Executive Summary

The climate challenge: business as usual is not an option

The global climate is changing, and the release of greenhouse gases (GHGs) from human activity has contributed to global warming. While there is significant uncertainty about the costs of inaction, it is generally agreed that failing to tackle climate change will have significant implications for the world economy, especially in developing countries, where reduced agricultural yields, sea level rise, extreme weather events and the greater prevalence of some infectious diseases are likely to be particularly disruptive (OECD, 2008a). Furthermore, there are significant risks of unpredictable, potentially large and irreversible, damage worldwide. The exact economic and welfare costs of policy inaction could equate to as much as a permanent 14.4% loss in average world consumption per capita (Stern, 2007), when both market and non-market impacts are included.

To understand how to best tackle these challenges, Chapter 1 provides a picture of what emissions and temperatures would be like over the next half century in the absence of new policy action. This is referred to as the business-as-usual (BAU) baseline.[1] This is not meant to be a realistic course of events, but provides a basis against which the economic implications of climate change mitigation efforts can be assessed. Under this business-as-usual scenario, world GHG emissions, which have roughly doubled since the early 1970s, would nearly double again between 2008 and 2050. As a result, atmospheric concentrations of CO_2 and GHGs more broadly would increase to about 525 parts per million (ppm) and 650 ppm CO_2 equivalent (CO_2eq) in 2050, respectively, and continue to rise thereafter. This could cause mean global temperatures to be about 2°C higher than they were in pre-industrial times[2] in 2050, about 4-6°C higher by 2100, and higher still beyond that.

The current economic crisis provides no room for complacency. Although it is expected to result in a non-negligible reduction in global emissions, the impact is likely to be temporary, with the upward trend resuming as the economic recovery gets underway. The crisis is not a reason to delay action on climate change; delaying mitigation action would mean that larger cuts would be needed later to achieve the same target, and would ultimately be more expensive than taking a more gradual approach. Instead, if well-designed climate mitigation policies are phased-in gradually over the coming years this will avoid unnecessary scrapping of capital, and initial costs should be very low. In the short term, there may be scope for stimulating the depressed economy by bringing forward some low-carbon investment expenditures. In the longer term, the crisis has also created sizeable government funding shortfalls in many OECD countries, which prospective fiscal revenues from carbon pricing could help reduce at low, if any, welfare costs.

Examining scenarios for a low-emission future

Wide economic and environmental uncertainties surround the expected damage from the business-as-usual scenario, but there is a significant probability of very large losses. Given these uncertainties, an economically rational response would be to reduce global emissions to levels which ensure a "low" probability of extreme, irreversible damage from climate change.

The size of reductions and the timeframe over which they should be achieved are two of the key issues in current discussions leading up to an international agreement at the UN Framework Convention on Climate Change (UNFCCC) conference in Copenhagen at the end of 2009. It is widely accepted that cuts should be large enough to stabilise GHG concentrations at a level that would "prevent dangerous anthropogenic interference with the climate system" (IPCC, 2007). A global mean temperature increase of around 2-3°C has been considered by many to be the maximum for avoiding such interference, and this would mean stabilising overall GHG concentration in the atmosphere at no more than about 450-550 ppm. Reflecting the uncertainties and risks involved with any global temperature increase, a number of both developing and developed nations have recently rallied around the more ambitious objective of limiting temperature rises to 2°C. However, for illustrative purposes only, the analysis presented in this book is mostly based on a 3°C objective. It is not an endorsement of such a target.

Given the magnitude of emission cuts required to achieve this objectives (a reduction in world emissions by at least 30% by 2050), it is essential to minimise the costs involved. Different scenarios built around this objective are also assessed and discussed in more details in Chapter 1. While they mainly differ in terms of their timeframe, most scenarios imply substantial worldwide emission cuts compared both to the situation today and the baseline level in 2050. The results show that if these cuts can be achieved through the global pricing of carbon, the economic cost (lost GDP) could be relatively modest.

This is especially the case when some overshooting of the long-term concentration target is allowed. For instance, achieving stabilisation of GHG concentrations at 550 ppm according to a pathway that allows for global emissions to continue rising until around 2025 would reduce average annual world GDP growth projected over 2012-2050 by 0.11 percentage points – resulting in world GDP being lower by about 4% in 2050, compared to the BAU baseline scenario. This is despite a sharp increase in the carbon price, from less than USD 30 in 2008 to around USD 280 in 2050. The reason for the GDP loss relative to the BAU scenario is that substantial human and capital resources will have to be reallocated to GHG mitigation, thus reducing the resources available for producing other goods and services. To put this loss in perspective, world GDP would still be expected to grow by more than 250% over the same period, even if significant mitigation action is undertaken. Thus, citizens would still be financially better off on average in three or four decades than they are today. Furthermore, the large benefits from mitigation, in the form of reduced damages from climate change, are not taken into account in this calculation.

The cost from mitigation policies are expected to be unevenly distributed across countries. Those using carbon more intensively and/or exporting fossil fuel, such as Russia and major oil-exporting countries would face the largest GDP costs. In general, despite their cheaper emission abatement opportunities, emerging economies and developing countries are more affected than developed countries because the level and growth of their production is more intensive in fossil fuels.[3] Likewise, the mitigation efforts in terms of percentage reductions in GHG emissions per capita relative to the BAU scenario is also generally higher in developing countries, in this case owing in part to cheaper abatement opportunities.[4] Again, these estimated mitigation costs are assumed to take place in the context of a global, broadly-based carbon market with relatively few distortions or imperfections. Without this precondition, costs would be higher. In order for such cost-efficient mitigation action to be feasible, a number of policy instruments must be put in place or expanded so as to create the proper incentives to ensure that emissions are reduced first where it is cheapest to do so.

What policies are best for cost-effective emissions cuts?

There is a variety of national and international policy instruments available for tackling climate change. But what are the pros and cons of each, and can they be integrated into a coherent policy framework? Carbon taxes, emissions trading (or cap-and-trade) schemes, standards and technology-support policies (R&D and clean technology deployment) are all examined in Chapter 2 according to three broad cost-effectiveness criteria:

- Is the instrument cost-effective, and does it provide sufficient political incentives for wide adoption (static efficiency)?
- Does it encourage innovation and diffusion of clean technologies in order to lower future abatement costs (dynamic efficiency)?
- Can it cope effectively with climate and economic uncertainties?

A mix of policy instruments will be required

In principle, putting a price on GHG emissions through price mechanisms such as carbon taxes, emissions trading (cap-and-trade) systems (ETS), or a hybrid system combining features of both, can go a long way towards building up a cost-effective climate policy framework. Although taxes and ETS differ in a number of respects, both are intrinsically cost-effective and give emitters continuing incentives to search for cheaper abatement options through both existing and new technologies. They can also be designed and adjusted to minimise short-term uncertainty about emission abatement costs (*e.g.* through the use of banking and borrowing provisions and price caps in the case of permits) and longer-term uncertainty about environmental outcomes.

However, market mechanisms are unable to deal with all the market imperfections (monitoring, enforcement and asymmetric information problems) which prevent some emitters from responding to price signals. Furthermore, it might not be politically feasible currently to achieve a global carbon price. Thus, a broad mix of policy instruments in addition to emissions pricing will be needed. These could include the targeted use of complementary instruments, including standards (*e.g.* building codes, electrical appliance standards, diffusion of best practices) and information instruments (*e.g.* eco-labeling). Furthermore, R&D and technology adoption instruments could encourage innovation and diffusion of emissions-reducing technologies, beyond the incentives provided by the pricing of carbon.

But while multiple market failures arguably call for multiple policy instruments, poorly-designed policy mixes could result in undesirable overlaps, which would undermine cost-effectiveness and, in some cases, environmental integrity. For example, if a price is put on carbon, applying other policy tools such as renewable, energy efficiency or biofuel targets in addition to the carbon price can lead to overlap and might lock-in inefficient technologies. While these policies may be motivated by other objectives, in many OECD countries the side benefits for innovation and/or energy security do not seem to justify the very high implicit carbon abatement prices currently embedded in renewable and biofuel subsidies and targets. As a general rule, different instruments should address different market imperfections and/or cover different emission sources.

What are the implications of incomplete mitigation policy coverage?

Despite the fact that more and more cap-and-trade systems are put in place or envisaged, it will be a while before their coverage reaches the levels assumed in the various scenarios examined. Furthermore, most of these systems exclude certain important emission sources and sectors (especially transport and forestry). The costs, environmental consequences and competitiveness implications of this incomplete coverage are assessed in Chapter 3:

- Exempting *energy-intensive industries* from policy action could increase the costs of achieving the illustrative 550 ppm CO_2eq scenario by over half in 2050 compared to a situation where all sectors were to participate.
- If policies only target *CO_2 emissions*, rather than all GHGs, costs also increase significantly. If the illustrative stabilisation scenario were to be achieved through CO_2 emission cuts only, the costs in 2050 would amount to 7% of world GDP rather than 4% of world GDP as reported above.
- An incomplete *country coverage* of GHG mitigation policies would not achieve much. All but the laxest (*e.g.* 750 ppm CO_2eq) of GHG concentration targets are found to be virtually out of reach if Annex I countries act alone, either because they simply do not emit enough to make a big enough difference – for concentrations below 650 ppm – or else, because of the very high costs of action concentrated on such a narrow base.

Fears of carbon leakage should not be exaggerated

However, while incomplete country coverage raises the costs of achieving any global target, it does not necessarily imply significant carbon leakage – *i.e.* that emission cuts in a limited number of participating countries might be partly offset by increases elsewhere. Unless only a few countries take action against climate change, for instance the European Union acting alone, leakage rates are found to be almost negligible. For example, if the European Union acted alone (*i.e.* no other countries put in place climate policies), almost 12% of their emission reductions would be offset by emission increases in other countries. However, if all developed countries were to act, this leakage rate would be reduced to below 2%.

If the coalition of acting countries is very small, imposing countervailing tariffs (border tax adjustments) on the carbon content of imports from non-participating countries could be one way to prevent leakage. However, such tariffs would imply potentially large costs for both participating and non-participating countries, is likely to be administratively burdensome, and could provoke trade retaliation, while not necessarily reducing the output losses incurred by energy-intensive industries in participating countries.

Integrating forest protection in the international climate framework is desirable but challenging

The various scenarios to stabilise GHG concentration referred to so far do not take account of the potential from forest protection. Yet, emissions from deforestation are thought to amount to about 17% of global emissions. The implications of incorporating forestry into an international climate policy framework are therefore treated separately in Chapter 3 as part of the discussion on incomplete coverage. Reducing Emissions from Deforestation and forest Degradation (REDD) could potentially reduce the cost of global action by 40% (although there could be an impact on land and food prices). However, one

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reason why the abatement potential from forest protection is left out from most scenarios examined in the book is that the measurement of this potential is still in its infancy.

Furthermore, incorporating forest protection in a global policy framework raises a number of implementation issues, including how to certify performance and ultimately compliance, limiting emissions leakage – as deforestation may shift to areas not subject to control – and addressing non-permanence, as emissions may simply be delayed. These risks can be better addressed if a REDD mechanism is implemented and performance overseen at the national, rather than the individual project, level. Applying any REDD mechanism as widely as possible across forest nations will also help to manage the risk of international leakage.

Clear and robust eligibility criteria for environmental integrity will need to be developed if a REDD mechanism is linked to the international carbon market. Access to the carbon market might be limited to only those countries that meet these well-designed eligibility criteria and funding from developed countries could help some developing countries to build the capacities needed to meet those criteria.

Several approaches could be envisaged during the transition towards integration of a REDD market in the international carbon market, all of which have pros and cons. One approach, could be to establish a REDD market that is separate from other carbon markets. Alternatively, a fund-based approach would rely on voluntary or institutionalised contributions to a Fund from developed country governments and other sources but this approach may not provide adequate incentives to significantly reduce the rate of deforestation.

What are the key steps towards a global carbon market?

A broad-based international carbon market will only be achieved gradually. A number of concrete steps towards achieving this objective are thoroughly reviewed in Chapter 4, and the main findings are summarised here:

Removing environmentally-harmful energy subsidies

Fossil fuel energy subsidies are currently high in several non-OECD countries. OECD countries also provide subsidies to energy production and/or consumption, but it is estimated that they are small in comparison to non-OECD countries, and they are often provided through channels that are harder to measure, thus they are not reflected in the modelling analysis presented here (IEA, 1999). In the latter case, they are particularly substantial in Russia, other non-EU Eastern European countries, and a number of large developing countries, particularly India. These subsidies amount to a negative carbon price that keeps fossil fuel consumption, and hence GHG emissions, higher than they would otherwise be. Thus, removing them is a necessary, though politically difficult, step towards broad-based international carbon pricing. It would also free up finances for more direct reallocation to the social objectives being supported by the subsidies. Removing energy subsidies in non-OECD countries will have positive effects:

- Closing the gap between domestic and international fossil fuel prices could cut GHG emissions drastically in the subsidising countries, in some cases by over 30% relative to BAU levels by 2050, and globally by 10%. Nonetheless, broad-based energy subsidy removal would lower the demand for, and thereby the world prices of, fossil fuels. As a result, emissions would rise in other (mainly developed) countries, limiting the decline in world emissions. However, with binding emission caps in developed countries, such leakage would be contained, and world emission reductions would be even larger.

- Energy subsidy removal would also raise GDP per capita in most of the countries concerned, including India and, to a lesser extent, China. Conversely, broad-based energy subsidy removal would imply terms-of-trade and output losses for producing countries. Still, the global GDP effect would be positive.

Linking and harmonising carbon markets

Given the political and institutional challenges of achieving a global carbon price, less ambitious interim arrangements will be needed for the coming years. The increase in domestic/regional ETSs and discussions on reform of the Clean Development Mechanism (CDM) present some opportunities. A global carbon market could be gradually built up through direct linking of domestic/regional ETSs, and/or indirect linking via a scaled up CDM or other mechanisms that provide credits for mitigation action in developing countries to offset emission reduction commitments in developed countries. Compared with a fragmented approach under which a number of regions would meet their emission reduction objectives in isolation, this gradual path towards global carbon pricing could reduce mitigation costs, and possibly carbon leakage:

- Linking could be an important step towards the emergence of a single international carbon price. By equalising carbon prices, and thus marginal abatement costs, across different ETSs, the cost of achieving a joint target will be reduced. Other significant, but difficult to quantify, gains arise from the enhanced liquidity of permit markets.

- The greater the difference in carbon prices across countries prior to linking, the larger the cost savings from linking (Box 0.1). Countries with higher pre-linking carbon prices gain from abating less and buying cheaper permits. Countries with lower pre-linking prices benefit from abating more and selling permits, although their economy may be negatively affected by the real exchange rate appreciation triggered by the large permit exports (the Dutch disease effect). If domestic Annex I ETSs were linked, permit buyers would include Canada, Australia and New Zealand and, to a lesser extent, the European Union and Japan. Russia would be the main seller.

Box 0.1 The impacts of linking Annex I emission trading schemes

In the absence of linking, a scenario in which each region of Annex I (industrialised) countries is assumed to cut its GHG emissions unilaterally by 50% below 1990 levels by 2050 is estimated to reduce average Annex I income by 1.5% and 2.75% relative to BAU by 2020 and 2050. Linking ETSs would lower these cost estimates by just under 10%, or about 0.25% percentage points of income. Mitigation cost saving achieved through linking is found in this analysis to be quite low because there is relatively little heterogeneity in carbon prices across countries before linking. Furthermore, if some degree of carbon price convergence is already achieved through indirect linking of ETSs via the use of crediting mechanisms, the (additional) gains from explicit linking are reduced.

Linking ETSs enhances emission reductions in those schemes which had lower marginal abatement costs before linking (especially Russia), but these increases are offset by lower emission reductions in the others. On the whole, a scenario in which Annex I (industrialised) GHG emissions are cut unilaterally by 50% below 1990 levels by 2050, without or with linking, would still lead to increases in world emissions relative to 2005 levels and would, therefore, need to be rapidly tightened and/or supplemented with further action in non-Annex I countries in order to achieve ambitious emission reduction targets.

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- National intensity targets could increase GHG mitigation action by fast-growing emerging economies as they catch up with developed countries, without unduly constraining their economic growth prospects. Unlike absolute targets, intensity targets are measured in emissions per unit of output and are linked to future GDP. They would automatically adjust to unexpected growth trends and insure countries against the risk of unexpected increases in mitigation costs. Within a linked system, they would therefore stabilise the carbon price. However, they would require frequent government intervention to be met and would imply greater uncertainty about overall emission abatement. Over the longer term (in the context of a world ETS), another way to reflect economic development concerns would be to allocate absolute targets across countries linked to actual output and expected economic growth rates and to adjust them over time.
- However, although direct linking across schemes could be very beneficial for mitigation costs, it also creates incentives for participating countries to relax their target for future compliance periods (in order to become a permit seller). Also, when systems are linked, different design features (links to other emission trading and crediting schemes, safety valves, banking and borrowing provisions) can spread to the others, undermining environmental integrity. While some of these problems could be reduced by limiting linking for regions with low-quality permits or offsets (*e.g* by imposing discount factors on sellers, allowance import quota or tariffs), this could have several drawbacks. For example, it could trigger retaliation, and such mechanisms would need to be progressively removed as environmental integrity improved. A more cost-effective approach would be for all parties involved to reach agreement on key issues prior to linking, including on levels and/or procedures for setting future emission caps, the adoption of safety valves, and rules about future linking to other ETSs or crediting mechanisms.

Expanding the role of crediting mechanisms

A more indirect way of gradually building up an integrated world carbon market and lowering mitigation costs occurs when an ETS allows part of a region's emission reductions to be achieved in countries outside the ETS. This can occur through a crediting mechanism such as the Clean Development Mechanism (CDM), which is one of the flexibility mechanisms of the Kyoto Protocol. The CDM allows emission reduction projects in non-Annex I countries – *i.e.* developing countries, which have no GHG emission constraints – to earn certified emission reduction (CER) credits (or offsets), each equivalent to one tonne of CO_2eq. Annex I countries can buy these CERs and used them to meet part of their emission reduction commitments:

- The cost-saving potential for developed countries of well-functioning crediting mechanisms appears to be very large, reflecting the vast low-cost abatement potential in a number of developing countries. The same benchmark scenario as above was examined (each region of Annex I countries cuts its GHG emissions unilaterally by 50% below 1990 levels by 2050). This time 20% of Annex I emission reduction commitments were allowed to be met through cuts in non-Annex I countries. This would nearly halve mitigation costs in Annex I countries, and raising this cap on offset credit use from 20% to 50% would bring further benefits. Cost savings would be largest for the more carbon-intensive Annex I economies, such as Australia, New Zealand, Canada and Russia. China has the potential to be by far the largest seller, and the United States the largest buyer in the offset credit market, each of them accounting for about half of transactions by 2020.
- In theory, by lowering the carbon price differential between participating and non-participating countries, crediting mechanisms can also reduce carbon leakage and reduce competitiveness

concerns. However, whether crediting mechanisms reduce leakage in practice depends in part on how the baseline against which credits are granted is set.

These gains are unlikely to be fully reaped under the current CDM. Concerns about the latter include its environmental integrity (the difficulty of establishing that emission cuts are indeed "real, additional and verifiable"), and the fact that it may create perverse incentives for developing countries to increase emissions. Existing proposals to scale up the CDM, such as "programmatic", "sectoral" or even possibly "policy" CDMs, could reduce other problems, such as transaction costs and bottlenecks, but may not address these deeper problems. One approach might be to negotiate baselines today for the largest possible number of sectors for a sufficiently long time period (*e.g.* a decade), and to set these baselines below BAU emission levels. A long-term baseline would address the perverse incentive issue by ruling out the possibility that any future increase in emissions might, if offset by subsequent reductions, deliver CERs. It would also minimise the risk of leakage, especially if the number of countries and sectors covered would be large. Setting baselines below BAU levels might insure against over-estimating baseline emissions and the excess supply of CERs. The main weakness of this approach is that estimating and negotiating baselines simultaneously across a wide range of countries and sectors would involve significant methodological and political obstacles.

Another incentive problem is that the large financial inflows from which developing countries may benefit under a future CDM could undermine their willingness to take on binding emission commitments at a later stage. Agreement on CDM reform could therefore incorporate built-in phasing-out mechanisms under which developing countries would commit to increasingly stringent actions as their income levels increase. For instance, the sectoral and/or national baselines negotiated in the context of scaled-up CDM might be gradually tightened, and eventually converted into binding emission caps which could be expanded across sectors and lowered as financing for action through crediting mechanisms is removed.

A role for sectoral approaches

Sectoral approaches have been put forward as a way to broaden participation in emission reductions to developing countries. They could lower overall mitigation costs, facilitate international technology transfers, and are likely to require less institutional capacity than nation-wide targets. The argument is that a narrowly-focused agreement covering firms that share some characteristics and compete among themselves may be easier to achieve than broader agreements. Indeed, a relatively small number of sectors account for a large share of world emissions. For instance, the emissions of energy-intensive industries (EIIs) and the power sector together account for almost half of current world GHG emissions from fossil fuel combustion. International shipping and air transport, due to their transnational character, are another two industries where a sectoral approach could be useful.

Two types of sectoral approaches could play a useful role:

- *Binding sectoral targets,* under which some developing countries might cap the emissions or the emission intensity of key GHG-emitting sectors. A binding sectoral cap covering EIIs and the power sector in non-Annex I countries could substantially reduce emissions worldwide. Owing to the fast emissions growth expected in non-Annex I countries, a 20% emissions cut in these countries would achieve a larger reduction in world emissions (compared to a BAU scenario) than a 50% cut in Annex I countries. Linking a sectoral scheme covering non-Annex I countries to an Annex I economy-wide ETS would also bring an economic gain to participating countries as a whole, but could generate winners and losers. In order to ensure that the overall gain from linking is shared widely across participants, permit allocation rules might need to be adjusted upon linking.

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- *Sectoral crediting mechanisms,* which would reward emission cuts below a baseline in a specific sector. Given the rapid projected BAU emission growth in most developing countries, meeting ambitious world targets through sectoral crediting alone would not be feasible. Therefore sectoral crediting would have to evolve gradually into more binding arrangements such as sectoral caps, at least for key developing country emitters. In the transitory period during which sectoral crediting operates, baselines could be progressively tightened – *i.e.* set further below BAU emission levels – from one commitment period to the next. Sectoral crediting could even increase the income of developing countries and may, therefore, be easier to adopt. At the same time, it would raise many of the same limitations as other CDM reform options. If credits are granted to governments, ways would also need to be found to ensure that the price signal is effectively transferred to firms.

In the long run, however, to achieve ambitious global emission reductions at low cost, such approaches will need to be integrated in a unified, global carbon market, such as through the use of binding national caps with trading. By exploiting low-cost abatement opportunities in developing countries, both sectoral caps and sectoral crediting mechanisms have the potential to lower the cost of achieving a given global emissions target. If appropriately designed, they can also curb leakage and the competitiveness and output losses of EIIs in developed countries. Even so, both approaches would need to be ambitious in order to be environmentally effective. Other sectoral initiatives, such as voluntary, technology-oriented approaches can help diffuse cleaner technologies, but are unlikely to provide sufficient emission reduction incentives to individual firms as they put no explicit opportunity cost on carbon.

Regulating carbon markets

Carbon markets will naturally develop as more and more countries undertake mitigation actions. As they become large, institutions and rules will be needed to foster their development and to reduce the problems of linked systems of multiple independent and varied cap-and-trade schemes:

- An *ad hoc* framework may fail to reduce global emissions sufficiently. This environmental risk will ultimately have to be addressed through agreement on longer-term targets. Centralised institutions created to implement the UNFCCC and the Kyoto Protocol have a key role to play in building consensus.
- Compliance mechanisms at the national or regional level will also be needed. For example: i) a system of performance bonds under which governments would put some of their own bonds before the start of a compliance period into the hands of a compliance committee, which would then have the right to sell those bonds in the market in the event of compliance failure; or ii) a system of buyer liability, under which buyers would be liable for the poor quality of the permits or offsets they hold while, as a result, sellers would also face costs in the form of price discounts on future sales. This system ultimately rests on the willingness of (net) buying countries to enforce penalties on their domestic emitters, and would also require an independent international institution to assess permit and offset quality.
- The financial market institutions in charge of monitoring and regulating these markets need to be clearly identified. If inadequately regulated, the development of carbon derivative markets could become a source of financial instability. Unlike in other commodity markets, a majority of regulated firms will tend to hedge against the (one-sided) risk of carbon price increases. Therefore, financial traders will have to take the reverse position, bearing some of the net risk and playing a major role in the development of derivative markets. At the same time, one open issue is whether existing limits on the size of short positions in spot and derivative commodity

markets should also be set in emission permit markets, in order to limit the risk of sudden and/or unwarranted carbon price fluctuations. The creation of a working group of regulators could facilitate exchange of information about regulations, risks and harmonisation needs.

- Liquid spot markets and credible commitments on future emission levels or mitigation policies can foster the development of derivative markets, and lower the cost of insurance against carbon price uncertainty. Market liquidity risks could be limited by regular spot sales of permits that could be banked between compliance periods. Releasing longer-dated permits could signal the strength of government commitment and build a political constituency to support the continuation of mitigation action. However, it could also fragment the market and should, therefore, be only considered if the credibility of the scheme cannot be established otherwise.
- With a large proportion of transactions taking place in over-the-counter markets, the counterparty risk in carbon markets could become significant. Options to address this include expanding access to clearing houses and exchange trading, or specifying penalties for performance failures in contracts. If delivery failures were nevertheless to develop, they might reflect imbalances between supply and demand, which could be addressed though temporary lending of allowances by governments. More broadly, limiting the uncertainty around long-term commitments and the associated supply and demand for permits would also contain this risk.

How can the cost of abatement be lowered through technology policies?

Speeding up the emergence and deployment of low-carbon technologies will ultimately require increases in – and reallocation of – the financial resources channelled into energy-related R&D. However, average public energy-related R&D expenditure has declined dramatically across the OECD.

The impact of technological development on mitigation costs hinges crucially on the nature of R&D. When R&D leads to only minor improvements in energy efficiency, impacts on mitigation costs are only modest, especially under less stringent concentration targets which provide a lower stimulus to innovation. This reflects the declining marginal returns to R&D and low-carbon technology deployment, and the current availability of low-carbon options in the electricity sector (such as nuclear and, soon, carbon capture and storage). By contrast, if R&D were to lead to major new technologies – especially in transport and the non-electricity sector more broadly, where marginal abatement costs are higher – future mitigation costs could fall dramatically, by as much as 50% in 2050.

These issues are explored in Chapter 5 and the main conclusions are as follows:

- Pricing GHG emissions – including removing implicit emission subsidies such as fossil fuel energy subsidies – would increase the expected returns from R&D in low-carbon technologies. Future increases in carbon prices will have powerful effects on R&D spending and clean technology diffusion. For instance, setting a world carbon price path to stabilise overall GHG concentration at about 550 ppm CO_2eq in 2050 is estimated to quadruple energy R&D expenditures and investments in installing renewable power generation. Future carbon price expectations – and, therefore, climate policy credibility – are also crucial. R&D investment will be much higher under more stringent long-run concentration objectives, because these reflect higher expected future price increases.
- Specific policies aimed at boosting climate-friendly R&D may be needed in addition to carbon pricing for major breakthroughs in low-carbon technologies to occur. Carbon pricing does not

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address the large market failures undermining R&D in climate mitigation, such as incompatibility with existing infrastructure and weak intellectual property rights protection. Possible policies could include rewarding innovation through the use of "innovation prizes", and/or establishing a global fund for helping with technology transfers and rewarding innovations, *e.g.* by buying out the associated patents. A global fund to support R&D and/or low-carbon technology deployment could further reduce mitigation costs, in particular if it is a complement to pricing carbon. However, as indicated above, there is a risk that public support for installing existing technologies will lock-in potentially inefficient technologies for years to come.

- Relying on R&D policy *alone* (in the absence of a carbon price) would not be enough to reduce emissions sufficiently. Model simulations indicate that even under very large increases in spending and very high returns to R&D, CO_2 concentration would still rise continuously, reaching over 650 ppm by the end of the century, with overall GHG concentrations reaching more than 750 ppm CO_2eq.

How big are the regional incentives to participate in global mitigation action?

Ambitious mitigation action at the world level will require a coalition of countries to be built that is, i) environmentally effective (*i.e.* that can, in principle, achieve ambitious world targets even if non-participating countries take no mitigation action); ii) economically feasible (*i.e.* that can meet the target without inducing excessive mitigation costs); iii) delivers a net benefit to its member countries as a whole; and iv) provides each member country with sufficient incentives to participate. In Chapter 6, modeling analysis is used, first to identify the minimal size of a coalition for achieving a global GHG concentration target, and then to study the incentives for the main emitting regions to participate in the coalition. The main results are:

- Ambitious mitigation action would have net global benefits. This is the case even though the analysis does not include the large likely co-benefits from mitigation action (the positive implications of mitigation policies on other policy domains such as for instance, the reduction in local air pollution and its impact for human health, and the improvement of energy security and of biodiversity).
- Given the current emissions growth of a number of developing regions, achieving an overall GHG concentration target equal to (or below) 550 ppm CO_2eq will require significant action by all developed countries, as well as by China and India, by 2050. The coalition would also need to expand to the entire world (with the possible exception of Africa) by 2100. Smaller coalitions would not achieve that target.
- From an economic perspective, ensuring incentives for all emitting regions to participate in action will be challenging, because most of them are found to gain less individually from participating than from staying outside and benefiting from the abatement efforts of others ("free riding"). This is especially the case for countries where the mitigation costs from a world carbon price are relatively high and/or the expected damages from climate change are relatively low (Russia and other carbon-intensive, fossil fuel producing Eastern-European economies, Middle-Eastern countries and China).
- One powerful way to broaden country participation is through international financial transfers or other support (including financing for mitigation, R&D, and climate change adaptation, as well as through technology transfers and international trade policies). However, even with international transfers, it will be difficult to convince countries who gain the least to participate, while ensuring that nobody else incurs net losses. In order for the incentives to free ride to be

broadly overcome, it may therefore be necessary that a set of key regions be willing to accept relatively minor losses.

- In a situation where national emission caps were to be adopted by all participants, financial incentives to free-ride could be reduced through the allocation or negotiation of emission reduction commitments. For instance, compared with a world carbon tax (or a full permit auctioning) scenario, developing countries could gain significantly by 2050 from allocation rules under which their emission rights cover their business-as-usual emissions ("BAU" rule), or else are inversely related to their contribution to past cumulative emissions ("historical responsibility" rule). Developing countries would also usually benefit from rules based on population size ("per capita" rule) or GDP per capita ("ability to pay" rule), albeit to a somewhat lesser extent. All four rules – in particular the former two – would impose significant costs on developed countries, although these vary widely from country to country. Allocating emission rights across countries in a way that separates where the action occurs from who pays for it could help to secure participation of all major emitters. This would also help to ensure that abatement takes place wherever it is cheapest.

How to build political support for action?

In the lead up to the UNFCCC conference in Copenhagen at the end of 2009, several countries and the European Union have adopted, declared or suggested emission reduction targets for 2020. These targets, as well as the main instruments used currently to limit GHG emissions are reviewed in Chapter 7. Assuming that the more ambitious targets are implemented in a context of fully harmonised emissions trading schemes, they would together imply a 14% reduction of emissions in Annex I countries by 2020 from 1990 levels (including emission reductions through offsets in developing countries). Given projected growth in emissions in non-Annex I countries, world emissions in 2020 would still rise by more than 20% above their 2005 levels (compared to +35% in the BAU projection).

The declared targets and actions are therefore insufficient to put emissions onto a pathway that could keep temperature increases within 2°C above pre-industrial level, which is the objective recently supported by major developing and developed countries. And, even though ambitious stabilisation targets might still be achievable, they might imply far more significant efforts after 2020, at a higher cost and with a greater risk of potentially irreversible climate impacts. Hence, international climate policy action will need to evolve gradually to achieve more ambitious emissions reductions, including possibly through tighter targets as well as enhanced actions or commitments by developing country emitters. As also discussed in more details in Chapter 7, one way to support this evolution would be by improving international financial transfer mechanisms across countries. In addition to the allocation rules for emission rights mentioned above, such devices could include:

- International public funding to support mitigation actions in developing countries has gained prominence recently with a proliferation of multilateral funds and a number of bilateral initiatives. To enhance their effectiveness, these funds should be rationalised and targeted primarily at those emission sources and/or market imperfections not covered by other market-based financing mechanisms, and in a way to help leverage private sector investments.
- A cost-effective way to boost international deployment of clean technologies would be to remove policies that work against mitigation efforts, such as barriers to trade and foreign direct investment and weak intellectual property rights.
- Compared with technology transfers, R&D policies have received only limited attention in the international context thus far. Yet, previous analysis has found the rationale for policy

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intervention to be particularly strong in this area, due to both their large potential impact on future mitigation costs and the multiple market failures undermining them. Climate-related R&D could thus be better incorporated in the portfolio of activities of existing multilateral funds.

- Adaptation financing could be increased through a mix of domestic policy reforms, such as adequate pricing of water and ecosystems, and through international and national financing for relevant local public goods, including sea walls, flood defences, and disaster relief. For least developed countries, the Adaptation Fund will be particularly important to support these investments.

Political support for action will also likely be influenced by the perceived comparability of mitigation efforts across countries. Even though a broad range of factors need to be taken into account in comparing efforts, one way to do so is by assessing the emission reductions and the associated cost of action over a range of carbon taxes applied uniformly across all Annex 1 countries. The results reported in Chapter 7 suggest that both total costs and emission reductions achieved in 2020 compared with 1990 levels for a given uniform carbon price vary substantially across countries. Put differently, the carbon price required to bring emissions back to the 1990 level would be much higher in some countries than others.

A global post-2012 international climate policy framework

Countries are currently working together to agree how they might address climate change globally after 2012, when the first commitment period of the Kyoto Protocol comes to an end. A broad framework for international action is expected to be agreed at the UNFCCC Conference in Copenhagen. The main elements of the post-2012 framework are likely to include: quantified economy-wide targets for emissions reductions by developed countries; nationally appropriate actions to reduce GHG emissions by developing countries, reflecting the principle of common but differentiated responsibilities and respective capabilities; support for GHG mitigation action in developing countries, including finance, technology and capacity development; and measures to help countries, especially the most vulnerable least developed countries, to adapt to the climate change that is already locked-in.

How can the work reported in this book inform the climate policy framework? To summarise:

- Significant and cost-effective emission reductions in a post-2012 framework will require a mix of policy instruments. A carbon price should be applied as widely as possible across the major emitting countries and sectors, starting with the removal of fossil fuel subsidies. This book discusses the instruments and approaches that can be used to gradually build such an international carbon price, as well as the financing and support that might be provided to assist developing countries in their efforts to reduce emissions. But it also describes the other policies that will also be needed, such as support for R&D and technology diffusion, or targeted standards and regulations to help address market and information barriers.

- Developed countries have acknowledged that they should take the lead in reducing emissions, and a number of them have already declared or suggested emission reduction targets. However, on their own, these will be insufficient to achieve the ambitious reductions required to achieve a pathway consistent with keeping temperature increases below 2°C.

- Developing countries will need to increase their mitigation action and reduce their reliance on external financing as their national circumstances evolve. The post-2012 international framework will need to evolve over time to reflect changes in emission sources as well as the capability of different countries to undertake mitigation action. The future framework will need to be sufficiently flexible to adjust over time to reflect changing national circumstances, sectoral developments, and the developing understanding of the science of climate change.

- To ensure the political acceptability of any agreement, it will be essential to ensure a distribution of the burden of action that addresses free-riding incentives while being perceived as fair and equitable. This may imply that support for action is prioritised to those areas where it has the largest impact on world emissions and to those that need it most.

Notes

1. More specifically, the BAU projection assumes that no further action is taken to limit emissions beyond what had been done or planned by 2005. Hence, the baseline incorporates the effect of the EU emission trading scheme and assumes that it will be sustained in the future.

2. Including the 0.5°C rise above pre-industrial levels already observed.

3. For instance, under the same scenario that stabilises GHG concentration at 550 ppm, the cost in terms of lower GDP in 2050 relative to BAU would be around 15% in major oil-exporting countries, Russia and other non-EU Eastern European countries, and nearly 10% in China, as compared to around 2% or less in the United States, the European Union and Japan.

4. One exception is the United States, where the percentage reduction in GHG emissions per capita under this scenario would be comparable to that of Russia and China (around 70-75% below the BAU reference in 2050), and significantly higher than in the European Union or Japan (around 50%).

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