UNIVERSITY OF CAMBRIDGE

Briefing Paper series from the Cambridge Centre for Climate Change Mitigation Research

4CMR

Uncertainty and Climate Policy

Policy summary

Risks associated with climate change are characterised by significant uncertainties. In traditional risk-based environmental decisions, uncertainties are addressed through the precautionary principle and development of margins of safety, each resting on formal descriptions of the uncertainty in risk estimates. The ability to produce similarly quantitative descriptions of uncertainty is limited in climate risk, although advances are being made. In the interim, the treatment of uncertainty in climate policy and other areas of risk-based environmental policy is likely to differ.

The Setting

Establishing policies that address the risks of climate change through mitigation requires estimates on three relationships:

- The relationship between policies and GHG emissions
- The relationship between emissions and extent/timing of climate change
- The relationship between climate change and adverse impacts

These relationships are beset by significant scientific uncertainty, both in regard to the effectiveness of policies in driving down emissions, and the adverse effects caused by climate-related damage.

Uncertainty has been addressed traditionally in environmental policy through the use of the precautionary principle and related concepts such as margins of safety in regulatory limits. A margin of safety might have a subjective basis such as a policy default to uniformly increase the stringency of regulatory limits by some factor (10, 100, etc) to account for the possibility that uncertainty has caused an underestimation of risk. Or the margin of safety might have a more scientific basis based on formal depictions of the uncertainty as a probability density function on risk, and selection of a target level of confidence in the belief that a policy protects individuals against "unreasonable" levels of risk.

	Relationship between…		
	Cumulative emissions and mean global temperature	Mean global temperature and climate measure	Climate measure and impact
Qualitative epistemic judgment			
Confidence interval			
Confidence distribution			

If climate change policy were placed on a similar footing in regard to analysis of uncertainty, it and other environmental policies might be harmonised. Through this process of harmonisation, climate policy could draw on the well-tested legal precedents set by more general environmental policy.

To consider the ability to provide such a formal description of uncertainty underlying risk-based environmental decisions as reflected in climate policy, 4CMR conducted a workshop in June of 2011 in collaboration with the E3 Foundation.

The Briefing Papers series by 4CMR provides policy makers, organisations, communities and citizens with advanced research on the roles of economic, energy and environmental strategies for reducing the risk of climate change.

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The Solution

The workshop focused on the ability of current science to produce formal descriptions of uncertainty for three questions of climate change risk: (i) how are global emissions related to mean global temperature, (ii) how is mean global temperature related to climate changes specifically in the UK and (iii) how is climate change in the UK related to specific measures of adverse impact there? Uncertainty was considered at three levels of detail: (i) stating only that this uncertainty is high/medium/low (a form of epistemic analysis), (ii) stating a confidence interval, but not further stating the relative degree of confidence in estimates within this interval or (iii) stating a fully quantitative probability density function.

The Results

The workshop revealed an incomplete ability at present to produce the third level of detail on uncertainties in any of the three questions, and an insufficient ability to produce anything other than an epistemic analysis for the third question. For the relationship between emissions and mean global temperature, some aspects of uncertainty are captured in analyses such as Meinshausen et al ("Greenhouse-gas Emission Targets for Limiting Global Warming to 2 °C", Nature, 458, 1158-1162, 2009). These results suggest that cumulative global emissions consistent with a mean global temperature increase of 2 °C or lower, lies somewhere within the confidence interval of 1200 to 1800 Gt, but that further specification of the PDF is not possible at present.

Global mean temperature (ºC)									
	2020s			2050s			2080s		
Probability	10%	50%	90%	10%	50%	90%	10%	50%	90%
High emissions	1.0	1.3	1.6	2.1	2.7	3.3	3.4	4.3	5.3
Medium emissions	1.0	1.3	1.6	1.9	2.4	3.0	2.6	3.4	4.2
Low emssions	0.9	1.2	1.6	1.6	2.1	2.6	2.0	2.6	3.4

An example of probabilistic results generated by the UK Climate Impacts Programme in UKCIP 09.

For the relationship between global mean temperature and UK-specific climate measures, confidence intervals can be constructed where the lower and upper ends are the 10% and 90% values of the cumulative distribution function, respectively. These lower and upper ends for mean UK summer temperature increase are obtained when the central tendency mean global temperature increase is multiplied by 0.6 and 1.7, respectively; for increase in mean winter temperatures the central tendency mean global temperature increase is multiplied by 0.4 and 1.2, respectively. For summer precipitation, the mean central tendency change in summer precipitation for the UK is multiplied by 2.1 and –0.2, respectively; for winter precipitation, the mean central tendency change in winter precipitation for the UK is multiplied by 0.2 and 2.2, respectively.

Conclusion

The current science of climate change does not yet allow for the level of probabilistic interpretation available in many other areas of environmental policy; hence risk-based decisions in climate policy are not fully harmonised with other areas of environmental policy. At best, we can provide lower and upper bounds for estimates of mean global temperature change and both temperature change and precipitation specific to the UK. More complete probability density functions are not feasible at present, but the science of developing these is advancing rapidly.

The Cambridge Centre for Climate Change Mitigation Research (4CMR) studies the interconnected economic, energy and environmental policies at the heart of climate change policy.

This Briefing Paper was developed from research by Doug Crawford-Brown of 4CMR.

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