



CLIMATE CHANGE ASSESSMENT PAPER

*Benefits and Costs of the Climate Change Targets
for the Post-2015 Development Agenda*

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Post-2015 Consensus

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Highlights

The results of this paper suggest a reconsideration of traditional climate policy that was designed to limit the level of total emissions per year and/or atmospheric concentrations. The traditional emission target approach has faced political resistance due to excessive costs associated with current technological limitations to the integration of low-carbon energy. Moreover, it often conflicts with the continued pursuit of economic growth and development. Despite various emission reduction agreements, globally there has been a steady rise in annual emissions and there is a vital need to pursue policies that address the drivers of emissions and the inevitable effects of rising emissions through adaptation.

Within climate change, the target that has the best benefit-cost ratio is:

- Invest 0.5% of GDP in energy technology RD&D which has a B/C ratio of 1 – 15. In contrast to emission reduction targets, this approach allows nations to continue to develop economically until cost-effective low-carbon technologies become available. It will be necessary to use this in conjunction with incentives (intensity targets/standards, carbon pricing) to adopt technologies when they become available.
- Invest 0.05% of GDP in adaptation. Despite a highly location specific and uncertain benefit/cost, this approach will be essential for the hardest hit areas, allowing for both damage prevention and continued economic development.

The analysis shows that the following targets are relatively ineffective or there is large uncertainty in the benefit-cost ratio:

- Global annual carbon emission reduction targets for example, 2°C reduction below pre-industrial level – extremely costly due to a lack of low-carbon energy sources.
- Emission intensity targets – essentially a version of emission reduction targets if economic growth can be well predicted. Both are inefficient due to a lack of scalable low-carbon technologies.

INTRODUCTION.....	1
INTERNATIONAL CLIMATE COOPERATION	1
THE ENERGY TECHNOLOGY PROBLEM.....	2
THE POST-2015 PROCESS.....	4
PROMINENT TARGETS UNDER CONSIDERATION: BENEFIT-COST ANALYSES (BCAS).....	5
GLOBAL ANNUAL CARBON EMISSION REDUCTION TARGETS.....	5
EMISSION INTENSITY TARGETS.....	7
ALTERNATIVE TARGETS (BCAS).....	8
INVEST 0.5% OF GDP IN ENERGY TECHNOLOGY RD&D	8
INVEST 0.05% OF GDP IN ADAPTATION.....	9
TARGET RECOMMENDATIONS FOR POST-2015 AND CONCLUSION.....	10
REFERENCES.....	12

Introduction

It has been argued that climate change is the greatest threat facing humanity and yet is not explicitly targeted in the UN Millennium Development Goals (MDGs) but falls rather under Goal 7's (Ensure Environmental Sustainability) target 1, "Integrate the principles of sustainable development into country policies and programs and reverse the loss of environmental resources", and less directly through Goal 8: "global partnership for development". Since their implementation in 2000, the MDGs have been shown to be quite successful in mobilizing support for health, hunger and education. The sub-prioritization of climate change recognises an implicit conflict between development, with the energy use (and emissions) it entails, and climate policy. Climate change mitigation in emerging and developing countries could be harmful from a development perspective if it slows economic growth by requiring more costly, low-carbon energy sources (Jakob and Steckel 2013).

This paper will discuss and evaluate common and innovative global climate policy targets and metrics within a benefit-cost framework appropriate for use as Post-2015 goals. Moreover, it will highlight the potential for the UN post-2015 MDGs to acknowledge current technological limitations and developmental objectives facing policy makers and thus identify policies that are regionally acceptable, appropriate and most importantly, effective in slowing global warming.

International Climate Cooperation

The Intergovernmental Panel on Climate Change (IPCC) was created over a quarter century ago to assess the risks associated with anthropogenic climate change. In 1992 the United Nations Framework Convention on Climate Change (UNFCCC) was created to help establish enforceable treaties to "avoid dangerous climate change" through yearly Conferences of the Parties (COPs). The past 18 years of climate negotiations have shown that establishing such an agreement is a highly challenging task. In 1996 the goal of limiting climate change to a 2 °C rise in average global temperature came on the scene and has become key focus of the international climate debate. Despite much media attention and repeated negotiations within the UNFCCC framework, if measured by performance, global climate policy has failed. Since 1990 the globe has witnessed a steady rise in emissions, only halted by the global recession, with carbon dioxide emissions having increased by more than 46%.

"Despite the variety of existing policy efforts and the existence of the UNFCCC and the Kyoto Protocol, GHG emissions have grown at about twice the rate in the recent decade (2000–2010) than any other decade since 1970. (robust evidence, high agreement) [1.3.1]" (IPCC 2014, ch.1, p.4)

Given this complete failure of the UNFCCC process, why does the world continue to pursue this framework? Studies have shown that international cooperation would significantly reduce the costs of climate policy and accelerate the transition to a low-carbon economy (Aldy, Barrett et al. 2003, Victor 2006, Aldy and Stavins 2007, Clarke, Edmonds et al. 2009,

Blanford, Kriegler et al. 2013). Generally, the failure of international climate agreements, for example the Kyoto Protocol, is attributed to strong incentives to free-ride and ineffective compliance mechanisms and sanctions. This fails to acknowledge the fundamental nature of the climate change problem: the energy technology problem. The IPCC has recently published its Fifth Assessment Working Group 3 Report (AR5 WG III) on the mitigation of climate change (IPCC 2014). This latest report acknowledges the need for large-scale changes to energy systems at all levels and that these changes are inconsistent with current trends (ch.6, p.6). Unfortunately the limitations (including scalability, socio-political, etc.) of technologies, such as CCS, nuclear, renewables among others are scarcely touched upon. The lack of scalable, reliable and cost-effective low-carbon energy sources is a leading cause of failure of global efforts to curb greenhouse gas emissions. The UNFCCC's universal membership provides it with a high degree of global legitimacy (Karlsson-Vinkhuyzen and McGee, 2013) and thus its lack of clarity about technological limitations is misguided at best and at worst a dangerous impediment to progress towards a low-carbon world. As Bullis (2014) points out governments are unwilling to commit to emission reduction targets since the costs of developing and deploying low-carbon technologies is uncertain.

Recently there has been an increase in unilateral and multilateral action outside of the UNFCCC process (IPCC WG3 AR5). In the case of “fragmented” action—in which OECD countries join a climate treaty immediately, the emerging economic (BRIC) in 2030, and other developing economies in 2050—the increased costs to first movers (OECD countries) are found to be double those of the perfectly cooperative case¹. In addition, fragmentation has contributed to carbon leakage, a growing transfer of carbon emissions from the developed world to the emerging economy/developing world (Davis and Caldeira 2010, Peters, Minx et al. 2011).² Although it is still unclear how much of the transfer is attributable to fragmented climate policy and how much to globalization and other cost advantages that would have occurred in the absence of climate policy, carbon leakage is a growing concern for policy makers.

The Energy Technology Problem

The UN Secretary-General's High-Level Panel of eminent persons on the Post-2015 Development Agenda (HLP) strongly endorses the call to hold the increase in global average temperature to 2⁰C above preindustrial levels, in line with international agreements. The HLP (2013) report states that “tools are already available. We can reach large-scale, transformative solutions worldwide with more investment, collaboration, implementation and political will.” These assertions pose the greatest threat to dealing with climate change effectively. While free-riding and politics may be part of that climate challenge, they are not the major factor. The HLP is not the only entity to misdiagnose the climate change problem as one of political will to generate price incentives to adopt existing tools. The IPCC has for years asserted the readiness of low carbon alternatives although recently acknowledges the need for “nearly all governments promptly engage in international cooperation, adopt stringent national and international emission control

¹ In NPV at 5% discount rate over 2015-2100. (IPCC WG 3 AR5 (2014) Ch.6)

² Evaluated on production-based accounting

policies, and deploy rapidly a wide array of low- and zero- emission technologies” (IPCC 2014). The IPCC (2014) goes on to admit that real world assumptions including fragmented action and limited technologies drastically increases policy costs. Moreover, low-concentration scenarios are rarely found in the literature given their higher costs or unrealistic technological assumptions (Tol 2013). The assumptions about availability and scalability of low-carbon technologies determine the estimates of the world’s ability to cost-effectively achieve given atmospheric concentrations of GhGs (Kriegler, Weyant et al. 2014). In a technology constrained world, estimated mitigation costs can be more than double those in a non-constrained world (IPCC 2014, Kriegler, Weyant et al. 2014).

Stabilizing global greenhouse gas concentration (stock) requires stabilizing emissions (flow), followed by deep reductions beyond anything experienced to date. Since 2010, coal fired electricity generation growth has increased more rapidly than non-fossil sources combined. Moreover the majority of this increase has been the least efficient type of coal-fired generation, driving significant increases in emissions. It is widely recognized that climate models that reveal low to moderate abatement costs include some type of backstop technology to offset this use of coal. In the recent IPCC report, of particular significance is the clear importance of: (i) carbon capture and storage (CCS) and (ii) bio-energy technologies and sources, to achieving low atmospheric carbon concentration goals at reasonable costs. Similarly in Redrawing the Energy-Climate Map (IEA 2013) there is strong reliance on BECCS (bio-energy with carbon capture and storage) to achieve negative emissions in order to achieve the 2 degree scenario. Alternatively they define a ‘4-for 2°C scenario’³ to 2020 that does not require technological breakthroughs. Despite being potentially cost-effective, this scenario does not expect to achieve significant emission reductions in the short term.

“The future of CCS is uncertain; at present, the technology is advancing slowly, due to high costs and lack of political and financial commitment. Near-term progress in CCS research, development and demonstration is needed to ensure long-term and cost-competitive deployment towards meeting climate goals.” (IEA 2014)

CCS still remains large untried and untested at large scales and its political acceptability is weak, since it suffers from the NIMBY phenomenon that has contributed to the cancellation of several plants⁴. Biomass and bioenergy not only compete with other important uses of land (e.g., food), but also the conversion of pasture and unused land to bio-energy production may release substantial carbon from the soil (Searchinger, Heimlich et al. 2008, Haberl, Erb et al. 2013). Further, second generation bio-energy from algae and wastes may not prove scalable to the extent required. The potential limits on bio-energy have implications for scaling up other renewables, because without it, or some other low carbon energy source, scaling up the currently non-storable intermittent and variable solar and wind energies would imply relying on fossil fuels (especially natural gas) for “spinning

³ ‘4-for 2°C scenario’ measures – energy efficiency, limit inefficient coal-fired plants, minimise methane emission, and further phase out of fossil-fuel subsidies.

⁴ http://sequestration.mit.edu/tools/projects/index_cancelled.html

reserve” back-up. This is not an insignificant concern as reliability is a serious concern for energy producers as well as governments.

There is a substantial literature addressing the limitations of current technologies directly and their use in emission scenarios as baselines. These have been shown to substantially understate the magnitude of the technology challenge and therefore do not provide a valid means for assessing whether current technologies are sufficient (Hoffert, Caldeira et al. 1998, Galiana and Green 2009, Nemet 2009, Schilling and Esmundo 2009, Galiana and Green 2010, Anadon, Bunn et al. 2011, Constable 2011, Hoffert 2011, Edmonds, Calvin et al. 2012, Myhrvold and Caldeira 2012). According to Kriegler, Weyant et al. (2014) “technology is a key element for reaching climate targets.” Of course as is clear from the IEA report Redrawing the Energy-Climate Map (among others) implementing cost-effective policies today can set the world on a cleaner path and limit lock-in to fossil based energy. Most scenarios present modest emission cuts over the near term followed by deep emission cuts, or negative emissions in the future. These policies present the potential for a time-inconsistency if cheaper, scalable, low-carbon technologies do not materialize in the future. Actively pursuing the development of such technologies in combination with currently cost-effective mitigation measures appears may be a way forward (Galiana and Green 2010, Bullis 2014).

The Post-2015 Process

Climate change is not simply an issue of environmental sustainability or sustainable development; it must be addressed as a distinct objective since its consequences are so widespread and overarching. The HLP – P2015 report highlights 12 universal goals. Climate change policy falls primarily within the scope of goals 7, 9 and 11. Goal 7, ‘Secure Sustainable Energy’ has the related sub goals of doubling the share of renewable energy in the global energy mix; ensuring universal access to modern energy services; and the phasing out of fossil fuel subsidies that encourage wasteful consumption. Goal 9 ‘Manage natural resource assets sustainably through the specific goal of reducing deforestation and increasing reforestation’. Goal 12, ‘Create a global enabling environment and catalyze long-term finance’, explicitly states the climate change goal of holding the increase in global average temperatures below 2°C above preindustrial levels. These are some potential targets but the issue of how to achieve the targets is sidestepped by the HLP.

As part of the UN Post-2015 process the Open Working Group (OWG) on Sustainable Development Goals⁵ published an Outcome Document in July 2014. As a result of multiple consultations with stakeholders, interested parties, governments, NGOs, etc, climate change has been assigned a specific goal; “Goal 13. Take urgent action to combat climate change and its impacts”. The specific targets under goal 13 appear to focus on adaptation, resilience, and planning, as well as the Green Climate Fund⁶. While the energy goals and innovation goals within the latest OWG document do not explicitly mention greenhouse gas emissions, a number of them could be considered climate targets; namely, those targeting renewables, energy efficiency and clean energy research/R&D spending.

⁵ <http://sustainabledevelopment.un.org/focussdgs.html>

⁶ <http://www.gcfund.org/home.html>

In order to identify the mechanism through which each goal is targeting emissions, it is helpful to present the Kaya Identity. Each goal targets one or more of the drivers of emissions (income, energy intensity of output, carbon intensity of energy) either directly or indirectly. Emission reduction targets is the only policy to focus on the left-hand side of the Kaya Identity, growth in emissions, without necessarily addressing the means of achieving these reductions. Emission intensity, renewable standards, and energy R&D all target the means of reducing emissions without explicitly targeting an emission level. Adaptation on the other hand, sidesteps the issue of reducing emissions altogether. It is likely that some portfolio of complementary policies will be needed to address the environmental, technological and political limitations of each.

The Kaya Identity

$$\hat{C} = \hat{GDP} + \left(\frac{\hat{E}}{\hat{GDP}} \right) + \left(\frac{\hat{C}}{\hat{E}} \right)$$

where

- 1) \hat{C} is the growth in carbon emissions
- 2) \hat{GDP} is the growth in global income
- 3) $\left(\frac{\hat{E}}{\hat{GDP}} \right)$ is the growth in energy intensity of output
- 4) $\left(\frac{\hat{C}}{\hat{E}} \right)$ is the growth in carbon intensity of energy

Prominent Targets Under Consideration: Benefit-Cost Analyses (BCAs)

Global Annual Carbon Emission Reduction Targets

The target of stabilizing global temperature rise at less than 2°C above pre-industrial levels can be translated into atmospheric GHG concentrations and further into yearly emission allowances (Meinshausen, Meinshausen et al. 2009). Targets of 450 and 550 ppm CO₂e require substantial reduction of CO₂ emissions from fossil fuel use and industry compared to baseline levels (Blanford, Kriegler et al. 2013). This target is the most common metric used in international climate negotiations and deals with policies that target the left-hand side of the Kaya identity, i.e. emissions growth. For example, the Kyoto protocol called for fixed emissions reduction targets relative to 1990 levels. Copenhagen pledges have been based on both reductions relative to a historical base year, as well as reduction relative to a base year's business-as-usual trends.

Interestingly, many if not all integrated assessment models that successfully achieve the 450, 500 or even 550ppm targets allow for overshooting the target and then rely on

negative emissions through either advanced CCS or BECCS⁷. Lemoine and McJeon (2013) use the technology-rich GCAM integrated assessment model to assess the implications of 450 and 500ppm carbon targets. They find that the 500ppm target provides net benefits across some futures, but the 450ppm target provides net benefits only when social costs of carbon are high, low-carbon technological breakthroughs abound, and discount rates are low. Blanford, Kriegler et al. (2013) show that models that find a feasible solution for the 450ppm CO₂e target, have added a technological option for negative emissions, in most cases BECCS in the electric sector. This allows for atmospheric concentration overshoot followed by rapid reductions in the latter half of the century.

Rogelj, McCollum et al. (2013) show that the 2 °C target can be met with a >66% probability under central technology and energy demand assumptions only if there is immediate and globally coordinated action. These conditions are what are referred to in the IPCC AR5 as 'idealized' situations. Figure 1 shows the consequences of deviations from these idealized conditions; the probability of achieving the 2 °C target is greatly hindered by either a lack of technological availability, strong energy demand (also associated with economic development) or delayed and fragmented action.

⁷ Bio-energy with carbon capture and storage

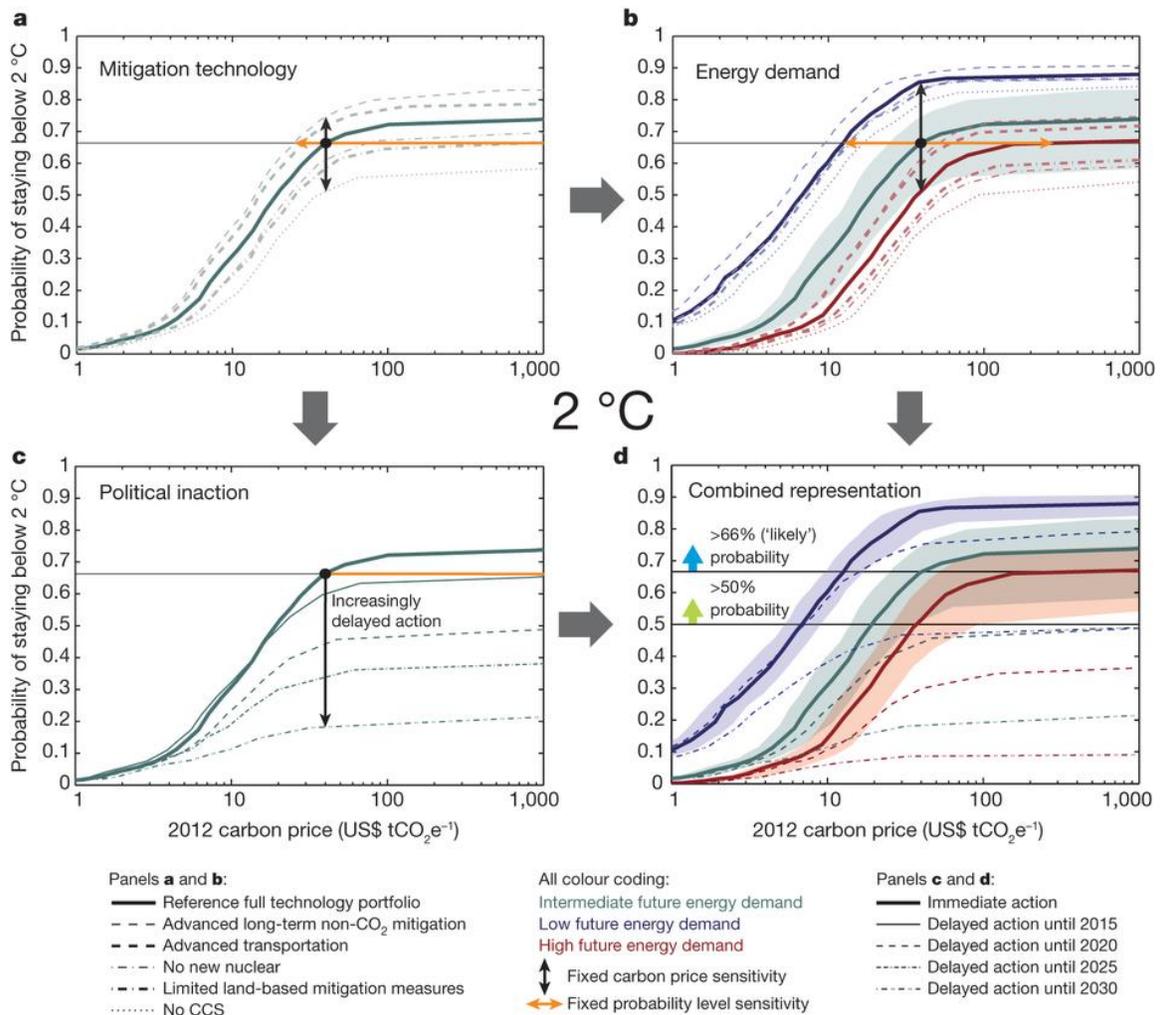


Figure 1: Cost distributions for six cases with varying future availability of specific mitigation technologies (a) and three sensitivity cases for future energy demand (b, thick solid lines). Shaded areas and dashed lines in b represent technology-sensitivity cases comparable to those shown in a. Shaded areas and dashed lines in d represent technology- and politics-sensitivity cases comparable to those in b and c, respectively. c, Impact of delayed global mitigation action. d, Overview figure combining all sensitivity cases. The horizontal line in a–c is the 66% line. (Rogelj, McCollum et al. 2013)

Tol (2013) under more realistic conditions finds that cost-effective emission reduction would set the world on a path to 625 ppm CO₂e and that targets such as the 2°C, 450ppm or 550ppm would not be supported by benefit-cost analyses.

Emission Intensity Targets

Emission intensity targets can be reassuring if economic forecast are uncertain. These allow for continued growth by focusing on the per unit emissions rather than the level. Intensity targets have been proposed by China and India: their pledge is a reduction of carbon intensity (i.e., emissions/gross domestic product (GDP)) between 40 and 45% and

20 and 25% respectively by 2020 with respect to 2005 (Steckel et al., 2011; Zhang, 2011; Yuan et al., 2012; Cao, 2010b; Government of India, 2012). Another carbon target linked to GDP was the one planned by Argentina in 1999 (Barros and Conte Grand, 2002). Emission intensity targets focus on the right hand side of the Kaya identity by encouraging energy efficiency improvements and/or reductions in the fossil fuel content of energy. These goals are similar to the emission reduction targets with a business-as-usual baseline as opposed to a historical year baseline. Emerging economies in particular have strong economic growth forecasts that imply rapidly growing emissions. The majority of emission growth over the past decade has been from emerging economies and their share of emissions is expected to continue to increase (IPCC 2014). Policies with strong development goals prefer this type of target as it allows flexibility should growth be strong. Emission intensity targets have been criticised as they do not explicitly limit the amount of CO₂ entering the atmosphere and do not necessarily provide strong incentives for innovation.

Alternative Targets (BCAs)

Invest 0.5% of GDP in Energy Technology RD&D

There is growing awareness of the need for innovation in energy technologies to address the climate change problem. Energy Technology Perspectives (IEA 2014) presents evidence that an additional global investment of USD 44 trillion could decarbonise the energy system sufficiently to meet the 2° target by 2050. Moreover, this expenditure is more than offset by over USD 115 trillion in fuel savings – resulting in net savings of USD 71 trillion. Even with a 10% discount rate, the net savings are more than USD 5 trillion (IEA 2014). This objective has also been raised at the Sixth session of the Open Working Group on Sustainable Development Goals⁸ and World Economic Forum (WEF 2013).

The Green Investment Report calls for an acceleration of low-carbon innovation. In particular, it recommends using revenues from carbon pricing measures to increase support for research, development, demonstration and pre-commercial deployment of low-carbon technologies by pooling international efforts (WEF 2013). Galiana and Green (2010) evaluate a proposal of a technology-led approach to climate policy funded by a low and slowly rising carbon tax and find that the BCAs to be between 1.3 and 10. When comparing the Galiana-Green approach to the standard carbon pricing approach to policy, BCRs are in the range of 12-15.

Policies that advance low-carbon technologies have substantial value in making future reduction in CO₂ cost-effective. Further, CO₂ targets and improved low-carbon technologies are probably correlated to some degree. Pricing carbon emissions can induce some innovation that reduces the cost of attaining the carbon target but will primarily drive the initial uptake of more costly innovations as they reach the market. According to modeling by (Lemoine and McJeon 2013), the 450 ppm target is only likely to be welfare enhancing in a world with multiple breakthroughs in low-carbon technology.

⁸ <http://sustainabledevelopment.un.org/content/documents/3412Summary%20CoChairs%20OWG6.pdf>

Invest 0.05% of GDP in Adaptation

Adaptation can be defined as purposeful adjustments in behavior in order to reduce society's vulnerability to climate. Climate adaptation includes reducing existing vulnerabilities, building adaptive capacity, current and future risk management, and building long-term resilience to climate change. Adaptation tends to occur reactively and there is tremendous benefit to taking planned measures.

Adaptation has been seen as especially important in developing countries since those countries are predicted to bear the brunt of the effects of climate change and have lower adaptive capacity. In fact, much of the literature on reducing vulnerability to climate change conveys a well-defined relationship between adaptation and development (Schipper and Pelling, 2006, Pouliotte et al., 2009, Klein et al., 2005, Jerneck and Olsson, 2008). Contrary to most other responses to climate change, adaptation does not suffer from a free-rider problem and consequently there are strong incentives to adapt even unilaterally (Bosello, Carraro et al. 2013). Most studies on costs and benefits of adaptation take a sectoral approach (Agrawal 2010, Hunt and Watkiss 2011). There is some concern that effective adaptation could lead to lesser mitigation⁹ and thus higher atmospheric concentrations in the long run, with tragic consequences for countries (like small island nations) with limited means to adapt. de Bruin, Dellink et al. (2009) show that adaptation reduces the benefit–cost ratio of mitigation.

Bosello (2004) shows that in 2050 a complete adaptation to the damage implied by the four climate change consequences (full coastal protection, space heating and cooling, resettlement and migration costs and health) is roughly equal to 0.15% of world GDP. Depending on the study, adaptation covers some 7–25% of total damages for a doubling of the atmospheric concentration of carbon dioxide. (Tol 2005, Hallegatte, Shah et al. 2012). Bosello, Carraro et al. (2012) find benefit-cost ratios of adaptation expenditure are larger than one (and up to 3) for all considered scenarios and BCRs are always greater when combined with mitigation. Adaptation, as with other climate policies, should be used as part of a portfolio that includes, mitigation policies both in the form of pricing and RD&D.

Ultimately adaptation needs to be combined with mitigation policy since most adaptation analyses focuses on 2-3°C climate change impacts, the costs beyond this are highly uncertain but undoubtedly significantly higher.

⁹ Mitigation and adaptation policies can be viewed as substitutes.

Target Recommendations for Post-2015 and Conclusion

Table 1: Benefit-Cost Summary¹⁰

Benefit – Cost Ratios				
	3% discount	5% discount	Co-benefits	Criticism
Emission targets 450ppm or 550ppm	<1	<1	Certainty of emission if policy is effective. Induces innovation. Reduces conventional air pollutants.	Costs can be massive. Limits growth. Does not address long-term climate concerns.
Emission intensity targets	uncertain	uncertain	More palatable for countries with high growth uncertainty.	Emissions can vary. Does not address long-term climate concerns.
EU 20-20-20¹¹	0.03-0.06	<0.03	First mover advantage. May incite other nations to follow suit.	Unnecessarily costly from a \$/emission reduction perspective.
0.5% of GDP in low-carbon energy RD&D^{**}	2-15	1-12	Spillovers to other sectors. Potential for significant mitigation at much lower cost.	No guarantee of emission reductions. Uptake will be limited in the absence of other mitigation policies.
Adaptation^{**}	Project and region specific (>1)	Project and region specific (>1)	Resilience to all types of climate variability.	Potentially reduces the need for mitigation.

Current emission reduction targets under consideration are dangerously unlikely to produce results. They rely heavily on the assumption that climate policy failures to date are simply a matter of political ill will and that technologies are available. Studies that show

^{**} Recommended targets

¹⁰ Estimates of the costs and the benefits of an intervention are never complete and rarely do justice to the complexity of the situation: the table provides approximations.

¹¹ Tol, R. S. (2012). "A cost-benefit analysis of the EU 20/20/2020 package." *Energy Policy* 49: 288-295.

strong benefit costs of emission reduction targets rely heavily on negative emissions through CCS and BEECS in future decades. The development of these and other burgeoning technologies is key to achieving significant cuts in GhG emissions. By setting goals that target low-carbon energy RD&D and adaptation, the UN post-2015 will be acknowledging current technological limitations and developmental objectives of emerging economies. Moreover, these targets will not conflict with economic objectives and access to energy needs. It is likely that a portfolio of policies including RD&D funding, adaptation and moderate carbon pricing would yield the most significant results; the complementarity of three approaches should not be overlooked. Lastly, this portfolio of approaches will address both short term and long term needs without burdening economic development and thus would be globally acceptable, realistic and most importantly, effective.

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This paper was written by Isabel Galiana, Lecturer at McGill University. The project brings together 62 teams of economists with NGOs, international agencies and businesses to identify the targets with the greatest benefit-to-cost ratio for the UN's post-2015 development goals.

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