ClimateCost

Policy Brief

The PAGE09 Integrated Assessment Model

The objective of the ClimateCost project is to advance the knowledge of the economics of climate change, focusing in three key areas:

- The economic costs of climate change (the costs of inaction);
- The costs and benefits of adaptation;
- The costs and benefits of mitigation.

The project aims to advance multi-disciplinary research, developing integrated bottom-up and top-down analysis, and providing policy relevant outputs. It includes the development and use of economic models, including a number of Integrated Assessment Models (IAMs).

This briefing note summarises the development and first results of one of these models, PAGE09[1], a new integrated assessment model that calculates the economic impacts of climate change and the costs of policies to abate and adapt to it. The model is designed to help policy makers understand the costs and benefits of action and inaction. The development of the model received funding from the project, as part of the EC's Seventh Framework Programme[2].

PAGE09 is an updated version of the PAGE2002 probabilistic integrated assessment model, which was used to perform the headline calculations in the Stern Review (2006). The update to PAGE09 been made to take account of the latest scientific and economic information, primarily in the 4th Assessment Report of the IPCC (2007).

The model – which is freely available - has been run to provide new results. Key early findings are summarised below:

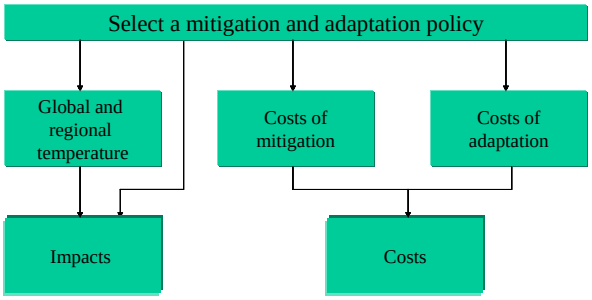
- The new information and model updates leads to higher estimates than the previous PAGE02 model. This is because of the likelihood of higher temperature change, the higher chance of major discontinuities (at lower temperature), less effective adaptation and accounting for very large effects.
- The economic costs of climate change have been estimated for a 'business as usual 'type scenario and a stabilisation scenario broadly consistent with the EU's 2 degrees target.
- The study finds that mean economic costs of climate change over time, discounted back to the present day are five times lower in the stabilisation scenario compared to the business as usual scenario.
- Perhaps more importantly, the stabilisation scenario removes the possibility of very high economic costs and discontinuities towards the upper end of the probabilistic outcome.
- A comparison of the costs and benefits reveals that the stabilisation scenario has mean net benefits, i.e. that the benefits of action outweigh the costs of mitigation.
- The model has also estimated the social cost of carbon (SCC), i.e. the marginal global damage cost per tonne of carbon. It finds the new model estimates a significantly higher SCC than the previous model.

[1] Prepared by Chris Hope and Paul Watkiss. September 2010. This information reflects the views of the authors. The Community is not liable for any use made of this information.

[2] Development of the PAGE09 model received funding from the European Community's Seventh Framework Programme, as part of the ClimateCost Project (Full Costs of Climate Change, Grant Agreement 212774) www/climatecost.eu and from the UK Department of Energy and Climate Change. The development of the model and the analysis of the stabilisation scenario here also benefited from work funded under the AVOID programme, and discussion with the Met Office.

Description of the Model

Integrated assessment models combine the scientific and economic aspects of climate change within a single, iterative framework. PAGE09 uses simple equations to simulate the results from more complex specialised scientific and economic models. It does this while accounting for the uncertainty that exists around climate change. The PAGE09 models works with eight world regions, ten time periods to the year 2200, for four sectors (sea level rise, market, non-market and major discontinuities), and is able to examine the costs of climate change, as well as the costs of mitigation and adaptation.

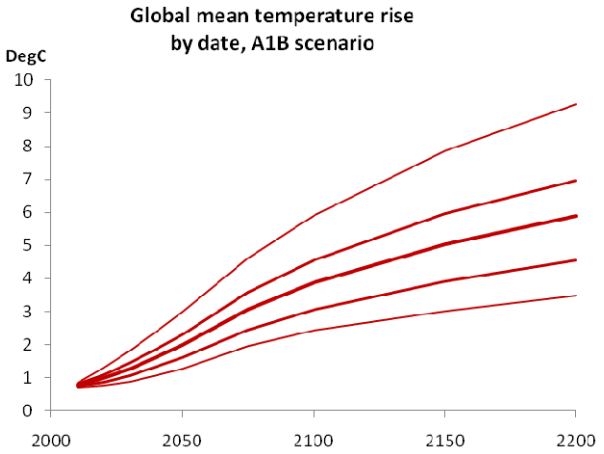


The update to PAGE09 takes account of the latest scientific and economic information, primarily in the 4th Assessment Report of the IPCC (IPCC, 2007). It also includes major improvements and updates to the climate, economic cost, mitigation and adaptation modules. The probability distributions for all inputs have been reviewed, and new ranges have been included where appropriate, which allows the model to take account of uncertainty. Additional features in PAGE09 include a specific category of sea level rise, explicit dependence of impacts on GDP per capita, smooth marginal abatement cost curves, and the reduction of costs through learning and technical change.

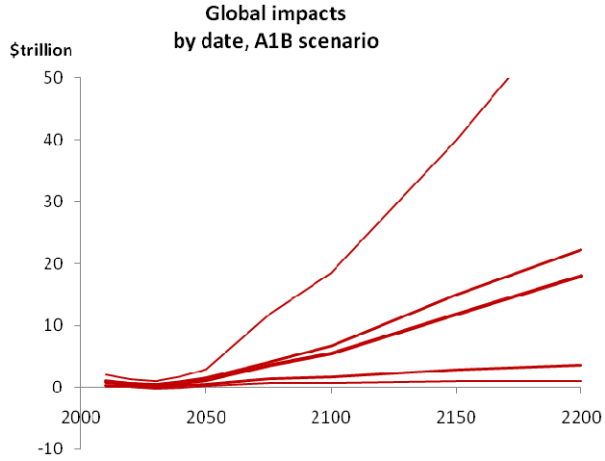
The Economic Costs of Climate Change

The ClimateCost project has run the new model to provide initial results, summarised below. The analysis has run a stabilisation scenario, comparing the economic costs and benefits, for a business as usual and a mitigation scenario broadly consistent with the EC's 2 degrees target.

The figure below shows a typical illustrative output from the new PAGE09 model, for the initial estimation of global temperature over time from the A1B scenario, the main 'business as usual' scenario being considered in the ClimateCost project, showing the 5%, 25%, 50% (mean), 75% and 95% outputs from the uncertainty analysis.

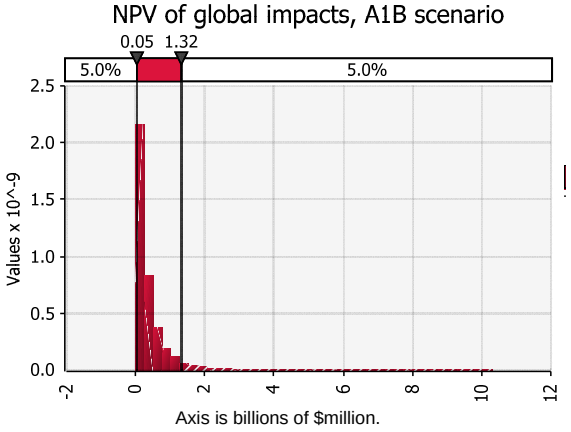


The estimated total global economic impacts over time (for all sectors, measured in $US2005) from the model for the A1B scenario are shown in the figure below, again for the uncertainty analysis. The mean global impact is kept below $1 trillion (million million $US(2005)) until 2050 but then rises rapidly to $5 trillion in 2100. Note that the scenario does include some adaptation.

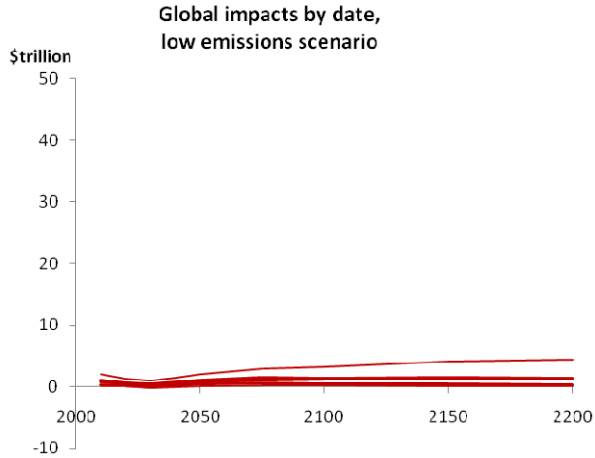


The uncertainty in temperature carries through to impacts and is augmented by uncertainties in economic valuation, and the likelihood of discontinuities. For example, the 95% probability line shows a 5% chance that the annual global impacts will exceed about $20 trillion by 2100.

The economic costs over time (to the year 2200) can be discounted back to the present day (a net present value, NPV), and are shown as a probability distribution of the total impacts for all world regions and all time periods, in the figure below. The mean net present value for the A1B scenario is around $400 trillion, but the effect of uncertainty can be clearly seen, with a 5% chance that the impacts will exceed $1300 trillion, and a small possibility of impacts exceeding $10000 trillion.

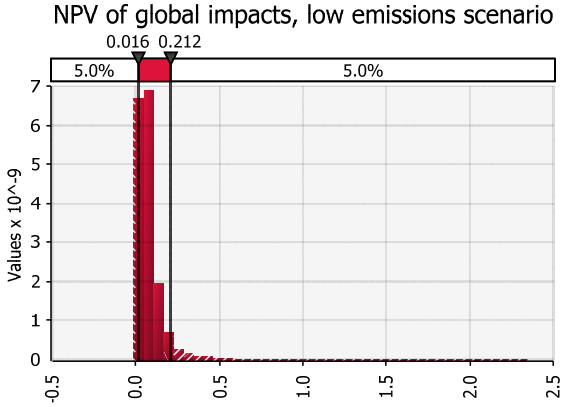


The analysis has also considered a stabilisation scenario, using the '2016 r5 low' scenario from the AVOID programme: a scenario designed to have a 50% chance of keeping the global mean temperature rise below 2 degrees. Total economic impacts are shown first below (again, this includes some adaptation).

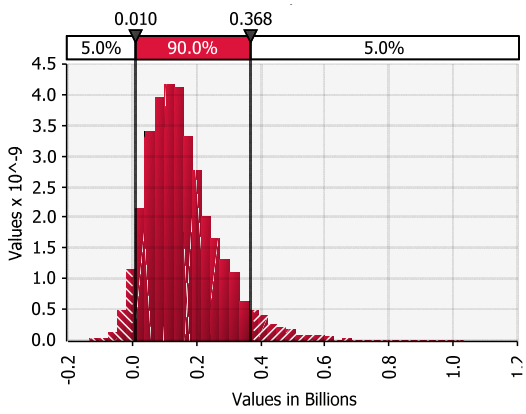


In the low emissions scenario, the mean global impact stays below $1.5 trillion, as global mean temperatures stay generally below the level likely to trigger a discontinuity.

The estimated economic costs of the stabilisation scenario over time, discounted back to the present day (NPV) is a mean value of about $80 trillion. This compares to the mean value of $400 trillion in the A1B scenario (a factor of five less). The 5% to 95% range is about $15 trillion to $200 trillion and the largest impacts are just over $2000 trillion i.e. the stabilisation scenario removes the possibility of very high economic costs and discontinuities towards the upper end of the probabilistic outcome.



The study has also compared the present value of mitigation costs for the stabilisation scenario, shown below. The total abatement costs for all regions and all time periods to 2200 of this scenario, discounted back to the present day, have an estimated mean value of about $150 trillion, with a 5% chance that costs will exceed about $350 trillion. The mean costs are therefore lower than mean benefits, i.e. tat the benefits of action outweigh the costs of mitigation.



This type of information, based on the best available scientific and economic inputs, while recognising the limits to our present knowledge, is useful for policy-makers.

The Social Cost of Carbon

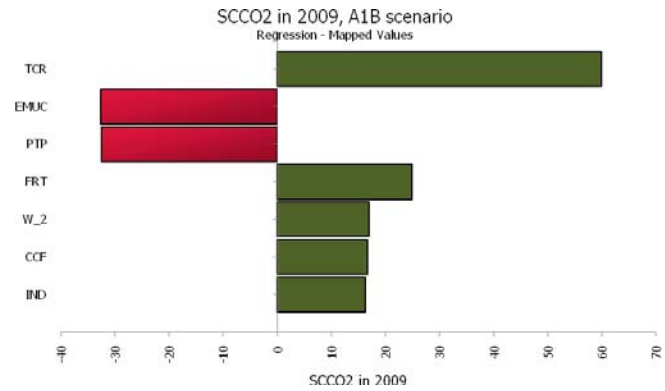
The study has also looked at the economic costs of climate change per tonne of emissions. The relevant metric here is the marginal global net damage cost of an additional tonne of carbon or CO_2 emitted today, aggregated over time and discounted back to the present day, know as the social cost of carbon (SCC) or CO_2 ($SCCO_2$). These values can be interpreted as the marginal cost of one additional tonne of emissions, or the marginal benefit of reducing emissions by one tonne. These values have a number of potential uses as an input to policy deliberations.

The PAGE09 model has been run with an additional pulse of emissions, to allow calculation of these marginal social costs.

In the A1B scenario, the mean $SCCO_2$ for emissions in 2009 is estimated at about \$95 per tonne of CO_2, with a 5% to 95% range of about \$10 to \$230, all in \$US(2005). This is a significant increase from the PAGE02 model, which estimated the mean value of about \$30 per tonne of CO_2. The higher costs are due to the likelihood of higher temperature change, the higher chance of a discontinuity (at lower temperatures), proper accounting for very large impacts, less effective adaptation, and the fact that numbers are reported in \$2005 not \$2000.

The mean $SCCO_2$ in the low emissions scenario is about \$45 per tonne of CO_2, with a 5% to 95% range of about \$10 to \$120, i.e. around half that of the A1B scenario. This is due to the reduced chance of a discontinuity.

It is also important is to know what affects the total impacts and the $SCCO_2$. The 'tornado' figure below shows the most important influences in PAGE09 are the transient climate response (TCR), the equity weights (EMUC), the pure time preference rate (PTP), and the feedback response time of the Earth (FRT), each of which can alter the $SCCO_2$ in the A1B scenario by more than \$25 if they vary by one standard deviation from mean values.



Next Steps and Further details

The PAGE model is freely available. The update to the model has been written up in a separate technical paper, available on request.

Further iteration of the model is being undertaken within the project, incorporating the information from bottom-up studies, and using alongside other economic models and IAMs in the project to look at policy runs.

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Further information

To find out more about ClimateCost, please visit

www.climatecost.eu

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