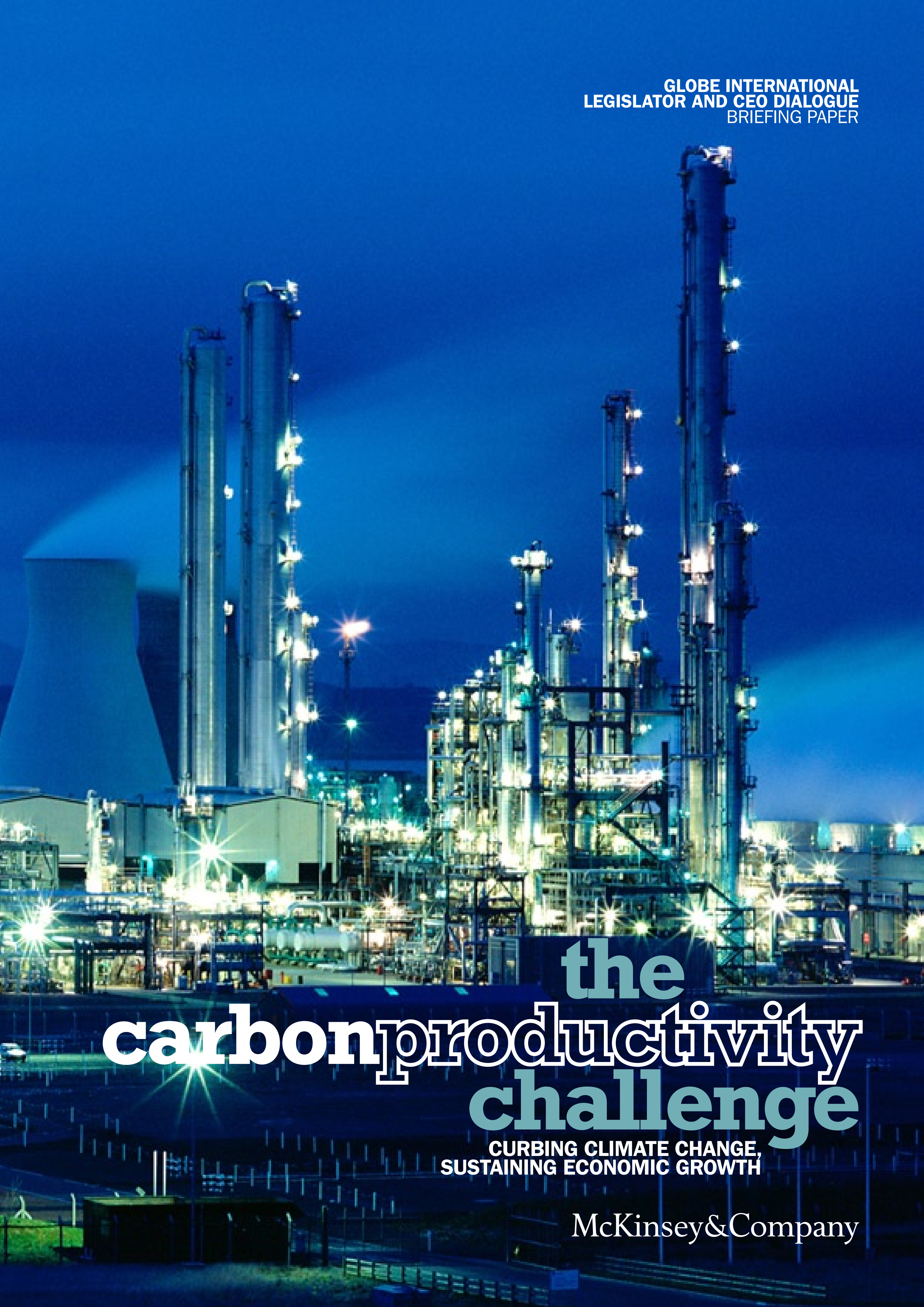

GLOBE INTERNATIONAL
LEGISLATOR AND CEO DIALOGUE
BRIEFING PAPER

the carbon productivity challenge

CURBING CLIMATE CHANGE, SUSTAINING ECONOMIC GROWTH

McKinsey&Company

preface

This paper was prepared by McKinsey & Company to support the GLOBE International Legislator-CEO Dialogue. The work draws on research from McKinsey's Climate Change Initiative, the McKinsey Global Institute, McKinsey's work with Vattenfall on the global carbon cost curve, and research by various outside experts. McKinsey takes sole responsibility for the paper's content unless otherwise cited, and its contents do not necessarily reflect the views of either GLOBE International or BP. The discussion of the cost curve results represents McKinsey's interpretation and does not necessarily reflect the views of Vattenfall.

The authors would like to thank Chris Mottershead of BP for his support and input, and Ben Irons and Makreeta Lahti for their efforts, as well as Matt Rogers, Scott Nyquist, Per-Anders Enquist, and the members of McKinsey's Climate Change Initiative.

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introduction and executive summary

The purpose of this paper is to help frame the discussion for the GLOBE International Legislator and CEO Dialogue, offer some common language for the participants, and provide a background fact-base. The paper does not attempt to propose specific answers to the problems raised by climate change, but rather suggests a way to think about the issues, and raises a series of questions that we hope will be helpful to the participants in the discussion

The complexity of the climate issue means that the paper inevitably does not discuss all issues—for example we do not discuss adaptation. Rather our approach was to use the interview process to guide us and we focused on issues that were a.) of most concern to the participants, and b.) most relevant to their positions as political and business leaders.

The key messages of the paper are as follows:

- Any successful program of action on climate change must support two objectives—stabilizing atmospheric greenhouse gases and maintaining economic growth;
- Reconciling these two objectives means that "carbon productivity", the amount of GDP produced per unit of carbon equivalents ("CO2e") emitted, must increase dramatically
  - In order to meet commonly discussed abatement paths, we estimate that carbon productivity must increase from approximately $1,130 GDP per ton of CO2e today to $17,100 GDP per ton of CO2e by 2050—a 15-fold increase
  - This is comparable in magnitude to the labor productivity increases of the Industrial Revolution
  - While the magnitude of economic change implied is similar to the Industrial Revolution, the "carbon revolution" must be achieved in one third of the time;
- The macroeconomic costs of this "carbon revolution" are likely to be manageable, on the order of 0.6-1.4 percent of GDP by 2030
  - Many of the costs could potentially be financed by borrowing, limiting the impact on near-term GDP growth
  - The real challenges lie in the broad array of microeconomic changes that must be driven across the global economy;
- The "global carbon cost curve" developed jointly by McKinsey and Vattenfall, shows the microeconomic changes that must be made to meet abatement targets while minimizing costs
  - The cost curve identifies 27 gigatons per annum of potential CO2e abatement (consistent with a stabilization target of 450-500 ppm) which can be achieved by 2030 for under €40 per ton using technologies that are either available or visible today
  - It also shows that 7 gigatons, or approximately a quarter of the potential has positive economic returns due to energy efficiency and other savings;

- Analysis of the cost curve identifies five areas of focus for driving microeconomic changes:

  1. **Capturing the energy efficiency opportunity**—Energy efficiency opportunities across the residential, commercial, transport, industrial, and energy sectors have the potential to cut end-use energy demand by over 20 percent, yielding $900 billion in annual energy savings by 2020 which in turn would generate an average investment return of 17 percent and yield approximately 4.7 gigatons of abatement

  2. **De-carbonizing energy sources**—To meet abatement targets both the power and oil and gas sectors will undergo significant restructuring

     - The power sector will need to abate 6 gigatons of CO2e by 2030, significantly changing its energy source mix with wide variations by country; under all scenarios carbon capture and storage (CSS) will need to play a major role with open questions on the future of nuclear and bets on emerging renewable technologies

     - Oil and gas abatement savings will come largely from demand reduction through fuel efficient vehicles and increasing use of alternative fuels with potential to reduce crude oil demand by 29 percent versus today's level or about half of business as usual forecasts

  2. **Accelerating the development and deployment of new low-carbon technologies**—It is estimated that global investments in new technology research will need to multiply 4 times versus the business as usual path and reach $80 billion per year by 2050; technology transfer to developing countries is a clear priority but lessons from experience with technology transfer in the context of economic development suggest this will be difficult without addressing broader development issues

  4. **Changing the attitudes and behavior of managers and consumers**—Carbon productivity will be driven not just by investments in low emission capital stock and technologies, but by billions of daily decisions by managers and consumers; many of these will be subject to influence by a carbon price, but many will not and will require substantial efforts at public education and changing social norms; successful anti-smoking and recycling campaigns give evidence this is possible

  5. **Preserving and expanding the world's carbon sinks**—Forestation and avoided de-forestation together offers the single largest abatement levers at 25 percent of the global total under €40 per ton; if this opportunity is not captured the marginal cost of carbon would potentially increase 50 percent to €60 per ton; there are multiple challenges in creating incentives for forest preservation and expansion and addressing economic displacement issues;

- Driving the required microeconomic changes for improved carbon productivity will demand new policies, regulatory frameworks, and institutions that address four issues:
    1. **Creating market-based incentives**—There is a growing consensus that a carbon price is fundamental to driving increased carbon productivity and significant political momentum behind various cap-and-trade initiatives, but critical questions remain as to the degree such systems will be global versus regional or national, what they will cover, and the timing of implementation
    2. **Addressing market failures**—A significant portion of low and negative cost abatement potential will be resistant to price signals due to market failures; addressing these failures will require a broad array of actions including efficiency standards and new forms of financing at national, regional, sectoral, and global levels
    3. **Resolving allocation and fairness issues**—The microeconomic changes described will create massive shifts in economic rents across company, industry, and national boundaries (again on par with the Industrial Revolution, but faster); some will need to be addressed for ethical and economic reasons, but many will need to be addressed for political reasons to avoid powerful stakeholders with vested interests from blocking required changes
    4. **Accelerating progress**—There are critical timing issues that need to be resolved, in particular the "window of opportunity" presented by the rapid infrastructure build-out underway in developing countries, particularly China and India; likewise there may be a mismatch between the pace of CCS development and the timing needed for deployment; active and urgent intervention will be required to address these timing issues;
- Meeting the twin objectives of carbon abatement and growth over the next five decades is possible, but there are no silver bullets; rather it will require a broad and rapid microeconomic re-structuring of the global economy that will only be possible with innovative approaches to policies, regulations, and institutions at the national, regional, sectoral and global level, and a historically unprecedented level of international collaboration between government and business.

TWO IMPERATIVES: DRIVING CARBON STABILIZATION AND MAINTAINING ECONOMIC GROWTH

The debate on climate change has shifted dramatically over the past five years. The debate about whether a response is needed has now largely been settled by the strong evidence presented by the scientific community through the IPCC process. There is also growing consensus on what the broad outlines of the response should be – a path of emissions cuts that stabilizes atmospheric carbon and other GHG concentrations in a way that minimizes the risks of damage from climate change. We are now entering what will be the most challenging phase of the debate—answering the specific questions of how to achieve this end.

The starting point for any successful program of action that answers the how question is that it must meet two conditions:

First, it must be effective in stabilizing the levels of carbon dioxide and other greenhouse gases (together "CO2e")[1] in the atmosphere at a level and within a timeframe that minimizes likely temperature rises and thus the negative consequences of climate change to some acceptable level. Defining this acceptable level is still the subject of debate, but the European Union has committed to a target of a mean temperature increase of 2 degrees Celsius above pre-industrial levels, and the G8 in Heiligendamm in 2007 targeted a 50 percent reduction in global emissions by 2050. These targets are consistent with IPCC emissions scenarios of stabilizing CO2e concentrations at 445-535 parts per million (ppm) and cutting annual emissions by 30 to 85 percent versus year 2000 emissions by 2050.[2] In order to be conservative and assess the upper end of potential costs, we have have taken a point estimate from the higher end of this range. For the analysis that follows, we assume reductions of 75 percent versus 2000 levels, meaning an emissions target of 10Gt per year by 2050. The 10Gt target implies a reduction in annual global emissions versus "business as usual" of 88 percent by 2050 and is consistent with stabilization at approximately 450-500 ppm **(Exhibit 1)**.

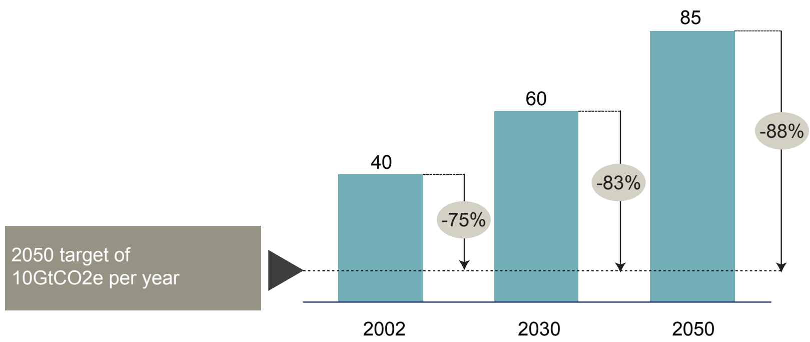
[1] CO2e is "carbon dioxide equivalent," a standardized measure of greenhouse gases that accounts for the differing warming potentials of other greenhouse gases such as methane. Emissions are measured in metric tons of CO2e per year, i.e. millions of tons (megatons) or billions of tons (gigatons).

[2] IPCC Working Group III, 4th Assessment Report, "Summary for Policymakers," 30 April-4 May 2007.

Exhibit 1

Science suggests we need to reduce emissions by 88% by 2050 to stabilize the climate

Global "business as usual" GHG emissions, $GtCO_2e$



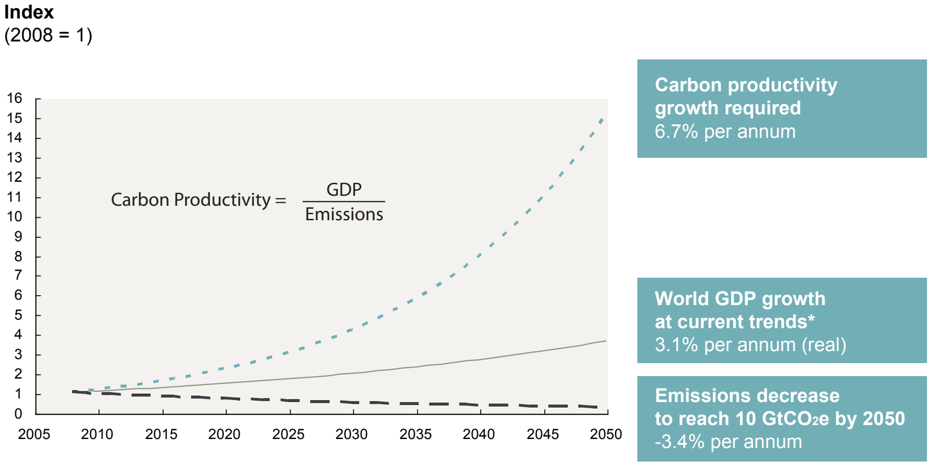
Source: IPCC Working Group III, 4th Assessment Report, "Summary for Policymakers,"; McKinsey analysis

Second, any solution must recognize that the world has both a right to and a need for continued economic growth. Over the two centuries since the Industrial Revolution began, economic growth has enabled approximately a third of the world's population, largely concentrated in Europe and North America, to escape from a life of hunger, hardship, and disease. Over the past two decades, another third of the world's population, mostly in Asia, has begun this journey too. It is hoped that over the coming decades, the final third will make their escape. The need for economic growth is both a moral imperative and deeply ingrained in the human spirit—in both the developed and developing worlds.

If we accept these two imperatives— carbon stabilization and continued economic growth—we have only one choice. We must dramatically increase the level of "carbon productivity" in the economy. By carbon productivity we mean the level of GDP output per unit of CO2e emitted. One can think of carbon productivity in the same way one thinks about labor productivity (GDP output per hour worked) or capital productivity (GDP output per unit of capital). The current level of global carbon productivity is approximately $1,130 per ton of CO2e. In order to meet the twin goals of growth continuing at its current trajectory of 3.1 percent per annum and reducing emissions to 10Gt/year, carbon productivity must increase in real terms by four times to $4,700 per ton of CO2e by 2030 and by 15 times to $17,100 per ton of CO2e by 2050 **(Exhibit 2)**.

Exhibit 2

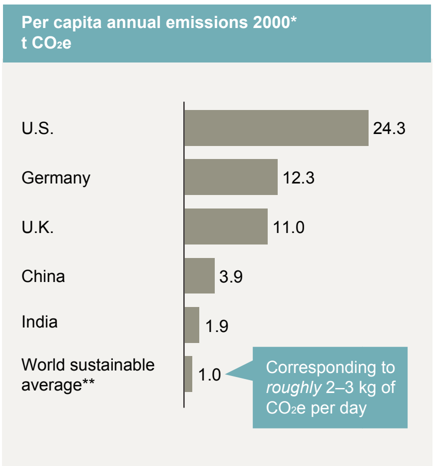
Reducing emissions and maintaining growth implies carbon productivity must increase by more than 15 times



** Global Insight GDP forecast to 2037, extrapolated to 2050*
Source: McKinsey analysis

Exhibit 3

If we had to live at 10 gigatons CO_2e per year today there is not much we could "afford"



"Emission budget" for a day (alternatives)	
Travel	10–20 km car ride
Stay home	5-10 hours air conditioning
Shop	1 new t-shirt (3 kg of CO_2, so don't drive to the shop)
Eat	1 meal a day (3kg CO_2): 300 g meat, 200 g fries, tap water

* *Emissions from land-use change not included*
** *Based on 10Gt/year sustainable emissions and future population of 10 billion people*
Source: *McKinsey analysis*

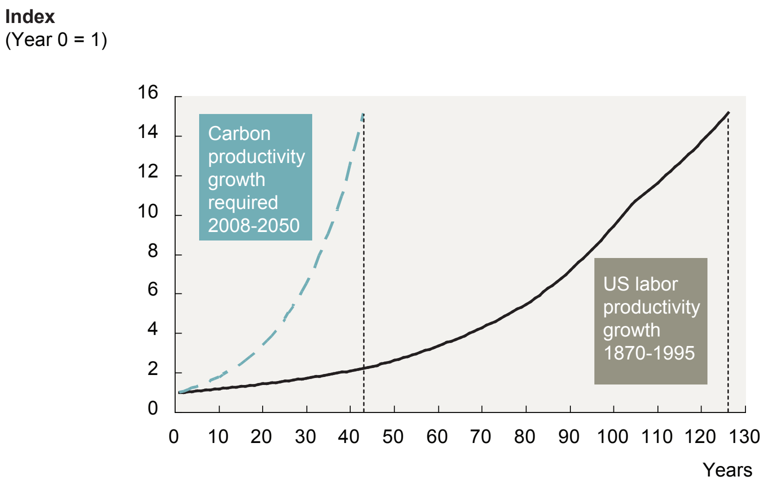
If we do not reach such a level of carbon productivity, the consequences will be stark. Meeting the 10Gt per year target implies a per person carbon budget of 2-3 kg of CO2e per day. If one had to live on such a carbon budget with today's low levels of carbon productivity, one would be forced to choose between a 10 to 20 km car ride, a few hours of air conditioning, buying one new t-shirt (without driving to the shop), or eating one meal **(Exhibit 3)**. Without a major boost in carbon productivity, stabilizing greenhouse gas emissions would require a major drop in lifestyle for developed countries and the loss of hope for economic growth for developing nations.

Achieving a 15-fold increase in carbon productivity will require radical changes in the world economy. But it is a level of change the world has seen before. During the Industrial Revolution, the U.S. achieved an increase in labor productivity of 15 times between 1870 and 1995.[3] The key difference is the time frame. This 15-fold increase was achieved in 125 years versus the 42 years required for carbon (Exhibit 4). In short, we need a carbon revolution of equivalent magnitude to the Industrial Revolution, but in one third of the time.

Economists know quite a bit about what drives increases in productivity. Inevitably such increases are the result of widespread microeconomic changes in the economy. New technologies are developed and deployed, new investments made, and changes occur in the decisions, practices, and behaviors of millions of business managers, workers, and consumers. Key to driving those micro level changes are political, institutional, and cultural changes in the wider macro-environment.

Exhibit 3

A "carbon revolution" is needed 3 times faster than the Industrial Revolution



Source: "Contours of the World Economy 1 – 2030 A.D.", Maddison (2007); McKinsey analysis

[3] Angus Maddison, *Contours of the World Economy 1-2030 AD, Oxford University Press, 2007.*

For example, the productivity increases of the Industrial Revolution were partly the result of technological innovations such as the spinning jenny and the steam engine. But just as important were innovations in the way people organized and managed their businesses, such as Richard Arkwright's creation of the first large-scale factories, Henry Ford's invention of the production line, or Alfred Sloan's development of the divisionalized corporation. These technological and organizational innovations were in turn encouraged and enabled by a series of changes in government policy, institutional structures, and the regulatory environment. For example, governments created a legal framework for public companies, enabling large amounts of capital to be pooled for the first time. They also strengthened property rights enabling businesses to make long-term investments. And they passed consumer protection laws enabling customers to trust the products and services they were buying, thus spurring demand.

Achieving a 15-fold increase in carbon productivity over the next four to five decades will likewise require widespread microeconomic changes that are encouraged and enabled by changes in the policy, regulatory, and institutional framework of the global economy. In approaching the carbon productivity challenge we can then ask three questions:

- What specific microeconomic changes would enable us to both abate carbon and maintain growth?
- What are the issues that need to be addressed and barriers that need to be overcome in order to make those changes?
- What policies, regulatory approaches, and new institutions would enable and encourage such microeconomic changes?

IDENTIFYING THE CHANGES NEEDED TO INCREASE CARBON PRODUCTIVITY

In order to achieve a dramatic increase in carbon productivity, actions by governments and businesses will need to be focused on opportunities to abate the maximum amount of carbon for the minimum amount of cost. Without such a focused approach, the costs of abatement will be significantly higher and the world will be forced into difficult trade-offs between abatement and growth.

This section of the paper discusses:

- A carbon abatement "cost curve" that identifies which actions should be prioritized in order to maximize impact and minimize cost; and
- How those actions would likely impact overall GDP growth.

Maximizing abatement impact and minimizing cost

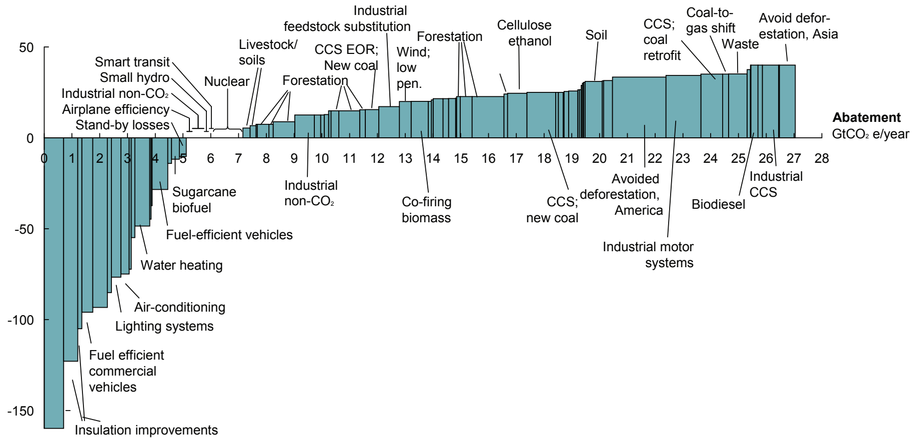
In 2006-07, McKinsey and Vattenfall worked together to create a comprehensive global map of the microeconomic changes required to abate greenhouse gases. The resulting CO2e "cost curve" (Exhibit 5) shows the full range of actions that are available with technologies that are either available today or where there is significant certainty about their near-term potential. The width of the bars indicates the amount of CO2e that could potentially be abated and height shows the marginal cost per ton abated.[4] The graph is ordered left to right from the lowest cost abatement opportunities to the highest cost. The cost curve is built on a number of assumptions consistent with a scenario in which 27Gt of abatement versus business as usual is delivered by 2030 - a quantity that could lead to CO2e peaking in the 450-500ppm range. It is not intended to forecast a particular reduction scenario or a carbon price, but rather to show, under a set of plausible assumptions, which levers yield the greatest potential abatement for the lowest cost.

[4] "A cost curve for greenhouse gas reduction," *The McKinsey Quarterly, 2007/1*

Exhibit 5

The cost curve provides a "map" of abatement opportunities

Cost of abatement, 2030, EUR/tCO_2e



Source: Vattenfall and McKinsey analysis

The first thing that stands out is that a significant portion of the abatement potential, approximately 7 gigatons of annual emissions, would be at a negative cost to society (the left side of the graph). In other words, these actions would earn a positive economic return. These positive returns come largely from savings in energy costs, for example more energy efficient lighting, or more fuel efficient vehicles. The second key point is that the 27 gigatons per annum of abatement required to get to the 450-500 ppm stabilization target by 2030 can be achieved for a marginal cost of under €40 per ton. Finally, the cost curve counters a number of myths about carbon abatement—for example, that there are limited low cost abatement opportunities in the developed world, or that we can only achieve abatement with new technologies **(Exhibit 6)**.

If these abatement actions were taken, the annual total cost to society would be €500-1,100 billion in 2030, or 0.6-1.4 percent of that year's projected global GDP assuming growth continues on its long-term trend. (This estimate is also based on an oil price of $40/barrel; if prices were higher the abatement cost would be lower because of the greater value of energy efficiency and fuel efficiency savings and the increased relative attractiveness of alternative fuels). This cost estimate is roughly in the middle of the range of 0.2 to 3 percent of GDP for targets from 445-590 ppm found in a survey by the IPCC.[5] If one were to view this spending as a form of insurance against potential damage due to climate change, it might be relevant to compare these figures to global spending on insurance (excluding life insurance), which was 3.3 percent of GDP in 2005.

Exhibit 6

Myths and realities about GHG abatement

Myths	Realities
▪ Abatement opportunities are concentrated in the industry and power sectors	▪ Industry and power represent <45% of the total 2030 abatement potential*
▪ Limited amount of low-cost opportunities in industrialised countries	▪ Negative cost abatement potential represents 35–45% of the total in industrialised countries
▪ Abatement opportunities are concentrated in industrialised countries and China	▪ Developing world excluding China represents >40% of the total 2030 abatement potential*
▪ We can only achieve the required abatement through new technology	▪ 70% of the total 2030 abatement potential* not dependent on new technology
▪ Addressing GHG emissions will severely strain the global economy	▪ Reaching 450ppm could cost as little as 0.6% of GDP if all low-cost opportunities efficiently addressed

** Below 40 EUR/tCO_2e*
Source: McKinsey analysis

How abatement costs would likely impact GDP growth

It is important to note that these cost estimates (and most of the cost estimates provided by other researchers) represent a "welfare" cost versus what society would be spending under the business as usual scenario.[6] This is not the same as the headline GDP figures one is accustomed to seeing reported for countries. Thus the above should not be interpreted as meaning that world GDP will drop by 0.2 to 3 percent by 2030. In fact, many of the actions required to abate emissions would increase headline GDP growth for many countries. For example, a transition to lower emissions vehicles would raise GDP if it resulted in a faster than normal replacement of the vehicle stock. Likewise, major deployments of renewable energy or carbon capture and storage (CCS) would require substantial infrastructure investments that would raise headline GDP.

A critical question is how much of the money for these investments would be taken from current consumption, thus lowering GDP in other parts of the economy (e.g., consumers pay for their efficient cars or green energy by spending less on something else) versus simply substituting for business as usual investment in capital stock (e.g., investment in clean coal capital substituting for investment in traditional coal capital). Our research suggests that the bulk of the investment required would come from substituting low-emissions capital for traditional capital. But as carbon productivity is currently low, there would nonetheless be an incremental cost (e.g., a clean coal megawatt will cost more than a traditional coal megawatt). In a detailed study of the U.S. carbon cost curve conducted by McKinsey, it was estimated that the cumulative net new investment associated with capturing 3.0 gigatons per year of abatement through 2030 would be $1.1 trillion. While this is a large amount, it is important to note that it represents only 1.5 percent of the $77 trillion in real investment the U.S. economy is expected to make over this same period.[7] Thus most of the investment required for carbon abatement will come from investments that would otherwise have been made in traditional capital.

[5] IPCC Working Group III, 4th Assessment Report, "Summary for Policymakers," 30 April-4 May 2007.

[6] Nicholas Stern, *The Economics of Climate Change – The Stern Review, 2006*; William Nordhaus, *The Challenge of Global Warming: Economic Models and Environmental Policy, Sep 2007*; United Nations Development Program *Human Development Report 2007/2008*. *Fighting climate change: Human solidarity in a divided world, Nov 2007.*

[7] McKinsey & Company, "Reducing US greenhouse gas emissions: How much at what cost?" Nov 2007 (www.mckinsey.com/clientservice/ccsi/pdf/US_ghg_final_report.pdf).

The key question then is how the investments in the incremental capital required will be financed. Some economists argue that it would make more sense for the amounts to be borrowed since the investments would be made to benefit future generations.[8] If the incremental capital is financed by reducing current consumption, then such investments would slightly lower GDP growth, but if they are financed through an expansion in borrowing, they would not. The U.S., for example, would have no difficulty financing the incremental $50 billion per year in incremental investment required through its $56 trillion capital market, and could do so with no drop in consumption by adding just over 5 percent to its current account deficit.[9] The EU and other parts of the developed world would also likely find it possible to finance their incremental investment through borrowing.

In essence, such borrowing would be the equivalent of a significant fiscal stimulus on the economy, boosting GDP growth, but without increasing inflationary pressures as the expansion in credit to pay for the investments would go towards replacing traditional capital stock with low emissions capital stock rather than increasing consumption.[10] There is also precedent for this kind of borrowing as the U.S. and other countries have historically borrowed significantly to finance major infrastructure expansion as well as to fight wars.

Many developing nations, however, would find it harder to finance the incremental investments and face more difficult trade-offs between sacrificing current consumption for future abatement benefits. It is possible that such incremental investments could be financed by the international community, just as investments in traditional capital stock are financed through organizations such as the World Bank. It should be noted, however, that countries with strong net savings positions, such as China and the oil producing Gulf states, would be in a different position than other developing countries. Like the developed world, these countries would have the ability to finance their incremental abatement investments without sacrificing near-term consumption and growth (in fact they would also likely be lending funds for such purposes to the U.S. and other developed countries). Their challenge would rather be to create the price signals, incentives, and reforms to their capital markets for this to happen.[11]

Thus at a global, macroeconomic level, the costs of transitioning to a low carbon economy are not, in an economic “welfare” sense, all that daunting – even with currently known technologies. Financing much of the incremental investment costs through the global capital markets should be possible, and the shift to a low emissions capital stock could probably be accomplished without significant sacrifices in current consumption, overall employment, or headline GDP growth.

[8] Duncan K. Foley “The Economic Fundamentals of Global Warming”, Santa Fe Institute Working Paper 2007-12-044.

[9] By increasing its current account deficit the U.S. would be borrowing from countries with net savings to finance its transition to a low carbon economy. In essence dollar flows to countries such as China or oil-exporting nations would be recycled back to finance investments in low-emissions capital (although the net savings positions of these countries would likely decline over time as they invested in their own abatement actions and oil demand peaks).

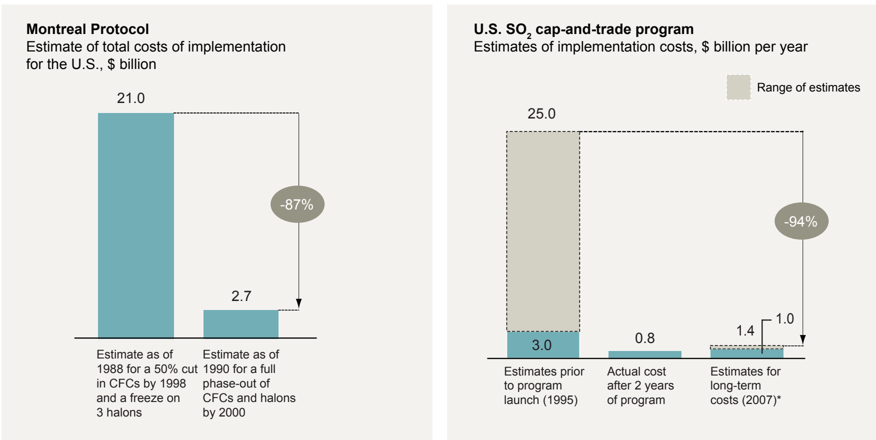
[10] This result in fact is not surprising. Increases in productivity raise the non-inflationary growth path of an economy. If CO2e was in some way to be priced it would become a “factor” in total factor productivity. If total factor productivity, including CO2e, increases, the non-inflationary growth path should increase as well.

[11] McKinsey Global Institute, “Putting China’s Capital to Work: The Value of Financial System Reform”, May 2006 (www.mckinsey.com/mgi).

Finally, we should also note that given the multi-decade timeframes involved, costs estimated today may turn out to be higher than the costs actually incurred. The reason is that it is very difficult to predict the response to changed incentives and the impact of future (and today unknown) innovations in technology and how businesses are organized and managed. There are two recent case examples that illustrate this point. In 1988 it was estimated that the costs in the U.S. for a 50 percent cut in CFCs by 1998 would be $21 billion **(Exhibit 7)**. The next year, the Montreal Protocol went into force and industry responded with product substitutions, technological innovations, and changed business practices. By 1990, within two years, the estimated cost for a full phase-out of CFCs had dropped to $2.7 billion—87 percent less than the original estimate. Likewise, the original estimates for the annual costs of the U.S. SO2 cap-and-trade program prior to launch in 1995 ranged from $3-25 billion. The estimates for the actual long-term costs as of 2007 range from $1-1.4 billion—between 53 and 94 percent less than the original estimate. CFC and U.S. SO2 abatement were far simpler and smaller scale problems than global carbon abatement, but the basic principle—that many of the factors that will reduce future costs are unforeseeable—likely still holds true.

Exhibit 7

The Montreal Protocol (ozone depletion) and the U.S. SO_2 cap-and-trade scheme successfully reduced emissions at lower than expected costs



* *Long-term costs are higher than short-term costs because in Phase I (1995-99) the program covered only the most SO_2 emission- intensive power generating units, whereas in Phase II (2000-) the program was broadened to cover almost all units*

Source: S. Barrett (2003) Environment and Statecraft: The Strategy of Environmental Treaty-Making; Environmental Defense; D. Burtraw et al (2005) Economics of Pollution Trading for SO_2 and NO_x

ISSUES AND BARRIERS: FIVE AREAS OF FOCUS

The cost curve and other work thus shows that macroeconomic cost is not the greatest barrier to raising carbon productivity. Rather, the issues and barriers lie in the realm of microeconomics. The cost curve shows that the abatement opportunities that the world must capture are scattered across scores of industry sectors and geographies. The largest single abatement lever, forestation and avoided deforestation, still only accounts for 25 percent of the total abatement opportunity, and the power sector only 22 percent. Likewise, 42 percent of the total is scattered across dozens of developing countries. Addressing each of these abatement levers will inevitably create winners and losers as economic surplus shifts across companies, sectors, and countries. The challenge, therefore, is to drive abatement and carbon productivity increases across all sectors and geographies effectively, efficiently, and fairly. Meeting this challenge will require addressing five specific issues:

1. Capturing the energy efficiency opportunity
2. De-carbonizing energy sources
3. Accelerating the development and deployment of new low-carbon technologies
4. Changing the attitudes and behaviors of managers and consumers, and
5. Preserving and expanding the world's carbon sinks

This section of the paper briefly outlines the changes needed in each area; considers the policy and regulatory interventions required to enable and encourage those changes; and reviews the barriers that stand in the way of these interventions. We also present some potential questions for consideration in the GLOBE International legislator-CEO dialogue.

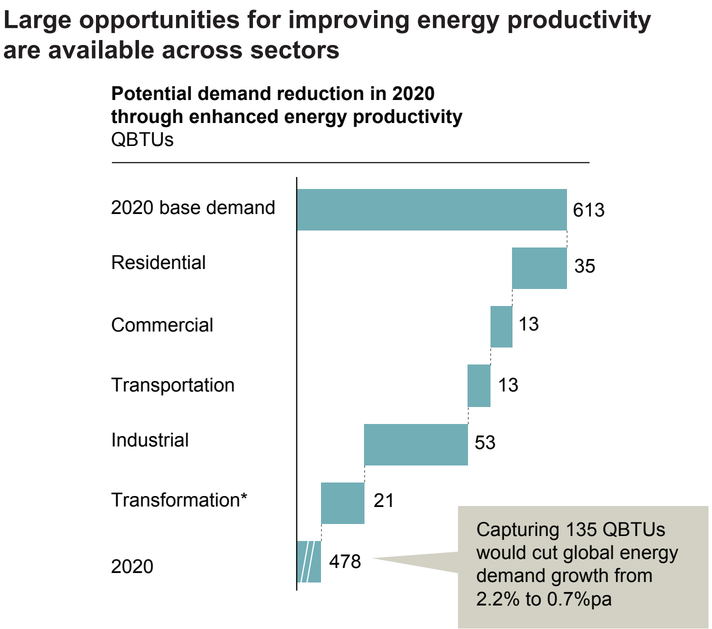
1. Capturing the energy efficiency opportunity

The left side of the cost curve shows the abatement opportunities with negative cost or positive economic returns—that is, each ton of CO2e abated saves money either through reduced energy use or other efficiencies. Of the 7.0 gigatons of positive return opportunities, 4.7 gigatons can be classified as energy efficiency opportunities.

In a detailed study of energy efficiency opportunities, the McKinsey Global Institute estimated that there is potential to reduce global energy demand by 125 to 145 quadrillion BTUs (QBTUs), the equivalent of 20 to 24 percent of projected end-use energy demand in 2020.[12] All of these investments would use existing technologies and generate internal rates of return (IRR) of 10 percent or more. These opportunities break down into five categories (Exhibit 8):

[12] The McKinsey Global Institute, "Curbing Global Energy Demand Growth: The Energy Productivity Opportunity", May 2007, and "The Case for Investing Energy Productivity", Feb 2008 (both http://www.mckinsey.com/mgi/).

Exhibit 8



* 20 QBTU power sector opportunity not included in capital analysis.
Source: McKinsey Global Institute

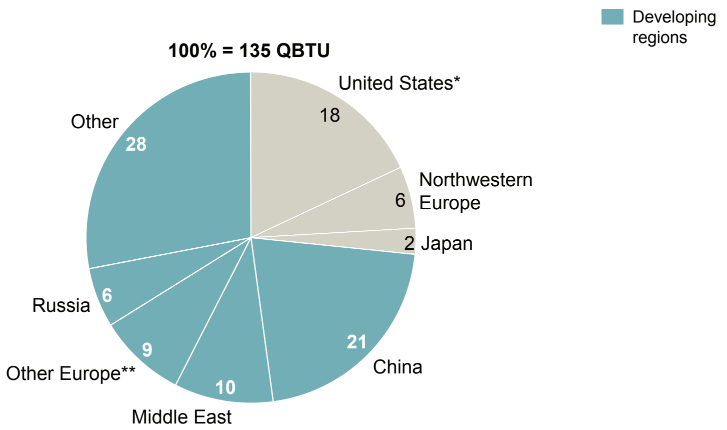
- **Residential** (26 percent of the opportunity)—examples include high-insulation building shells, compact fluorescent lighting, efficient water heating, and reducing standby power;
- **Commercial** (10 percent)—significant opportunities in commercial real estate, largely in heating, cooling, and lighting;
- **Transport** (10 percent)—vehicle manufacturers, consumers and commercial users have not fully captured positive economic returns from vehicle fuel efficiency;
- **Industrial** (39 percent)—this is the largest area of opportunity with a broad array of fragmented opportunities in steel, chemicals, aluminum, food processing, textiles, electronics and many other industries;
- **Transformation** (16 percent)—energy is lost when the power generation and refining sectors transform energy from one form to another; investing in efficient technologies with 10 percent IRR or better could boost BTU conversion efficiencies to 55 percent.

Geographically, the opportunities are also widespread (Exhibit 9). China and the U.S. are the two largest countries in terms of QBTU potential, representing 21 and 18 percent of the total, respectively. The Middle East, at 10 percent, represents another large region of opportunity due to its fast rising status as a user of energy and its low energy efficiency encouraged by high energy subsidies.

Exhibit 9

Vast majority of energy efficiency opportunities are in U.S. and developing world

Potential demand reduction in 2020 through enhanced energy productivity



* *Includes Canada (2.4 QBTU opportunity)*
** *Includes Baltic / Eastern and Mediterranean Europe and North Africa*
Source: McKinsey Global Institute

Capturing these opportunities would require a significant changing out of low-efficiency capital stock in the economy for higher-efficiency buildings, factories, and vehicles. The McKinsey Global Institute estimates that the incremental cost of replacing this capital stock would average $170 billion per year between now and 2020, or 1.6 percent of global fixed-capital investment today. However, these investments would yield $900 billion in annual energy savings by 2020 (assuming an average oil price during the period of $50 per barrel) and generate an average IRR of 17 percent.

Given the high returns and relatively low risk of these investments, it is natural to ask why these opportunities have not been realized. There are a variety of market failures at work, including:

- "Principal-agent" problems—Neither builders, owners, nor tenants of commercial real estate have incentives to make efficiency investments as builders would pay the capital costs but not see the returns, owners do not pay the utility bills, and most tenants are on leases that are too short for them to capture the gains;
- Lack of information—Many decisions are made by parties ranging from consumers to industrial managers who have little information on efficiency alternatives and potential savings;
- High consumer discount rates—Surveys show that only 27 percent of consumers are willing to consider energy efficiency investments with payback periods greater than two years;
- Too small to be a priority—Many opportunities are too small individually to be a priority for business managers or consumers, even though they are large in aggregate;
- Access to capital—Capital is often not available to businesses, individuals and the public sector for smaller efficiency investments with longer payback periods; developing countries also often lack capital for these investments;
- Subsidies and other distortions—Many governments subsidize energy consumption or create other distortions; examples include fuel subsidies in oil-exporting countries, lack of gas metering in Russia, widespread energy subsidies to state-owned enterprises, and 30 year depreciation schedules for energy efficiency investments in the U.S.

These market failures help explain why the energy efficiency opportunity has not yet been captured, despite significant rises in energy prices in recent years. Addressing these market failures will require action across a number of fronts, including government intervention to set minimum energy and fuel efficiency standards; provision of financing and incentives for energy efficiency investments; creation of new financing intermediaries for businesses and consumers; increased access to energy efficiency capital and technologies in the developing world; and the unwinding of distorting subsidies and policies.

Questions for discussion

- What will it take for businesses to see energy efficiency as a serious profit opportunity? What can governments do to encourage this?
- How can businesses support government regulatory efforts to boost energy efficiency? What types of standards would businesses be willing to sign up for? Are they best set at the national, regional, or sectoral level?
- How can capital be mobilized to capture the positive IRR opportunities? What new market mechanisms and intermediaries are needed?
- What would enable legislators to take steps to unwind politically popular but distorting subsidies and other policies?
- Will governments take steps to improve their own energy efficiency and make it a factor in government purchases thus boosting demand for energy efficient products and services?

2. De-carbonizing energy sources

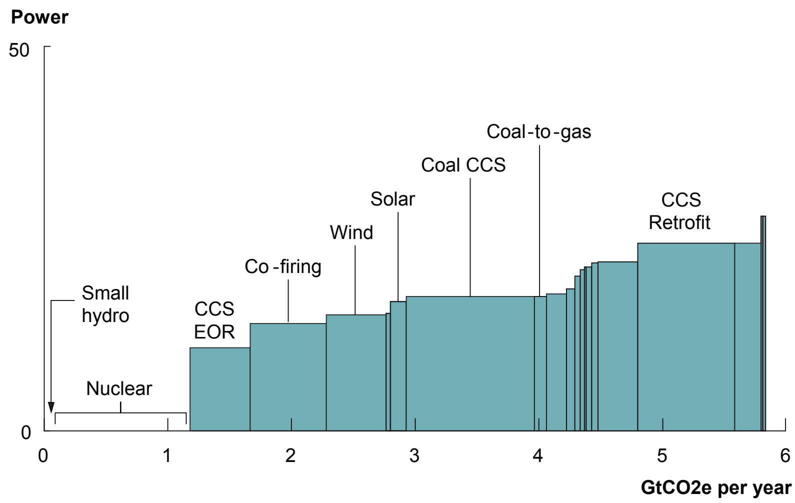
The world is dependent on carbon-emitting fossil fuels for 81 percent of its total energy needs. While supply from low-emission sources has been growing (e.g., renewables at the rate of 12 percent per annum 2000-05, biofuels recently 15-20 percent per annum), low carbon emitting sources still only make up 19 percent of total energy provision. Given our assumption of continued economic growth, the world will see end-use energy demand rise from 422 QBTUs in 2003 to 613 QBTUs in 2020, a 45 percent increase. To simultaneously reduce emissions by a third of current levels by 2020 (on a trajectory to reach 10Gt/year by 2050) the carbon efficiency of energy sources must more than double from 14 MBTUs/ton of CO2e to 32 MBTUs/ton of CO2e between now and 2020.

The two major sectors creating, transforming, and distributing those BTUs are the power sector and the oil and gas sector. The global cost curve for power generation makes clear that there are no silver bullets for this sector. In order to reach a target of 6.0 gigatons of annual CO2e abated by 2030 and to keep the costs below €40 per ton, the sector will need to "pull all possible levers" **(Exhibit 10)**. Due to the large installed base of coal-fired generation, and likely continued dependence on coal, the largest potential, 3.0 gigatons or 11 percent of total abatement, lies in various forms of carbon capture and storage (CCS). Nuclear could also provide significant abatement potential – 1.1 gigatons or 4 percent of the total. A mixture of renewables (in particular wind) would make up 1.5 gigatons or 6 percent.

Exhibit 10

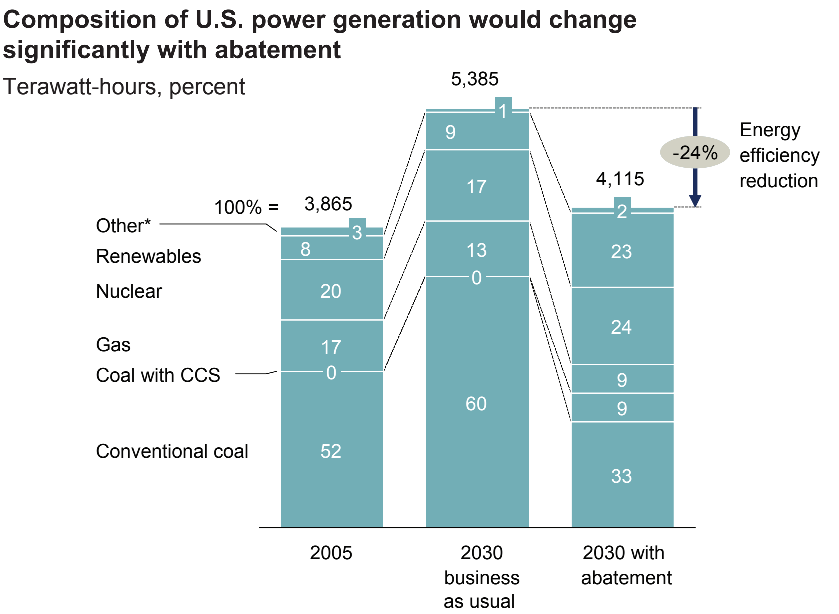
Power sector abatement cost curve 2030

EUR/t CO2e



Source: Vattenfall and McKinsey Cost Curve

Exhibit 11



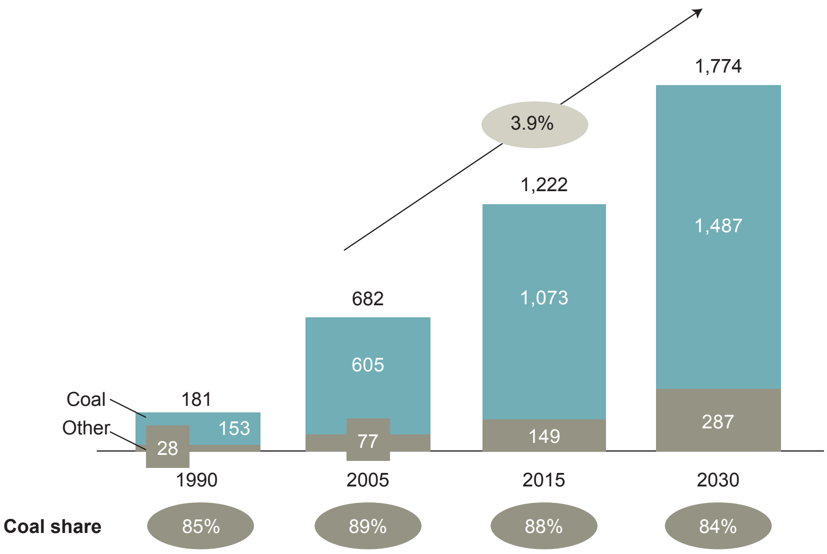
* Includes oil, geothermal, municipal solid waste and pumped storage
Source: U.S. EIA Annual Energy Outlook (2007) "Reference case"; McKinsey analysis

Power sector abatement strategies will vary significantly by country however, depending on their starting position, level of dependence on coal, and whether they have existing nuclear power generation. For example in the U.S. our base case projections show power demand increasing from 3,865 terawatt hours today to 5,385 terawatt hours by 2030 **(Exhibit 11)**. As outlined in the previous section, energy efficiency savings could reduce that by 24 percent – and thus constitute the most important lever for reducing power sector emissions. Capturing abatement opportunities at under $50 per CO2e ton would dramatically change the U.S. generation mix. Renewables would expand from 8 percent of supply today to 23 percent by 2030, nuclear would expand slightly from 20 to 24 percent, and coal with CCS would grow to account for 9 percent. It is important to note that even with these changes, conventional (non-CCS) coal would still account for a third of the overall mix, though in absolute terms it would decline from approximately 2,010 terawatt hours to 1,350 terawatt hours.

Exhibit 12

China's rapid growth in power sector will be fuelled mostly by coal

Energy demand in power sector, Millions of tons of oil equivalent per year



Source: IEA World Energy Outlook 2007; McKinsey analysis

China presents a particularly difficult case. The IEA projects that Chinese energy demand will grow by 3.9 percent per year through to 2030. The vast majority of this demand will be met by coal **(Exhibit 12)**, though coal's share will fall slightly from 89 to 84 percent. China's power sector is expected to continue to experience efficiency gains of 15 percent by 2030, but the emissions implications of its growth in coal-fired power are nonetheless enormous: they alone are expected to grow from 4.2 to 8.9 billion tons from 2005 to 2030. By necessity, demand reduction from energy efficiency improvements and significant investments in CCS will need to be a major part of any emissions reduction plan for China.

We have been fairly conservative in our assumptions about technological progress in these projections. Faster development and deployment of CCS (which we assume is not commercially deployed until 2020), lower-cost standardized nuclear designs, breakthroughs in solar or other renewable technologies, and investments in grid technologies that improve efficiency and lower the cost of integrating distributed renewable sources, all have the potential to change the shape of the sector's cost curve.

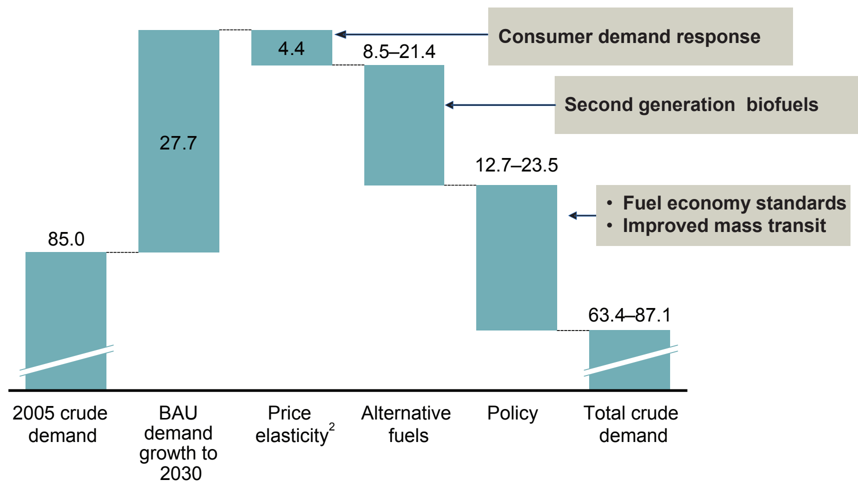
[13] IEA, *World Energy Outlook*, 2007.

Abatement potential for the oil and gas sector comes from three levers: reducing end-user demand, fuel substitution, and reducing the industry's own emissions. Of these, the first two are by far the largest. The McKinsey Global Institute's work on future energy demand shows a wide range of potential scenarios for oil demand depending on how aggressively the world moves towards higher efficiency vehicles and alternative fuels **(Exhibit 13)**.

Exhibit 13

There is a massive range in potential future demand for oil

2030 global demand, Million barrels per day



Source: McKinsey Global Institute global energy demand model; Petrosims; McKinsey analysis

At a global level, more fuel efficient vehicles represent a 0.9 gigaton of CO2e abatement opportunity, or 3 percent of the total under €40 per ton. Significant opportunities exist for fuel efficiency increases with existing technologies, in particular engine optimization, weight and aerodynamic drag reduction, and substitution of high efficiency diesel engines for gasoline engines. For example, such changes enable emissions from a standard VW Golf to be reduced from 176 g/km to 99 g/km, a 44 percent reduction. Hybrids and plug-in hybrids could offer further reductions with fuel economy of up to 113 miles per gallon, but their abatement potential depends on the steepness of cost declines, and for plug-in hybrids, the availability of low carbon electricity sources.

The challenge in increasing fuel efficiency in vehicles is that while there may be significant payoffs from a societal perspective, the high up-front costs are a deterrent and consumers have historically shown unwillingness to pay them. For example in Germany, McKinsey estimated that 40 percent of the abatement potential from vehicles (14 megatons of CO2e out of 37 megatons total potential) had positive payoffs, but the payoffs were too long to be attractive to consumers.[14]

Biofuels offer significant, but in some countries controversial, potential for de-carbonizing energy for vehicles and some types of industrial production. We estimate its potential at 1.4 gigatons or 5 percent of the total abatement opportunity. At present, Brazilian sugar cane offers the highest energy output relative to energy input—a ratio of 8.3 versus 1.3 for U.S. corn based ethanol or 1.9 for European sugar beet.[15] The lack of energy efficiency of corn, beets, and other feedstocks means that their carbon impact may actually be negative despite their renewability.[16] However, second generation "lignocellulosic" biofuels that may become available as early as 2010 and have the potential to dramatically boost energy outputs from a wider variety of feedstocks and make biofuels viable in new geographies—for example, they could drop biofuel costs in China from $1.80 per gallon to $0.60.[17]

[14] "Costs and Potentials of Greenhouse Gas Abatement in Germany. A Report by McKinsey& Company, Inc, on Behalf of "BDI Initiative - Business for Climate", Sep 2007 (http://www.mckinsey.com/clientservice/ccsi/pdf/Costs_And_Potentials.pdf).

[15] Petrobras presentation to Financial Times Conference, 19 June 2007.

[16] See, e.g, Searchinger et al, "Use of U.S. Croplands for Biofuels Increases Greenhouse Gases Through Emissions from Land Use Change" and Fargione et al "Land Clearing and the Biofuel Carbon Debt", both *Science*, Feb 2008.

[16] "Betting on biofuels", *The McKinsey Quarterly,* May 2007.

Questions for discussion

- Given the importance of CSS under virtually all scenarios, what can be done both at the national and international level to speed its development and global deployment? How should the significant costs of CSS development and deployment be financed? How can fairness issues of coal-dependent regions bearing significant transition costs be resolved?
- Is nuclear energy an essential element in abating carbon, or do its issues make it unviable? For which countries? Is international cooperation needed to help address safety, proliferation, and spent fuel concerns?
  - For countries where it is part of the strategy, what can be done to accelerate development and deployment of next-generation technology? Again, would international cooperation help?
  - For countries de-emphasizing or phasing out nuclear, what is the low-abatement replacement strategy?
- What specifically can be done to encourage the power sector to reduce end-use demand through energy efficiency gains (i.e. to view energy efficiency as the “fifth fuel”)? Is a separate regulatory framework needed to increase incentives for the power sector on this issue?
- How might dramatic increases in fuel efficiency be turned into an opportunity for the auto sector? Does it depend on forcing changes in consumer behavior and accelerating the turnover of the existing vehicle stock (i.e., forced retirement for low-efficiency vehicles)? How would the oil industry respond?
- What should the approach to biofuels be? Should trade barriers be lowered for carbon-efficient biofuels? How do we manage biofuel’s competition with agriculture and the impact on deforestation and water? What can be done to speed the development of next-generation biofuels?

3. Accelerating the development and deployment of new technologies

In the analyses discussed thus far, we have been conservative in assuming no significant or unforeseen breakthroughs in technology. All of the abatement potentials and costs in the cost curve were calculated using either existing technologies or technologies with a highly visible path and timeframe to commercialization.

Yet, economic history tells us that technological innovations have been critical in driving all major increases in productivity. Thus two important questions are: how much extra R&D investment will be required to drive the required increases in carbon productivity; and what will be the right mechanisms for mobilizing that R&D spending and channeling it in ways that are effective in generating innovation?

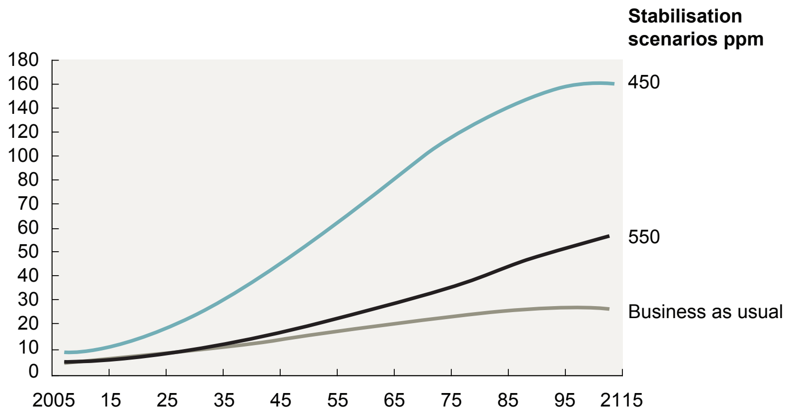
A group of researchers affiliated with the Center for Economic Policy Research (CEPR) have modeled the R&D flows required for various levels of carbon stabilization.[18] They estimate that global R&D investments aimed at increasing energy efficiency and de-carbonizing energy sources are currently $10 billion per year. These investments would need to double by 2020 to support a path to 450 ppm and reach $80 billion by 2050—nearly four times the estimated business as usual path **(Exhibit 14)**. For 550 ppm the incremental R&D investments are much smaller—doubling by 2035 and reaching approximately $30 billion per year by 2050.

[18] Valentina Bosetti, Carlo Carraro, Emanuele Massetti, and Massimo Tavoni, "Optimal Energy Investment and R&D Strategies to Stabilise Greenhouse Gas Atmospheric Concentrations," Center for Economic Policy Research Discussion Paper No. 6549.

Exhibit 14

Global R&D investments required to support CO_2e stabilization

Annual energy R&D investments, $ billions



Source: Bosetti, Carraro, Massetti, and Tavoni (2007), "Optimal Energy Investment and R&D Strategies to Stabilize Greenhouse Gas Atmospheric Concentrations."

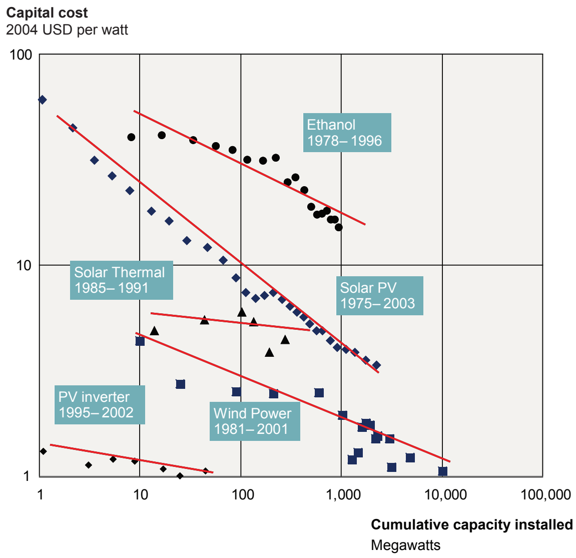
The key swing factors in the level of R&D required for the 450 ppm versus 550 ppm scenarios were that a 450 ppm target would require much faster development and deployment of integrated combined cycle gasification (IGCC) and CCS to enable a rapid ramp-down of traditional coal. The 450 ppm target would also require either substantial R&D investments to support a ten-fold increase in nuclear generation, or if nuclear were restricted, large investments in as yet unidentified technologies that could economically provide up to a quarter of the world's energy by the end of the century. If the choice is the latter, these new technologies would need to be ramped up very quickly (18 times present levels) in the next two decades to support a 450 ppm path, given the lead times in discovery, development, commercialization, large-scale deployment, and global diffusion in the energy sector. The magnitude of this challenge only adds to the urgency of clarifying nuclear strategies.

We thus face four very different types of R&D problem:

- **Developing the "next generation" for a mature technology**—if nuclear energy is to be a significant part of the solution, substantial investments will be required in new plant designs and in addressing safety, proliferation, and disposal concerns in the entire fuel cycle.
- **Scaling up, commercializing, and deploying emerging technologies**—IGCC and CCS play critical roles in all scenarios and large investments are still required in the R&D phase and massive investments in deployment ($100 billion per year by 2020, according to the CEPR study).
- **Driving existing high-cost technologies down the learning curve**—portions of the "unidentified" energy source piece could come from existing technologies if learning curve cost declines are steep enough (Exhibit 15).
- **Creating a dynamic innovation portfolio across a broad array of promising new technologies**—other portions of the "unidentified" piece could come from new technologies arising out of basic R&D activity and a broad portfolio of innovation initiatives, e.g., innovations arising out of biotech/bio-energy or from improved use of information technology in power and energy management.

Exhibit 15

Historical learning curves for renewables



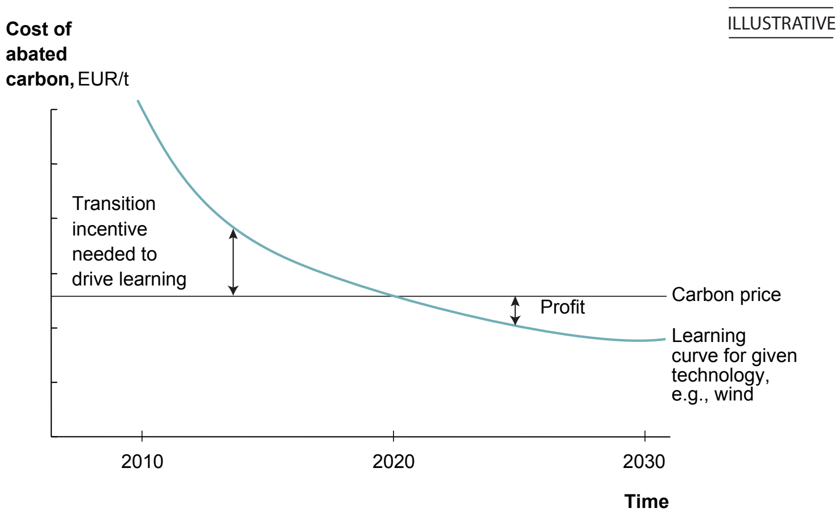
Historical learning rates (i.e., cost decreases) per doubled cumulative capacity:

- 23% for solar PV
- 13% for wind power
- 15% for ethanol
- 6% for PV inverters
- 3% for solar thermal

Source: UC Berkeley Energy Resource Group; Navigant consulting

Exhibit 16

Transition incentives are required to drive learning in new technologies



Source: McKinsey analysis

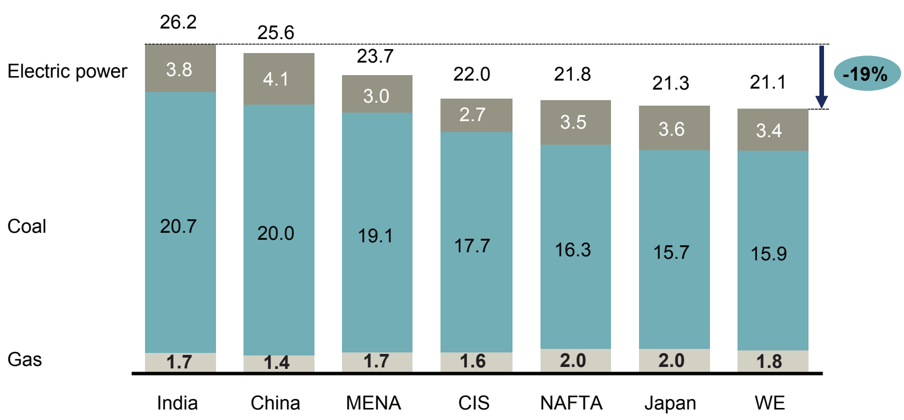
Each of these problems would require significantly different R&D strategies for both governments and business. Neither of the first two will be solved without significant government intervention and partnerships with the private sector. Public R&D money will be required, and uncertainties around future regulation, legal liabilities, and other issues will need to be addressed. The second two problems require incentives for the private sector, but a lighter touch from governments. In addition to creating a carbon price, key government roles for these latter two include support for basic R&D as well as help in creating a critical mass of demand through energy efficiency standards and government purchasing. In addition, "transition incentives" might also be needed to help private sector companies drive technologies down the learning curve to make them economic under a carbon price (Exhibit 16). The history of technological innovation shows, however, that government efforts to pick technology "winners" should be avoided as they are less likely to be successful.

The final technology issue is that of technology transfer. The large variations in energy and carbon productivity between the developed and developing world make clear the need for low-emissions technologies to flow to the developing world. For example, it takes approximately 20 percent more energy to manufacture a ton of steel in India or China than in Western Europe or Japan **(Exhibit 17)**. Likewise, given China's dependence on coal it will be in the world's interest to ensure China has access to the most advanced and cost effective CSS technology. Technology transfer was adopted as an element of the Bali Action Plan; the US, UK and Japan jointly launched what is intended to become a $30 billion "Marshall Plan" to pay for clean technologies in the developing world; and a group of companies including Sony and Nokia have created an "eco-patent commons" with initial donations of 31 energy efficiency patents for free.

Exhibit 17

Variations in energy intensity within the steel sector shows opportunity for technology transfer

MBTU per metric ton of crude steel



Source: J.F. King; McKinsey Global Institute analysis

However, a long history of attempts to raise technology levels in low and middle income countries in the context of economic development shows the challenges that will be faced. A recent World Bank study on technology diffusion (technology in general, not green technologies specifically) sheds light on these challenges with the following findings:[19]

- Market forces and globalization are driving technology diffusion in the developing world at a more rapid rate than ever before and are closing the gap with the developed world in many areas; some technologies have been adopted very quickly (e.g., mobile phones)
- However, the gap in absolute terms across a broad set of technologies remains large, based on two primary determinants:
  - Technology adoption closely tracks overall economic development and income levels
  - Technology diffusion within a country depends on the quality of governance, institutional structures, availability of infrastructure, property rights, education, human capital, and a host of other factors
- Technology "leapfrogging" is rare (mobile phones are the exception rather than the rule); the more typical pattern is technology advancing with rising income and moving from low- to intermediate- to high-tech.

One sobering interpretation of the report is that technology transfer will not be solved by market incentives, funding from developed world governments, and the sharing of IP rights alone. Rather success in technology transfer will be linked closely to broader development issues in the developing countries themselves.

[19] "Technology Diffusion in the Developing World," *World Bank Global Economic Prospects 2008.*

Questions for discussion

- Even assuming significant CSS deployments, most scenarios show that power generation requires either expansion of nuclear or a bet on yet to be identified low-emissions technologies—how big a bet are we willing to take?
- What can be done to increase the odds of significant new technologies emerging? What role should government play versus business in promoting such technologies?
- Which technology transfer issues will likely be addressed by market forces with a carbon price, and which require other mechanisms?
- Do we believe that existing international institutions such as the World Bank are the best vehicles for channeling technology transfer funds, or are new vehicles needed?
- Are there opportunities to encourage effective technology transfer through sector-level schemes?
- Do trade policies need to change to encourage technology transfer?
- Are IP rights a serious barrier to technology transfer or a side issue?
- How can technology transfer be made more effective through links to overall country development?

4. Changing the attitudes and behaviors of managers and consumers

To a large extent, carbon emissions are the product of billions of decisions made by individual managers and consumers around the world every day. The history of both productivity growth and changes caused by previous environmental issues shows that it will be critical to influence and change many of these micro-level decisions. Because many of these decisions are small and scattered throughout the economy, they are difficult to measure and their impact is often hard to predict in advance.

One example is laundry detergents. Retail success for packaged goods such as laundry detergents depends to a large extent on supermarket shelf-space, and on convincing consumers of a product's value for money. Producers thus have strong incentives to use fillers in laundry detergents that have no cleaning function but make the boxes and bottles look bigger, in order to fill more shelf space and create an impression of providing more detergent for a given price. The carbon impact of "filled" detergents is significant through the value chain. Filler materials need to be produced and transported to the detergent manufacturer, the detergents are then heavier which adds to transportation fuel use, and more packaging is needed. An independent study of the environmental impact of laundry detergents showed that concentrated detergents have 20 percent lower CO2 emissions through their lifecycle than traditional products.[20]

In a three year period Wal-Mart alone sells approximately 800 million units of liquid laundry detergent. It recently made a commitment through the Clinton Global Initiative to sell only concentrated detergents and estimates that this will save more than 400 million gallons of water, 95 million pounds of plastic resin, and 125 million pounds of cardboard, not to mention the energy required to manufacture and transport this unnecessary material. Wal-Mart also committed to educate consumers on the benefits of concentrated detergents.

[20] Gert van Hoof, Diederik Schowanek, and Tom CJ Feijtel, "Comparative Life-Cycle Assessment of Laundry Detergent Formulations in the UK," Tenside Surf. Det. 40 (2003).

The key point is that these abatement savings involved no new technology, no significant capital investments, no loss of functionality for consumers, and in economic terms, no loss of GDP. Rather these savings required taking CO2 impact into consideration as an objective in the design for the product and its supporting value chain, which in turn required a change in mindset by both management and consumers. In this case, the mindset change was driven by Wal-Mart's broader initiative to reduce its carbon impact and that of its suppliers. More generally it would be driven by a carbon price. With a sufficiently high carbon price, large numbers of such opportunities would surface.

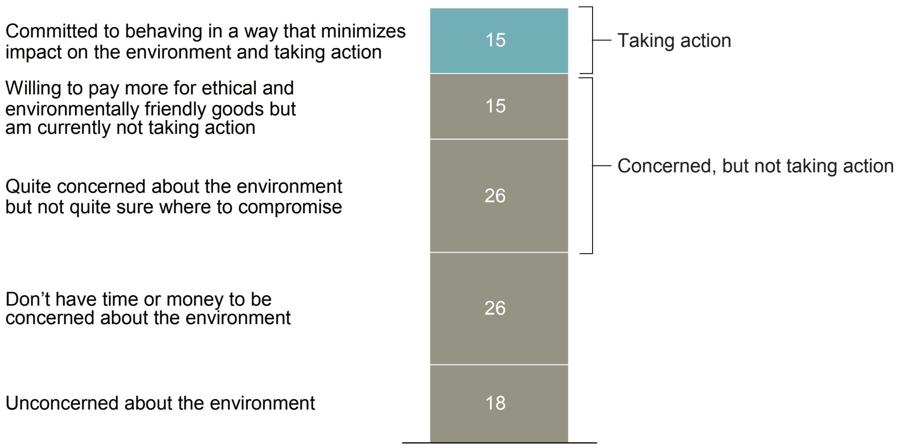
But the example also shows why a carbon price alone may not be enough to drive behavioral changes. With a carbon price of €40 the difference between a standard versus compact bottle of detergent would be on the order of €0.10 on a product that sells for between €3-5—too small to make a difference to many consumers. Furthermore, the difference might not offset producers' incentives to fight for shelf space with large packaging. We see similar issues in energy efficiency where gains that are small individually but sizeable in aggregate go un-captured despite high energy prices.

The implication is that efforts to educate consumers – such as Wal-Mart's initiative on compact detergents or efforts at labeling products with their carbon impact – are also critical. However, surveys show that consumers are open to being influenced on the climate issue. For example, a McKinsey survey of 4,000 U.S. consumers showed that 56 percent of consumers are motivated to take action, but many are unsure of how they can do so (**Exhibit 18**). Governments can also play critical roles in educating consumers about the impact of their choices (as they have in successful anti-smoking and pro-recycling campaigns) and by setting standards to break producer's incentives to follow inefficient practices.

Exhibit 18

The vast majority of U.S. consumers are not changing their behaviors, despite declaring concern for the environment

U.S. self-reported level of consumer concern and action towards global warming
Percent



Source: McKinsey Business in Society consumer survey of U.S. consumers, 2007 (n=~4,000)

Questions for discussion

- What can companies do to initiate mindset and behavior changes that result in abatement? What incentives and help are required from government?
- What can both governments and companies do to raise awareness, provide better consumer information, and create social norms around "green" behavior?

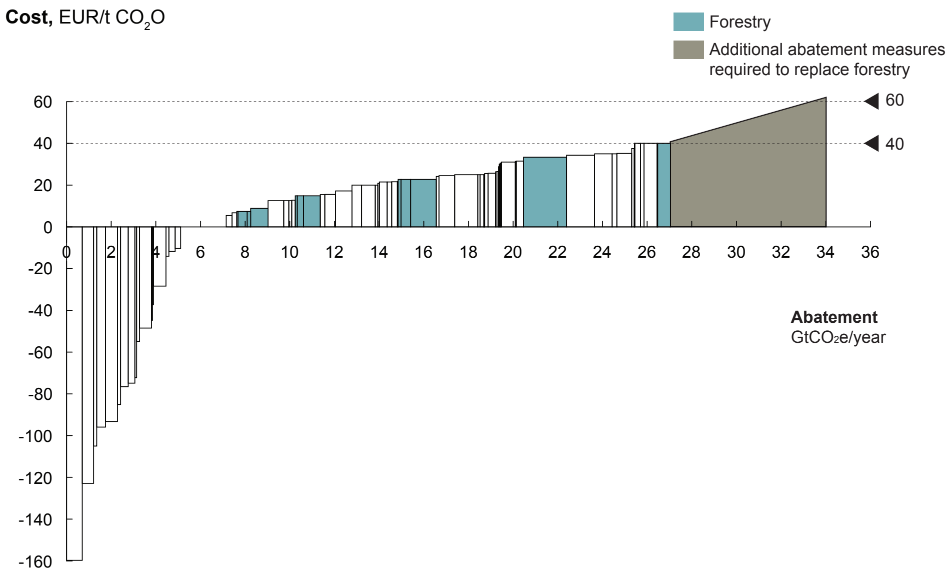
5. Preserving and expanding the world's carbon sinks

Preserving and expanding the world's carbon sinks must be a critical element of any strategy to abate emissions and raise carbon productivity. Beyond CCS, discussed in section 2, the world's critical carbon sinks are its forests, particularly in its tropical and sub-tropical regions. Forestation and avoided deforestation are among the largest abatement levers on the global cost curve. Avoided deforestation offers about 3.3 GtCO2e of abatement potential beyond BAU by 2030 (12 percent of the total opportunity), while forestation offers about 3.5 GtCO2e per year (13 percent of the total).

If this abatement potential is not captured, then other higher-cost sources of abatement will need to be found. As these other sources of abatement lie above the €40 per ton level on the cost curve, we estimate that the impact would be to increase the marginal cost of abatement in the region of €20 per ton to €60 per ton, a 50 percent increase **(Exhibit 19)**.

Exhibit 19

Success in forestry is vital to meeting global emissions reduction targets



Source: McKinsey analysis

Satellite and field-based methods allow increasingly precise measurement of net forestry changes. This could enable international compensation for countries that preserve and increase net forest cover. Forestation is already eligible for project-based Clean Development Mechanism (CDM) credits under the Kyoto protocol. However, there are two issues with forestation. First, CDM eligibility has had limited impact to date, suggesting that project-based mechanisms for forestation may be too unwieldy. A number of experts believe that simpler market-based incentives might prove more effective. Second, forests take a long-time to grow, so the impact of forestation on carbon abatement is over a longer time frame than avoiding deforestation where the impact is immediate.

Unfortunately no general framework for reducing emissions from deforestation and forest degradation (together referred to as REDD) exists today. Unlike forestation where market incentives may be workable, any viable framework for REDD may require both national policies and baselines, as well as intergovernmental agreements. Such a framework would need to address issues such as deforestation leakage from one region to another, high year-on-year forest cover variation (e.g., from forest fires), and uncertainty about the permanence of CO2 sequestration from REDD. A further challenge for both forestation and REDD measures is that many forest-rich developing countries lack an efficient bureaucracy capable of administering, monitoring, and enforcing forestry schemes and tackling illegal logging and agricultural clearing.

Finally, both forestation and REDD tend to result in economic displacement for some of the world's poorest people (although there may be economic gains for others, particularly in traditional tribal communities). Avoiding social problems and potentially violent backlashes requires involving key stakeholders and creating other opportunities for people using forests and the relevant areas. Approaches will need to be tailored as the economic drivers of deforestation vary significantly by country: for example, commercial timbering in Southeast Asia; cultivation of crops and cattle pasture in South America; and small-scale subsistence agriculture and demand for fuel wood in Africa.

Questions for discussion

- What do national governments need to do to move the forestry issue forward? What are the key hurdles? What role should NGOs play?
- Although most businesses are not directly affected by forestation issues, all have a stake in it due to its impact on future carbon price. What can businesses do to support progress on this issue?
- What mechanisms are needed to compensate and find new opportunities for those displaced as a result of forestation and avoided de-forestation efforts?

ENABLING AND ENCOURAGING CARBON PRODUCTIVITY GROWTH

Reconciling the twin objectives of carbon stabilization and economic growth requires us to drive significant changes in a broad range of microeconomic decisions throughout all sectors and geographies of the global economy. The carbon cost curve provides a map of where those changes are likely to yield the greatest impact for the least cost, and helps us identify issues and barriers to making those changes. The final question is what interventions are required by government and business to drive those changes. One can group the interventions into four categories:

- Creating market-based incentives;
- Addressing market failures;
- Resolving allocation and fairness issues; and
- Accelerating progress.

Creating market-based incentives

It is widely recognized that creating a market price for carbon is foundational to creating the incentives for abatement. There is significant political momentum at both the global and national levels behind the creation of a cap-and-trade system with binding targets, versus other mechanisms such as carbon taxes.

In parallel with the UNFCCC global process, regional (e.g., the EU ETS) and national (e.g., potential U.S. legislation) schemes are also being pursued. While there are concerns about a fragmented carbon market, or national schemes reducing pressure for a global cap, others argue that regional and national schemes will provide highly valuable learning as well as near-term abatement gains while the world works towards a global deal.

It is also important to remember that there are other mechanisms for creating carbon prices that may be appropriate at the national or sectoral level. For example, a critical issue for businesses currently making long-term investment decisions is uncertainty over the future price of carbon and when (and whether) such a price would come into effect. One innovative proposal is for "carbon contracts" where governments auction promises to buy a stream of emissions reductions over time—in effect it provides a put-option for companies on the price of carbon.[21] The auction mechanism ensures the lowest cost abatement opportunities are addressed first, while the price of the contract gives companies certainty that enables them to make investment decisions and access financing. Although governments would be the most credible counter-party in such contracts, they could also be written by large foundations or international organizations interested in kick-starting abatement investments.

[21] Dieter Helm and Cameron Hepburn, "Carbon Contracts and Energy Policy: An Outline Proposal," New College and St. Hugh's College, Oxford, working paper, October 6, 2005.

Questions for discussion

- Will global, regional, and national mechanisms create a carbon price that is sufficiently high to drive abatement at a level that is consistent with the required level of stabilization?
- Will the inevitable compromises in designing such systems allow low-cost opportunities to "leak out" and thus raise the overall costs? What can be done to prevent this?
- Will an evolving patchwork of national or regional carbon markets help or hinder progress towards a global market?
- Will the timing of establishing pricing systems be consistent with the timing needed to achieve stabilization goals, or will it be "too little, too late"?
- How can we create a system with the institutional stability required for businesses to make long-term decisions?

Addressing market failures

As discussed, a wide variety of market failures have been identified, particularly in the energy efficiency space, that will cause abatement opportunities not to respond adequately to a price for carbon. Most of these market failures will need to be addressed at the national level, although some may be addressed at the regional or industry sector level (e.g., global energy efficiency standards for particular industries).

Governments will need to lead in these efforts, but business can be active partners in designing standards, generating better information for consumers, and creating innovative new mechanisms for financing investments. One further challenge for governments will be to remove distortions in the market created by subsidies, existing regulations and trade policies.

Questions for discussion

- Where is there sufficient consensus between government and industry to take near-term action? What specific actions can be taken to create "early wins" on energy efficiency?
- Where are the failures due to lack of information—what investments are needed to fill information gaps?
- How can impact on emissions be taken into account in assessing exisiting and future government subsidies, regulations and trade policies?

Resolving allocation and fairness issues

It is clear that a rise in carbon productivity will cause massive rent shifts across the economy (as did Industrial Revolution increases in labor productivity). Abating climate change will inevitably create both stranded assets and stranded people. There are also significant allocation and fairness issues between the developed and developing world. Many developing nations argue that the developed world is primarily responsible for the current stock of atmospheric greenhouse gases. Furthermore, while the developing world contains 72 percent of the world's future abatement opportunities, even by 2030 it will be contain only 21 percent of its GDP.[22] If the costs for abatement were allocated based on GDP shares, the developed world would be transferring $205 billion per year to the developing world by 2030 in payments for carbon abatement.

Addressing the allocation and fairness issues resulting from a transition to a low-carbon economy will be among the most difficult issues for governments and business to address. Yet the political reality is that addressing these issues will be essential for progress at both the global and national level as parties with large stakes in the status quo have significant incentives to block change. The issues cut along three dimensions: geographic (e.g., developed versus developing world), industry (e.g., winning versus losing companies), and stakeholder (e.g., society versus shareholders).

Questions for discussion

- What constitutes a legitimate "fairness" issue? Economies create winners and losers all the time (e.g., we don't compensate people every time there is a technology change). What distinguishes cases where some form of allowance is made or assistance given, versus cases where we simply let the market decide?
- Which constituencies truly have the power to block progress at the global or national level, and thus present a political rather than an economic case for addressing their concerns?
- In addressing both economically and politically driven questions of fairness, how do we compensate losers without destroying incentives for winners?

[22] Developed world is defined as the U.S., OECD Europe, and other industrialized nations, developing world includes China, India, and all other nations not included in the developed world definition. GDP data and projections from IMF World Economic Outlook Database, April 2003

Accelerating progress

There are a series of critical timing issues in the climate debate that need to be resolved. In particular, the speed and scale of the infrastructure build-out in China, India, and other parts of the developing world creates a unique window of opportunity to incorporate low-emissions technologies in that capital stock. Given the long lifecycle of much of that capital stock, once that infrastructure is built it will be a long time before the replacement cycle opens the window again.

Likewise, as discussed, there may be a mismatch in the pace of development of commercially scalable CSS technology with when that technology will be needed to meet abatement targets.

Finally, also as mentioned, the cost of abatement in many areas would be lowered by accelerating the creation of a critical mass of consumer demand to drive costs down the learning curve.

Questions for discussion

- What practically can be done to accelerate progress in two critical areas—incorporating low emissions technology in Chinese and Indian infrastructure, and developing CSS?
- How can we break the “chicken and egg” problems where lack of consumer demand keeps costs high and discourages investment?

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Increasing carbon productivity 15-fold in less than 50 years will be one of the greatest tests humankind has ever faced. But both history and economics gives us confidence it can be done—the world can abate carbon and continue to grow. We have many of the technologies we need, the world has the investment capital required, and it is clear that if the right incentives are in place and behaviors change, a wave of innovation will be unleashed. The world is also waiting—a recent BBC Globescan survey of 22,000 people in 21 countries found that 65 percent of respondents felt it was necessary to take major steps to address climate change very soon, while only 6 percent believed action was not necessary. What is missing are the policy, regulatory, and institutional structures to drive a revolution in carbon productivity in the timeframe that the health of the planet requires. These will not be created without a close partnership between government and business.

In the end, addressing climate change is not a scientific challenge, nor even an economic challenge—it is a human challenge.