iisd International Institute for Sustainable Development / Institut international du développement durable

DICE Model Reassessment

Summary and key findings from first phase of analysis

By Dr. Robert Easton and Dr. Robert Repetto

September 2014

The DICE model is an integrated assessment model created by Yale Professor William Nordhaus for the analysis of climate policy. It has been widely cited by climate economists and policy professionals and in its successive versions has been influential in climate policy deliberations for several decades. For example, it was one of the three models used recently by the U.S. government to establish a new estimate of the social cost of carbon, a figure that is important in setting U.S. government policy toward mitigation and adaptation actions, and was also used by the Office of the U.S. President to analyze the consequences of delay in reducing emissions. Professor Nordhaus himself has used various versions of the model extensively over decades in several books and dozens of articles devoted to climate policy analysis, most recently in *The Climate Casino: Risk, Uncertainty, and Economics in a Warming World*, and has thereby become one of the most influential climate economists in the world.

The results of analyses based on the DICE (Dynamic Integrated Climate-Economy) model have come under criticism, from Lord Nicholas Stern and many others, because they imply that the best balance of mitigation costs and climate damages would let global temperatures rise well beyond the two degree limit deemed acceptable by the international community. These criticisms have centered on the model's alleged under-estimation of damages from climate change and its excessive discounting of damages occurring decades from now.

The DICE model portrays how the world economy generates income and output for consumption and investment and, as a by-product, releases emissions of greenhouse gases; how those emissions drive climate change, as indicated by mean global temperature; how climate change then imposes economic losses; and how mitigation actions can reduce emissions at some economic cost in terms of available output.

Of course, the results generated from any model depend entirely on the assumptions used in its construction. Usually, however, and especially in large complicated models, the implications of particular assumptions for the model's results or predictions are not transparently obvious. Therefore, when a model becomes influential, as the DICE model is, it is important to carry out sensitivity analyses in order to assess the role of key assumptions in generating the model results. This is especially important when a model assumes single values for important parameters about which there exists considerable uncertainty, as the DICE model does. We have carried out such a sensitivity analysis.

We have found a number of assumptions in the model that are dubious or mistaken. When these assumptions are corrected, the model actually implies that much more aggressive policies to reduce emissions are warranted. The best balance of mitigation costs and climate change damages would indeed keep the global temperature increase below two degrees, as the international community has concluded. The costs of doing so are much less than previously estimated.

The amended results imply that even if emissions are rapidly reduced to keep climate change within safe limits, economic growth would continue robustly. By 2050 world income would have more than doubled and by 2100 would have increased six-fold despite keeping temperature change below two degrees centigrade.

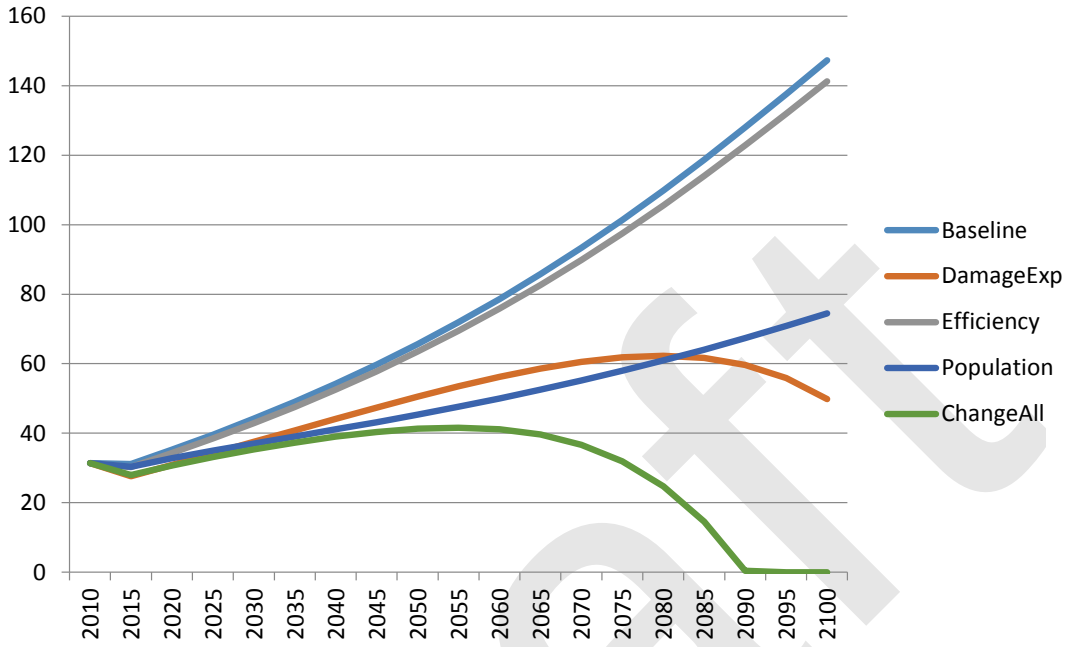
The problematic assumptions in the DICE models that have led to unduly pessimistic results and have been changed include the following:

- Future improvements in renewable energy costs will be an order of magnitude slower than what has been achieved in past decades. *Our alternative assumption is that costs will fall by two percent per year, still well below historical rates.*
- Mitigation costs increase at the same rate as the economy expands, other things equal. *Our alternative assumption is that such costs will depend only on the tonnage of emissions that are abated and the costs per ton of doing so.*
- Damages from climate change increase at a modest constant rate, even at high degrees of temperature increase. *Our alternative assumption is that damages will increase as the third power of the temperature increase rather than the second power, implying a more rapid acceleration of damage costs as temperature rises.*
- Long-run population growth is unaffected by climate change, even if the global climate changes dramatically. *Our alternative assumption is that world population will stabilize at nine billion rather than the 10.5 billion assumed by the DICE model.*

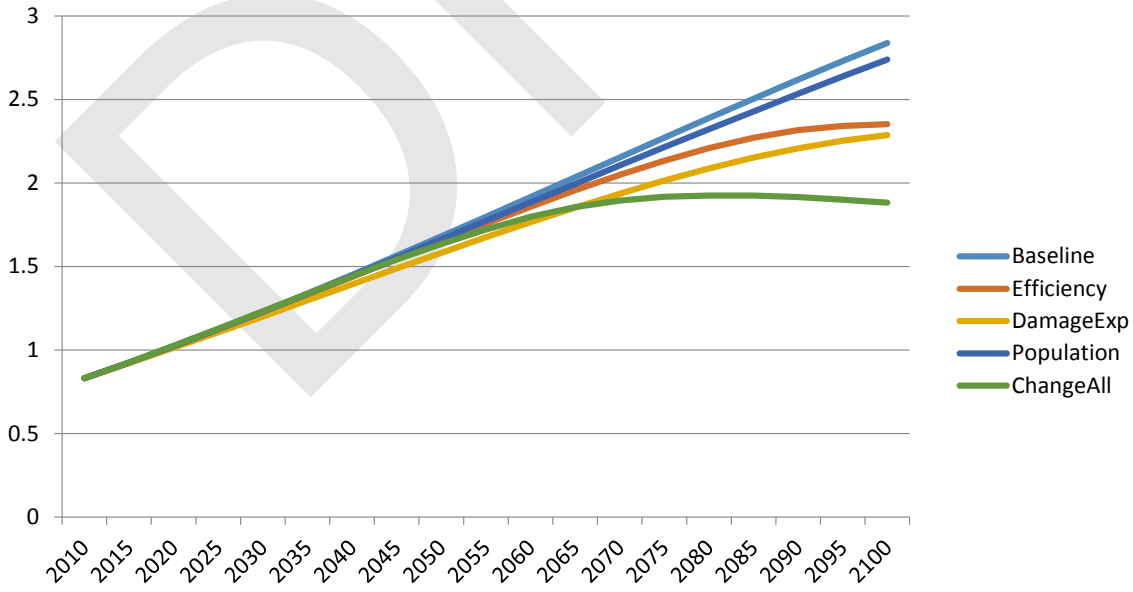
The following graphs illustrate the results of the sensitivity analyses. The dark blue line represents the primary results of the DICE model, using its baseline assumptions. Other lines represent the results when the individual assumptions indicated above are changed. The orange line at the bottom indicates the results when all the questionable assumptions are changed.

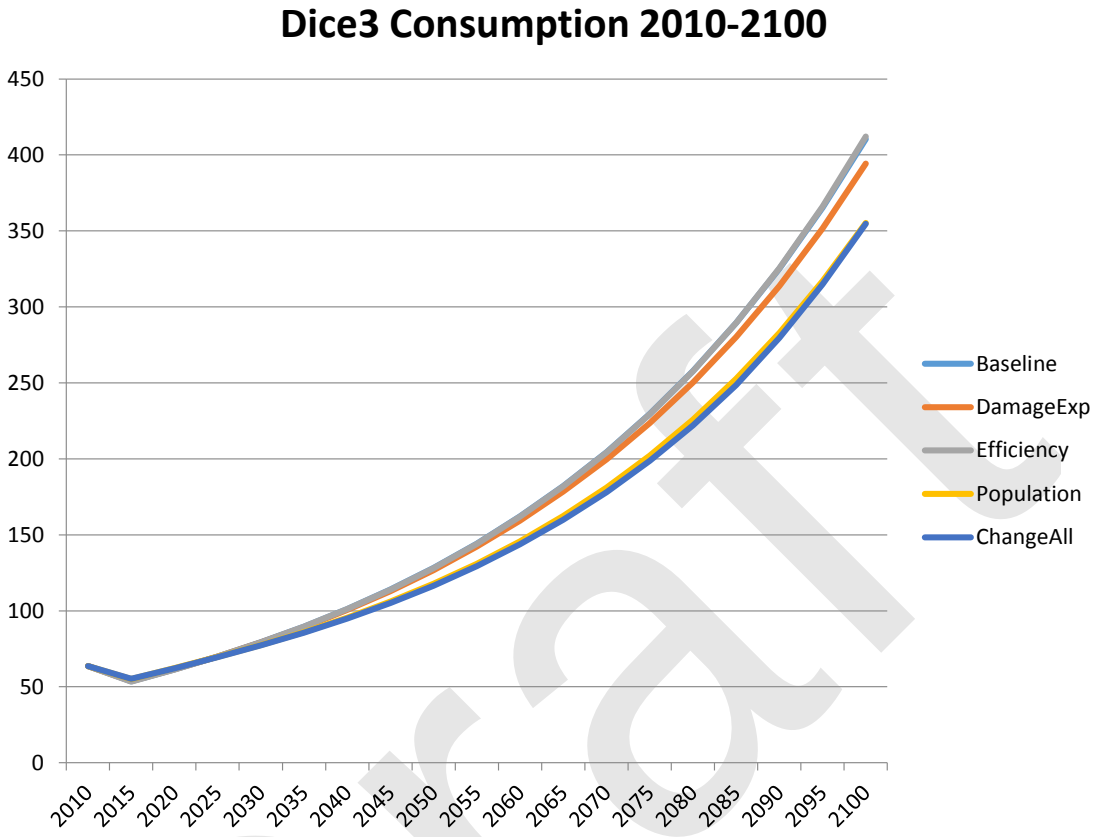
As the graphs show, when that is done, it appears that the best policies would result in a rapid fall in emissions to a very low level in the latter decades of this century, and a temperature increase that would stay below the two degree limit.

Dice 3 Emissions 2010-2100



Dice3 Temperatures 2010-2100




Dice3 Consumption 2010-2100
450
400
350
300
250
200
150
100
50
0
2010
2015
2020
2025
2030
2035
2040
2045
2050
2055
2060
2065
2070
2075
2080
2085
2090
2095
2100
Baseline
DamageExp
Efficiency
Population
ChangeAll

Published by the International Institute for Sustainable Development.

International Institute for Sustainable Development
Head Office
161 Portage Avenue East, 6th Floor, Winnipeg, Manitoba, Canada R3B 0Y4
Tel: +1 (204) 958-7700 | Fax: +1 (204) 958-7710 | Web site: www.iisd.org

About IISD

The International Institute for Sustainable Development (IISD) contributes to sustainable development by advancing policy recommendations on international trade and investment, economic policy, climate change and energy, and management of natural and social capital, as well as the enabling role of communication technologies in these areas. We report on international negotiations and disseminate knowledge gained through collaborative projects, resulting in more rigorous research, capacity building in developing countries, better networks spanning the North and the South, and better global connections among researchers, practitioners, citizens and policy-makers.

IISD's vision is better living for all—sustainably; its mission is to champion innovation, enabling societies to live sustainably. IISD is registered as a charitable organization in Canada and has 501(c)(3) status in the United States. IISD receives core operating support from the Government of Canada, provided through the International Development Research Centre (IDRC), from the Danish Ministry of Foreign Affairs and from the Province of Manitoba. The Institute receives project funding from numerous governments inside and outside Canada, United Nations agencies, foundations and the private sector.