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BEYOND COPENHAGEN: A REALISTIC CLIMATE POLICY IN A FRAGMENTED WORLD

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SUMMARY We propose a realistic approach to climate policy based on the Copenhagen Agreement to reduce Greenhouse Gases (GHGs) emissions by assessing the impact of this non-binding, albeit official, commitment on the level of world GHGs emissions in 2020. Our estimates are based on official communications to the UNFCCC, on historic data and on the Business-as-Usual scenario of the WITCH model. We are not interested in estimating the gap between the expected level of emissions and what would be needed to achieve the 2°C target. Nor do we attempt to calculate the 2100 temperature level implied by the Copenhagen pledges. We believe these two exercises are subject to high uncertainty and would not improve the current state of negotiations. Rather, we take stock of the present politically achievable level of commitment and suggest an effective way to push forward the climate policy agenda. The focus is on what can be done rather than on what should be done. To this end, we estimate the potential of the financial provisions of the Copenhagen Agreement to sponsor mitigation effort in Non-Annex I countries. Using scenarios produced with the WITCH model, we show that lower commitment on domestic abatement measures can be compensated by devoting roughly 50% of the Copenhagen financial provisions in 2020 to mitigation in Non-Annex I countries. The policy implications of our results will be discussed.

Keywords: Kyoto Protocol, International Climate Agreements, Climate Policy, Clean Development Mechanism

JEL: F5, Q01, Q54, Q58

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1. Introduction

As many analysts predicted, the Copenhagen summit held in December 2009 did not achieve the lofty goals that were set for it years ago. It failed to produce a legally binding agreement to substitute the Kyoto Protocol after 2012 (Stavins 2009, Doniger 2009, Tol 2010). But it did make progress. Indeed, a realistic assessment must admit that the outcome of the summit could not have been different. Hopes for a more ambitious result were not based on the reality on the ground. There were and still exist three insurmountable obstacles.

First, the USA could not sign a binding agreement, as the Senate had not passed the Boxer-Kerry Bill. That bill, coupled with the already approved American Clean Energy and Security Act (Waxman-Markey Bill), would have given President Obama the credibility to propose more ambitious steps (see also Grubb 2010).

Second, the lack of commitment from fast-growing developing countries to reduce emissions – not necessarily immediately, more realistically after a "grace" period – meant that any attempts from developed countries to contain temperature increases to safe levels would have been in vain.

Third, fast-growing developing countries are reluctant to take on any legally binding commitment, citing that their primary objective is to reduce poverty and to spread economic well-being to their poorest citizens. They also point out that responsibility for the high concentrations of greenhouse gases in the atmosphere today is only marginally attributable to their emissions. Hence, their refusal to sign any legally binding agreement, when the major world economies are not ready to do so, is largely understandable.

These are the basic ingredients of the so-called "climate deadlock" that prevented the signing of a real successor to the Kyoto Protocol and pushed the climate summit in Copenhagen to "take note" of a more modest Copenhagen Accord on the morning of Saturday, 19 December 2009.

During the past ten months climate negotiations have not made progress. The chances to have a legally binding treaty signed in Cancun at the next COP16 are extremely low, and US difficulties in approving national legislation aimed at enforcing domestic targets to reduce Greenhouse Gases (GHGs) emissions are only part of the problem. Indeed, the "climate deadlock" is the symptom of the present fragmented international climate architecture: countries are willing to take steps towards the reduction of GHGs, but on a voluntary and uncoordinated basis. The European Union is acting fiercely to recompose the picture in order to reproduce a Kyoto-style, legally-binding agreement with well-defined targets, although without success so far.

There are many reasons to believe that the stall in climate negotiations will not be overcome in the near future. Not only in Cancun, but for several years beyond. It is therefore of the utmost importance to build a realistic climate policy firmly grounded on the actions that countries have unilaterally promised in Copenhagen. The two pillars of climate policy in the years to come are the two important outcomes from Copenhagen. First, a non-binding, but politically relevant, declaration of national emissions targets for 2020. Second, the definition of the resources that will be transferred to developing countries for mitigation and adaptation actions (the Copenhagen Green Climate Fund – CGCF).

The primary aim of this paper is to offer guidance to policy makers and negotiators on how to structure efficiently and effectively climate policy in a post-Copenhagen world. We address key issues that will be discussed during the next round of negotiations in Cancun and will very likely remain at the core of climate policy for several years. We proceed as follows. We start by estimating the level of 2020 emissions implied by the Copenhagen pledges. We then compute the expected level of emissions and the level required to achieve the 2°C target. We argue that such a comparison is informative, but that it might be inconclusive and possibly misleading. A more realistic approach is needed. Therefore, we identify what is feasible and explore the role of international finance to reduce emissions in Non-Annex I countries.

2. What is the effect of the announced Copenhagen targets on global greenhouse gas emissions in 2020?

The Annex I to the Copenhagen Accord[1] contains communications of the parties to the United Nations Framework Convention on Climate Change (UNFCCC) on the voluntary mitigation actions that they intend to put in place to reduce emissions of GHGs in 2020. We have used the UNFCCC Annex I quantified economy-wide emissions targets for 2020 and Annex II nationally appropriate mitigation actions of developing country Parties as source of information. These targets are voluntary, announced in an informal – although public – session on 18 December 2009, or communicated later at the UNFCCC Secretary. While still not legally binding, the commitments announced at Copenhagen are very informative on future climate policies. For this reason a first step of any analysis of post-Copenhagen climate policy must start from an assessment of the likely level of GHGs emissions in 2020. Table 1 presents historic and future levels of emissions, with and without the Copenhagen targets, based on our analysis. We estimate emissions for twenty-two countries, covering 75% of global emissions both in 2005 and in 2020.

Quantifying emissions in 2020 for Annex I countries is a straightforward task, because targets are expressed in terms of historic emissions. The only exception is Turkey, that announced its intention to follow its Business as Usual (BaU) scenario for 2020. We compute emissions reduction targets without including emissions from Land Use Land Use Change and Forestry (LULUCF).[2] The future pattern of emissions from LULUCF is instead derived from the Business-as-Usual (BaU) scenario of the WITCH model (Bosetti et al 2006; Bosetti, Massetti and Tavoni 2007; Bosetti et al 2009).[3]

[1] Decision 2/CP.15, the “Copenhagen Accord”.

[2] GHGs emissions excluding LULUCF for Annex I countries are from the UNFCCC. LULUCF emissions for Annex I countries, and GHGs emissions for Non-Annex I countries– with and without LULUCF – are from IEA (2009).

[3] For a description of the model, references and access to scenarios please visit www.witchmodel.org .

Country	Pledge at COP15	Greenhouse Gases Emissions (GT CO2-eq) [11]									Copenhagen Pledges [12]							
		Excluding LULUCF			LULUCF			Total			Target		wrt 1990 (%)		wrt 2005 (%)		wrt BaU (%)	
		1990	2005	2020	1990	2005	2020	1990	2005	2020	LC	HC	LC	HC	LC	HC	LC	HC
Australia [1, 3]	-5%, -15% to -25% wrt 2000	0.42	0.53	0.62	0.02	0.02	0.01	0.44	0.54	0.63	0.48	0.37	11%	-15%	-11%	-32%	-23%	-41%
Belarus	-5% / '-10% wrt 1990	0.14	0.08	0.10	0.00	0.00	0.00	0.14	0.09	0.10	0.13	0.13	-6%	-11%	56%	48%	29%	22%
Canada	-17% wrt 2005	0.59	0.73	0.83	0.02	0.04	0.04	0.62	0.77	0.88	0.65	0.65	6%	6%	-16%	-16%	-26%	-26%
Croatia	-5% wrt 1990	0.03	0.03	0.04	0.00	0.00	0.00	0.03	0.03	0.04	0.03	0.03	-5%	-5%	-2%	-2%	-20%	-20%
Euro 27	-20% / -30% wrt 1990	5.57	5.12	6.13	0.02	0.01	0.02	5.59	5.13	6.15	4.47	3.91	-20%	-30%	-13%	-24%	-27%	-36%
Iceland	-30% wrt 1990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-30%	-30%	-36%	-36%	-44%	-44%
Japan [1]	-25% wrt 1990	1.27	1.35	1.54	0.02	0.02	0.02	1.29	1.38	1.57	0.98	0.98	-24%	-24%	-29%	-29%	-38%	-38%
Kazakhstan [4]	-15% wrt 1992	0.36	0.24	0.26	0.00	0.00	0.00	0.36	0.24	0.26	0.31	0.31	-16%	-16%	29%	29%	18%	18%
New Zealand [1]	-10% to -20% wrt 1990	0.06	0.08	0.09	0.00	0.00	0.00	0.06	0.08	0.09	0.06	0.05	-9%	-19%	-28%	-36%	-37%	-44%
Norway	-30% / -40% wrt 1990	0.05	0.05	0.06	0.00	0.00	0.00	0.05	0.05	0.06	0.03	0.03	-32%	-42%	-36%	-46%	-44%	-52%
Russian Federation [1]	-15% / -25% wrt 1990	3.32	2.12	2.31	0.06	0.04	0.01	3.38	2.16	2.32	2.83	2.50	-16%	-26%	31%	16%	22%	8%
Switzerland	-20% / -30% wrt 1990	0.05	0.05	0.06	0.00	0.00	0.00	0.05	0.05	0.06	0.04	0.04	-23%	-32%	-22%	-31%	-32%	-40%
Turkey	BaU	0.19	0.33	0.40	0.00	0.00	0.00	0.19	0.33	0.40	0.40	0.40	115%	115%	22%	22%	--	--
Ukraine	-20% wrt 1990	0.93	0.42	0.52	0.00	0.00	0.00	0.93	0.42	0.52	0.74	0.74	-20%	-20%	75%	75%	44%	44%
United States	-17% wrt 2005	6.11	7.10	8.23	0.07	0.03	0.00	6.18	7.13	8.23	5.90	5.90	-5%	-5%	-17%	-17%	-28%	-28%
Total Annex I [5]		**19.09**	**18.24**	**21.20**	**0.22**	**0.17**	**0.11**	**19.31**	**18.41**	**21.31**	**17.06**	**16.04**	**-12%**	**-17%**	**-7%**	**-13%**	**-20%**	**-25%**
Brazil [1, 7]	-0.97 / -1.05 GtCO2-eq wrt BaU	0.72	1.11	1.53	0.89	1.45	1.13	1.61	2.56	2.66	1.68	1.61	4%	0%	-34%	-37%	-37%	-40%
China [2, 6]	reduce carbon intensity of output by 40-45% wrt 2005	3.72	7.61	10.75	0.04	0.03	-0.28	3.76	7.64	10.47	10.47	10.47	179%	179%	37%	37%	--	--
India [2, 8]	reduce carbon intensity of output by 20-25% wrt 2005	1.33	2.05	2.59	0.05	0.04	0.01	1.38	2.09	2.60	2.60	2.60	89%	89%	24%	24%	--	--
Indonesia [1]	-26% / -41% wrt BaU	0.45	0.73	1.13	0.41	0.84	0.49	0.86	1.57	1.62	1.20	0.96	40%	12%	-24%	-39%	-26%	-41%
Mexico [1]	-51 Mt CO2-eq / -30% wrt BaU	0.45	0.61	0.84	0.03	0.04	0.03	0.48	0.65	0.87	0.82	0.61	71%	27%	26%	-6%	-6%	-30%
South Africa [1]	-34% wrt BaU	0.34	0.44	0.51	0.00	0.00	0.00	0.35	0.44	0.51	0.34	0.34	-2%	-2%	-23%	-23%	-34%	-34%
South Korea [1]	-30% wrt BaU	0.30	0.67	0.79	0.00	0.00	0.00	0.30	0.67	0.79	0.55	0.55	84%	84%	-18%	-18%	-30%	-30%
Other Non-Annex I [9]		5.91	7.69	9.59	3.75	2.98	2.00	9.66	10.67	11.59	11.59	11.59	20%	20%	9%	9%	--	--
Total Non-Annex I		**13.22**	**20.90**	**27.72**	**5.17**	**5.40**	**3.39**	**18.38**	**26.30**	**31.11**	**29.25**	**28.72**	**59%**	**56%**	**11%**	**9%**	**-6%**	**-8%**
International Bunker [10]		0.61	0.94	1.09				0.61	0.94	1.47	1.47	1.47	141%	141%	57%	57%	--	--
World		**32.92**	**40.08**	**50.01**	**5.38**	**5.57**	**3.50**	**38.30**	**45.65**	**53.90**	**47.79**	**46.23**	**25%**	**21%**	**5%**	**1%**	**-11%**	**-14%**

Notes: [1] This country is part of a wider regional aggregate in the WITCH model. The growth of emissions in the BaU scenario is calculated using the average growth rate of the wider regional aggregate to which the country belongs. [2] We use the increment of GHGs emissions in the WITCH model BaU scenario because the committed reduction of carbon intensity is inferior to the BaU autonomous carbon intensity improvement. [3] Australia's total GHGs emissions were equal to 496 Mt CO_2-eq in 2000. [4] Kazakhstan is a Party included in Annex I for the purposes of the Kyoto Protocol in accordance with Article 1, paragraph 7, of the Protocol, but is not a Party included in Annex I for the purposes of the Convention. The base year is 1992 for Kazakhstan. We estimate 1992 total GHGs emissions based on 1992 CO_2 emissions from CDIAC. [5] Targets of Annex I countries do not consider emissions from LULUCF. Minor countries are not included. [6] China also committed to increase the share of non-fossil fuels in primary energy consumption to around 15% by 2020 and to increase forest coverage by 40 million hectares and forest stock volume by 1.3 billion cubic meters by 2020 from the 2005 levels. [7] Brazil has announced specific mitigation measures. They correspond to GHGs emissions reductions of, respectively, -36.1% and -38.9% wrt the official BaU scenario. Here we use WITCH BaU scenario, which is very close to the official one. [8] The emissions from the agriculture sector will not be part of the assessment of emissions intensity of India. [9] We assume that Other Non-Annex I countries will follow their BaU pattern of emissions. [10] WITCH does not account for international bunkers explicitly. We have projected the level of emissions from international bunkers using the 2000-2005 growth rate. [11] Source of data for GHGs emissions excluding LULUCF in Annex I countries is the UNFCCC. LULUCF emissions in Annex I countries and GHGs emissions in Non-Annex I countries – including and excluding LULUCF – are from IEA (2009). [12] Future emissions are authors' calculations based on BaU scenarios of the WITCH model. We use the UNFCCC Annex I quantified economy-wide emissions targets for 2020 and Annex II Nationally appropriate mitigation actions of developing country Parties as source of information.

Table 1. Historic emissions, Business-as-Usual emissions and Copenhagen Pledges.

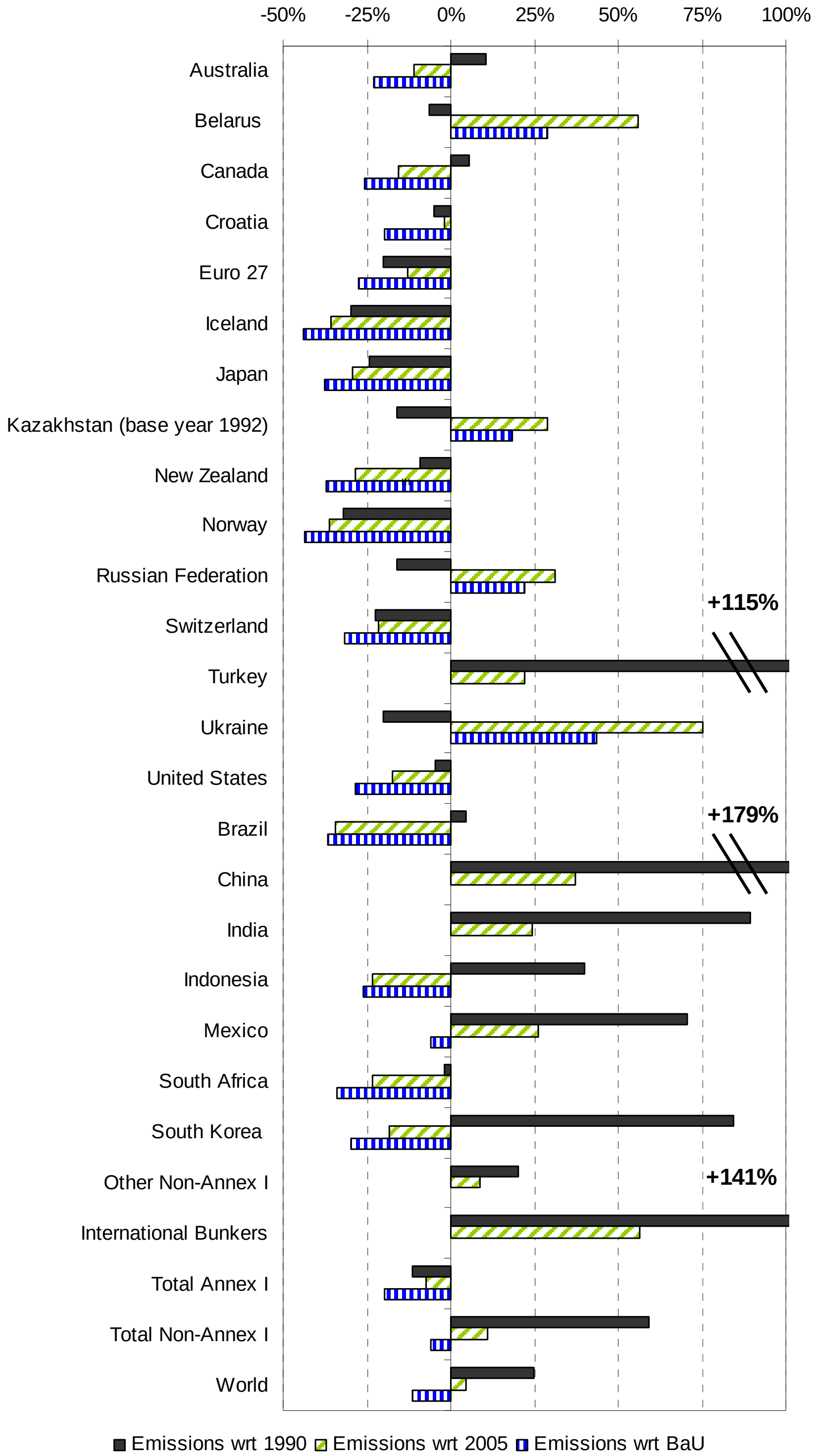


Figure 1. Copenhagen Pledges: comparison between the LC pledged emissions, historical level and the BaU.

Some Annex I countries have announced two targets. We have therefore distinguished between a Low and a High Commitment level (LC and HC henceforth).[4] The HC is usually conditional on other regions collectively taking aggressive action to reduce GHGs emissions.

GHGs emissions in Annex I countries as a group – excluding LULUCF emissions – were equal to 19 GTon CO_2-eq in 1990, they declined to 18.2 GTon CO_2-eq in 2005. If no action is taken to reduce GHGs we expect emissions to be 21.2 GTon CO_2-eq in 2020.[5] Combining the Copenhagen pledges and the expected pattern of emissions from LULUCF we estimate that emissions will be 17 GTon CO_2-eq in the LC scenario and 16 GTon CO_2-eq in the HC scenario.[6] In the LC case emissions will be 12% lower than in 1990 and 7% lower than in 2005. In the HC case emissions will be 17% lower than in 1990 and 13% lower than in 2005.

Instead of announcing emissions targets with respect to a specific base year, Non-Annex I countries have generally taken a more flexible approach. A group of countries has expressed the intention to reduce emissions below the BaU scenario (Indonesia, Mexico, South Africa, South Korea, …). China has a goal to reduce the carbon intensity of Gross Domestic Product (GDP) by 40-45% compared to the 2005 level, to increase the share of non-fossil fuels in primary energy consumption to around 15% in 2020 and to increase forest coverage by 40 million hectares and forest stock volume by 1.3 billion cubic meters by 2020 from 2005 levels. India also has an intensity target of -20% / -25% with respect to 2005.[7] Brazil has quantified specific mitigation actions that range from -0.97 to -1.05 GTon CO_2-eq; when compared to the Brazilian government BaU, this is equivalent to a contraction of emissions of 36.1% and 38.9%, respectively.

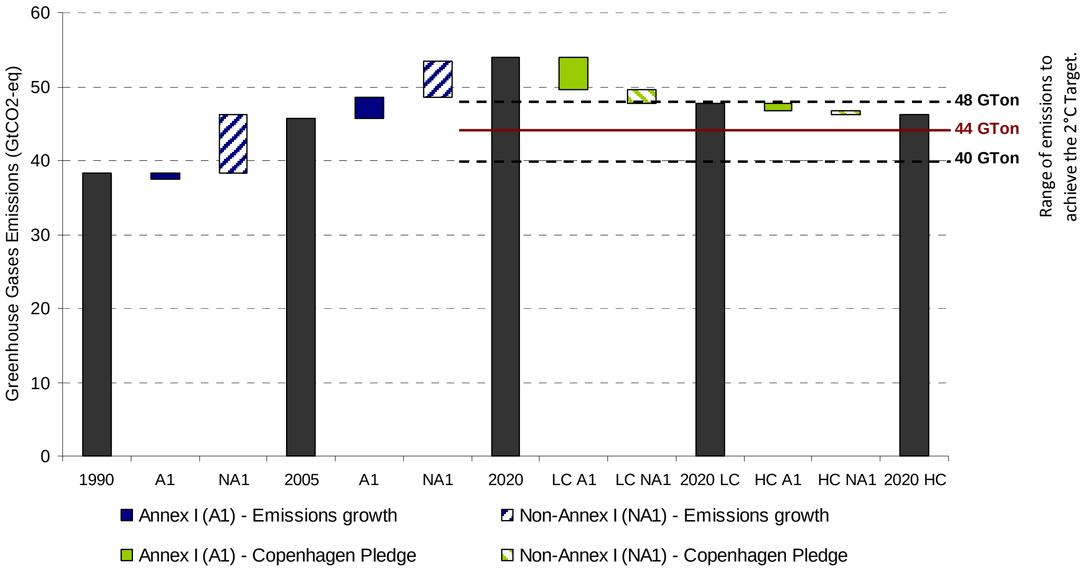
Quantifying emissions reductions pledged by Non-Annex I countries is not an easy task. The most important source of ambiguity is the lack of a clear reference. In general, countries have not indicated their expected BaU level of emissions and therefore any assessment of their future level of emissions is subject to a wide margin of uncertainty. Also, many countries have not specified whether the promised emissions cuts will include or exlude LULUCF emissions. Brazil has clearly indicated that part of the mitigation effort will be directed towards the reduction of deforestation and land degradation. But other countries have not been as specific. Moreover, there is still wide uncertainty on the BaU pattern of emissions from LULUCF. Since LULUCF emissions account for 20% of total GHGs emissions in the Non-Annex I group, the uncertainty that surrounds their inclusion in the target and their future BaU pattern are other major sources of ambiguity. Since emissions reductions from avoided deforestation and land degradation (REDD) are among the cheapest options to reduce GHGs emissions, we assume here that all Non-Annex I countries have included emissions from LULUCF in their Copenhagen pledges.

[4] For those countries that have an intermediate level of commitment we consider only the two extremes.

[5] The "20-20-20" European Union policy is not part of our BaU scenario.

[6] Using IEA 1990 GHGs emissions – excluding LULUCF – emissions in the HC pledge would be equal to 15.6 GTon CO_2-eq. In the LC pledge emissions would 16.6 GTon CO_2-eq. Different data sources for 1990 imply roughly +/- 0.4 GTon CO_2-eq in 2020.

[7] India includes all GHGs emissions in the target, but not emissions from the agricultural sector.



Notes: LC stands for Low Commitment. HC stands for High Commitment. The range of emissions in 2020 to achieve the 2°C target in 2100 is from UNEP (2010). 44 GTon CO_2-eq is considered by Nicholas Stern a "climate responsible target" for 2020. Van Vuuren et al (2010) have established a range of 44 to 46 GTon CO_2-eq for emissions in 2020 to attain the 2°C target at the end of the century.

Figure 2. Historic emissions, BaU emissions, the Copenhagen Pledges and the 2°C target.

In order to quantify the Copenhagen pledges of the Non-Annex I group we focus on the pledges announced by six major emitters (60% of Non-Annex I emissions) and we assume that the other countries will follow their BaU scenario. As a group, the Copenhagen commitments would imply 29.2 GTon CO_2-eq of emissions in the LC case and 28.7 GTon CO_2-eq in the HC case (including LULUCF). The expected level of emissions represents a contraction of -6% (LC) and -8% (HC) with respect to the BaU scenario. If compared to 1990, emissions would increase instead by 59% (LC) and 56% (HC). Compared to 2005 the increment would be less dramatic, equal to 11% (LC) and 9% (HC).

The quantified emissions targets of China and India deserve a comment. We find that both countries would achieve their Copenhagen targets as the consequence of autonomous efficiency improvements, triggered by long-term price and technology dynamics, more than by a specific mitigation policy. The BaU scenario of the WITCH model shows an autonomous contraction of the carbon intensity of output equal to 57% for China and equal to 45% for India, with respect to 2005 (for a wider discussion see Carraro and Tavoni 2010).[8] Since the two targets do not appear to be binding, in Table 1 we have set 2020 emissions for China and India equal to their BaU scenario.[9]

Globally, we expect GHGs emissions to be equal to 47.8 GTon CO_2-eq in the LC case and 46.2 GTon CO_2-eq in the HC case. This represents a contraction of emissions of 11% (LC) and 14% (HC) with respect to the BaU. However, emissions still increase, not only with respect to 1990 (+25% in LC and +21% in HC) but also with respect to 2005 (+5% in LC and +1% in HC).

The information on historic emissions, future BaU emissions and quantified emissions

[8] GHGs intensity of India's GDP declines by 51% in 2020 with respect to 2005 in the WITCH BaU scenario.

[9] Both the Energy Information Administration (EIA) and the International Energy Agency (IEA) expect a contraction of carbon intensity equal to 47% in China, in 2020 compared to 2005. For India, the EIA and the IEA see a contraction of carbon intensity of 2020 relative to 2005 equal to 52% and 46%, respectively. Therefore, for both the IEA and the EIA the intensity targets of China and India are already reached in a reference scenario.

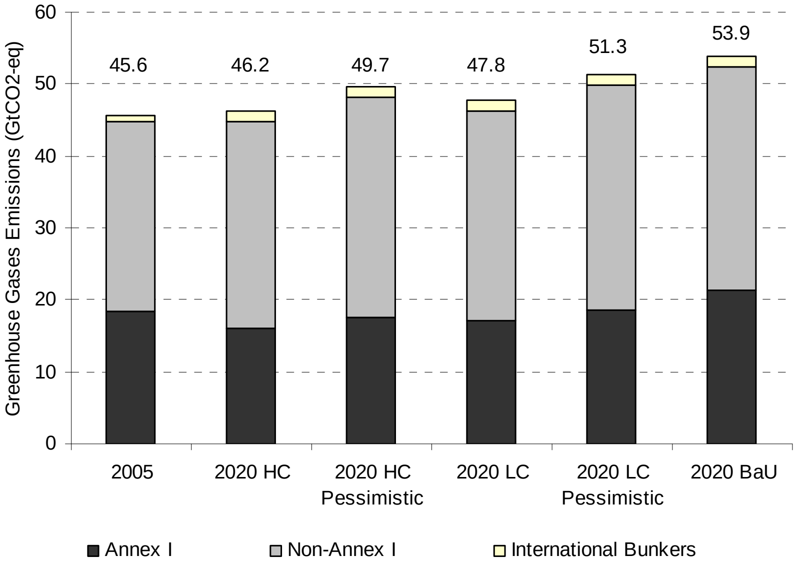
reduction targets is summarized in Figure 2. From 1990 to 2005 global emissions have increased mainly in Non-Annex I countries. Annex I countries, as a group, have followed a rather flat pattern: growing emissions from the USA, Canada, Australia, Japan and fast-growing countries of the European Union have been compensated by a collapse of emissions in Transition Economies after 1990. We expect to see emissions rising again in Annex I countries from 2005 until 2020. Globally, emissions in 2020 are expected to be 8.25 GTon CO_2-eq higher than 2005. In the LC case, emissions reductions with respect to the BaU scenario (6.11 GTon CO_2-eq) would mainly come from Annex I countries (4.25 GTon CO_2-eq), but the contribution from Non-Annex I countries would be non-negligible (1.86 GTon CO_2-eq). In the HC case, the additional contraction of emissions would be modest compared to the LC case: total emissions would decrease only by an additional 1.55 GTon CO_2-eq with respect to the BaU. Two thirds of the additional effort would come from Annex I countries. By moving to the -30% target Europe would contribute with 0.56 GTon CO_2-eq, half of the Annex I effort but barely noticeable at global level.

This first analysis of the Copenhagen Pledges conveys some important policy messages. First, there are high chances that emissions of GHGs will not be lower than 2005. This is not good news if we expect emissions to start declining at a fast pace in the near future. However the efforts will not be vain. Emissions are expected to depart from their BaU pattern in 2020, at the end of a decade that will very likely continue to see the fast growth of the most dynamic emerging economies, with millions of people lifted out of poverty and hungry for energy. The level of commitment registered at Copenhagen is perhaps not as high as some had wished, but it cannot be judged negligible. Second, policy makers and negotiators should avoid harsh confrontations on the level of commitment: moving from low to high pledges does not bring us much closer to the desired abatement level. Equivalently, unilateral moves to a HC target appear ineffective in controlling global warming.

Our estimates tend to be slightly lower than in other studies, mainly due to different assumptions on LULUCF emissions in the BaU, and to a different level of BaU emissions in Non-Annex I countries. Most studies found that emissions in the HC case will be roughly equal to 48 GTon CO_2-eq, while we expect them to be equal to 46.2 GTon CO_2-eq. Estimates of emissions in the LC case range from 49.2 to 55 GTon CO_2-eq in the literature while we expect them to be 47.8 GTon CO_2 (Dellink et al 2010; den Elzen et al 2010; Lowe et al 2010; Höhne et al 2010; Houser 2010; Stern and Taylor 2010).[10]

Some caveats apply to our analysis. First, we have used the BaU scenario of the WITCH model to derive the pledges of Non-Annex I countries in 2020. The level of economic activity in WITCH is endogenous and is governed by a Ramsey-type optimal growth model that is suited to study productive capital accumulation in the long-run. With perfect foresight and no uncertainty, the expansion of economic systems follows a smooth path, unable to reproduce short-term fluctuations due to economic crises or booms. Therefore, the actual level of economic activity, and of carbon emissions, in 2020, might well be above or below the long-term pattern of Non-Annex I countries depicted in our scenario.

[10] It must be noticed that many of the estimates in the literature are very similar because they have been generated using the same BaU scenario produced by the IEA.



Notes: HC stands for High Commitment. LC stands for Low Commitment. In the Pessimistic Scenarios LULUCF emissions remain as high as in 2005 and surplus AAUs from the first commitment period are banked and carried over to the second commitment period.

Figure 3. Emissions in the Optimistic and Pessimistic scenarios.

The second caveat concerns the pattern of emissions from LULUCF. Emissions from LULUCF are exogenous in WITCH and are assumed to decline over time. In the BaU scenario, the contraction of LULUCF emissions accounts for a net reduction of 2 GTon CO_2-eq in 2020, with respect to 2005, mainly concentrated in Non-Annex I countries. If emissions in 2020 from LULUCF will be as high as in 2005, an extra 2 GTon CO_2-eq should be added to our estimates.

The third caveat concerns emissions from fossil fuels displaced in international bunkers, not explicitly modelled in WITCH. Since they are non-negligible in level and are one of the fastest growing sources of carbon emissions, we project emissions in 2020 by applying the same growth rate observed from 2000 to 2005. Any specific action of countries to reduce emissions from international bunkers would bias our estimates upward, or vice versa.

The fourth caveat concerns the possible use of surplus emission allowances or assigned amount units (AAUs), often referred to as "hot air", of Russia and Ukraine. While we do not make here any specific assumption on the future use of AAUs, a recent study has shown that banking and use of surplus AAUs from the first commitment period would add up to 1.5 GTon CO_2-eq to the pledges of Annex I countries (den Elzen et al 2010).

Finally, the LC and HC cases do not span the whole range of plausible scenarios for 2020 GHGs emissions. The HC seems to be an optimistic scenario. Annex I countries take on the high commitment pledge, Non-Annex I reduce emissions below a BaU scenario that already sees a marked contraction of energy intensity. LULUCF emissions are halved by 2020 and AAUs are not carried over to the future after the first commitment period of the Kyoto Protocol. The LC scenario has slightly higher emissions, but the gap between the two is not large. In Figure 3 we compare these two benchmark cases with two pessimistic alternatives in which emissions from LULUCF in 2020 remain as high as in the present and AAUs are carried over to the future. Emissions in the HC pessimistic scenario are higher than in the LC scenario, meaning that LULUCF emissions and AAUs need careful consideration. More optimistic views on emissions from international bunkers would reduce emissions below the benchmark cases.

3. Are the promised emissions reductions sufficient to control global warming?

Scientific consensus states that severe climate change cannot be avoided unless we limit the earth's average temperature rise to something like below 2°C. Specifically, the goal announced by the "Group of eight" (G8) and the Major Economies Forum (MEF) in L'Aquila in July 2009 and also mentioned in the Copenhagen Accord, is to keep average temperature to no more than 2.0 °C above the pre-industrial level, by 2100. The Copenhagen Accord also mentions the necessity to explore possible ways to constrain temperature increase below 1.5°C.

The GHGs emissions stabilisation scenarios presented in the Fourth Assessment Report (FAR) of the International Panel on Climate Change (IPCC 2007) show that this will require GHGs emissions to: a) peak before 2015, b) decrease by roughly 5-10% starting from 2020 c) then decline steadily. In particular, the UNFCCC prescribes a contraction of Annex I emissions from -25% to -40% with respect to 1990 and Non-Annex I emissions should be -15% to -30% below BaU.

An assessment of post-FAR literature has found that 2020 emissions of GHGs should be in the range of 20-48 GTon CO_2-eq to meet the 2°C target (UNEP 2010). Nicholas Stern has fixed a "climate responsible target" of 44 GTon CO_2-eq in 2020 (Stern and Taylor 2010). Van Vuuren et al (2010) find that emissions in 2020 should fall in the range of 44 to 46 GTon CO_2-eq to attain the 2°C target at the end of the century.

Our HC and LC scenarios fall both in the range of 40-48 GTon CO_2-eq – although in the LC case we are very close to the upper bound of the range – but remain above the "climate responsible target" (See Figure 2). In the pessimistic case, both the HC and LC would remain above the range indicated by UNEP (2010).

Controlling whether emissions in 2020 will be in the range indicated by the literature to achieve the 2°C target is certainly an informative comparison. However, it is misleading to assess a very long-term temperature target on action taken to reduce emissions in the short-term. The level of emissions in 2020 is an important indicator of how strong the commitment is to move forward with mitigation action, but the implications in terms of long-term temperature rise are overshadowed by what will be done after 2020. We briefly explain here why this is the case.

Recent work has shown that the contribution to global warming caused by anthropogenic CO_2 emissions can be directly related to cumulative emissions of carbon dioxide (Solomon et al 2010).[11] Global mean temperature is basically a linear function of

[11] We do not consider here other GHGs because their lifetime is much shorter than for CO_2 and their warming effect is therefore transitory. Increasing the natural absorption capacity of carbon dioxide by means of afforestation, combined use of biomass and carbon capture and storage or other artificial methods would relax the budget. Geoengineering methods would instead not affect the stock of GHGs in the atmosphere but would reduce the temperature increase.

the stock of GHGs in the atmosphere. This direct link between concentrations and temperature suggests thinking in terms of "carbon budget". This budget can be "spent" with a certain freedom over time. If the temperature target must be met with a chance higher than 95%, the carbon budget for the future is equal to 1,000 GTon CO_2. If we are willing to accept that the probability of achieving the 2°C target is just above 50%, the carbon budget increases to 2,000 GTon CO_2. If the probability decreases to just below 50% the carbon budget increases up to 3,000 GTon CO_2 (Solomon et al 2010, Tavoni et al 2010). This means that, without mitigation policy, according to the WITCH BaU scenario, the budget would be exhausted in 2030 in the high probability case, in 2045 in the just above 50% case or in 2060 in the just below 50% case.[12]

It is therefore clear that, although not even mentioned in the text of the Copenhagen Accord, the probability with which the international community wants to achieve the 2°C target is by far the most important missing piece of information to test whether we are on the right or wrong track towards the long-term goal. Let us assume, however, that there is consensus to reduce to the minimum the probability not to achieve the 2°C target.[13] When do we spend the remaining 1,000 GTon CO_2?

Tavoni *et al.* (2010) estimate that a minimum budget of 2,000 GTon CO_2 emissions is needed to allow a fair growth of Non-Annex I countries[14] and a floor of emissions in Annex I countries.[15] It is therefore necessary to absorb about 1,000 GTon of carbon dioxide from the atmosphere and to store it in forests or underground, by means of bio-energy with carbon capture and sequestration (BECCS). Without net negative global emissions of carbon dioxide, the 2°C target can be achieved only with a probability just below 50%. This simple, back-of-the-envelope calculation is confirmed by a wide range of scenarios produced by the IAM community (Clarke et al 2010): without net negative emissions on a gigantic scale (roughly 40 years of emissions), it is not possible to achieve the 2°C target with a sufficiently high probability. Unfortunately, we still know very little about the possibility to manage a global carbon dioxide sequestration project. We know very little about the costs, the policy challenges, the technological feasibility and the repercussions on ecosystems of what looks closer to geo-engineering than to mitigation action (see also Carraro and Massetti, 2010). The few IAMs scenarios that have shown a feasible pattern of emissions to achieve the 2°C target with high probability rely on speculative assumptions on costs, technical availability and feasibility of net negative emissions beyond 2050 (see Clarke *et al.*, 2010, Tavoni and Tol, 2010). These results are informative, but fragile.

It is therefore clear that few extra GTons of carbon dioxide in 2020 do not much affect the chances to achieve the 2°C target. Even if we assume inertia in mitigation action, the level of carbon dioxide emissions in 2020 has modest implications on the long term temperature target. For remaining below 2°C

[12] WITHC model BaU scenario.

[13] With lower probability the carbon budget is sufficiently large to relieve the pressure on short term targets.

[14] For Non-Annex I countries: 1,500 GTon would allow 15 GTon of emissions per year over 100 years. This long-term level of emissions would be 60% lower than BaU emissions of Non-Annex I countries in 2050, according to WITCH.

[15] For Annex I countries: 500 GTon would allow 5GTon of emissions per year over 100 years. This long-term level of emissions would be 80% lower than BaU emissions of Annex I countries in 2050, according to WITCH.

with high probability what really matters is the possibility to absorb carbon dioxide at an unprecedented scale. Policy makers should be aware of this important caveat. More attention should be paid to defining the range of probability within which the international community wants to meet the 2°C target, and to studying the possibility of realizing negative emissions on a vast scale. Without more information on these two key issues any evaluation of future targets on the basis of present action is highly speculative.

For these reasons, we do not make heroic assumptions to extrapolate temperature targets from the estimated level of 2020 emissions, as many other studies have done. We would only add uncertainty on top of uncertainty. Also, we do not focus on measuring the “gap” between the projected emissions and a desired target. Rather, we take stock of what is the present politically achievable level of commitment and we suggest an effective way to push forward the climate agenda. The focus is on what can be done, rather than on what should be done.

Policy makers and negotiators should avoid harsh confrontation on the level of commitment in the next rounds of negotiations. It is not the right time to renegotiate targets. The Copenhagen pledges are a sufficiently good starting point. If combined with an efficient allocation of the funding provisions of the Accord there are high chances to achieve non-negligible emissions reductions and to start a long-term trend towards a low-carbon world. In the next Section we propose a sensible approach to the use of the funding provisions of the Accord employing a consistent set of scenarios produced by the WITCH model.

4. Financing mitigation action in Non-Annex I countries

The main commitment contained in the Copenhagen Accord is to set up a fast track fund that will consist of $10 billion per year from 2010 to 2012 (totalling $30 billion). If there is sufficient and transparent action towards mitigation, developed countries have committed to mobilise, jointly, $100 billion dollars a year by 2020.[16] A significant portion of such funding will flow through a newly established Copenhagen Green Climate Fund (CGCF).[17]

Recent research with an enhanced version of the WITCH model – designed to quantify the optimal time profile of investments in adaptation and in mitigation – clearly shows that it is optimal to invest immediately in mitigation actions, while delaying most investments in adaptation to the future (Bosello, Carraro and Cian 2009). The reason is that it is imperative to control greenhouse gas emissions as soon as possible to attain low-temperature targets, while the short-term climate change impacts are still moderate and given that adaptation measures can be put in place relatively quickly in the future.

We therefore suggest that the financial resources mobilised in Copenhagen should be used primarily to mitigate greenhouse gas emissions. The CGCF could be transformed into the International Bank for Emissions Allowance Acquisition (IBEAA) envisaged by Bradford (2008). The resulting climate

[16] It has not been specified what the level of funding would be between 2012 and 2020.

[17] It has not yet been decided what fraction of the total funding will flow trough the CGCF. For simplicity, in the discussion that follows we assume that the CGCF will distribute all international funding promised in the Copenhagen Accord.

architecture would not follow a pure "purchase of a global public good approach" (Bradford 2008) because there would still be a multilateral, non-binding but official, set of emissions reductions pledges that countries need to fulfil. The second difference is that the CGCF is meant to finance adaptation and mitigation in Non-Annex I countries alone, while the IBEAA proposed by Bradford (2008) has a global scope. The resulting climate architecture would be similar to the "No Cap but Trade" proposal put forward by Tol and Rehdanz (2008) and proposed again in Tol (2010).

Annex I - High Commitment				Annex I - Low Commitment			
Cost of abatement	Non-Annex I Commitment			Cost of abatement	Non-Annex I Commitment		
	High	Low	BaU		High	Low	BaU
< 10$	0.0	0.4	2.3	< 10$	0.0	0.6	2.5
>10$ and <20$	3.2	3.3	3.3	>10$ and <20$	3.4	3.3	3.3
>20$ and <30$	1.3	1.3	1.3	>20$ and <30$	1.3	1.3	1.3
< 30$	4.5	5.0	6.9	< 30$	4.7	5.2	7.1

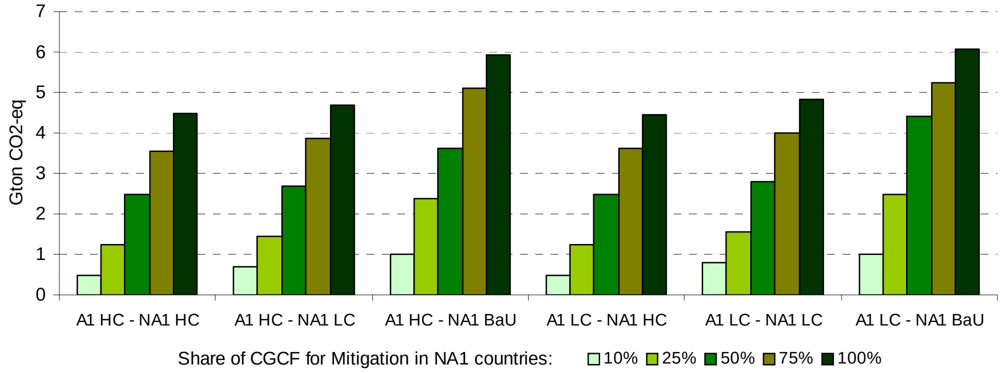
Notes: Abatement potential is measured in GTon CO_2-eq. The abatement potential in Non-Annex I countries has been estimated running three global GHGs tax scenarios. The tax is on all GHGs and includes emissions from LULUCF. The three taxes start at 10, 20 and 30$ at 2020 and increase by 5% per year thereafter. Tax revenues are recycled lump-sum into the economies. We then assume that Annex I countries cover 20% of their Copenhagen Pledges target using international offsets. The abatement potential shown here is net of international offsets to meet the Copenhagen Pledges.

Table 2. Mitigation potential in Non-Annex I countries, at different costs, with different assumptions on the level of commitment.

Let us move a step forward and quantify what the potential impact of the CGCF would be on emissions in 2020, assuming different allocation of funds between mitigation and adaptation. We estimate cumulative abatement potential in 2020 using scenarios produced by the WITCH model.

The advantage of our approach is that we can use a consistent set of scenarios to study BaU emissions, to estimate the Copenhagen pledges and to assess the mitigation potential. It is important to recognize that mitigation opportunities in Non-Annex I countries depend on the level of abatement effort in Annex I countries, on domestic targets and on the number of international offsets. For this reason we start by estimating how many GTon of CO_2-eq can be sponsored by the CGCF and at what cost, under different levels of commitments, as displayed in Table 2. We assume that Annex I countries always cover 20% of the domestic abatement target by means of offsets in Non-Annex I countries. The mitigation potential that we consider is therefore net of international offsets to meet the Copenhagen Pledges.

A first analysis of Table 2 reveals that if Annex I countries have a low commitment and Non-Annex I countries follow their BaU pattern of emissions, there are 4.5 - 6.9 GTon CO2-eq of mitigation potential in Non-Annex I countries at a cost below 30$ per Ton of CO2-eq. The mitigation mix includes energy efficiency measures, fuel switching, a new mix in electricity generation, reduction of non-CO2 gases and avoided deforestation. The right balance of the mitigation mix is endogenously determined in WITCH by taking into consideration a range of interaction channels among countries and a future path of carbon prices.



Notes: HC stands for High Commitment. LC stands for Low Commitment. A1 stands for Annex I countries; NA1 stands for Non-Annex I countries. 20% of abatement in Annex I countries is covered by offsets in Non-Annex I countries.

Figure 4. International offsets available under alternative schemes of the CGCF and alternative commitment levels of Annex I and Non-Annex I countries.

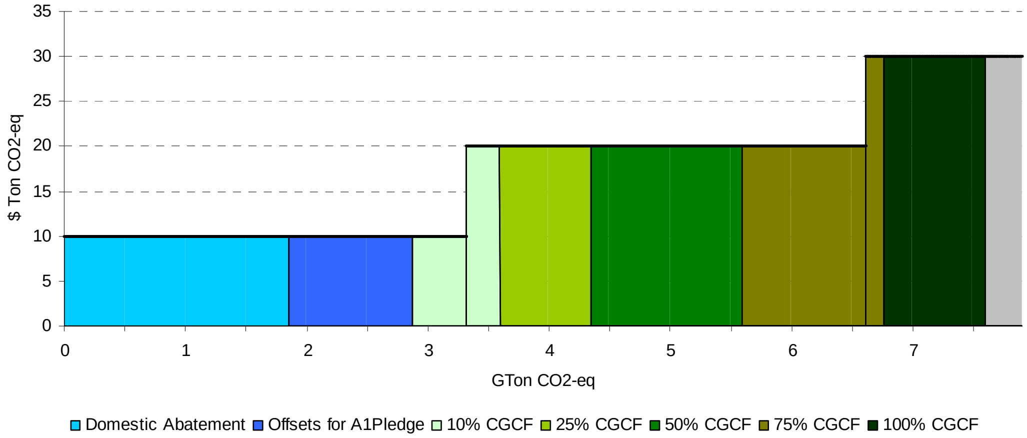


Figure 5. The distribution of GHGs abatement potential in Non-Annex I countries in 2020, LC scenario.

The estimated mitigation potential is therefore consistent with long-term action to reduce global warming.[18] Higher effort to reduce emissions in Annex I countries – at a constant level of effort in Non-Annex I countries – reduces the amount of mitigation that can be financed via the CGCF because the demand for offsets increases. Also, higher effort from Non-Annex I countries, – at constant level of effort in Annex I countries – reduces the number of available mitigation projects that can be financed by international donors. With the level of emissions prescribed by the high Copenhagen pledge in Non-Annex I countries, there would be no mitigation opportunities below 10$ per Ton of CO_2-eq.

Figure 4 shows how large the impact of the CGCF on global emissions efforts can be with different combinations of commitment and with allocation rules for the CGCF. In case of high commitment (A1 HC – NA1 HC), 50% of CGCF in 2020 would allow the global reduction of emissions by a further 2.5 GTon CO_2-eq; with a more relaxed level of commitment (A1 LC – NA1 BaU) the same amount of emissions reductions could be financed with only 25% of the CGCF for mitigation.

[18] We have run three GHGs tax scenarios to have three different levels of abatement in 2020. The starting level for the taxes in 2020 is 10, 20 and 30$. The taxes grow at 5% per year afterwards.

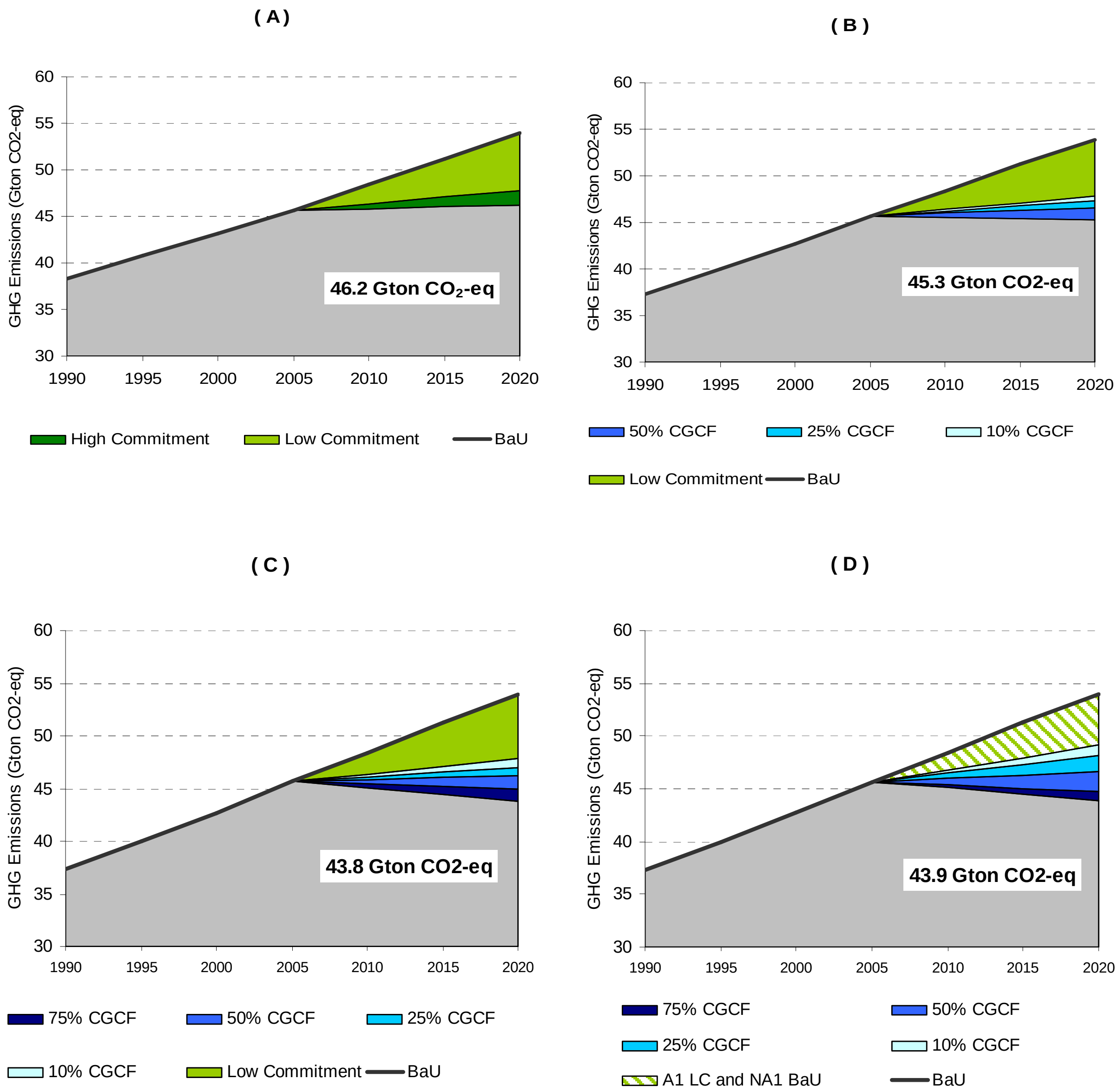


Figure 6. Different combinations of Copenhagen commitments and international funding of mitigation in Non-Annex I countries.

Figure 5 presents for the A1 LC – NA1 LC scenario a detailed picture of how the abatement potential could be shared between domestic mitigation, international offsets to cope with the Copenhagen pledges and international finance, different allocation rules of the CGCF.

Our analysis shows that the same mitigation target can be achieved by a different combination of domestic pledges and international funding of mitigation. High pledges and international financing of mitigation can be substitute. Given the present climate deadlock the financial provisions of the Copenhagen Accord could compensate the lack of more energetic action on the domestic mitigation side.

Figure 6 gives illustrative examples of the possible combinations between financing and domestic mitigation actions. Panel A shows the level of emissions with the HC pledge and no funding of mitigation in Non-Annex I. Panel B considers instead a LC pledge plus 50% of the CGCF for mitigation. With support of international finance it would be possible to more than compensate the lack of high commitment in domestic mitigation effort. Panel C and D tell a different story. In Panel C, both Annex I and Non-Annex I countries commit to the low end of the pledges and Annex I countries devote 50% of the CGCF to mitigation. In Panel D the only difference is that Non-Annex I countries do not make any voluntary domestic abatement effort.

The resulting level of emissions would be practically identical in the two cases, the reason being that the cost of abatement measures increases due to the competition of domestic and internationally sponsored mitigation projects.

5. Conclusions

The mitigation targets set in Copenhagen will have a moderate, although non-negligible impact on global emissions in 2020. Emissions will increase by 26%-22% with respect to 1990, but they will be 13%-16% lower than in the BaU scenario. This reduction will be particularly remarkable in years in which fast-growing developing economies will be responsible for the greatest share of global GHGs emissions. In a pessimistic scenario, with low commitment from both Annex I and Non-Annex I parties, pessimistic assumptions on LULUCF emissions, banking of AAUs and increasingly high emissions from international bunkers, emissions would be only 6% below BaU in 2020. For both levels of commitment emissions will be higher than in 2005.[19]

Nonetheless, our best estimate lies within the range of 40-48 GTon CO_2-eq indicated by a recent study by UNEP as a safe corridor towards the 2°C target. However, we prefer not to attempt to measure the gap between the level of emissions implied by the Copenhagen Accord and what would be needed to limit global warming below 2°C. Also, we do not make heroic assumptions to quantify how the Copenhagen pledges will affect global temperature in 2100. As opposed to the focus of most of the literature so far, we believe that it is impossible to make sensible predictions on future temperature by looking only at emissions in the very short-term. At the same time, the uncertainty on the long-term implications of any target on global emissions in 2020 and the very poor chances of an agreement on more ambitious emissions cuts, suggest a shift in the focus of the debate away from what should be done towards what can be done.

To this end, the Copenhagen Green Climate Fund represents a formidable tool to finance investment in the development of low carbon technologies (and their diffusion) in energy efficiency, in avoiding deforestation, in carbon capture and storage technology, etc (see also Bradford 2002, Tol and Rehdanz 2008, Tol 2010).

We estimated the potential of using different shares of the CGCF to finance abatement actions in Non-Annex I countries. The number of cheap abatement options (<30$ per Ton CO_2-eq) is large enough to reduce emissions by several GTon CO_2-eq in 2020. Although we realize the complexity of managing such widespread offsets schemes, it cannot be denied that there are low- hanging fruits to be picked, especially in the form of reduced emissions from deforestation. For example, 25% of the CGCF in 2020 will enable to scale by a factor of 15 the amount of resources invested by the Forest Carbon Partnership Facility in REDD projects.[20]

Future negotiations should devote greater attention to discussing opportunities to reduce emissions based on what has already been established in the Copenhagen Accord. Trying to renegotiate the targets and fuelling a harsh confrontation on the commitment levels of individual countries will not make the fight against global warming any easier.

[19] It is important to note that the simple fact that emissions in 2020 will not be lower than emissions in 2005 does not imply that emissions have not peaked between 2005 and 2020.

[20] The amount of funding at March 2009 was 1.7$ billions (Bosquet et al 2010).

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