny J., O'Riordan T., Haxeltine A., (2005) Developing regional and local scenarios for climate change mitigation and adaptation; Part 2: Scenario creation: Tyndall Working Paper 67

Turnpenny J., Haxeltine A., O'Riordan T., Lorenzoni I., (2005) Mapping actors involved in climate change policy networks in the UK: Tyndall Working Paper 66

Adger W. N., Tompkins E. L, Brown K, (2004) Why do resource managers make links to stakeholders at other scales?: Tyndall Centre Working Paper 65

Peters M., Powell J, (2004) Fuel cells for a sustainable future II: Tyndall Working Paper 64

Few R., Kovats S., Matthies F., Ahern M., (2004) Floods: health and climate change: A strategic review: Tyndall Centre Working Paper 63

Barker T., (2004) Economic theory and the transition to sustainability: a comparison of approaches: Tyndall Centre Working Paper 62

Brooks N, (2004) Drought in the African Sahel: long term perspectives and future prospects: Tyndall Working Paper 61

Few R., Brown K, Tompkins E. L, (2004) Scaling adaptation: climate change response and coastal management in the UK: Tyndall Working Paper 60

Anderson D., Winne S., (2004) Modelling Innovation and Threshold Effects In Climate Change Mitigation: Tyndall Working Paper 59

Bray D, Shackley S., (2004) The Social Simulation of The Public Perceptions of Weather Events and their Effect upon the Development of Belief in Anthropogenic Climate Change: Tyndall Working Paper 58

Shackley S., Mander S, Reiche A, (2004) The Public Perceptions of Underground Coal Gasification (UCG): A Pilot Study: Tyndall Centre Working Paper 57

Vincent K, (2004) Creating an index of social vulnerability to climate change for Africa: Tyndall Working Paper 56

Mitchell T., Carter T R, Jones P, Hulme M, New M, (2004) A comprehensive set of high-resolution grids of monthly climate for Europe and the globe: the observed record (1901-2000) and 16 scenarios (2001-2100): Tyndall Centre Working Paper 55

Turnpenny J., Carney S, Haxeltine A., O'Riordan T., (2004) Developing regional and local scenarios for climate change mitigation and adaptation Part 1: A framing of the East of England: Tyndall Working Paper 54

Agnolucci P., Ekins P., (2004) The Announcement Effect And Environmental Taxation: Tyndall Working Paper 53

Agnolucci P., (2004) Ex Post Evaluations of CO2 -Based Taxes: A Survey: Tyndall Centre Working Paper 52

Agnolucci P., Barker T., Ekins P., (2004) Hysteresis and Energy Demand: the Announcement Effects and the effects of the UK Climate Change Levy: Tyndall Working Paper 51

Powell J, Peters M., Ruddell A, Halliday J, (2004) Fuel Cells for a Sustainable Future?: Tyndall Working Paper 50

Awerbuch S., (2004) Restructuring our electricity networks to promote decarbonisation: Tyndall Working Paper 49

Pan H., (2004) The evolution of economic structure under technological development: Tyndall Working Paper 48

Berkhout F, Hertin J, Gann D M, (2004) Learning to adapt: Organisational adaptation to climate change impacts: Tyndall Centre Working Paper 47

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Boyd E., Corbera E., Gutierrez M, Estrada M, (2004) The politics of afforestation and reforestation activities at COP-9 and SB-20: Tyndall Briefing Note 12

Dessai S, Schipper EL, Corbera E., Haxeltine A., Kjellen B, Gutierrez M, (2004) Challenges and Outcomes at COP-9: Tyndall Briefing Note 11 HTML version & PDF version

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Contributors

Neil Adger	Tyndall Programme Leader (Adaptation), School of Environmental Sciences, UEA
Kevin Anderson	Tyndall Programme Leader (Energy), and research lecturer in the School of Mechanical, Aeronautical, Civil and Electrical Engineering at the University of Manchester
Alice Bows	Tyndall senior researcher in the School of Mechanical, Aeronautical, Civil and Electrical Engineering at the University of Manchester
Kate Brown	Professor in the School of Development Studies at UEA, Tyndall Deputy Director for Social Science and Tyndall Programme Leader (International Development)
Bill Clark	Kennedy School of Governance, Harvard University, USA
Esteve Corbera	Tyndall senior research associate in the School of Development Studies at UEA
Marisa Goulden	PhD candidate and Tyndall researcher in the School of Development Studies at UEA
Mike Hulme	Director of the Tyndall Centre and Professor in the School of Environmental Sciences at UEA
Lisa Hurlston	Environmental Assessment Officer, Cayman Island Department of Environment and Tyndall-DFiD-FCO Visiting Fellow in 2004
Samantha Jones	Tyndall Centre Administration Manager, School of Environmental Sciences at UEA
Jonathan Köhler	Tyndall senior research associate, School of Environmental Sciences at UEA and 4CMR, Department of Land Economy, University of Cambridge
Asher Minns	Tyndall External Communications Manager, School of Environmental Sciences at UEA and Environmental Change Institute, University of Oxford
Robert Nicholls	Professor of Civil Engineering at the University of Southampton, and Tyndall Programme Leader (Coasts)
Emma Tompkins	James Martin Fellow, Environmental Change Institute, University of Oxford, and Honorary Tyndall researcher
John Turnpenny	Tyndall senior research associate in the School of Environmental Sciences at UEA
John Schellnhuber	Tyndall Distinguished Science Advisor, Director of the Potsdam Institute for Climate Impact Research, Potsdam, and Visiting Professor in the Department of Physics, University of Oxford
Andrew Watkinson	Professor in the Schools of Biological and Environmental Sciences at UEA, and Tyndall Deputy-Director for internal science co-ordination
Jim Watson	Senior Fellow, Sussex Energy Group and Tyndall Deputy Programme Leader (Energy), University of Sussex

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For more information contact:

Tyndall Centre UEA (HQ)
Zuckerman Institute for Connective Environmental Research
School of Environmental Sciences,
University of East Anglia, Norwich, NR4 7TJ, UK
Phone: +44 (0)1603 593900 Fax: +44 (0)1603 593901
Email: tyndall@uea.ac.uk