

# Impact of the financial crisis on carbon economics: Version 2.1 of the global greenhouse gas abatement cost curve

*McKinsey has updated its global greenhouse gas (GHG) abatement cost curve with a new baseline that reflects a post-crisis belief about the development of the global economy and associated emissions. The overall conclusion of this update is that the crisis has had relatively little impact on the greenhouse gas abatement challenge, and that the main messages and implications from our 2009 report 'Pathways to a low-carbon economy' have not changed substantially. The global business-as-usual emission projection for 2030 has dropped by only 6 percent relative to the pre-crisis estimate. The total abatement potential remains essentially the same. Emission reductions might become cheaper in relative terms as a result of higher fossil fuel price expectations by the external agencies that we rely on for the baseline forecast.*

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## Introduction

McKinsey & Company created Version 2.0 of its global greenhouse gas abatement cost curve in 2008 – during a period of steady economic growth – and published its findings in January 2009.<sup>2</sup> Since then, the global economic environment has undergone dramatic changes, which have led many to wonder what implications this will have on tackling the climate change challenge.

To help answer this question and to provide more recent emissions and abatement data, we have updated our cost curve. We call this update Version 2.1. We have focused this update primarily on examining the macroeconomic effects on business-as-usual (BAU) emissions, and the resulting impact on emission reduction economics. We have not updated our technology projections but will do so – along with new BAU projections for forestry, agriculture, and waste – when we produce our next comprehensive update. We have performed a small number of selected model upgrades and enhancements, and determined the associated changes in abatement potential, cost, and investment requirements. Several other organizations have also recently done analyses on the impact of the economic downturn on emissions, including the International Energy Agency (IEA), the International Institute for Applied Systems Analysis (IIASA), the Organisation for Economic Co-operation and Development (OECD), and the Joint Research Centre (JRC). We will compare and relate to their findings.

In this note, the focus is on changes relative to the results of our 2009 report and we refer readers to that document for a more comprehensive study of carbon economics.

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<sup>1</sup> The authors would like to thank our colleagues Amit Bhalla, Rahul Gupta, Vasudha Gupta, and Ruchin Jain for their contributions to this research.

<sup>2</sup> Pathways to a Low-Carbon Economy: Version 2 of the Global Greenhouse Gas Abatement Cost Curve, January 2009 ([www.mckinsey.com/globalGHGcostcurve](http://www.mckinsey.com/globalGHGcostcurve)).

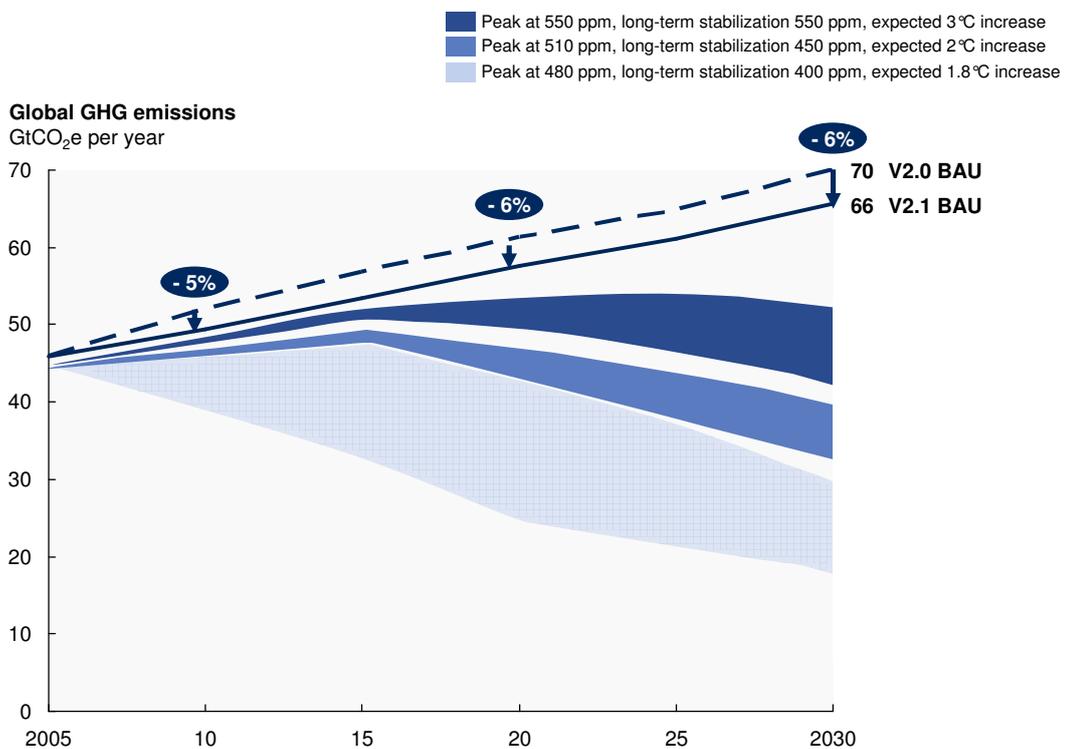
**Current emission baseline forecasts are approximately 6 percent lower than they were two years ago**

As in our previous abatement studies, in this update we rely primarily on well-known and accepted external macroeconomic and BAU emissions projections. We use the IEA’s World Energy Outlook 2009 (WEO 2009) as the main reference. In a few instances, we have complemented external data selectively with McKinsey analysis.

Based on these updated inputs, projections of global 2020 and 2030 BAU emissions have fallen by around 6 percent compared with the assessment two years ago (Exhibit 1). In 2020, there is a reduction of 3.6 gigatonnes of carbon dioxide equivalent (GtCO<sub>2</sub>e) in BAU emissions due to changes in economic forecasts (from 61.2 GtCO<sub>2</sub>e to 57.6 GtCO<sub>2</sub>e). In 2030, BAU emissions drop by 4.3 GtCO<sub>2</sub>e from 69.9 GtCO<sub>2</sub>e to 65.6 GtCO<sub>2</sub>e. This decrease is equivalent to more than the 2030 BAU emissions of Africa and would contribute to reaching absolute climate stabilization targets. However, the fact remains that the difference between BAU emissions and stabilization pathways is of the same order of magnitude as two years ago. The size of the emission reduction challenge remains more or less the same.

Three factors explain why recent economic developments have only produced this 6 percent drop in BAU emissions compared with projections two years ago: (1) the long time horizon under examination (relative to a business cycle); (2) the economic resilience of some large developing countries responsible for a large share of future emissions; and, (3) the fact that activities in agriculture, forestry, and waste generation correlate more with growth in population rather than GDP. Studies by the institutions mentioned above broadly concur with our finding that the global economic downturn will only have a modest impact on long-term emissions.

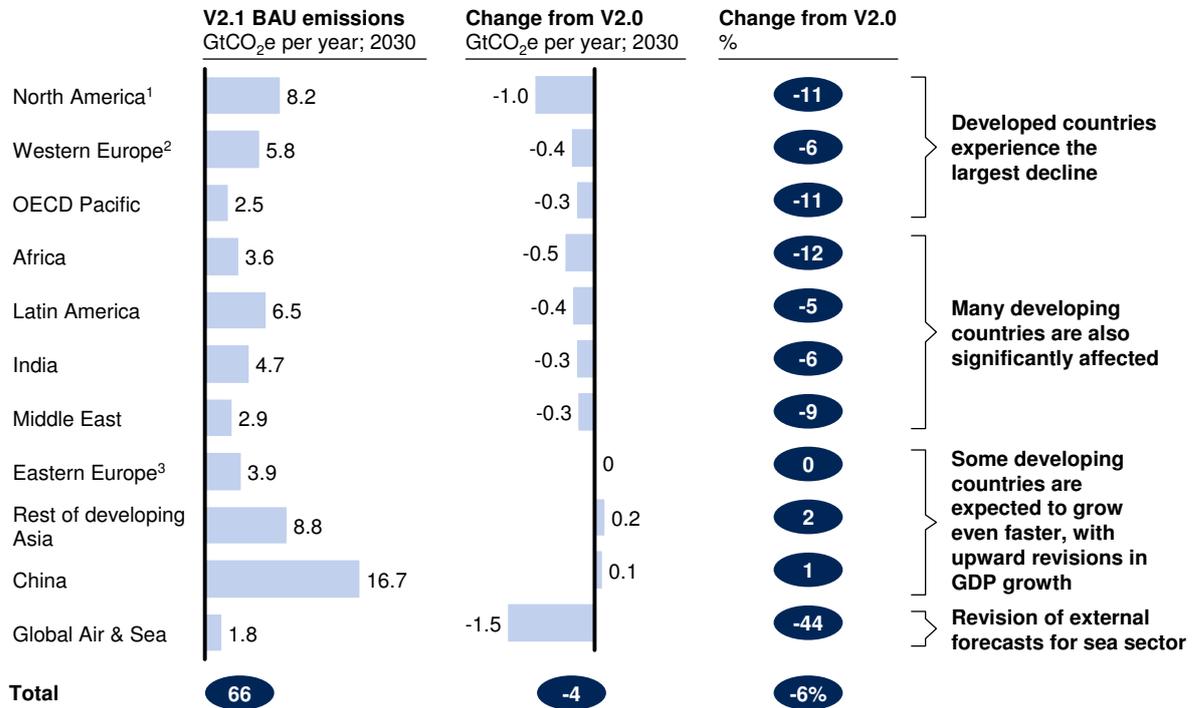
**Exhibit 1**  
**Business-as-usual (BAU) comparisons between V2.0 and V2.1**



Note: As a reference, 1990 total emissions were 36 GtCO<sub>2</sub>e.  
Source: Global GHG Abatement Cost Curve v2.0, v2.1; IEA; US EPA; Houghton; IPCC; OECD; den Elzen; Meinshausen; van Vuuren

## Exhibit 2

## Change in BAU emissions by region



1 United States and Canada.

2 Includes EU27, Andorra, Iceland, Lichtenstein, Monaco, Norway, San Marino, and Switzerland.

3 Russia and non-OECD Eastern Europe.

Source: Global GHG Abatement Cost Curve v2.1, v2.0, IEA WEO'09, IEA transport report 2009, JFK 2009, EIA 09, IMO

Examining the drop in BAU emissions in 2030 by region reveals that the emissions forecasts for developed countries have fallen by between 6 to 11 percent compared to the projections two years ago (Exhibit 2). Projections for the emissions of developing countries are more varied. In some regions and countries, including Africa, Latin America, India, and the Middle East, BAU emissions projections have declined by between 5 and 12 percent. In contrast, China, parts of developing Asia, and Eastern Europe now have higher BAU emissions projections due to these economies' relative resilience in the face of the global downturn and upward revisions in their expected GDP growth. Reduced BAU emissions will help countries achieve their reduction targets; on the other hand, the credit-constrained economic environment will likely make the financing of abatement measures more challenging.

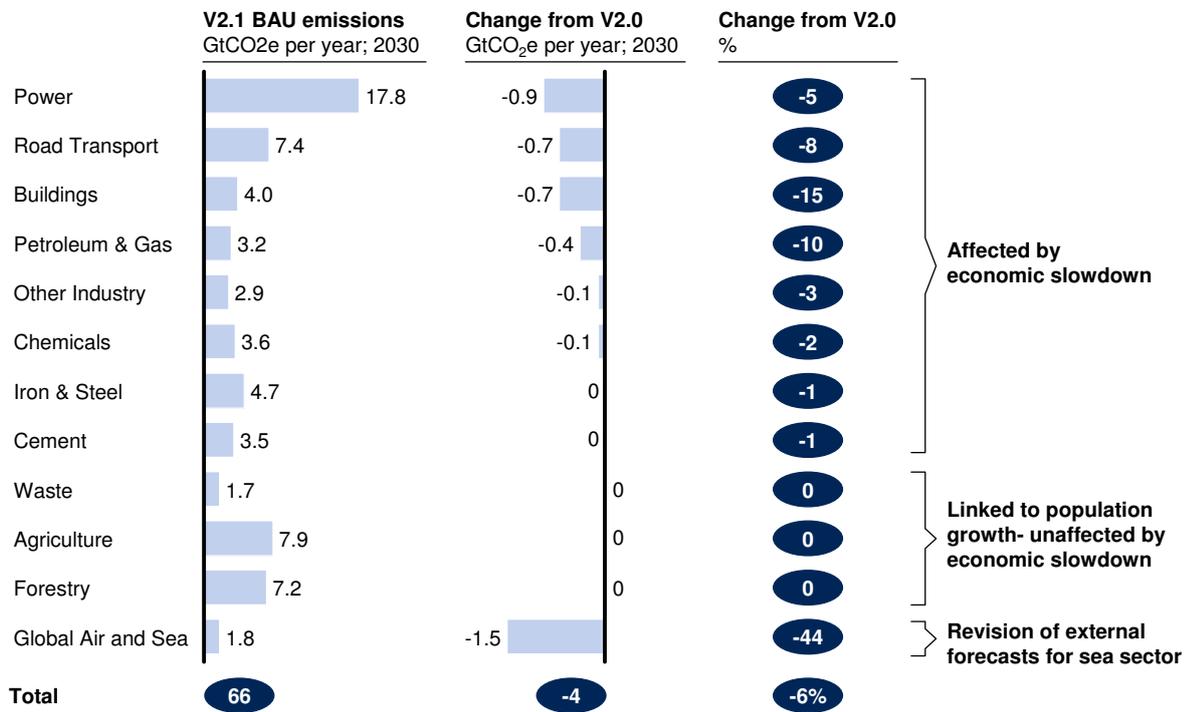
Turning to a sector-by-sector view, we find that the impact of the economic slowdown has varied according to the sectors (Exhibit 3). In the power, industry, and consumer sectors, BAU emission projections have dropped, as emissions are largely linked to GDP. But in the agriculture, waste, and forestry sectors, there has been no change in BAU projections, since emissions are primarily linked to population – and population projections have changed very little since our 2009 report. A specifically high drop is in sea transport, as new research from IEA and the International Maritime Organization (IMO) about this relatively uncertain sector has substantially revised emissions estimates downwards.

Going into more detail, new assumptions made by the IEA for two main macroeconomic drivers – GDP growth and energy prices – explain the majority of the change in BAU emissions between Version 2.0 of the cost curve and the assessment in this note (Exhibit 4).

- **GDP growth.** The financial crisis is expected to have a larger impact in developed countries than in the developing countries. In developed countries growth rates fall from 2.1 to 1.8 percent annually in the period from 2005 to 2030. In developing countries, the GDP effect is very small (from a

**Exhibit 3**

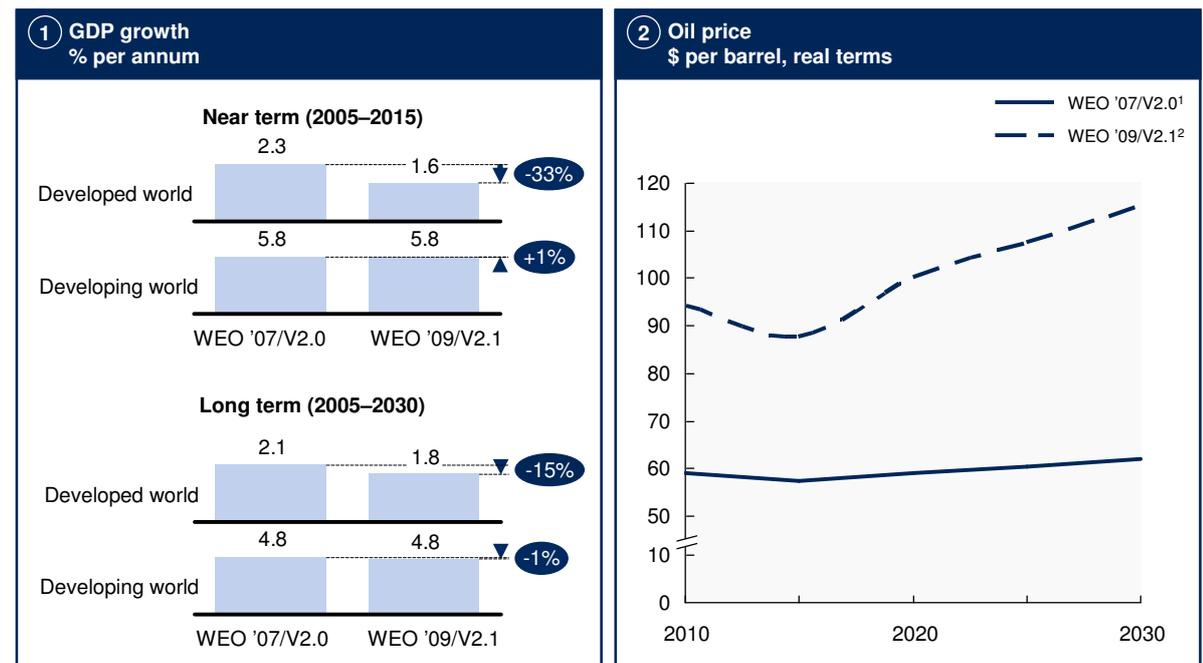
**Change in BAU direct emissions by sector**



Note: To obtain the total BAU emissions, only direct emissions are included.  
 Source: Global GHG Abatement Cost Curve v2.1, v2.0, IEA WEO'09, IEA transport report 2009, JFK 2009, EIA 09, IMO

**Exhibit 4**

**Drivers of change from V2.0 to V2.1**



1 In 2006 real prices.  
 2 In 2008 real prices (if adjusted to 2006 real prices, 2030 would be 109 \$ per barrel).  
 Source: IEA World Energy Outlook 2007 and 2009

4.8 to 4.7 percent compound annual growth rate in the period from 2005 to 2030) as developing countries seem to have been less affected by the recent slowdown. In absolute terms, GDP estimates for developing countries fall by only about 1 percent in 2030 from the forecast two years ago. In the case of developed countries, the forecast drop is about 8 percent.

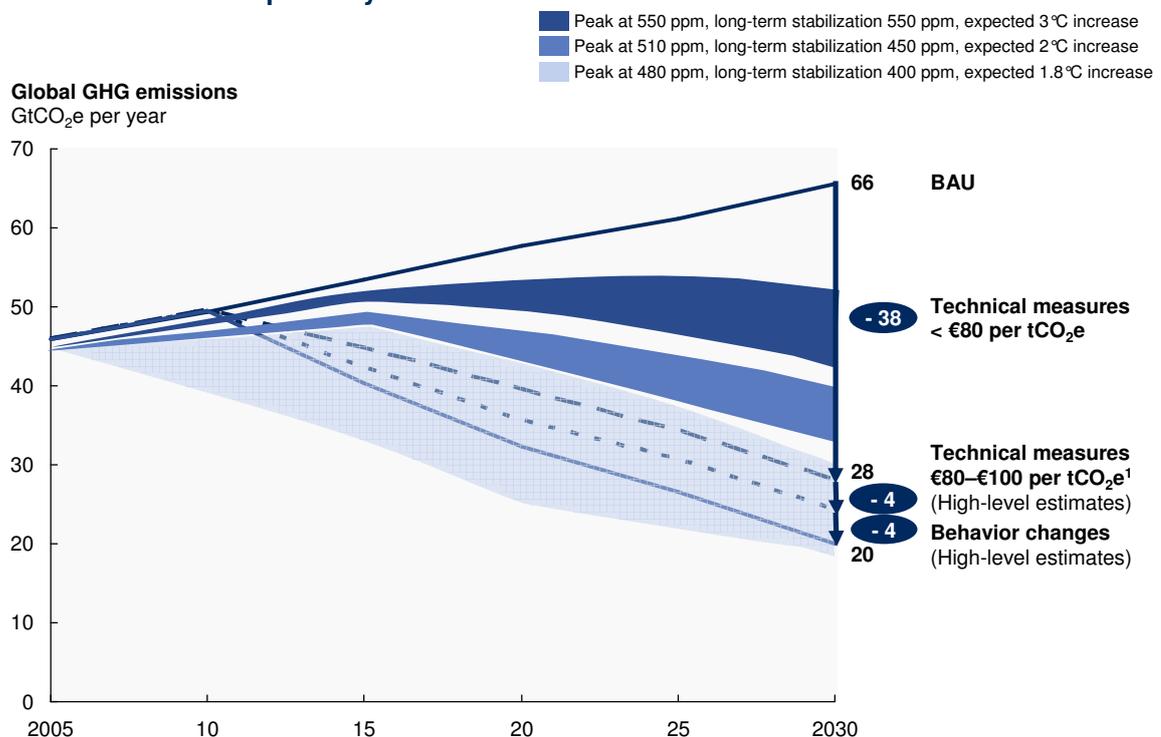
- **Energy prices.** The assumed trajectories of energy prices have risen significantly. The IEA's WEO 2007, which was the basis of Version 2.0 of the cost curve, assumed real oil prices in 2030 to be \$62 a barrel in 2006 prices. In its 2009 WEO, the IEA raised its assumption to \$115 a barrel in 2008 prices.<sup>3</sup> The IEA has also raised its assumptions about natural gas and coal prices considerably. Although the financial crisis has caused energy prices to fall since their 2007 spike, the IEA's WEO 2009 anticipates tighter energy markets coming up than it did in the 2007 edition.

### Despite a drop in BAU emissions, abatement potential remains stable at 38 GtCO<sub>2</sub>e in 2030, and comes at a lower incremental cost

Relative to BAU emissions of 66 GtCO<sub>2</sub>e in 2030, we have identified an abatement potential of 38 GtCO<sub>2</sub>e (58 percent) through technical measures costing below €80 per tonne of carbon dioxide equivalent (tCO<sub>2</sub>e) (Exhibit 5).<sup>4</sup> We estimate that an additional 8 GtCO<sub>2</sub>e of abatement potential exists (similar to Version 2.0 of the cost curve) if more expensive technical measures as well as changes in behavior are included. Taking this additional abatement into account would result in a total reduction

Exhibit 5

#### Emissions abatement pathway



Note: As a reference, 1990 total emissions were 36 GtCO<sub>2</sub>e.

<sup>1</sup> Upper cost threshold kept constant at 100 EUR/tCO<sub>2</sub>e, thus additional potential lower given increase of cost curve threshold to 80 EUR/tCO<sub>2</sub>e  
Source: Global GHG Abatement Cost Curve v2.0, v2.1; IEA; US EPA; Houghton; IPCC; OECD; den Elzen; Meinshausen; van Vuuren

<sup>3</sup> In real 2006 prices, the price is \$109 per barrel.

<sup>4</sup> We raised the global threshold cost to €80 per tCO<sub>2</sub>e from €60 per tCO<sub>2</sub>e in order to include known carbon capture and storage (CCS) levers. Their abatement cost increases due to the energy consumption necessary to run CCS. At a threshold cost of €60 per tCO<sub>2</sub>e, the abatement potential is about 36.5 GtCO<sub>2</sub>e.

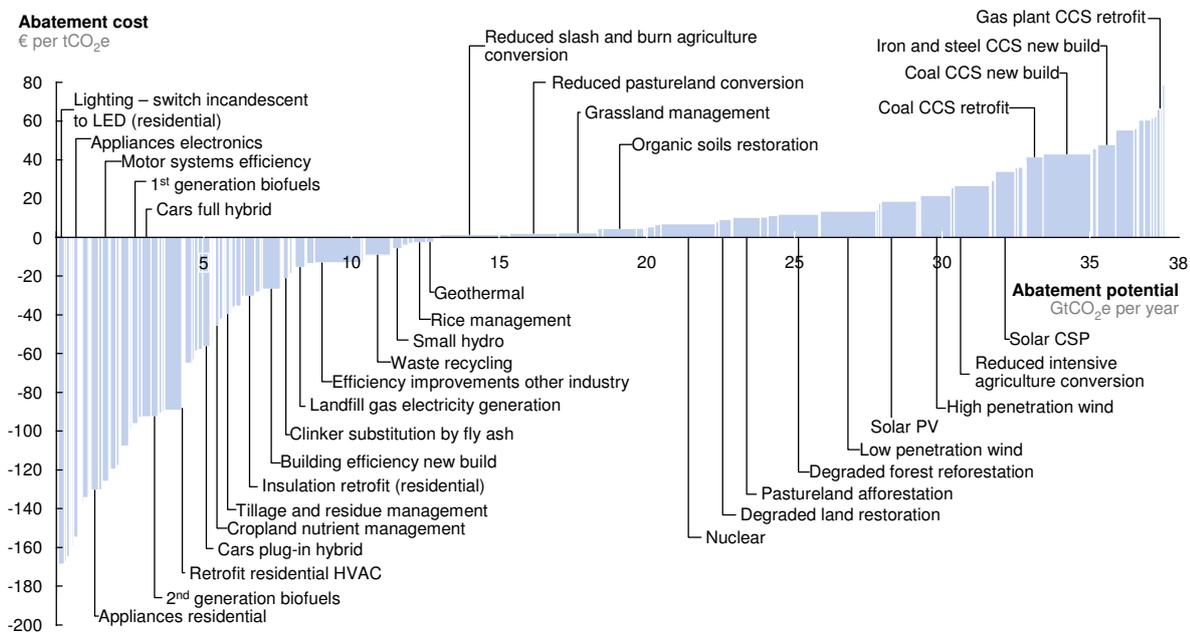
potential of more than 70 percent from BAU emissions. In 2020, technical measures costing below €80 per tCO<sub>2</sub>e provide an abatement potential of 19 GtCO<sub>2</sub>e. It should be noted that these values represent economic abatement potential if the measures are implemented aggressively, and not a forecast of how abatement will develop.

If all the abatement potential was fully captured across regions and sectors, the resulting emissions development would be broadly consistent with an emissions pathway put forward by Intergovernmental Panel on Climate Change (IPCC) authors that would see the atmospheric concentration of GHGs peak at 480 ppm and then start decreasing to stabilization levels of 400 ppm of CO<sub>2</sub>e. According to the IPCC authors' analysis, such a pathway would result with high likelihood in an increase of the global mean temperature of just below 2 degrees Celsius above preindustrial levels.<sup>5</sup> Abatement studies by the other institutions mentioned have also concluded that there is sufficient potential to contain global warming using technical measures.

Increasing energy price expectations lead to more abatement technologies being net profit positive – in the “compared to BAU” cost perspective that the cost curve takes. The average abatement cost across all levers has fallen from plus €4 per tCO<sub>2</sub>e to minus €6 per tCO<sub>2</sub>e between Version 2.0 and Version 2.1. The share of net profit positive measures (excluding transaction costs) has increased from 29 to 35 percent in our new assessment, reducing the cost challenge to some extent. Another 40 percent of abatement measures costs between zero and €20 per tCO<sub>2</sub>e and the next 10 percent costs between €20 and €40 per tCO<sub>2</sub>e. Only 15 percent of the abatement potential comes at a cost of between cost between €40 and €80 per tCO<sub>2</sub> (Exhibit 6).

**Exhibit 6**

**V2.1 Global GHG abatement cost curve beyond BAU – 2030**



Note: The curve presents an estimate of the maximum potential of all technical GHG abatement measures below €80 per tCO<sub>2</sub>e if each lever was pursued aggressively. It is not a forecast of what role different abatement measures and technologies will play.

Source: Global GHG Abatement Cost Curve v2.1

5 Den Elzen, Meinshausen, van Vuuren

In interpreting these numbers, readers should remember that they exclude three factors that might be important, depending on how abatement measures are implemented. First, we use a societal interest rate, similar to a long-term bond rate, of 4 percent, rather than the cost of capital to a private investor. Second, the cost excludes transaction and program costs to implement at a large scale, as these are highly dependent on policy choices for implementation. Third, the analysis does not include dynamic effects such as changes in energy prices due to the implementation of abatement measures (these dynamic effects could both increase and decrease cost).

Higher energy prices have a particularly large effect in the transport sector through higher savings on fuel costs, and in the buildings and industrial sectors through increased savings from energy efficiency measures. In the power sector, fossil-fuel-based generation technologies become more expensive and low-carbon alternatives such as renewables or nuclear become relatively cheaper.

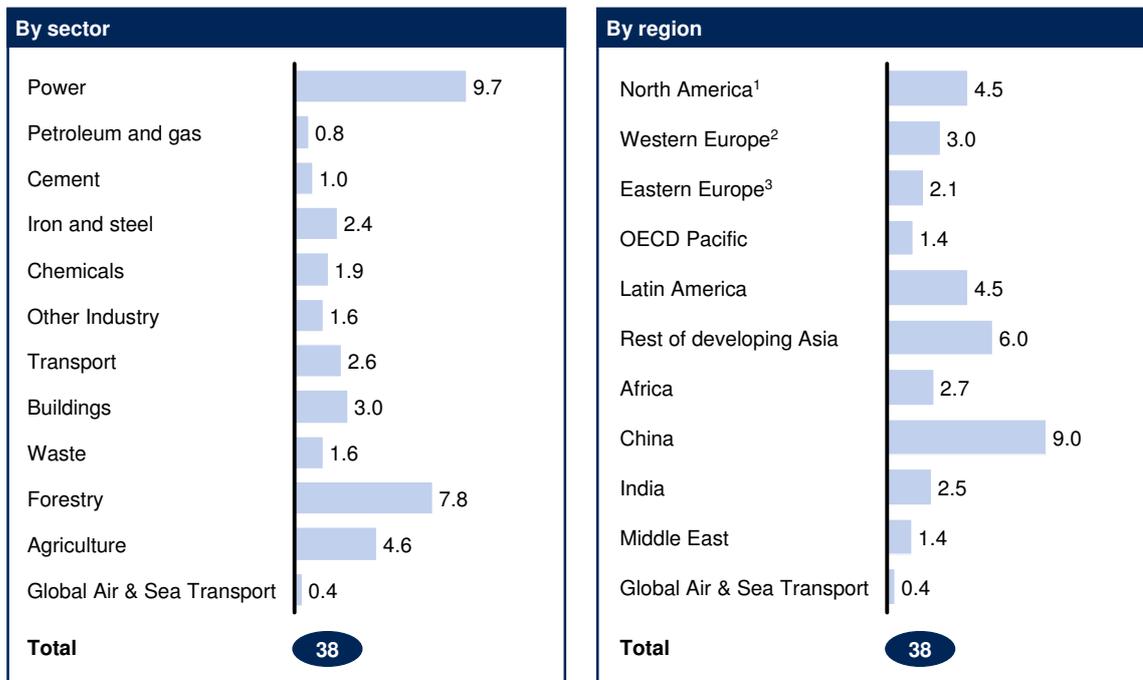
IPCC cost estimates for adaptation to climate change under a BAU scenario lie in the range of 1 to 5 percent of GDP on average across the globe.<sup>6</sup> Since our average abatement cost estimate across all levers has fallen to minus €6 per tCO<sub>2</sub>e (excluding transaction cost), mitigation would come a net profit to society (mainly due to the increased energy price expectations) and would represent a lower societal cost than that estimated for adaptation.

Looking at the distribution of abatement opportunities, there has not been much change between Version 2.0 and Version 2.1. The two largest sectors in terms of abatement potential remain power (26 percent of potential) and forestry (21 percent). The split of opportunities has shifted slightly more toward the developing world from 70 percent in Version 2.0 to 72 percent in this update. This is due to the fact that BAU emissions, and therefore abatement opportunities, have dropped more in the developed world than in the developing world between these two assessments (Exhibit 7). We note that the regional distribution of abatement potential does not hold any implications as to who would finance emissions reductions.

**Exhibit 7**

**Abatement potential by sector and region – V2.1**

GtCO<sub>2</sub>e per year; 2030



1 United States and Canada.

2 Includes EU27, Andorra, Iceland, Lichtenstein, Monaco, Norway, San Marino, and Switzerland.

3 Russia and non-OECD Eastern Europe.

Source: Global GHG Abatement Cost Curve v2.1

6 IPCC AR4, 2007.

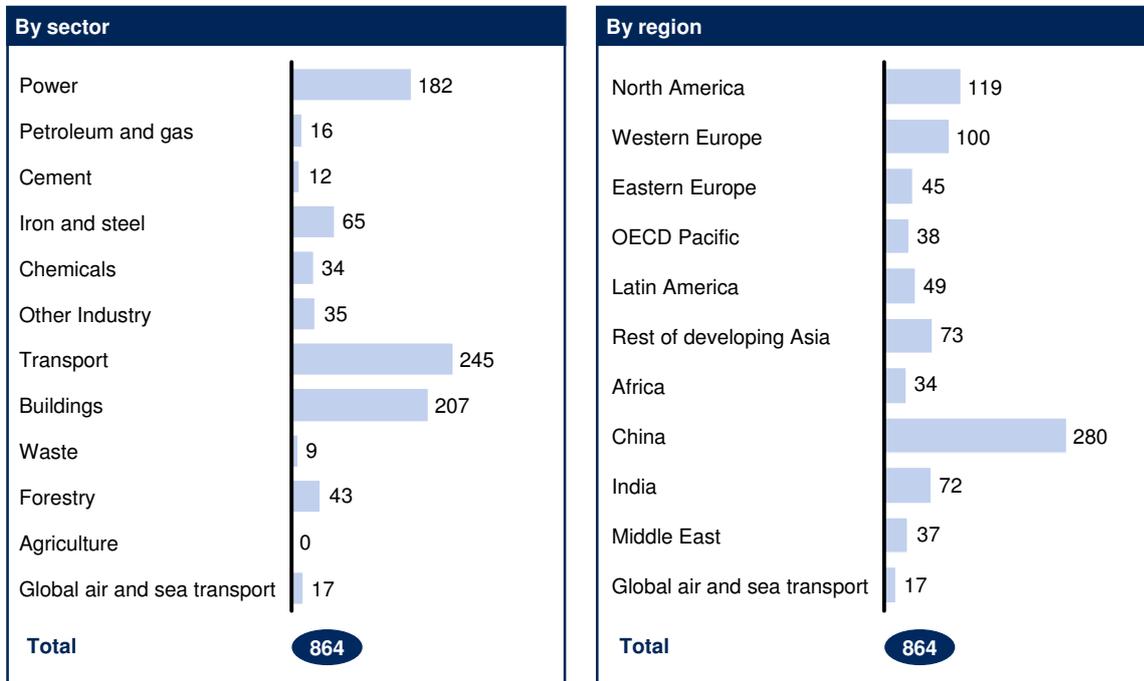
**Although the average abatement cost has fallen, capturing the full abatement potential identified will still require upfront investments of as much as €860 billion annually on top of BAU investments by 2030**

While higher fossil fuel prices help to reduce abatement costs, they do not change the capital expenditure necessary to finance abatement. To capture the full abatement potential in 2030, about €860 billion per year of capital expenditure (on top of BAU) will be required globally in 2030, and some €490 billion per year in 2020 (Exhibit 8). This represents an incremental 5 to 6 percent on top of BAU investments into fixed assets.

**Exhibit 8**

**Investment requirements to achieve abatement potential – V2.1**

€ billion per year; 2030; in addition to current projected BAU investments



Source: Global GHG Abatement Cost Curve v2.1

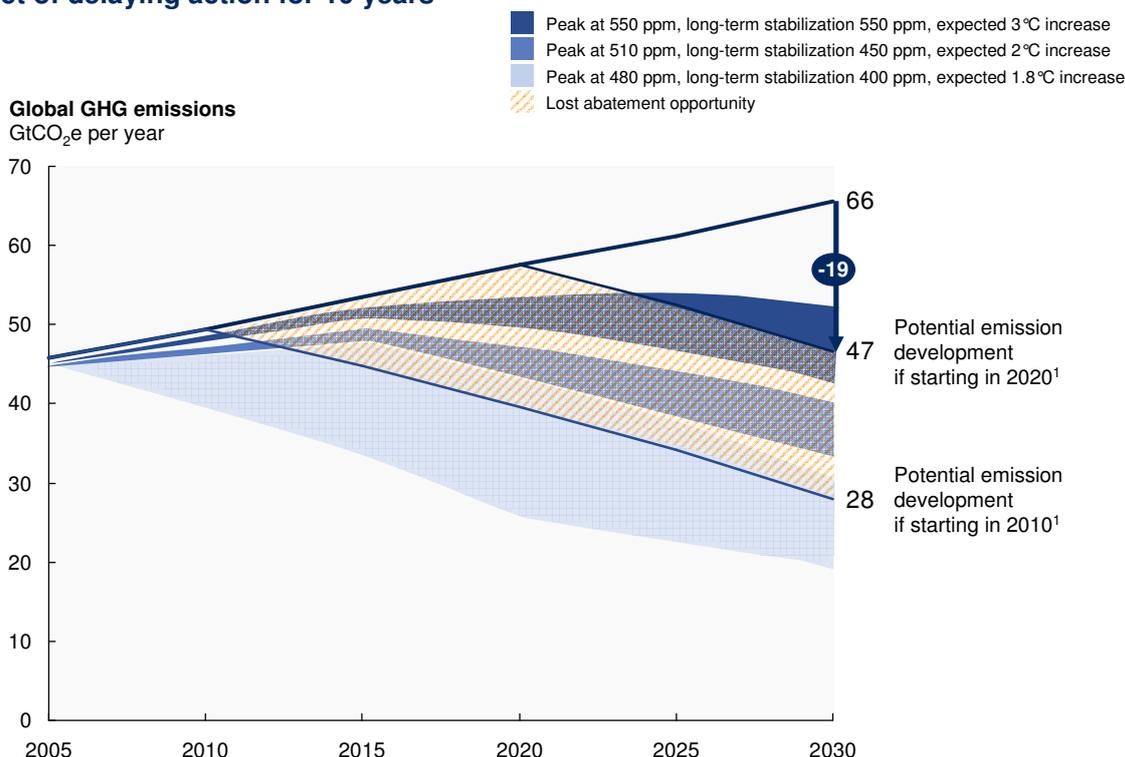
The change in investment requirements from Version 2.0 of the cost curve to this update is small. Taking a regional view, we see that China alone accounts for 32 percent of the required capital expenditure with North America and Western Europe together making up 25 percent of the total. If we then look at the capital expenditure by sector, we see that just three sectors (power, transport, and buildings) account for nearly three quarters of the investment required.

### Delaying action for ten years would reduce the technical abatement potential in 2030 by half

Timing remains of the essence. Policy makers need to act now if they want to reduce emissions to the levels that the climate scientists believe are necessary to stabilize global warming below 2 degrees Celsius. Our model shows that a delay of 10 years, with action on abatement starting in 2020 instead of 2010, would cut the abatement potential by half from 38 GtCO<sub>2</sub>e to 19 GtCO<sub>2</sub>e. Under such a “delayed” abatement path, the emissions trajectory would exceed a 550 ppm stabilization path – as laid out by IPCC authors – in some years. This would make it challenging to limit global warming to the 3 degree Celsius threshold associated with a 550 ppm stabilization (Exhibit 9).

**Exhibit 9**

#### Effect of delaying action for 10 years



<sup>1</sup> Technical levers < € 80/tCO<sub>2</sub>e.

Source: Global GHG Abatement Cost Curve v2.0, v2.1; IEA; US EPA; Houghton; IPCC; OECD; den Elzen; Meinshausen; van Vuuren

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We hope that this analysis will serve as a useful starting point for discussions on how best to manage the transition to a low-carbon economy. In 2011, we aim to release Version 3.0 of the global GHG abatement cost curve in which we will undertake a new and more comprehensive review of greenhouse gas abatement economics.

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