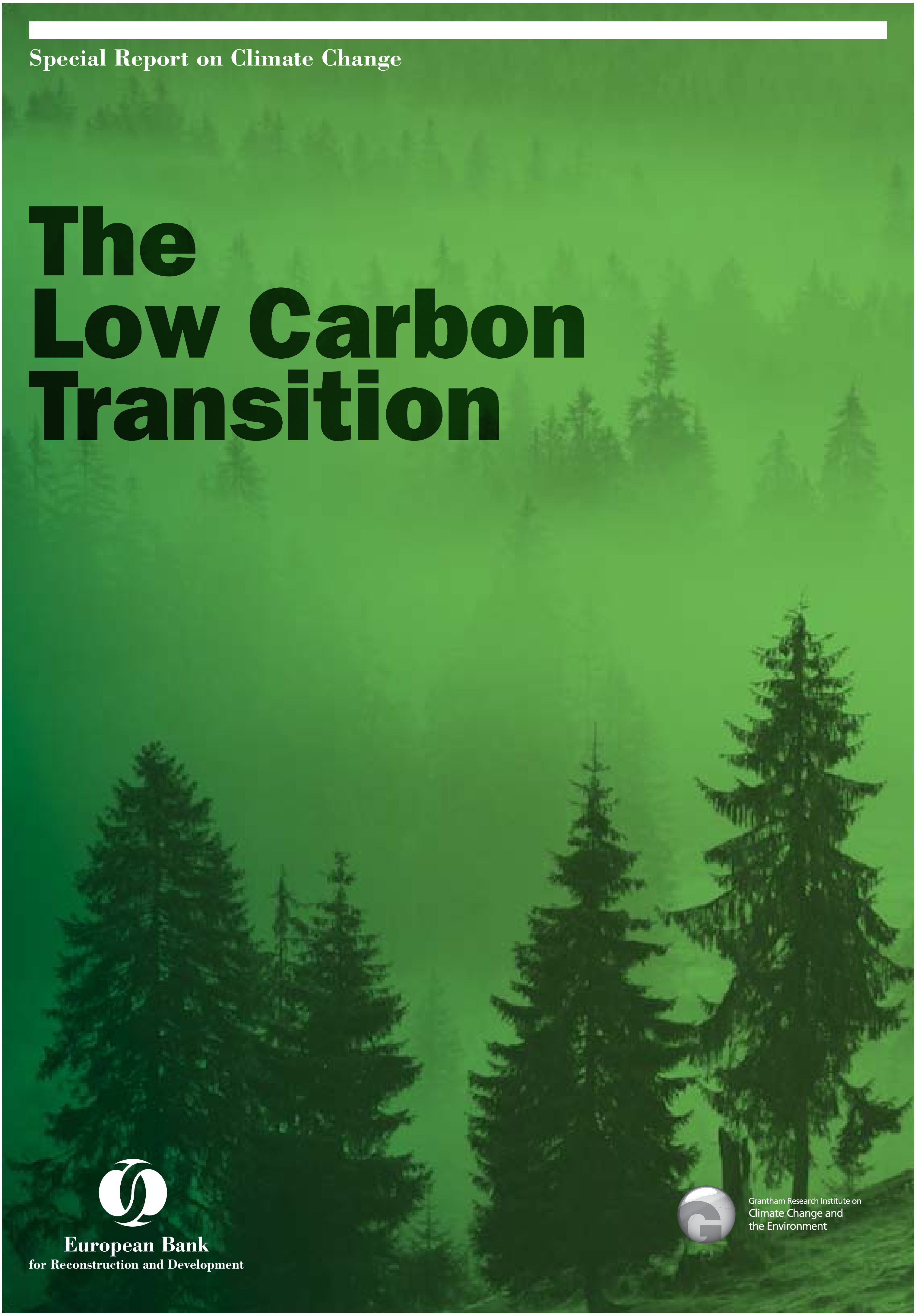
Special Report on Climate Change

The Low Carbon Transition



European Bank for Reconstruction and Development

Grantham Research Institute on Climate Change and the Environment

About this report

The EBRD is an international financial institution that supports projects from central Europe to central Asia. Investing primarily in private sector clients whose needs cannot fully be met by the market, the Bank fosters transition towards open and democratic market economies. In all its operations the EBRD follows the highest standards of corporate governance and sustainable development.

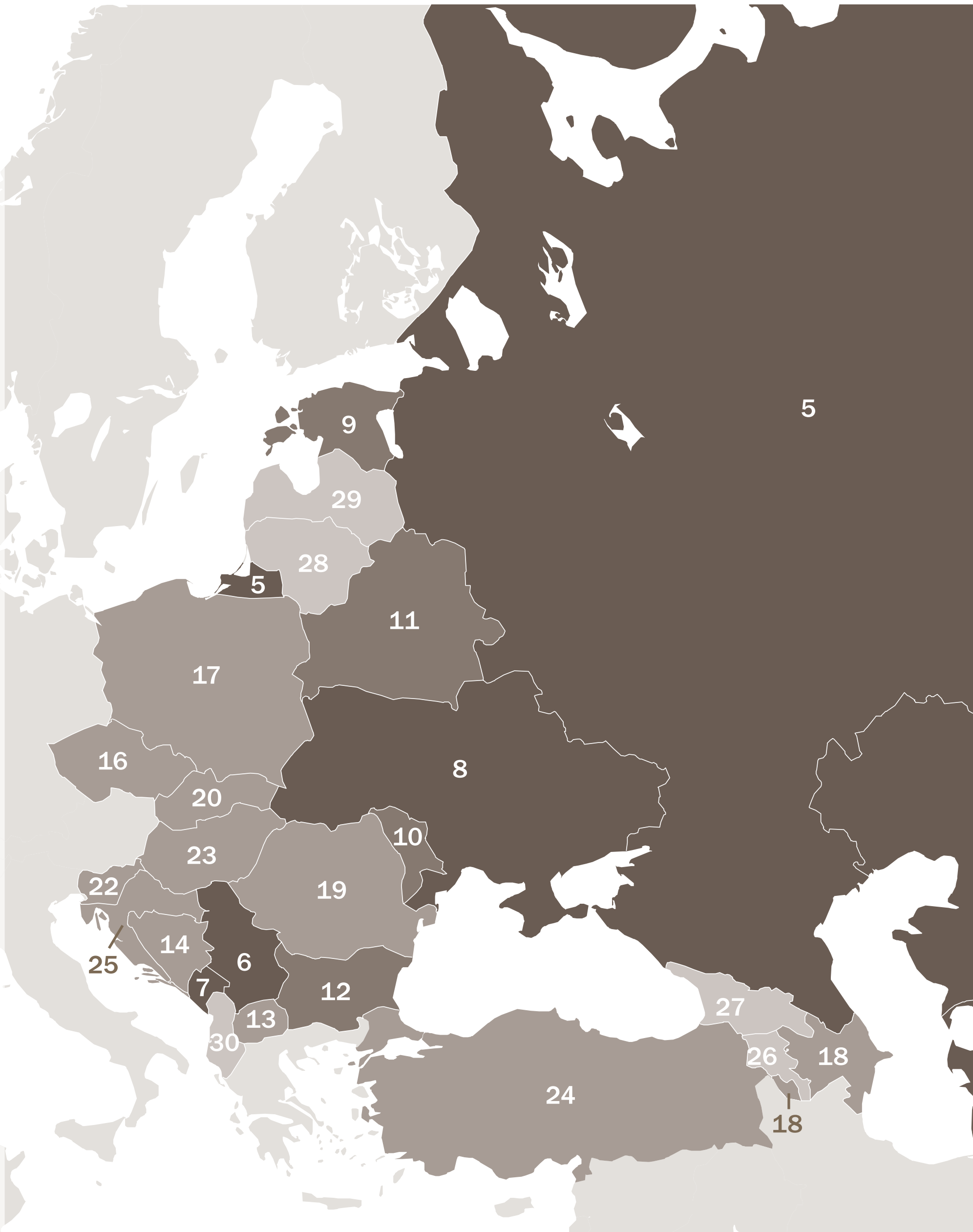
The Grantham Research Institute on Climate Change and the Environment is based at the London School of Economics and Political Science (LSE). Established in 2008, the Institute aims to generate world-class, policy-relevant research on climate change and the environment for academics, policy-makers, businesses, non-governmental organisations (NGOs), the media and the general public.

As the EBRD seeks to foster transition and promote entrepreneurship, it needs to analyse and understand the process of transition. The purpose of this Special Report on Low Carbon Transition is to advance understanding of climate change mitigation and to share this analysis with partners.

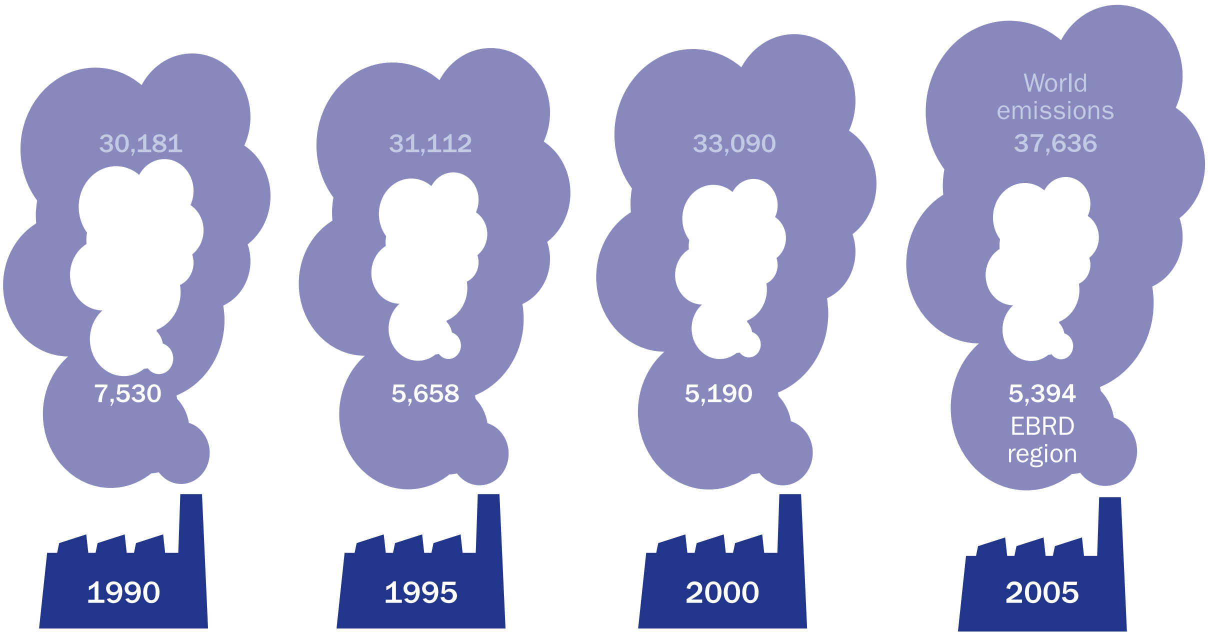
The responsibility for the content of the Special Report on Climate Change is taken by the Office of the Chief Economist at the EBRD and the Grantham Research Institute. The assessments and views expressed in this report are not necessarily those of the EBRD. All assessments and data in the Special Report on Climate Change are based on information as of early March 2011.

Carbon intensity of transition countries in 2008 (kg CO_2 from energy use per US$ of GDP in 2000 pri

1	Uzbekistan	1.87
2	Kazakhstan	1.53
3	Mongolia	1.51
4	Turkmenistan	1.02
5	Russia	0.97
6	Serbia	0.96
7	Montenegro	0.96
8	Ukraine	0.91
9	Estonia	0.78
10	Moldova	0.77
11	Belarus	0.71
	EBRD	**0.71**
12	Bulgaria	0.64
	China	**0.60**
13	FYR Macedonia	0.59
14	Bosnia and Herzegovina	0.57
15	Kyrgyz Republic	0.56
16	Czech Republic	0.54
17	Poland	0.53
	USA	**0.48**
18	Azerbaijan	0.42
19	Romania	0.41
20	Slovak Republic	0.38
21	Tajikistan	0.36
22	Slovenia	0.34
	India	**0.33**
23	Hungary	0.33
24	Turkey	0.32
25	Croatia	0.31
26	Armenia	0.29
	EU-15	**0.28**
27	Georgia	0.28
28	Lithuania	0.26
29	Latvia	0.24
30	Albania	0.22



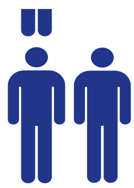
Total greenhouse gas emissions (Mt CO_2e)



CO_2 emissions

World

4.39

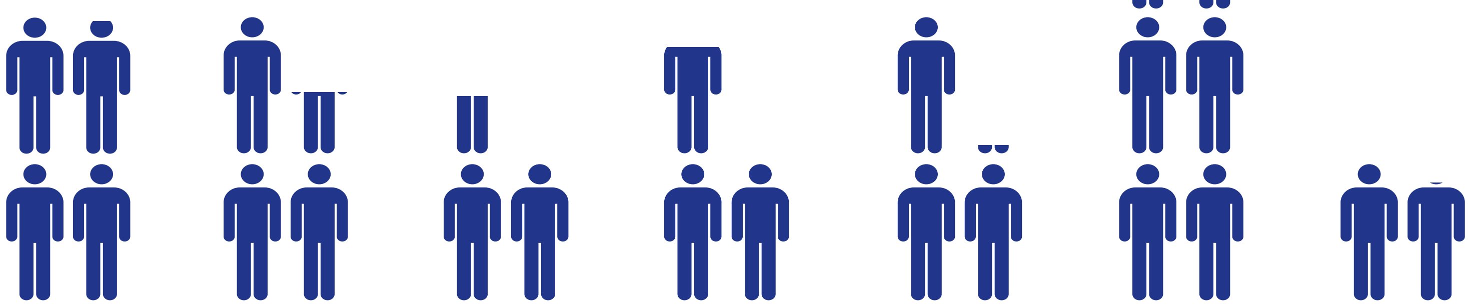


ces and PPP exchange rates)

per capita in 2008 (tonnes of CO_2 from energy use)

EU-15	Central Europe and the Baltic States	South-eastern Europe	Eastern Europe and the Caucasus	Central Asia and Mongolia	Russia	Turkey
7.94	6.95	4.84	5.55	6.12	11.24	3.71

= 2 tonnes of CO_2
(sustainable emissions target)



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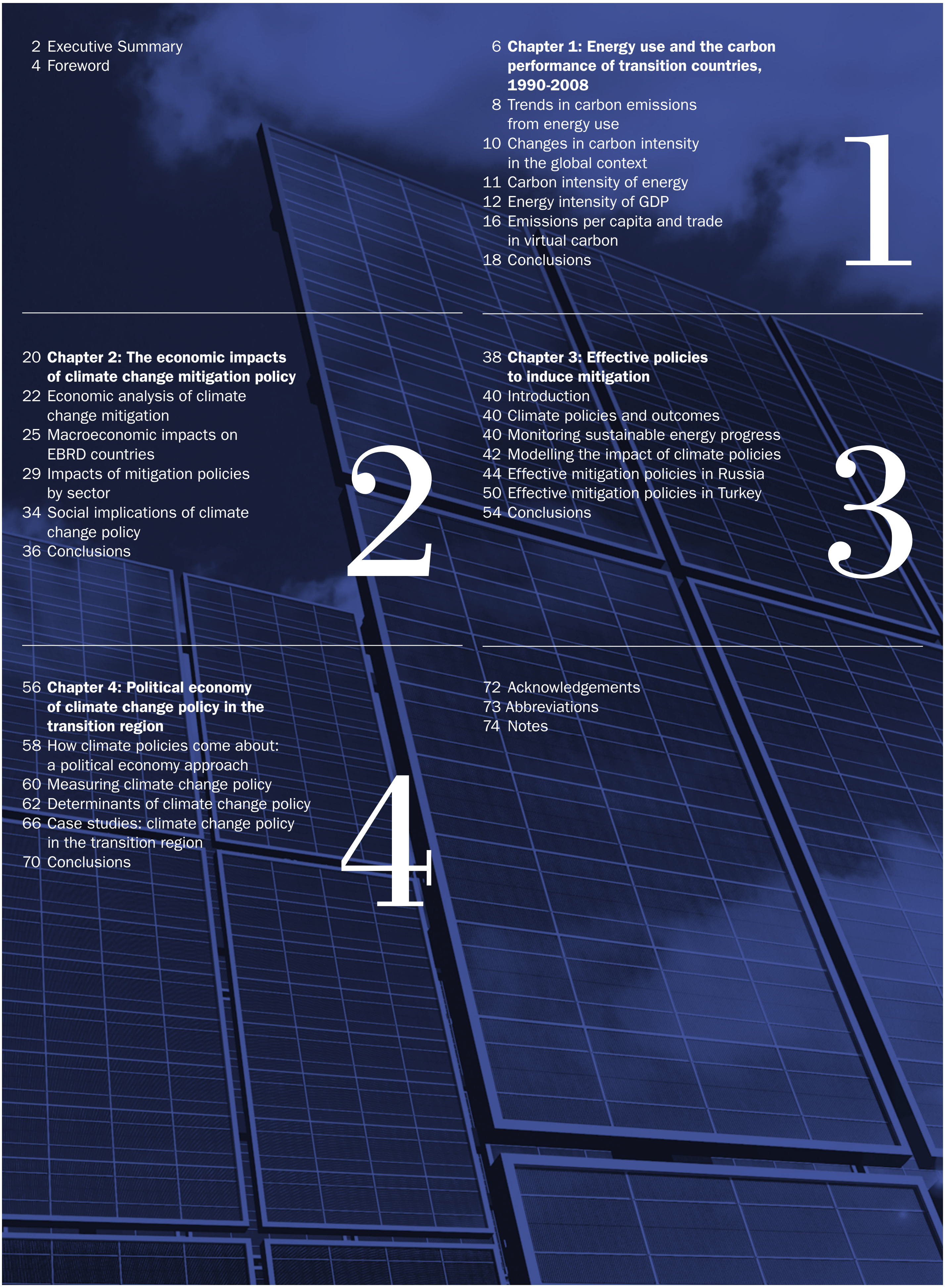
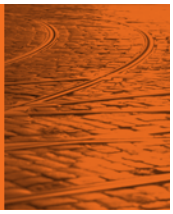


1



2

Energy use and the carbon performance of transition countries, 1990-2008

The EBRD region is the only major region in the world in which carbon emissions have fallen substantially – by about 28 per cent – between 1990 and 2008. This decline, which occurred notwithstanding an increase in real GDP by about 22 per cent over the same period, was a product of the transition from wasteful and energy-intensive planned economies toward market economies. Transition lead to both shifts to less carbon-intensive energy sources – in particular, increased usage of gas instead of coal – and most importantly lower energy usage per unit of GDP. The latter resulted both from deep energy efficiency improvements within economic sectors and (to a lesser extent) from structural change, that is, a shift from energy-intensive activities such as heavy industry to less energy-intensive activities such as services.

This said, there are large disparities both in changes in emissions between 1990 and 2008 – from a reduction of 56 per cent in Eastern Europe and the Caucasus (EEC) to an increase in emissions by 108 per cent in Turkey – and in 2008 emission levels per capita or per unit of GDP. Today, the region still includes some of the worst performers in the world in terms of carbon intensity (for example, Uzbekistan, Kazakhstan and Russia), as well as some countries, such as Latvia and Hungary, which are close to the global leaders in carbon or energy performance. The majority of the EBRD region remains carbon and energy intensive and there is much scope for further improvement.

Statistical analysis at the firm level reveals that private and foreign-owned firms tend to be more energy efficient than state-owned enterprises, and large firms more energy efficient than small firms. It also shows that there is a strong impact of energy prices on energy efficiency, suggesting that subsidy and tax policies that affect prices can have a large impact on emissions. These results are confirmed in country-level analysis, which also indicates that market-oriented reform and (for new EU members) the start of EU accession negotiations have played important roles in accelerating the improvement in carbon performance. ■

The economic impacts of climate change mitigation policy

Compared to a "business-as-usual scenario", mitigation policies consistent with global warming of no more than 2°C may entail economic costs, through three channels: (1) structural change toward less carbon-intensive production; (2) a reduction in the international demand for carbon-intensive goods (such as fossil fuels) that will hurt exporters of such goods; and (3) in a world with tradable carbon permits, the cost of purchasing (or revenues of selling) such emission rights. An "integrated assessment" model that analyses all three factors shows wide differences in mitigation costs within the EBRD region, with the lowest costs arising in new EU member states and higher costs in energy exporters. For the EBRD region as a whole, gross mitigation costs are halfway between those expected for advanced countries and those expected in the large energy exporters in the Middle East.

Although mitigation may be costly particularly for the energy exporters in the region, it is in the best interests of these countries to undertake mitigation policies, in order to adapt production and exports to the lower future global demand for fossil fuels and to maintain economic competitiveness. The sooner this occurs, the lower the costs of mitigation. Furthermore, decarbonisation is likely to offer significant benefits that are not fully captured by the models used to simulate mitigation costs. In addition to the obvious gains from reducing the risks of calamitous climate change, these benefits include higher long-run growth from lower resource dependence, technology spillovers associated with the development of alternative energy sources, and reduced distortions from energy subsidies and inadequate regulation of energy production and distribution.

Cost-effective climate change mitigation will entail structural change in the EBRD economies. These will be largest in the energy sector, where fossil-fuel production will have to shift away from oil, productivity will need to improve, renewable energy sources and technologies must be developed and carbon capture and storage needs to be deployed on a large scale. The industrial sector will need to reduce the share of the most energy-intensive industries. Elsewhere in the economy the pace of energy efficiency gains will need to be maintained or accelerated through improvements in the energy efficiency of industry and buildings and the carbon performance of transport.

Analysis for selected transition countries suggests that climate policies will not significantly reduce the affordability of electricity and gas for the average household, but may have a higher impact on the poorest households. Hence, climate policies need to be developed hand-in-hand with adequate social safety nets. ■

3

Effective policies to induce mitigation

What policies are most likely to make emission reductions attractive to profit-seeking investors? This question is analysed by extending a concept known as “marginal abatement cost” curves, which rank emission reduction opportunities across sectors of the economy in increasing order of relative costs. The analysis quantifies the impact of a range of policies – including removal of energy price subsidies, improvements in the business environment to reduce investment risks, direct support for renewable energy, and the introduction of an economy-wide carbon price – on the costs of abatement.

The analysis shows that the introduction of an economy-wide price on carbon would have a particularly powerful effect on emission reductions. This requires creating infrastructure that caps emissions and allows trade in carbon permits, which presently exists in the EU, but not in non-EU transition economies. In addition, general economic reforms that are not specifically targeted at climate change but would remove energy price distortions and improve the business environment also have a powerful effect in creating profitable abatement opportunities. Grasping these opportunities – many of which already exist – requires awareness-building and financing.

Detailed analysis for Russia and Turkey suggest that a portfolio of general economic and climate specific policies could turn carbon abatement into a major investment opportunity reaching potentially almost half of gross capital formation in Turkey and above 30 per cent in Russia. Profitable or zero cost abatement opportunities could exceed 1,100 $MtCO_2$ in Russia and 250 $MtCO_2$ in Turkey by 2030, equivalent to 45 per cent of the energy-related emissions in the EU-15 in 2008. The introduction of carbon taxes or auctioning emission permits would increase government revenue by 1 to 2 per cent in both countries.■

4

The political economy of climate policy in the transition region

Implementing climate change policy, even if it is economically beneficial, poses difficult political economy challenges. Domestic policymaking depends on the type of political regime – democratic or autocratic – as well as the relative strengths of the carbon-intensive and low-carbon industry lobbies, the role of the independent media and civil society agents, and the public’s broader political and economic preferences.

A new global index of Climate Laws, Institutions and Measures (CLIM), is used to compare the quality of domestic climate policies internationally, empirically assess which political factors drive policy, and find out whether the relationship between those factors and climate change policy outcomes is different in the transition region. The analysis shows that the level of democracy alone is not a major driver of climate policy adoption. Instead, public knowledge of climate change is a significant positive determinant of climate change policy adoption while the relative strength of carbon-intensive industry is a major deterrent, regardless of the level of democracy and administrative capacity in any given country. There is also evidence that emission reduction targets under the Kyoto Protocol and EU membership lead to better domestic climate policies. These factors appear to apply in transition countries and non-transition economies alike.

Accelerating the adoption of low-carbon policies at the level of individual countries may require different solutions in different countries, depending on the main political economy obstacle to better policies. However, some policy levers are likely to apply across countries, including entering international commitments, and educating public opinion and creating awareness of the risks associated with climate change and the economic benefits of mitigation.■

Foreword

> "It is in the long-term self-interest of the EBRD countries to be part of the energy-industrial revolution, adapt their economies and avoid being left behind."

Erik Berglöf
Chief Economist,
EBRD

Nicholas Stern
Chairman,
Grantham Research Institute on Climate Change and the Environment

The 2010 summer saw forest fires and poor harvests, the threat of a melting taiga and conflicts over diminishing water resources in the EBRD region. These served as a wakeup call; until then, the region had the lowest levels of public awareness of climate change in the world. This was a legacy, no doubt, of its history of central planning, with its cheap energy and chronic environmental neglect.

But despite the limited attention previously paid to climate change, no world region has reduced its output of greenhouse gases more radically over the last two decades than the countries in transition. Since 1990 regional greenhouse gas emissions from fuel combustion have fallen by 28 per cent.

The deep fall in emissions is to a large extent the result of an abysmal starting point. At the beginning of transition, energy and carbon intensities were substantially higher than anywhere else in the world. Emissions fell as a by-product of transition, as economic restructuring, price and regulatory reforms, pursuit of economic efficiency and greater respect for the environment began to take effect. Some countries switched from coal to natural gas, a cleaner and more efficient fuel. All this was, however, motivated by economic and air pollution considerations; climate change was not high on the agenda in the first decade of transition.

Chapter 1 of this report documents the region's considerable achievements. While regional greenhouse gas emissions began rising again after 2000, the rate of increase has been much lower than economic growth. The carbon performance of the leading countries in the region – Hungary, Latvia and Lithuania – has now caught up with the advanced economies of the EU-15. This demonstrates that a strong carbon performance is feasible with adequate reforms and good policies.

Yet the carbon performance of the EBRD region as a whole remains mixed. Kazakhstan, Russia, Turkmenistan, Ukraine, and Uzbekistan are among the most carbon-intensive countries in the world. In these countries, the polluting legacy of central planning is still pervasive.

Over the coming decades, transition countries will have to reduce emissions even further. Global emission reductions on the scale required will be impossible unless all major regions are involved. As members of the international community, EBRD countries will be expected to play their part.

However, the interest of transition countries in fighting climate change goes beyond international solidarity; they have much at

stake themselves. While other world regions – low-income countries in particular – may be worse hit by climate change, the transition countries will also suffer from the negative effects of climate change.

One cannot know for certain whether recent extreme weather events were the result of natural climate variability or human-induced climate change; the climate process involves both natural fluctuations and anthropogenic trends. But these events demonstrate that the region is vulnerable to the sort of calamities that climate change is likely to bring. Further – and here the region may be particularly vulnerable – unmanaged climate change would be likely to lead to major and disruptive movements of population, within the region and probably into the region.

The world is embarking on a new energy-industrial revolution that will see wholesale changes in economic activity, from what we consume to the ways in which we produce our goods. Established and emerging markets alike see new business opportunities in clean energy, low-carbon transport and carbon-efficient manufacturing.

The industrial revolution can and will happen everywhere, including agriculture and buildings. It is in the long-term self-interest of the EBRD countries to be part of this revolution, adapt their economies and avoid being left behind. The risk is not just falling behind technologically, but also in a decade or so of being shut out of markets if products are seen as "dirty" by countries and regions taking strong action.

Chapter 2 discusses the future decarbonisation challenges for the region. There is no denying that reducing emissions in countries with extensive fossil-fuel reserves and an energy-intensive industry base will be more costly in the short term than in already well-diversified economies. However, transition countries have the resources to transform their old and increasingly obsolete high-carbon capital into the low-carbon capital and human capital that will drive the new economies. Economic diversification in the energy-rich transition economies over the next two decades would lower the costs of reducing emissions.

In parallel, an adequate global collaboration arrangement would incentivise transition economies to take part in global climate change mitigation efforts, improve their access to clean technologies and facilitate their participation in emission-trading schemes that can further reduce the costs of decarbonisation.

Chapter 3 shows that with thoughtful policies it is possible to make emission reductions financially attractive and turn low-carbon technology into an opportunity for domestic and international investment. Many of the reforms that are needed are already on the policy agenda – and have been for years – and not all of them are specific to climate change. Implementing what is required includes broader economic reforms such as cost-reflective energy pricing, a better business environment and reduced transaction costs for investments in energy efficiency.

Improved general management and corporate governance have also proven to be powerful drivers of energy efficiency. Ultimately, the most important contribution to climate change mitigation will come from the economy-wide changes the EBRD was conceived to foster.

The most basic climate change policy is putting a price on carbon. Emissions trading and carbon pricing are powerful measures, not just to encourage emission reductions but to turn emission reduction into an engine for clean energy innovation. Businesses in the new European Union (EU) member states are already becoming accustomed to carbon pricing as members of the EU Emissions Trading Scheme (ETS). Elsewhere in the region, emission savings can be monetised by selling emission offsets on the international carbon market, through schemes such as Joint Implementation (JI) and the Clean Development Mechanism (CDM). The region has yet to take full advantage of the opportunities these mechanisms provide.

In the absence of well-functioning global carbon markets at the present time, an international carbon financing architecture is needed to encourage countries to start undertaking the necessary investments. The international financial institutions like the EBRD will play an important role in implementing these schemes and ensuring that the money is well spent. But the political feasibility of climate investment related grants from high to middle-income countries is limited and, as large as these grant funds may seem today, they are just a drop in the ocean if the EBRD region is to achieve mitigation objectives consistent with limiting global temperature increases to 2°C. Without functioning carbon markets or other mechanisms to generate predictable global prices for carbon emissions and dramatically improved policies the region will inevitably fall short.

Whilst these carbon markets and associated policies may be weak today, it would be unwise and risky to make investments with 10 or 20-year horizons on the assumption that policy structures will stay like this. Indeed it is more likely than not that over the next decade carbon markets and regulations will strengthen and tighten across the world, and dirty producers may find themselves shut out of markets. Both economically and environmentally, high carbon is a risky route to follow."

Good policy to make markets work well must, however, go way beyond carbon pricing. There are fundamental market failures, which good policy can correct, including on research and development, networks and infrastructure, capital markets and risk, property markets and information.

Political economy challenges can make some of the necessary reforms difficult to achieve. In particular, there are strong vested interests among incumbent industries. The short-term social costs of reform and economic adjustment costs due to higher energy prices can also be significant in the absence of well-functioning social support. It is important to recognise these problems, as they will require strong political leadership to overcome. We explore these in Chapter 4.

The public debate about climate change in the transition region is still at a relatively early stage. There are many misconceptions and the low-carbon agenda brings back memories of the painful early years of economic transition. The global debate is progressing much faster. Other countries, both established and emerging economies, are rapidly positioning themselves in the coming low-carbon world. But the EBRD region has the great advantage of understanding, through direct experience, the challenge and opportunity of a transition and the deep social and economic change it brings.

We hope that this Special Report on Climate Change – produced jointly by the EBRD's Office of the Chief Economist and the Grantham Research Institute at the London School of Economics – will further increase awareness of the challenges of climate change and help to stimulate and advance the debate about low-carbon prosperity in the transition region.

Chapter One
Energy use and the carbon performance of transition countries, 1990-2008

The EBRD region has significantly reduced its carbon emissions since 1990, but disparities among EBRD countries are substantial. The fall in carbon emissions in the region was not induced solely by the output collapse of the early 1990s; rapid improvements in carbon intensity have continued throughout the past two decades. But how does the EBRD region compare with the rest of the world? What reform measures were associated with the greatest improvements in carbon performance?

1

Energy use and the carbon performance of transition countries, 1990-2008

The EBRD region has witnessed a substantial reduction of carbon-dioxide (CO_2) emissions from energy use since 1990.[1] This year was chosen as the baseline for the emissions cuts agreed in the Kyoto Protocol. It is also when the countries of eastern Central Europe began the transition from central planning to market economies. This reduction in emissions, which contrasts with the steady worldwide rise over the same period, was initially triggered by the collapse of output in the formerly planned economies. However, it continued until the early 2000s even after output recovered. Since the early 2000s, regional emissions have started to rise again, reaching by 2008 the same level observed in the mid-1970s. However, they remain substantially lower than in the Kyoto Protocol base year of 1990.

What were the main drivers behind these large changes in energy-related CO_2 emissions, since the beginning of the transition? This chapter reviews emissions trends and the main driving forces behind them, including the region's carbon intensity of GDP (carbon emissions per unit of GDP), its energy intensity (energy use per unit of GDP), and per capita emissions.[2] It compares the performance of the EBRD region with three other economic regions – China, the US and the EU-15 countries[3] – as well as developments in sub-regions and countries within the EBRD region. It analyses the role of sectoral shifts – from less to more energy- or carbon-efficient sectors – with that of within-sector efficiency improvements.

The chapter then explores firm-level characteristics associated with better energy performance, and shows that there is a link between specific policies and improved energy and carbon performance at the country level.

Finally, the chapter explores trade-related aspects of carbon performance, using estimates of carbon embodied in internationally traded goods and services to compare production-based and consumption-based carbon emissions, and reveal the 'balance of trade' in virtual carbon between EBRD countries and their trading partners.

Trends in carbon emissions from energy use

The EBRD region started the transition from central planning to market economies with a highly distorted economic structure, one strongly focused on energy-intensive production. This was a legacy of the generous endowment of fossil fuel resources in the former Soviet Union, and exacerbated by an economic coordination mechanism that substantially underpriced energy and did not encourage its efficient use. Table 1.1 compares the annual average growth of energy-related CO_2 emissions in the EBRD region with other economic regions.[4]

Table 1.1
CO_2 emissions from fossil fuel use 1971-2008

	Annual average growth				Aggregate
	1971-1990	1990-2000	2000-2008	1990-2008	1990-2008
World	2.1%	1.1%	2.8%	2.0%	40.1%
US	0.7%	1.6%	-0.2%	0.8%	14.9%
China	5.5%	3.2%	9.9%	6.5%	191.9%
EU-15	0.2%	0.2%	0.0%	0.1%	1.8%
EBRD	3.0%	-4.2%	1.2%	-1.9%	-27.9%
OECD Total	0.9%	1.2%	0.2%	0.8%	14.4%
Non-OECD Total	4.2%	0.9%	5.6%	3.1%	68.9%

Source: IEA and EBRD calculations.
Note: Data for 1971-1990 is presented just as a comparison, as the data availability pre-1990 does not allow a meaningful assessment of energy and carbon emissions performance.

During 1971-1990, the two decades before the collapse of central planning, emissions in the EBRD region grew at an annual average of 3 per cent. This was slower than in China, but faster than the world average and much faster than in the US or the EU-15. Since the beginning of transition in 1990, emissions have declined substantially in the EBRD region in contrast to the fast-growing emissions in other regions of the world, particularly in the non-OECD countries. During the transition period, emissions fell sharply in the first decade 1990-2000 and rose moderately in 2000-2008. By 2008, EBRD carbon emissions were almost 28 per cent below their 1990 level.[5]

Drivers of emissions reductions

To help understand what drove these trends, the aggregate emissions (C) of a country can be decomposed into three contributing factors: population size, income per capita, and the carbon intensity of GDP.[6] These are expressed in the following identity:

$$C = \frac{C}{GDP} \times \frac{GDP}{Pop} \times Pop.^{7}$$

This identity allows a closer examination of the factors driving the carbon performance of countries and regions. It combines the size of the country (measured by population) with the level of economic activity (as measured by per capita GDP[8]) and a carbon performance indicator (which measures the amount of emissions per unit of GDP). This derives the change in emissions over time from the changes in these underlying factors. It is therefore possible to have both income growth and population growth with

[1] The principal gases associated with climate change are carbon dioxide (CO_2), methane and nitrous oxide, which together accounted for over 99 per cent of global anthropogenic greenhouse gas emissions in 2005 (OECD, 2008). While activities such as agriculture, industrial processes, waste, land use and land-use change all generate greenhouse gases, energy-related emissions account for over 80 per cent of the anthropogenic greenhouse gases in Kyoto Annex-I countries (IEA, 2010). Of all energy-related greenhouse gases, CO_2 accounts for about 94 per cent. The picture varies, however, across countries: emissions in high-income countries are largely dominated by power and transport, while agriculture and land-use change are the leading contributors in low-income countries. In middle-income countries, power, industry and land-use changes are the largest sources, with emissions from land-use change, namely deforestation of tropical forests, mostly concentrated in a handful of countries (World Bank, 2010).

[2] All data on energy-related CO_2 emissions presented in this chapter were drawn from IEA (2010) by using Sectoral Approach (SA) inventories. SA estimates account for all emissions from fuel combustion and do not include fugitive emissions as leakage or evaporation in the production and/or transformation stage (e.g. from oil refineries). As pointed out by the IEA, SA inventories may differ from countries' official UNFCCC submissions.

[3] Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, The Netherlands, Portugal, Spain, Sweden and the United Kingdom.

[4] Data for 1971-1990 is presented for comparison purposes. The availability of pre-1990 data does not allow a meaningful assessment of energy and carbon emissions performance.

[5] This reduction in emissions in the EBRD region (1.293 $GtCO_2$) is equivalent to the total energy-related emissions of France, Italy and the United Kingdom in 2008 and exceeds the annual energy-related emissions of Japan in 2008.

stable, or even declining, total emissions, provided that the carbon intensity of GDP declines at least as fast as GDP grows.

Decomposing emissions into these components[9] reveals very different driving factors over the past two decades of transition (Chart 1.1). Broadly speaking, the 18 years of data can be split into three distinctive periods:[10]

- In the initial period (1990-1996), emission declines were determined mainly by the collapse in economic activity.

- Between 1996 and 2002, the economy expanded while carbon emissions continued to decline – an absolute decoupling of emissions and growth, as carbon intensity was declining faster than GDP was growing.

- The period 2002-2008 corresponds to a relative decoupling of emissions and growth. Although the improvement in carbon intensity was even faster than in the previous six years, a 40 per cent increase in income led to a 10 per cent increase in carbon emissions.

The effects of changes in population were modest in the EBRD region as a whole – population growth contributed only one per cent to changes in carbon emissions over the entire period 1990-2008. Overall, in the absence of the observed improvements in carbon productivity, the total energy-related carbon emissions in the EBRD region would have increased by 24.2 per cent in 1990-2008; in fact, they fell by 27.9 per cent precisely due to such improvements.

Decomposition by sub-region

A decomposition of these trends by sub-region depicts a more nuanced picture (Chart 1.2). For the period 1990-1996, during which the largest fall in regional output occurred, the reduction in the carbon intensity of GDP in Central Europe and the Baltic States (CEB) and South-Eastern Europe (SEE) was the main driver of carbon-emission reductions. In contrast, the countries of the former Soviet Union initially experienced a further increase in the carbon intensity of their GDP. In these countries, the reduction in emissions between 1990 and 1996 was entirely driven by the collapse of their outputs.

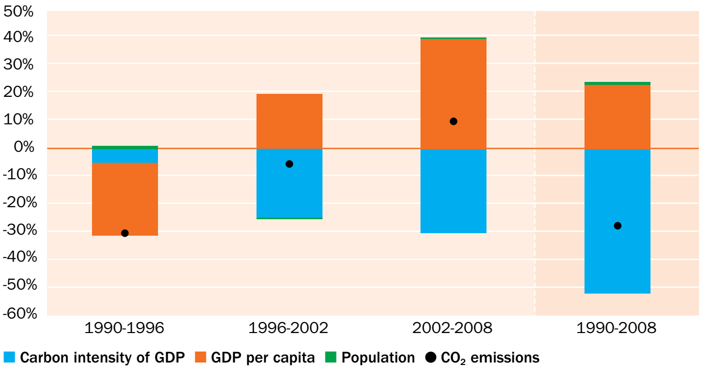
The middle period (1996-2002) is associated with an absolute decoupling of carbon emissions from income growth throughout the transition region. All sub-regions experienced significant income growth during this period. The reduction in the carbon intensity of GDP was strongest in CEB, Eastern Europe and the Caucasus (EEC), and Central Asia and Mongolia (CAM). Net carbon emissions registered a double-digit decline in CEB, SEE and EEC, reduced by a more modest 3.4 per cent in Russia, and moderately increased in Turkey and CAM.

This absolute decoupling ended in the early 2000s. However, the EBRD region as a whole still managed to partly offset the effects of economic growth, by further reducing the carbon intensity of GDP after 2002. This period can be referred to as relative decoupling, as carbon emissions increased substantially less than income growth in all the former socialist countries. In the absence of reductions in the carbon intensity of GDP, total regional emissions would have been almost 41 per cent higher during this period, instead of the actual 10 per cent increase.

Turkey has followed a different emissions path from the rest of the region. The country did not experience the output fall and subsequent restructuring process that characterised the formerly planned economies. Moreover, Turkey, over the entire period, did not achieve any reductions in the carbon intensity of its GDP. As a result, carbon emissions, boosted by strong population and income growth, increased by 108 per cent. This figure places Turkey among the world economies with the largest emissions growth since

Chart 1.1
Decomposition of CO_2 emission changes in the EBRD region

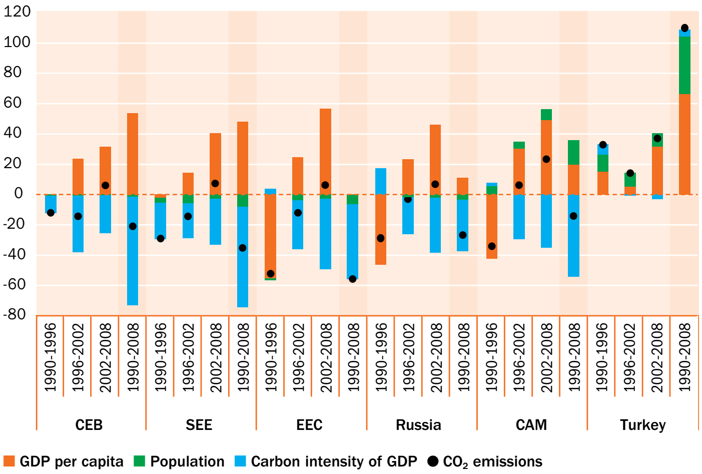
Causes of percentage change in CO_2 emissions



Source: IEA, EBRD calculations.

Chart 1.2
Decomposition of CO_2 emission changes 1990-2008

Causes of percentage change in CO_2 emissions



Source: IEA, EBRD calculations.

[6] The equation is a variation of the IPAT equation. This was developed in the early 1970s to describe the multiplicative contributions of population, affluence and technology to environmental Impact. Many variants of the IPAT equation have been used to decompose energy-related CO_2 emissions. For example, the climate change literature refers to the Kaya identity, in which emissions are usually expressed as the product of population, per capita GDP, the amount of energy produced per unit of GDP (the energy intensity of GDP) and the amount of carbon emitted per unit of energy produced ("carbon intensity of the fuel mix"). This chapter uses a reduced version of the Kaya identity, breaking emissions into three general categories: population, per capita GDP (valued using constant purchasing power parity dollars, GDP), and the amount of carbon emitted per unit of GDP.

[7] In the context of energy-related emissions, the carbon intensity of GDP (C/GDP) is often further disaggregated into the carbon intensity of energy (C/E) and the energy intensity of GDP (E/GDP). We will use this further disaggregation in the next section.

[8] Throughout this chapter, unless otherwise specified, we use purchasing power parity exchange rate measurements of GDP to account for both the tradable and non-tradable sectors that make up the economy.

[9] The results presented here are based on the complete decomposition model proposed by Sun (1998) which provides a method for factor analysis allowing us to link, in an additive form without residuals, changes in the emissions to changes in each of the contributing factors.

[10] Sensitivity analysis on the split of the three sub-periods does not alter the results significantly.

1990. This is partly because Turkey was already one of the most carbon-efficient economies, even in comparison to mature market economies. Thus, the room for improvement in the carbon intensity of GDP was and remains modest in comparison with the other EBRD countries.

Changes in carbon intensity in the global context

Across much of the world, reductions in carbon intensity have not been enough to offset the increase in CO_2 emissions associated with economic growth. In this global context, the EBRD region has outperformed world trends. However, with some notable exceptions, transition countries remain much more carbon intensive on average than either advanced economies or emerging markets like China.

Between 1990 and 2008, the EBRD region, as a whole, reduced the carbon intensity of GDP by 45.2 per cent. This was broadly similar to that achieved by China (48.1 per cent). As Chart 1.3 illustrates, the carbon performance of the EBRD region in the first half of the 1990s was worse than in the US and EU-15, and the world as a whole. However, since 1996 the transition economies have substantially outperformed the world and the mature market economies. Between 2002 and 2008, the EBRD region even outperformed China.

One reason for the weak decoupling of worldwide emissions from economic growth is that the carbon intensity of energy – as measured by the amount of CO_2 emissions per unit of total primary energy supply (TPES)[11] – has remained almost constant (Chart 1.4). This reflects a global energy supply that is still largely reliant on fossil fuels and, in recent years, an increase in the carbon intensity of energy due to increased use of coal.

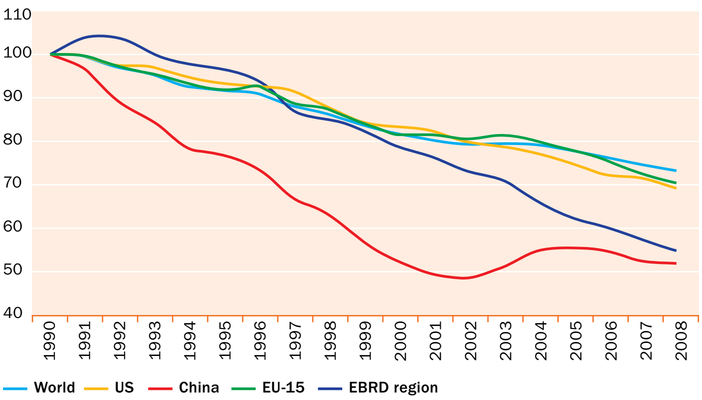
While the energy intensity of world economic output (TPES/GDP) fell by 27 per cent from 1990 to 2008, the global carbon intensity of energy (C/TPES) increased by 0.3 per cent. The first of these developments – a decline in the energy intensity of output – reflects global trends, with advances in the EBRD region and China even outpacing the relatively fast improvements in the advanced market economies of the US and the EU-15. In contrast, the relative stability in the carbon intensity of energy at the global level between 1990 and 2008 conceals very different trends among the regions. In some developing countries, the carbon intensity of energy increased – by almost 20 per cent in China, for example.

The EBRD region as a whole has achieved a very significant decline in the carbon intensity of its GDP through a balanced mix of improvements in both the energy intensity of economic output (- 40 per cent) and in the carbon intensity of energy (- 8 per cent). This is akin to developments in the US and the EU-15, but different to China, where the beneficial effects of the reduction of the energy intensity of GDP have been partly eroded by the increase in the carbon intensity of energy. In absolute terms, the carbon intensity of energy in the EBRD region stood at 2.46 tonnes of CO_2 per tonne oil equivalent (toe). This is comparable to the US (2.47), much lower than China (3.08), but higher than the EU-15 (2.16).

Again, a closer look at trends within the EBRD region reveals substantial differences among countries. For example, the reduction in the carbon intensity of energy contributed to about 40 per cent of the total reduction in the carbon intensity of GDP in Ukraine; in Poland, it accounted for only about 14 per cent, with the rest being a result of the sharp decline in the energy intensity of GDP. In Turkey, the only country in the region that experienced a small increase in the carbon intensity of GDP over the entire period, the increase in the carbon intensity of energy has largely offset the effects of a slight decline in the energy intensity of GDP.

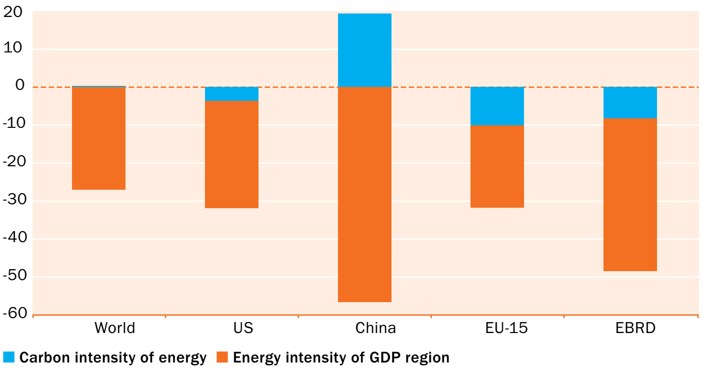
Despite improvements over the past two decades, the EBRD region as a whole remains one of the most carbon-intensive regions in the world. It is also one of the regions with the largest variations in the carbon intensities of GDP among its countries (Chart 1.5). The average amount of energy-related emissions per unit of GDP in the EBRD region is about two and a half times that of the EU-15 and 50 per cent higher than the world average. Several transition countries – Kazakhstan, Russia, Ukraine and Uzbekistan – still produce between 50 and 200 per cent more CO_2 per unit of GDP than China.

Chart 1.3
Carbon intensity of GDP



Source: IEA, EBRD calculations.
Note: The carbon intensity of GDP (in tCO_2 per thousand US$ GDP in constant 2000 prices at PPP exchange rates) in 1990 is the reference scenario (100).

Chart 1.4
Decomposition of carbon intensity changes 1990–2008



Source: IEA, EBRD calculations.

[11] The IEA (2010) defines TPES as the production of primary energy (i.e. hard coal, lignite/brown coal, peat, crude oil, natural gas, combustible renewables and waste, nuclear, hydro, geothermal, solar and the heat from heat pumps that is extracted from the ambient environment), calculated after the removal of impurities (e.g. sulphur from natural gas) + imports – exports – international marine bunkers ± stock changes.

However, in the course of the transition, some countries have managed to reduce their carbon footprints by achieving levels of carbon intensity that are now well below the world average. In some cases, these levels are close to, or even lower than, those of advanced market economies.

The rest of this chapter looks at the main drivers behind these developments in more detail.

Carbon intensity of energy

Changes in the fuel mix have played a lesser role than declining energy intensity of GDP in bringing down the carbon intensity of GDP in the EBRD region. However, a closer look at the carbon intensity of energy shows some interesting patterns.

The reduction in the carbon intensity of energy in the EBRD region has been driven largely by a shift away from coal and oil, which are carbon intensive, towards more natural gas and, to a smaller extent, nuclear power and renewable sources (Chart 1.6).

A key factor in the decarbonisation of the energy supply was the decline in the energy demand for carbon-intensive fuels for industry and power generation. Essentially this has decreased the demand for coal-based power and heat generation.

This trend was most pronounced in the countries of the former Soviet Union, where substantial coal-based power and heat generation capacities are no longer in use. In contrast, the fall in demand for coal-based power generation in CEB was moderate and the rapid growth in the transport sector was mainly met through oil products. Additionally, many EBRD countries commissioned significant new gas facilities and some nuclear power generation facilities. This led to a further displacement of coal. In Turkey, energy demand grew rapidly and was met with increased gas supplies.

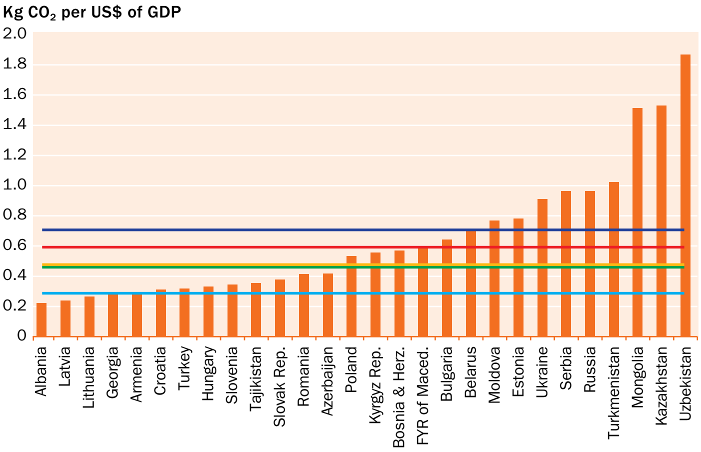
Consequently the share of fuels in the primary supply – which largely dictates the carbon intensity of energy – has changed substantially. Natural gas use increased substantially in the fuel mix – by more than 20 percentage points in Turkey and CAM, about 10 percentage points in Russia and EEC, and by 4 percentage points in CEB. The share of natural gas only decreased in SEE, where access to the regional pipeline network remains inadequate.

The share of nuclear energy increased in the sub-regions that traditionally used nuclear power (except CAM and Turkey). This is partly due to the commissioning of new nuclear power generation facilities (e.g. in Romania, Russia and Ukraine). Hydropower accounted for about 2 per cent of the fuel mix in 2007 (compared to 1.5 per cent in 1990), but hydropower is the dominant source of electricity in countries with rich water resources, such as Albania, the Kyrgyz Republic and Tajikistan.

The fuel shares of coal and oil have declined, by 5 and 7 percentage points respectively, for the whole EBRD region. The share of coal declined substantially in CEB (more than 13 percentage points), but increased in SEE (by 3 percentage points). The share of oil decreased dramatically in EEC (15.6 percentage points), Turkey (13.7), Russia (10.8) and CAM (10.9). This reflects primarily a decline in the use of oil for transport and to generate power and heat.

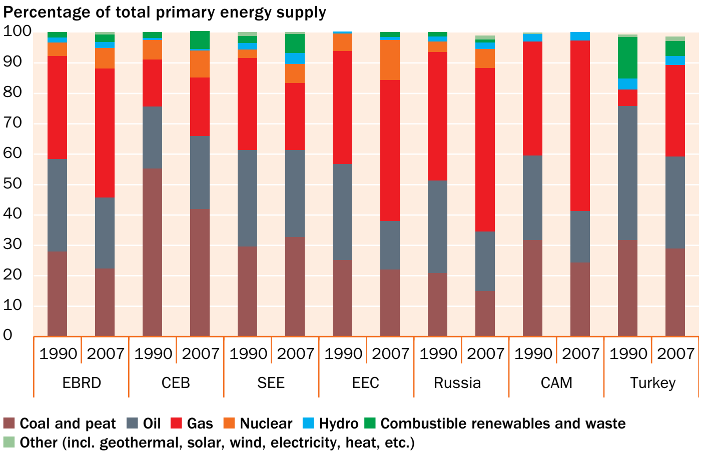
By contrast, the share of oil declined by a modest 3 percentage points in SEE, where the fall in use of heavy fuel oil for power generation was partially offset by increased demand for oil products in the road transportation sector. In CEB, the fuel share of oil increased by 3.6 percentage points, largely due to expansion in the transport sector. Combustible renewable sources, such as waste and biomass, reached a non-negligible share in CEB and SEE by 2007. By contrast, the share of combustible renewables and waste in Turkey declined by 8.6 percentage points, in a context of rising energy demand that was mostly met by fossil fuels.

Chart 1.5
Carbon intensity of GDP in 2008



Source: IEA, EBRD calculations.
Note: GDP in PPP exchange rates and 2000 prices.

Chart 1.6
Fuel shares in transition economies



Source: IEA, EBRD calculations.
Note: The sum may not add up to 100 in the case of high net electricity exports in the 'Other' category.

Energy intensity of GDP

About two-thirds of the reduction of the carbon intensity of GDP in the EBRD region can be attributed to reductions in energy intensity. The energy intensity of GDP is determined largely by the structure of each economy and encapsulates a wide range of driving forces, ranging from domestic resource endowments to the energy policy landscape characterising each economy.

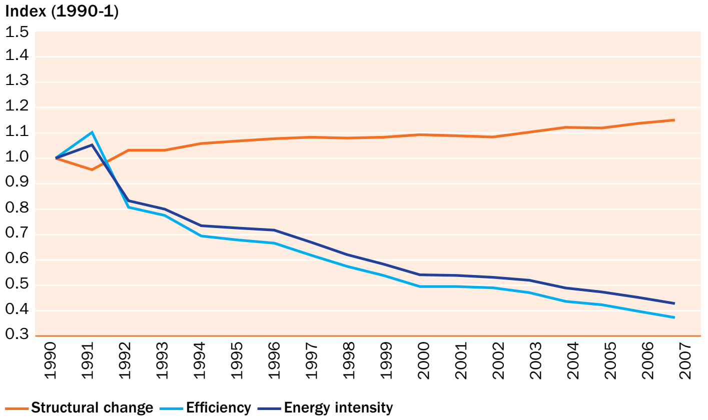
Energy intensity and economic structure

A reduction in the energy intensity of GDP can be traced back to two main sources – structural change (shifts towards less energy-intensive economic activities) and reductions in sector-level energy intensities (the amount of energy used to produce a unit of sector GDP). This second source reflects more fundamental improvements in energy efficiency throughout the economy.

We employ a standard decomposition method to attribute changes in energy intensity to structural changes in the sectoral composition of GDP (keeping the energy efficiency constant), and efficiency changes in the energy intensity of value added (keeping the sector structure constant).[12] The data do not allow for a direct comparison with the energy intensity data presented in the previous sections.[13] However, the analysis sheds light on the relative contributions of structural change and intrinsic efficiency improvements in the context of deep and far-reaching changes in the formerly planned economies of the EBRD region. This is particularly relevant in the context of transition, as central planning led to both distortions in the sector structure of the economies and intrinsic inefficiencies in the use of energy.

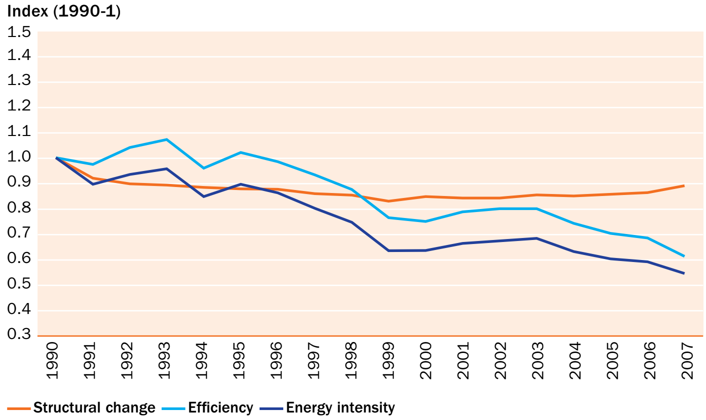
Charts 1.7a to 1.7f show the results of this decomposition. They reveal that improvements in intrinsic efficiency dominate structural changes across most of the EBRD regions. Over the period 1990-1997, efficiency improved in most transition regions, typically by about 40 per cent. Important exceptions are CEB, with an improvement of more than 60 per cent, and Turkey, which recorded no improvement in energy intensity. This reflects Turkey's less distorted legacy and low energy intensity from the beginning of the period.

Chart 1.7a
The decomposition of energy intensity – CEB



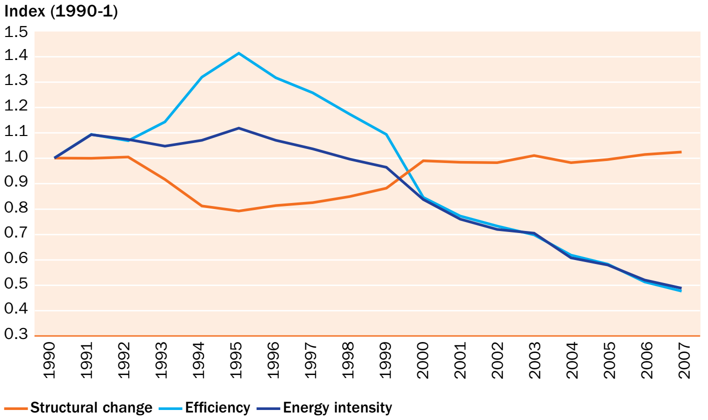
Source: UN, IEA, EBRD calculations.

Chart 1.7b
The decomposition of energy intensity – SEE



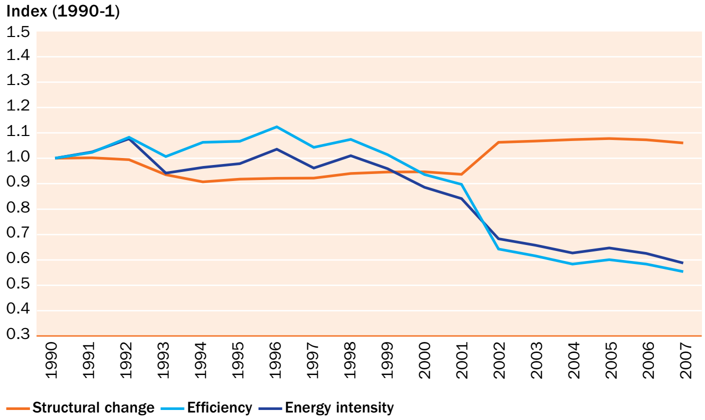
Source: UN, IEA, EBRD calculations.

Chart 1.7c
The decomposition of energy intensity – EEC



Source: UN, IEA, EBRD calculations.

Chart 1.7d
The decomposition of energy intensity – Russia



Source: UN, IEA, EBRD calculations.

[12] Metcalf (2008) has more details on this method – the so-called Fisher Ideal Index. We use UN data on sectoral value added in US$ in market exchange rates in constant 1990 prices and country energy balances to allocate energy use to each sector. The economy is disaggregated into five sectors: Agriculture, Construction, Industry, Services and Transport. The sectoral energy data was aggregated in the following way to match value added data: "Agriculture" includes energy data for Agriculture, Forestry and Fishing. "Industry" includes energy consumption in the Industry sector (including Mining but excluding Construction) and the entire transformation sector. "Construction" and "Transport" match the energy balances data, whereas the "Service" sector is formed by energy data for Other Sectors excluding Residential, Agriculture and Fishing. The energy data comes from the IEA Energy Balances 2009.

[13] The previous sections use GDP data in purchasing power parity in US$ constant 2000 prices. Here, value-added data is used in market exchange rates in US$ 1990 constant prices. However, the trends and magnitude of changes in energy intensity in 1990-2007 are very similar.

In terms of structural changes, the picture is more diverse. Only in SEE is there evidence that the structure of the economies moved towards less energy-intensive sectors. In CAM, CEB and Russia, the move appears to be in the opposite direction. This is consistent with the resurgence of activity in the heavy industries in countries like Russia in the 2000s, and with the boom in foreign direct investment in manufacturing in CEB.

The results imply that without efficiency gains, the energy intensity of value added would have increased by 6, 13 and 15 per cent in Russia, CAM and CEB, respectively. It would have remained constant in EEC and declined by 11 per cent in SEE. In Turkey, structural factors could have generated an increase in the energy intensity of GDP of about 11 per cent in the absence of intrinsic efficiency improvements.

The time-path of intrinsic efficiency improvements and structural changes differs across the sub-regions. In CEB, intrinsic efficiency improvements started in the early 1990s and continued throughout the period. In SEE, there was little improvement in intrinsic efficiency in the 1990s, but structural change had a positive impact from the onset. In CAM, EEC and Russia, energy efficiency deteriorated in the 1990s, accompanied by a positive effect due to structural changes. This was reversed after 2000, when the structural effects would have increased the energy intensity of GDP, but this was more than compensated by very rapid intrinsic efficiency improvements, which led to an overall decline in the energy intensity of GDP.

It is important to stress a caveat to these results. The sector data are highly aggregated,[14] meaning some of the energy-intensity improvements attributed to efficiency improvements hide structural changes within the sectors. A shift from more energy-intensive manufacturing (e.g. steel) to less energy-intensive manufacturing (e.g. electronics) would be reflected as an efficiency improvement, due to the aggregation of all industrial sectors. But in reality, it is a structural change effect. Thus the results presented here need to be interpreted with caution, noting that the effect of structural change is likely to be underestimated and the effect of efficiency improvements overestimated.

The energy intensity of firms

Having examined the role of structural changes and intrinsic efficiency improvements at the country level, we now turn to firm-level analysis and ask what specific characteristics are associated with better or worse energy performance by a firm.

As at the firm level, the measure of energy performance is defined by an energy-intensity indicator, that is, the ratio of energy used in production divided by the value of sales generated by that production.[15] A firm's energy input is derived from energy expenditure cost data and energy (electricity) prices for the country.

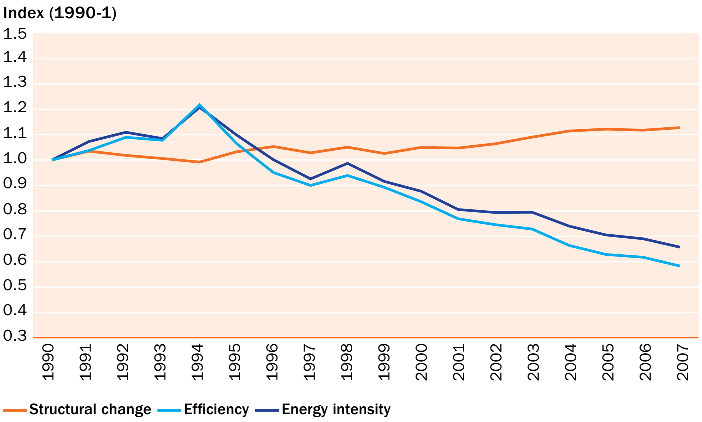
Several studies have investigated the factors that affect energy efficiency at the industry or firm level. While the techniques, data employed and explanatory factors differ, their results suggest that energy efficiency generally improves with the size of a firm, the degree of research and development/innovation, and appropriate energy price signals.[16]

The energy intensity of each firm is influenced by sector and country effects, but also by a set of characteristics. Sector effects are important determinants of energy intensity, as production processes and technologies differ by industry in their relative energy intensity. Energy intensity is also dependent on country characteristics, such as weather conditions, but also on more general economic variables, such as the price of energy within the country. Energy subsidies also reduce incentives to use energy efficiently.

Moreover, energy use is likely to be influenced by structural and behavioural effects that are specific to each firm. For example, location and size are structural factors that can impact its energy intensity. The ownership structure, level of competition, capacity utilisation, and whether the firm exports its goods can all influence energy efficiency.

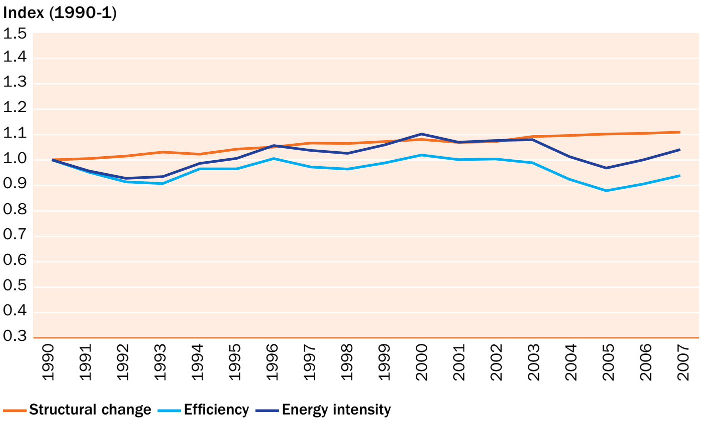
The analysis in this section is based on survey data from the 2009 Business Environment and Enterprise Performance Survey (BEEPS), which contains detailed information about firms' characteristics, sales, investment, innovation, employment, access to infrastructure

Chart 1.7e
The decomposition of energy intensity – CAM



Source: UN, IEA, EBRD calculations.

Chart 1.7f
The decomposition of energy intensity – Turkey



Source: UN, IEA, EBRD calculations.

[14] The availability of value added or energy consumption data limit our disaggregation to five economic sectors: Agriculture, Construction, Industry, Services and Transport.
[15] Due to data availability, we use sales data instead of value added, which is a more appropriate indicator.
[16] See, for example, Fisher-Vanden et al. (2004), Kumar (2003), and Rohdin et al. (2007).

services, access to financing, and firms' perceptions on the business environment.[17] The survey covered approximately 11,800 enterprises in the 29 EBRD countries of operations, and four countries from outside the transition region (Chile, Mexico, Morocco and South Africa) for comparison.[18]

The results presented in Table 1.2[19] reveal several interesting findings.

- Location, ownership and company size are important for a firm's energy performance.
- Firms located in capital cities tend to be more energy efficient, and efficiency increases in line with city population size.[20]
- Private *de novo*[21] and foreign firms are more efficient than state-owned firms. The effect is very strong when including all sectors covered by the dataset, but weakens when only manufacturing firms are included. This suggests that in the tradable sector, other factors such as competition may be more important in driving energy performance.
- Manufacturing firms that export part of their output appear to be more energy efficient.[22]
- Firms that acquire international certifications for their products or production processes are more energy efficient, suggesting a link between management quality and energy performance.

In line with the literature, the results also suggest that larger firms are more energy efficient – a finding that is robust to using different data subsets (e.g. manufacturing only) and to definitions of size. Medium and large firms are more energy efficient than small firms, which in turn are more efficient than micro firms. A ten per cent difference in firm size (measured by the number of employees) is associated with a 1.3 per cent difference in energy efficiency. This effect increases to 1.7 per cent for manufacturing firms.

The most energy-efficient sectors are services (in particular, wholesale and retail trade, transport, health and social work, and information technology), construction, and several manufacturing branches (transport equipment, machinery and publishing). The least energy-efficient sectors are the manufacture of non-metal and mineral products, and tobacco, food and beverages.[23]

It is interesting to compare the baseline level of efficiency across countries.[24] Chile, as a middle-income country comparable in terms of development with some of the transition economies, is used as a benchmark. The results suggest that the vast majority of transition economies are more energy intensive. The exceptions are Hungary and the Slovak Republic, which appear to be significantly more efficient than Chile.

Table 1.2
The determinants of enterprise-level energy efficiency

Dependent variable: Log energy intensity of the firm (First Stage); Country fixed-effect (Second Stage)								
Model	Firm size groups (micro, small, medium, large)				Firm size in log number of employees			
	All Sectors		Manufacturing		All Sectors		Manufacturing	
	First Stage	Second Stage	First Stage	Second Stage	First Stage	Second Stage	First Stage	Second Stage
Country Effects								
Climate (log heating degree days)		0.24***		0.24***		0.24***		0.23***
Climate (log cooling degree days)		0.14***		0.16***		0.14***		0.15***
Energy prices (log electricity price in USD PPP x-rate)		-0.94***		-0.91***		-0.95***		-0.91***
Firm Charactristics								
exporter	-0.06		-0.10*		-0.03		-0.07	
city (comparator Capital city)								
city over 1 million	0.12**		0.15**		0.12**		0.15**	
city 250,000 to 1 million	0.18***		0.09		0.18***		0.08	
city 50,000 to 250,000	0.30***		0.24***		0.29***		0.23***	
city less than 50,000	0.38***		0.33***		0.38***		0.33***	
ownership (comparator State-owned enterprise)								
Privatised from state	-0.04		0.24		-0.05		0.2	
Always private	-0.50***		-0.25		-0.52***		-0.32	
Foreign	-0.53***		-0.3		-0.53***		-0.35	
firm size (comparator Small firms - 10-49 employees)								
Micro (0-9 employees)	0.22***		0.21***					
Medium (50-249 employees)	-0.19***		-0.32***					
Large (more than 250 employees)	-0.24***		-0.32***					
Firm size (log number of employees)					**-0.13*****		**-0.17*****	
International certification	-0.05**		-0.04		-0.04*		-0.03	
Number of observations	8,244	14,470	3,823	7,326	8,236	15,487	3,823	15,487
R^2	0.33	0.88	0.21	0.84	0.33	0.88	0.21	0.87

Source: EBRD.
Note: ***, **, * represent significance at 1, 5 and 10 per cent, respectively.

[17] The latest round of BEEPS was undertaken jointly by the EBRD and the World Bank. In each country, the sector composition of the survey, in terms of industry versus services, was structured to reflect their relative contribution to GDP. Agricultural enterprises and sectors subject to governmental price regulation or supervision (such as banking, electric power, rail transport and water and waste water) were excluded from the survey. Companies that had 10,000 employees or more were not included in the sample. For more details see: www.ebrd.com/pages/research/economics/data/beeps.shtml

[18] Data for non-transition economies comes from World Bank enterprise surveys undertaken using the same methodology and comparable questionnaires.

[19] The analysis uses a two-stage approach to distil the factors that impact the energy intensity of any given firm. First, the energy-intensity indicator is regressed on firm characteristics, controlling for sectors and country-fixed effects. Second, the effect of energy pricing and climate on the country-fixed effects is estimated.

[20] This is generally consistent with other findings in the literature, as firms in larger cities tend to be more productive and more cost effective.

[21] Private de novo firms are those established after the collapse of central planning that were at no stage in majority state ownership.

[22] This could be because export activity creates incentives for better energy use, or that more energy-efficient firms are more likely to be exporters. The analysis used does not allow us to assess which of these factors is causing the other or vice versa.

For Croatia and Poland, the base energy-efficiency level does not appear to be significantly different to Chile. These results are slightly stronger for service-sector firms. In manufacturing, the broad picture is similar, but the country effect on energy efficiency in Belarus, Bulgaria, Lithuania, Romania and Slovenia is not significantly different to Chile.

Energy prices also have a very important effect on the country-level base energy performance. The regression results suggest that between 84 and 88 per cent of cross-country variation is jointly explained by energy pricing and climate variables (heating and cooling degree days). The effect of energy pricing is very strong – a 1 per cent difference in US$ energy prices (in purchasing power parities) between countries is associated with a 0.94 per cent difference in energy efficiency, with a 0.91 per cent difference for the manufacturing sector. The results are also robust to using the energy prices of the previous year[25] and highlight the importance of price signals as a mechanism for fostering firm-level energy efficiency.

Policies and energy intensity

The results above suggest that policies affecting the price of energy – in particular, the extent to which energy use is subsidised or taxed – play a key role in affecting energy intensity at the firm level. But what about policies more generally? To answer this question, we examine the correlation of policy choices with improvements in energy or carbon intensity at the country level.

We used panel data regression analysis on two datasets compiled from available sources, focused on the EU-27 member states[26] and the EBRD countries. We focus on three policy variables: the Kyoto Protocol ratification as a formal commitment to tackle carbon emissions; EU accession negotiation or actual joining date as a proxy for a set of carbon and energy-related policy commitments; and the EBRD transition indicators that measure the extent to which transition economies have progressed towards market economies. We considered both the average transition indicator and a specific sector-level indicator for power sector reform.

Two sets of regressions are presented. The first set (columns A-F of Table 1.3) presents energy and carbon intensity regressions performed on the EBRD countries. The second set of regressions (columns G and H) was performed only on the 27 member states of the EU.[27] All regressions control for price (industry or household electricity prices), income (GDP per capita) and climate (heating degree days).

The EU-27 dataset suggests that the carbon intensity of GDP is decreasing as income rises. The results also suggest that carbon intensity decreases as electricity prices rise. This is in line with theory predictions and the firm-level results described in the previous section.[28] The analysis also includes a time trend to capture unobservable technological progress or capital replacement. The effects seem to be robust: the results suggest that there is a time-trend improvement in energy and carbon intensity of between 1.1 and 4.9 per cent per year.

Table 1.3
Policies for carbon and energy performance

Dependant variable[&] ->	Energy intensity (EBRD)			Carbon intensity (EBRD)			Carbon intensity (EU-27)	
Model	A	B	C	D	E	F	G	H
Log elec price industry							-0.163***	-0.163***
Log elec price household	0.0002	0.011	0.017	-0.018	-0.002	0.007		
Log GDP per capita	1.704**	1.349*	0.561	2.806***	2.255**	1.053	-4.440***	-4.448***
Log GDP per capita square	0.09***	0.076**	0.043	0.133***	0.111***	0.061	-0.177***	-0.179***
Log HDD	0.312***	0.342***	0.399***	0.31**	0.355**	0.421***	0.152***	0.152***
Time trend square	0.001***	0.001	0.001***	0.002***	0.001*	0.002***	0.0004*	0.0004*
Constant	3.941	1.685	-3.453	11.857*	8.351	0.633	-29.719***	-29.695***
Average EBRD Transition Indicator		-0.077***			-0.120***			
EBRD Power Sector Transition Indicator			-0.034**			-0.061***		
EU negotiation Kyoto ratification#trend								
0 0	-0.03***	-0.014*	-0.033***	-0.048***	-0.023*	-0.049***		
0 1	-0.039***	-0.0233***	-0.041***	-0.062***	-0.038***	-0.063***		
1 0	-0.038***	-0.021**	-0.036***	-0.058***	-0.033***	-0.054***		
1 1	-0.043***	-0.026***	-0.040***	-0.065***	-0.039***	-0.060***		
Kyoto Joining trend								
0							-0.011**	
1							-0.012**	
EU accession Kyoto Joining#trend								
0 0								-0.011**
0 1								-0.013**
1 0								-0.012**
1 1								-0.013**
Number of observations	333	333	316	327	321	310	336	336
R^2	0.38	0.35	0.42	0.21	0.15	0.25	0.17	0.17

Source: EBRD.
Note: ***, **, * represent significance at 1, 5 and 10 per cent, respectively.
& Dependant variable always in log.

[23] These results need to be interpreted with caution. The use of sales data rather than value-added data introduces some distortions in the relative energy intensity of different sectors: it reduces the energy-intensity score of sectors with a high share of intermediate inputs (such as manufacturing), compared to sectors that consume few intermediate products, such as services. For an identical level of effort (energy, labour and capital input), the former firms achieve higher sales revenue, since they not only charge for their own effort but also pass on a larger cost of intermediate products.
[24] Country dummies were included in the regression but are not reported here.
[25] Although energy price effects on energy performance are likely to be a causal effect, the lack of time-series data does not allow us to estimate long-term price effects.
[26] Austria, Belgium, Bulgaria, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Ireland, Romania, Slovak Republic, Slovenia, Spain, Sweden, and the United Kingdom.
[27] The EU-27 dataset is a balanced panel 1990-2007 and includes accurate industrial electricity price data (Eurostat). The EBRD countries dataset is an unbalanced panel 1990-2007 and suffers from the reliability of household electricity pricing data, particularly for the 1990s.
[28] The relationship between carbon and energy intensity and prices in the EBRD countries is not significant. We note that energy price data is very "noisy", particularly for the 1990s, as it contains regulated household prices subject to severe distortions even in comparison to industry energy prices (which were not available).

The variables in this analysis suggest that policies are important and correlate strongly with energy and carbon performance. Market reforms as measured by the EBRD Transition Indicators (country average and power sector indicator) are both strongly correlated with better energy performance. The effect is roughly twice as strong for carbon intensity. Furthermore, the average transition indicator that captures both demand-side and power sector (supply-side) reforms has a double effect compared to just the power sector supply-side reforms.

These effects are remarkable for two reasons. The regressions separately take account of general improvements over time (through a time trend) that might otherwise be picked up by the transition indicators. Also, they separately capture the effect of electricity prices, which is one channel through which transition affects energy use. Hence, they capture the mechanisms that may accelerate the rate of carbon efficiency improvements, for example through more rapid demand and supply-side responses (e.g. faster replacement of old energy-related capital equipment, due to more competitive pressure or better access to capital and know-how).

For the EBRD countries we find that the start of EU accession negotiations is the most relevant factor in the analysis of each country's energy and carbon performance. After the negotiations for accession start, we find that the downward trend of carbon and energy intensity accelerates by between 3 and 6 per cent. Ratification or domestic entry into force of the Kyoto Protocol also has a strong effect in accelerating the improvement in carbon and energy intensity. This suggests that participation in internationally binding agreements acts as a policy commitment mechanism, which has a direct or perhaps indirect effect on outcomes. Furthermore, EU accession and Kyoto commitments jointly produce an additional effect, adding up to a total annual reduction of about 3.8 per cent for the EU-27 countries, and in excess of 10 per cent annually for all the EBRD countries.

Emissions per capita and trade in virtual carbon

A key challenge for global climate policy relates to ensuring an efficient and equitable distribution of emissions per capita among countries, to reflect not only production patterns, but also consumption patterns. Economic efficiency may lead to an uneven allocation of emissions among countries, as trade theory would suggest that energy (emission) intensive goods tend to be produced in countries with abundant energy resources. On the other hand, equity concerns would encourage a more even distribution of consumption-related emissions per capita, i.e. after adjusting for the carbon emissions embedded in trade.

Besides cross-country differences in resource endowments, emissions outsourcing (e.g. by relocating energy-intensive production overseas) can occur for other reasons, such as differences in economic policy environments, or legacy issues related to sticky economic structures and slow adjustment speeds. We now explore how the EBRD region compares in terms of consumption-related emissions and patterns of specialisation associated with energy resource endowment.

In the international climate change debate, it is common to assess the countries' carbon footprints in terms of their emissions per capita. According to authors like Stern (2009), by the middle of the century annual emissions cannot be more than about 2 tCO_2 per person, if we are to limit the likelihood of average global temperature increasing by more than 2°C. The world is a long way from this target. Since 1990, the amount of CO_2 emissions per capita related to energy use has increased by about 10 per cent worldwide, reaching 4.4 tCO_2 per person in 2008.[29]

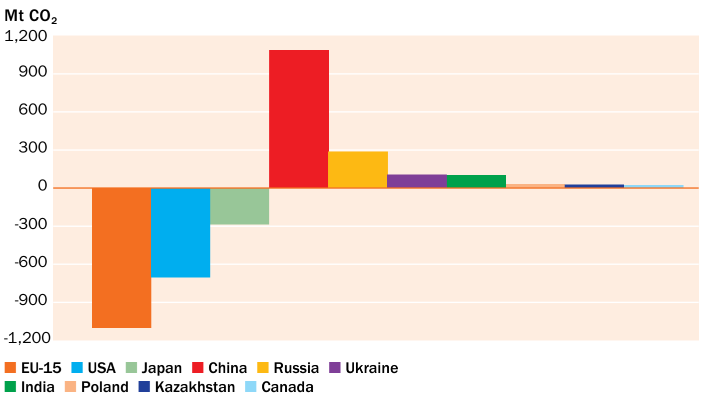
Per capita emissions from energy use alone in the EU-15 are currently around 8 tCO_2. This is less than half the amount in the US, but almost twice as much as in rapidly growing China. In the EBRD region, energy-related emissions per capita have declined by almost 29 per cent since 1990. In 2008, they averaged 7.2 tCO_2 per person, ranging from 0.44 tCO_2 in Tajikistan to 16.8 tCO_2 per person in Estonia.

The large worldwide disparities in average carbon footprints – as measured by CO_2 emissions produced within sovereign territories – do not merely reflect differences in national per capita incomes. Although the highest emissions per head are largely found in the wealthiest economies, and the lowest ones in the poorest countries, there are substantial differences between economies with very similar per capita incomes. Factors such as climate, resource endowments, economic structure, comparative advantage and distance between markets also matter.

Carbon intensity of international trade

Many of these factors manifest themselves in differences between the carbon intensity of economic activity in a country, and the carbon intensity of the goods and services its population consumes. In other words, there can be large imbalances in the carbon content of countries' imports and exports. Rather than reflecting substantial changes in lifestyles and shifts towards less carbon-intensive consumption patterns, a decrease in the emissions from production within a country may simply reflect a shift in the carbon-intensive activities to another economy. This may even result in higher global emissions if the imported goods use

Chart 1.8
The balance of CO_2 embodies in trade (2004)



Source: Davis and Caldeira (2010), EBRD calculations.
Note: Countries below the zero axis are net importers, countries above are net exporters of carbon.

[29] Total greenhouse gas emissions per capita are higher, as they include other greenhouse gases than CO_2 and sources of emissions other than energy use.

more carbon-intensive production processes than the domestically produced goods that they displace.

Various studies provide evidence of large flows of carbon emissions embodied in international trade. These studies have tried to calculate the balance of trade in virtual carbon by estimating the emissions associated with the production of traded goods and services.[30] Estimates differ as to how trade relationships are modelled and the carbon intensity of the export–import mix is assessed. But these studies generally suggest that countries' carbon performances, evaluated according to traditional production-based inventories, underscore the role played by emissions that are produced outside the country but are associated with consumption of goods and services within the country.

Chart 1.8 illustrates the CO_2 balances for some of the largest net importers and exporters of carbon embodied in trade, based on analysis by Davis and Caldera (2010). Using a multiregional input–output model constructed from 2004 global economic data, the study estimates consumption-based emissions by taking the emissions directly produced within each country ("production-based CO_2 emissions"), subtracting those associated with the exported goods, and then adding back emissions associated with import.

For the most advanced economies (e.g. Japan, EU-15 and the US), the positive difference between consumption and production-based per capita emissions shows that a substantial portion of the emissions embodied in the consumed goods and services is produced abroad – in countries such as China, India, Russia and Ukraine.

In contrast, the larger economies of the EBRD region are big net carbon exporters. Russia and Ukraine are the world's second and third largest net carbon exporters in absolute terms after China. More than 30 per cent of Ukraine's 2004 production-based emissions were exported in net terms. Poland and Estonia are also net carbon exporters.

At the other end of the spectrum, several transition economies are net carbon importers. The difference between the production-based per capita emissions and the trade-adjusted consumption-based per capita emissions can be high – in Latvia, consumption-based per capita emissions are almost twice as high as production-based per capita emissions, whereas in Georgia they are 60 per cent higher, 41 per cent higher in Lithuania and about 20 per cent in Armenia, Croatia, Hungary and Slovenia.

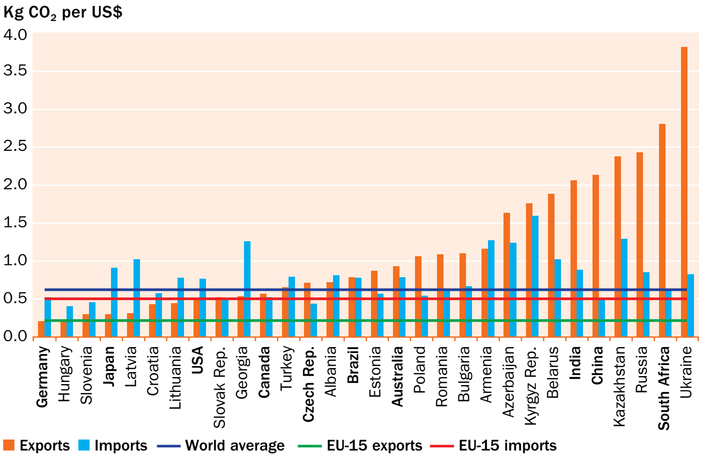
The data on carbon embedded in trade also offers insights into cross-country differences in the carbon intensity of the import–export mix, defined as the amount of CO_2 emissions per US$ of imports or exports. Chart 1.9 shows that the average carbon intensity of exports in many transition economies is higher than the world average amount of emissions embodied in internationally traded goods and services.

According to this data, Ukraine, Russia and Kazakhstan are the first, third and fourth most carbon-intensive exporters, ahead of China and India. But the transition region also includes some of the best performers – Hungary, Latvia and Slovenia are only slightly behind Germany, better or on par with Japan, and ahead of most advanced market economies.

Some transition countries have substantial fossil fuel resources and their economies were built on the availability of abundant cheap energy. It may be expected[31] that in international trade, the energy-rich countries of the EBRD region will specialise in the exporting of energy-intensive (and therefore carbon-intensive) goods, as we have seen in Chart 1.9. Furthermore, the carbon intensity of each country's exports should correlate with its abundance of energy resources.

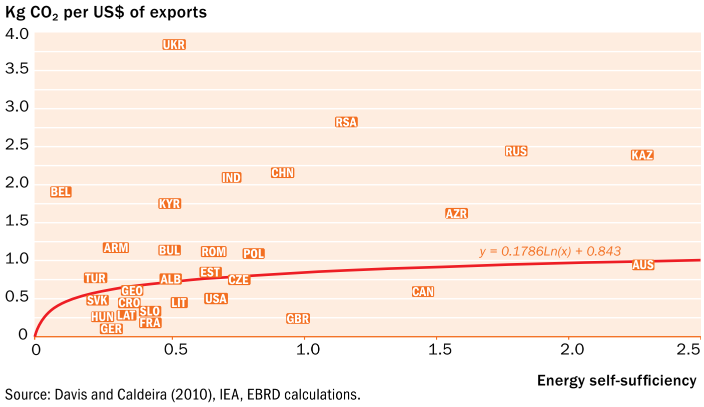
Chart 1.10 presents a cross-plot of energy self-sufficiency[32] and the carbon intensity of exports. The scatter plot confirms the hypothesis of a positive relationship – evidenced by the regression line on the chart.[33] However, while some transition economies are reasonably close to the regression line (suggesting that the carbon intensity of their exports is broadly in line with what would

Chart 1.9
The carbon intensity of trade in 2004



Source: Davis and Caldeira (2010), EBRD calculations.
Note: Countries in **bold** are not transition economies.

Chart 1.10
The correlation between energy resource endowment and carbon intensity of exports in 2004



Source: Davis and Caldeira (2010), IEA, EBRD calculations.
Note: Energy self-sufficiency is defined as the ratio of energy production to the total primary energy supply.

[30] Yunfeng and Laike (2009); Atkinson et al. (2010).
[31] The Heckscher-Ohlin theory of trade predicts that countries tend to export commodities that intensively employ the cheap and abundant factors of production, and import commodities that use the countries' relatively scarce factor of production.
[32] An ideal measure would be the total energy (fossil fuel) resource reserves. Due to the lack of such data, we use the energy self-sufficiency defined by the ratio of energy production over total primary energy supply in each country in 2004, based on IEA data.
[33] An important caveat is that this analysis is based on a simple correlation between one factor endowment (energy) and carbon intensity and abstracts from the influence of the other factors (labour, capital, land) on the carbon intensity of exports.

be expected, based on their energy endowment), in the energy-rich countries of the former Soviet Union the carbon intensity of exports substantially exceeds what is predicted by their resource endowment. Even some new EU members (Bulgaria, Poland and Romania) are substantially more carbon intensive than predicted by their resource endowment.

It is interesting to compare Azerbaijan, Kazakhstan or Russia with similarly energy-independent countries (e.g. Australia or Canada). The carbon intensity of exports in the former group is much higher. This suggests that the legacy of central planning, extremely low energy prices and high energy intensity, continues to mark the former Soviet Union countries. This argument is further strengthened by the position of countries such as Armenia, Belarus, the Kyrgyz Republic and Ukraine, which are not particularly energy rich, but are carbon intensive nonetheless.

The indication is that despite their progress in improving energy and carbon intensity over the past two decades, many transition economies continue to be marked by legacy issues. Further improvements can to be expected as these economies continue their transformation. The transition economies that have transformed and now deliver competitive outcomes in the energy and carbon area, provide evidence of this potential.

Conclusions

Since the beginning of transition, most EBRD countries have made substantial progress in reducing their carbon footprint. Although this has slowed lately, the pace of improvement has exceeded that in the advanced market economies and is comparable with China. Disparities among EBRD countries, however, are substantial. Emissions changes between 1990-2008 vary between a 56 per cent reduction in EEC and a 108 per cent increase in emissions in Turkey.

The region still includes some of the world's worst performers in terms of the carbon intensity of GDP (e.g. Kazakhstan, Russia, Ukraine and Uzbekistan). But the carbon intensity in a few transition countries is now on par with the advanced market economies. This is either because of reliance on low-carbon energy supply (e.g. Albania, Georgia, Latvia and Lithuania) or due to low energy intensity of output (e.g. Croatia and Hungary).

Substantial improvements in carbon performance since the second half of the 1990s mean that "decarbonisation" was achieved with little impact on output and growth. Indeed the EBRD region underwent a period of *absolute* decoupling of emissions and economic growth in the second half of the 1990s, before more recently moving to a *relative* decoupling – strong economic growth associated with modest emissions growth. The improved regional carbon performance was derived in a relatively balanced way between improvements in the carbon intensity of energy, due to switches to cleaner fuels, and improvements in the energy intensity of output.

The reduction in the energy intensity of regional GDP was derived in part from the structural changes that EBRD countries underwent in the course of their transition to market economies. However, intrinsic efficiency improvements within sectors played an even more important role. Economic reforms, whether domestically driven or triggered by international commitments, have enhanced the energy and carbon performance of the transition countries. The reform processes associated with EU accession and to a lesser extent the commitment to climate policies under the Kyoto Protocol were both associated with a faster improvement in carbon and energy efficiency in the economy.

Energy pricing is a key incentive mechanism, one that is strongly associated with lower energy intensity both at economy and firm levels. Firm-level data suggests that the energy efficiency of private firms is significantly better than state firms, and exposure to international competition (exporters) is associated with enhanced energy efficiency compared to firms selling on the domestic market only. It also suggests that product innovation is associated with better energy performance, and large firms, as well as firms located in big cities, are more energy efficient.

Despite the strong improvements observed over two decades, the EBRD region continues to be excessively carbon intensive, particularly the large industrial countries of the former Soviet Union. Analysis of the balance of trade in virtual carbon reveals that some EBRD countries are among the world's largest net carbon exporters. The carbon intensity of exports in Kazakhstan, Russia and Ukraine is extremely high, revealing structural and legacy issues that appear to go beyond their comparative advantage in carbon-intensive goods derived from their energy resource endowment. These countries tend to specialise heavily in energy-intensive goods. As a result, they remain behind the carbon performance standards of both advanced market economies and also emerging economies like China. Yet the EBRD region also includes countries – such as Hungary, Latvia and Slovenia – whose performance in terms of carbon embedded in exports are among the lowest in the world, comparable to Germany and lower than Japan or the US.

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The EBRD region will have to play an important role in global efforts to mitigate climate change. But what are the likely costs and the potential benefits for the transition region, when embarking on ambitious climate change mitigation policies? Chapter 2 analyses the likely range of macroeconomic effects, alongside the structural changes that will be required to set the region's economies on a decarbonisation path. Selected social implications of climate change mitigation policies are also discussed.

2

The economic impacts of climate change mitigation policy

The world needs to reduce global emissions of greenhouse gases (GHGs) sharply and rapidly if the risks associated with human-induced climate change are to be kept under control. The speed with which emissions fall will determine the ultimate rise in global temperatures.

At the UN Climate Change Conference in Cancún in 2010, countries agreed that deep cuts in global greenhouse gas emissions are required as documented in the Fourth Assessment Report of the Inter-governmental Panel on Climate Change (IPCC), to reduce global greenhouse gas emissions so as to hold the increase in global average temperature below 2°C above pre-industrial levels, and that Parties should take urgent action to meet this goal. Global emissions currently stand at around 48 gigatonnes of CO_2 equivalent ($GtCO_2e$) per year. Judging by the projected relationship between cumulative GHG emissions and the probabilities of global temperature increases, this requires that global emissions peak before 2020, fall back to 40-48 $GtCO_2e$ per year by 2020 and continue to fall, to between 6 and 17 $GtCO_2e$ per year by 2050.[1]

Achieving significant and lasting reductions in GHG emissions on this scale requires policy actions on several fronts by all countries with significant levels of emissions, including those in the EBRD region. Without policy intervention, the incentives facing emitters and users of GHG-intensive products to change their behaviour will be inadequate. In most countries, emitters do not bear the social cost of GHG emissions; social returns for the development of low-emission technologies often exceed their private returns; and incomplete information and other barriers stand in the way of realising energy-saving opportunities.

If policy-makers start to take action now, it would allow a more measured response, early capture of various co-benefits of climate-change mitigation such as reduced local air pollution, and the timely reallocation of resources from the types of capital accumulation and innovation rendered inappropriate by the need to switch to low-GHG growth paths. Early action could position the EBRD region well in the energy-industrial revolution that the decarbonisation of the global economy is expected to bring. Instead of being in a catch-up situation, the EBRD region can and should propel itself to the forefront of technological progress in the green economy.

The required policy actions are likely to have significant economic consequences for transition countries. These include impacts on the value of aggregate output, the balance between consumption and investment over time, real wages,[2] trade patterns, relative prices, the relative performance of different industry sectors, and long-run growth. Some of these impacts are likely to affect different households' well-being differently.

This chapter reviews the likely economic consequences of ambitious long-term climate change mitigation targets in the EBRD region. It starts by drawing out some of the general lessons of the economic literature on climate change mitigation. It then considers what economic models suggest about the macroeconomic impacts in the EBRD regions. Next, it investigates some of the sectoral implications, drawing on results from a specially commissioned analysis using the World Induced Technical Change Hybrid (WITCH) integrated assessment model. Lastly, the chapter reviews some of the possible social implications of climate change policy for EBRD countries.

Model results such as those presented here are useful to highlight trends, sensitivities and the relative importance of different economic factors in understanding the costs of mitigation. The actual numerical results should, however, be viewed as illustrative only. Furthermore, they illustrate only of the trade-offs that are captured in the model. As a result, the interpretation of the results is almost as important as the results themselves, and will be a focus of discussion in this chapter.

Economic analysis of climate change mitigation

Modelling mitigation costs

Macroeconomic modelling of climate change policy has tended to focus on the likely direct and indirect costs of reducing GHG emissions, and the structural changes in economies needed to minimise those costs. Costs are likely to be incurred for at least two classes of reasons.

First, "making the polluter pay" implies higher prices (relative to incomes), for three reasons:

- The price placed on GHG emissions increases costs for producers that buy GHG-intensive goods and services as inputs, and for consumers.
- The greater expense of such products is likely to induce some technology switching by producers, for example from carbon-intensive fossil fuels to renewable energy sources. These newly adopted low-GHG technologies are likely to be less efficient, at least initially, implying lower overall productivity.
- Consumers switch, to some extent, towards less GHG-intensive products, driving up their prices in turn.

Second, switching technologies entails the scrapping of some GHG-intensive plants, equipment and buildings, and new investment in capital that embodies low-GHG alternatives. For example, the International Energy Agency (IEA) has estimated that incremental energy-related investment of around US$10.5 trillion will be required between 2010 and 2030 (IEA, 2009). This additional investment may either crowd out consumption,

[1] Bowen and Ranger (2009). The emission trajectories estimated would give a 50 per cent probability of keeping the global temperature change to 2°C or less.

[2] Income after considering the effects of inflation on purchasing power.

thereby reducing well-being directly, or other investment, reducing future consumption opportunities.

Together these channels imply that climate change mitigation measures may have much the same effect as an adverse supply shock (for example, a sudden hike in the oil price) if introduced very rapidly. By sharply changing relative prices, for example introducing carbon pricing and inducing changes in the pattern of investment, mitigation measures risk disrupting economies and creating unemployment.

At the same time, it is important to underline that modeling mitigation policy like a "supply shock" constitutes a simplification which will tend to overestimate the costs and underestimate the benefits of mitigation policy, particularly in resource-rich countries in which legacies of wasteful energy use continue to exist, such as in the transition region.

For one, macroeconomic models generally assume that resources are fully utilised and allocated in a cost-minimising way. Hence, these models cannot capture the benefits of bringing into use idle workers or resources. They also do not capture mitigation through energy efficiency improvements that pay for themselves. However, bottom-up calculations suggest that the potential for such improvements could be very significant in the transition region (see Chapter 3).

In addition, the models do not take acount of the fact that climate change mitigation can generate significant co-benefits, such as reduced particulate pollution. Reducing GHG emissions in line with a 2ºC global scenario would reduce air pollution control costs in Russia by US$2.2 billion per year by 2030, a reduction of 16 per cent relative to the reference scenario. The reduction for the new European Union (EU) member states would be around 7 per cent, and around 5 per cent for the rest of the transition region (IIASA, 2009).

Tackling other barriers inhibiting decarbonisation can also generate co-benefits. This is demonstrated by efforts to resolve the information and incentive problems that lead to inefficient and excessive use of energy.

Perhaps most importantly, de-carbonisation policies may increase long-run growth, through several channels. In many countries with large fossil fuel sectors, the dependence on these sectors is widely regarded as a growth obstacle, rather than a boon. This "resource curse", which operates through both macroeconomic and institutional channels, is likely to apply particularly in countries with weaker institutional environments, which are typical for the transition region (see EBRD, 2009, Chapter 4). By creating incentives for reducing the size and economic significance of the natural resource sectors, climate change mitigation may also mitigate the "resource curse", allow other sectors to develop, and help these countries attain higher growth in the long run.

Policies designed to encourage innovation in low-carbon technologies may also stimulate innovation and growth more widely. This possibility underpins the arguments of advocates of "green growth" strategies. A carbon-free economy will require a wholesale transformation of the technologies that underpin modern economies today and this process of technological change may provide economic opportunities on the scale of an energy-industrial revolution. Countries and regions that fail to participate in this process may forego economic opportunities of historical proportions.

Top-down and bottom-up approaches

Few quantitative studies have tried to capture all these aspects of climate change mitigation. Integrated assessment models have focused on the general equilibrium macroeconomic adjustments necessary. This "top-down" approach tends to emphasise the productivity, sectoral change and investment effects, with simplified representations of technological choice.

Recent modelling work of this kind has concentrated on the question of how much it would cost to keep the expected global temperature rise below the 2°C limit. Some have concluded that this would be infeasible[3] while others have estimated that it would cost between 1 and 5 per cent of GDP per year.[4] Clarke et al. (2009) have shown that the feasibility of achieving stringent climate policies depends to a significant degree on the architecture of international agreements and the commitment of developing countries. Tavoni and Tol (2010) have emphasised the role of negative emission technologies and highlighted the uncertainty associated with their large-scale deployment.

An alternative, "bottom-up" approach has looked in more detail at technological options for reducing the GHG content of a wide range of activities. The possibilities are summarised in the form of an "abatement cost curve" that describes the costs of mitigation measures for various sectors of the economy.[5] Bottom-up approaches tend to pay less attention to economy-wide feedbacks such as interactions with labour and other markets, but pay more attention to the scope for correcting inefficient energy use. This has led to such studies usually suggesting that climate change mitigation is cheaper than top-down models project. McKinsey (2009a) concludes that "if the most economically rational abatement opportunities are pursued to their full potential … the total worldwide cost could be €200-350 billion annually by 2030". This would amount to less than 1 per cent of annual gross world product. Chapter 3 investigates abatement cost curves for Russia and Turkey.

These studies provide important lessons for assessing the costs of climate change policy in the EBRD region. They draw attention to the importance of the stringency of the policy goal in determining costs. They also identify the other key factors that affect costs (and feasibility), which differ across countries. These factors include:

- the likely rate of growth of GHG emissions under "business as usual". EBRD countries have the potential to grow more rapidly than the Organisation for Economic Co-operation and Development (OECD) countries.[6] Faster economic growth will make any given emissions target more costly to hit and require faster improvements in carbon intensity.

- the resources devoted to innovation and the intellectual property rights regimes governing technology transfer. Some EBRD countries have insufficiently developed intellectual property rights regimes, judging by patenting arrangements.[7] This may discourage rapid "green" technology transfers to EBRD countries.

[3] See, for example, Tol (2009).
[4] See, for example, Knopf et al. (2009); Rao et al. (2008); Edenhofer et al. (2009).
[5] See, for example, McKinsey (2009a) and Chapter 3 of this report.
[6] See EBRD Transition Report 2010.
[7] See World Bank (2009).

- the scope for demand-side adjustments by consumers and purchasers of inputs to production. EBRD countries have great opportunities to improve energy efficiency (even before considering changing the pattern of final production or substituting other inputs for energy). They have already taken advantage of this route to lower emissions in their efforts to modernise industry after the collapse of central planning (see Chapter 1), but substantial inefficiencies remain.[8]

- the level of energy subsidies. Many EBRD countries continue to have high rates of energy subsidies – energy-rich countries stand out. By correcting the distortions induced by subsidies, the net costs of emission-reduction policies will be reduced. International trade in emission-reduction permits would also help to correct distortions from this source.

- whether marginal abatement costs are equalised across firms, sectors (including – importantly – land use) and countries. Variations in marginal costs increase the overall cost of hitting any given target. Equalisation depends on policy design and is more likely to be achieved if policy results in a broadly uniform carbon price across the economy. At this point, energy subsidies in several EBRD countries are differentiated significantly by sector.[9]

- the response of labour markets. If labour is immobile among industry sectors and real wages are slow to adjust, climate change policies are likely to create sector-specific unemployment, especially in the energy sectors and energy-intensive industry.[10] However, in situations where aggregate demand is inadequate, climate-change policies could create extra jobs and reduce unemployment by stimulating low-carbon investment.[11]

Regional differences

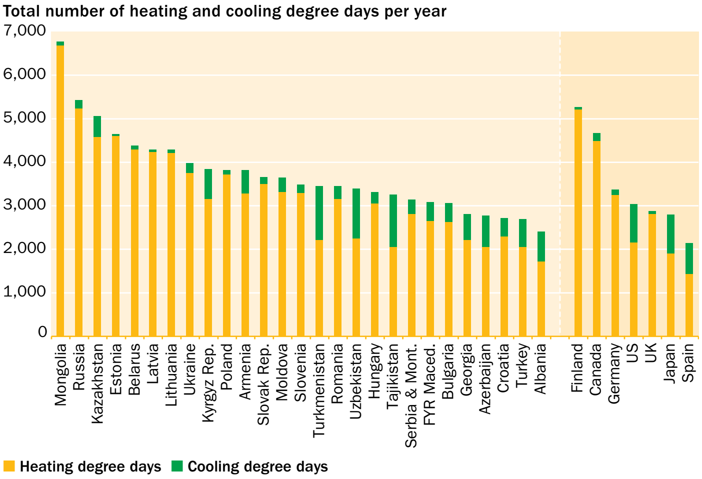
EBRD countries have substantially different endowments of fossil-fuel resources. Five countries – Azerbaijan, Kazakhstan, Mongolia, Russia and Turkmenistan – hold vast reserves and export a large share of their energy. As the demand for fossil fuels and carbon-intensive goods and services is likely to be considerably lower under stringent climate policy regimes, these countries are likely to incur larger climate change mitigation costs, due to deterioration in their terms of trade.[12] This will tend to depress their real exchange rates, just as resource discoveries tend to trigger an appreciation. In the long run, this may well benefit these economies as the size of their resource sectors shrinks and allows other sectors to develop which are more conducive to long run growth. In the interim, however, the terms or trade deterioration and the associated income loss will reduce the value of output.

The intrinsic variety in energy needs is a second important aspect in differentiating the impact of climate policies across EBRD countries. Countries with cold climates have higher energy demands for heating, if all else is equal. Most EBRD countries rank above the world average in terms of heating degree days. Chart 2.1 shows heating and cooling degree days in a selection of countries.[13] Similarly, large countries with dispersed populations need more energy for transport. Some EBRD countries, such as Kazakhstan and Russia, have particularly widely dispersed populations and hence transport fuel needs are high. Carbon pricing entails greater proportional increases in costs for these countries.

A third aspect is clean-energy potential. Projections of the deployment of renewable energy by 2050 demonstrate the wide range across the world – Poland and Russia, for example, have an estimated potential a little below the median and may find decarbonisation more difficult and expensive.[14] Central Asia, in contrast, has high potential in solar energy.[15] However, alternative mechanisms such as cross-border trade in energy can mitigate the slow development of renewable resources.

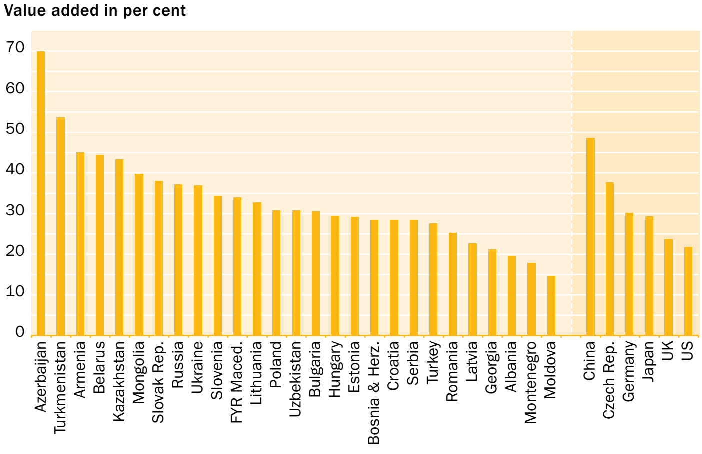
Fourth, the EBRD countries are heterogeneous in their industrial structures. The five countries with major energy resource endowments generate a much higher proportion of their value added from industry, which is more carbon- and energy-intensive than agriculture and services (Chart 2.2).[16] The share of industry

Chart 2.1
Heating and cooling degree days across countries



Source: World Resources Institute Climate Analysis Indicators Tool: http://cait.wri.org.

Chart 2.2
Industry value added as a proportion of total value added



Source: World Bank.

[8] For example, McKinsey (2009b) calculate that, for Russia, investments of €150 billion in energy efficiency between 2011 and 2030 could reduce primary energy demand in 2030 by 23 per cent (compared with business as usual), earning an internal rate of return of more than 30 per cent (see also McKinsey, 2008 and 2009c).
[9] Burniaux et al. (2009).
[10] Babiker and Eckaus (2007).
[11] Barker et al. (2008).
[12] The prospects for gas prices depend upon the scenario. In some, the demand for gas rises initially as it is lower in carbon content than other fossil fuels, making a switch to gas for electricity production attractive in the early stages of reducing emissions.
[13] These measurements are designed to reflect the demand for energy needed to heat or cool a home or business, derived from measurements of outside air temperature.
[14] See REN21 (2007).
[15] See, for example, UNDP (2007).
[16] "Industry" here comprises mining, manufacturing, construction, electricity, water and gas.

in value added in 2008 was, on average, just under 49 per cent in these countries, compared with 31 per cent for the new EU member states (very close to the average over all countries) and 28 per cent for the other EBRD countries. As a yardstick for comparison, the figures for the US and China are 21.8 per cent and 48.6 per cent, respectively.

Macroeconomic impacts on EBRD countries

The EBRD region as a whole is considerably more carbon-intensive per unit of GDP than the world, as described in Chapter 1. Many countries in the region have an economy based on fossil-fuel energy. Because of this, the economic impacts of climate change mitigation policy on EBRD countries could be larger, particularly in the absence of structural shifts away from the energy-based economy. If transition countries are to narrow the gap in income per head compared with the advanced economies, while adhering to ambitious international climate policy goals, their future growth will have to become less energy intensive. This section analyses the macroeconomic costs of a shift towards a low-carbon economy in the transition region within the macroeconomic modelling framework described at the beginning of the chapter.

Past modelling results

The literature on mitigation costs and emission-reduction modelling is vast.[17] Although it is common for models to include a region based on Russia (Russia alone, the former Soviet Union, or Russia and eastern Europe), regions are rarely defined to fit precisely with the sub-divisions of the EBRD region. Nevertheless, there are some interesting results.

Perhaps the most well-known integrated assessment model is the RICE model of William D. Nordhaus and his collaborators. This combines a multi-regional economic perspective with a climate model.[18] In the most recent set of results, for Nordhaus' analysis of pledges under the Copenhagen Accord, Russia would face abatement costs of US$92 billion in present value terms. However,

Box 2.1 Characteristics of the WITCH model

World Induced Technical Change Hybrid (WITCH) is a regional integrated assessment model structured to provide normative information on the optimal responses of world economies to climate policies. It is a hybrid model because it combines features of both top-down and bottom-up modelling. The top-down component consists of an inter-temporal optimal growth model. WITCH's top-down framework guarantees a coherent and forward-looking allocation of investments over time, including those in the energy sector.

However, the energy input of the aggregate production function has been integrated with a detailed bottom-up representation of the energy sector. This allows the model to produce a reasonable characterisation of future energy and technological scenarios and an assessment of their compatibility with the goal of stabilising greenhouse gas (GHG) concentrations. In addition, by endogenously modelling fuel prices (coal, natural gas, oil, uranium), as well as the cost of storing the CO_2 captured, the model can evaluate the implications of mitigation policies on the energy system in all its components.

Countries are aggregated in macro regions on the basis of geographic, economic and technological vicinity. The regions interact strategically on the global externalities induced by GHGs, technological spillovers, and a common pool of exhaustible natural resources. Emissions arise from fossil fuels used in the energy sector and from land-use changes that release carbon sequestered in biomasses and soils.[19] A climate module governs the accumulation of emissions in the atmosphere and the temperature response to growing GHG concentrations.

This study takes a "cost-minimisation" approach: given a target in terms of GHG concentrations in the atmosphere, scenarios are produced that minimise the cost of achieving this target. The estimated costs of climate policy therefore exclude any offset from avoided climate change damages.[20]

Endogenous technological dynamics are a key feature. Dedicated research and development (R&D) investments increase the knowledge stock that governs energy efficiency. Learning-by-doing curves are used to model cost dynamics for wind and solar power capital costs. Both energy-efficiency R&D and learning exhibit international spillovers.

There are two backstop technologies,[21] in the electricity sector and the non-electricity sector, which require dedicated innovation investments to become competitive. In line with the most recent literature, the costs of these backstop technologies are modelled through a two-factor learning curve, in which their price declines both with investments in dedicated R&D and with technology diffusion.

For each macro-region of WITCH, oil production is a function of extraction capacity built by means of endogenously determined investments. The cost of each barrel is the shadow cost of the resources invested in the oil sector. The price of each barrel is modelled as if it emerged from bargaining among all regions, rather than as a reduced-form cost function based on cumulative extraction. It is recognised that non-conventional oil extraction is very energy intensive.

The base year for calibration is 2005; all monetary values are in constant 2005 US$. The WITCH model uses market exchange rates for international income comparisons.

The WITCH model is representative of the class of models that are typically used in mitigation analysis, which tend to generate relatively high mitigation costs. Other models, in which it is cheaper to substitute energy sources and induce technical progress, tend to produce lower mitigation costs.

A more detailed description of key assumptions, equations and parameter values can be found in Bosetti, Massetti and Tavoni (2007) and Bosetti et al. (2009).[22]

[17] For a review of results, see IPCC (2007).
[18] See, for example, Nordhaus and Yang (1996), Nordhaus and Boyer (2000) and Nordhaus (2010).
[19] Emissions of CH_4, N_2O, SLF (short-lived fluorinated) gases, LLF (long-lived fluorinated) gases and SO_2 aerosols, which all have a cooling effect on temperature, are also identified. Avoided deforestation is not a source of emission reductions in the version of the model used for this study.
[20] WITCH also has a climate change damage function, but this was not used in this study; projections of climate damages are very uncertain.
[21] Backstop technologies can be thought of as a compact representation of advanced non- depletable carbon free technologies that can substitute nuclear power (for electricity) or oil (for direct energy uses).
[22] More information can be accessed at the model web site: www.witchmodel.org

these costs would be more than offset by the benefits from averted climate change damages and, more significantly, permit sales, which alone are estimated to be worth US$176 billion up to 2055.[23] One reason for the relatively low abatement costs is that Nordhaus assumes a relatively low growth rate for Russia's net national income, with an annual average of 1.73 per cent between 2005 and 2055, compared with a world average of 2.79 per cent.

Other studies[24] also find a large potential for cheap emission reductions in Russia, often linked to the country's huge biomass potential. But Russia (together with the Middle East and the US) will suffer worsened terms of trade related to its carbon-intensive exports. Russia loses large rents on fossil fuels in all policy scenarios described by Leimbach et al. (2009). This would increase its mitigation costs (consumption losses relative to the reference scenario) above 5 per cent of GDP, despite the fact that global losses average only around 1.5 per cent. The OECD (2009) agrees that Russia could lose from mitigation, both as a carbon-intensive economy and as a fossil-fuel producer. However, it expects Russia to benefit from permit trading, while mitigation costs for the other EBRD countries are also high.

The picture becomes more nuanced if the impacts of climate change are factored in. Burniaux et al. (2009) find that under a high-damages, low-discount-rate scenario, the new EU member states are likely to gain from global action by the middle of this century (an increase in consumption of around 0.8 per cent relative to business as usual), as averted climate damages outweigh the costs of mitigation. But the rest of the transition region, including Russia, still suffers a loss of around 2.7 per cent of business-as-usual consumption (the largest loss of any region except Africa).

Overall, the studies reinforce the point that the allocation of the global abatement burden is important, and that international transfers (for example, in the form of generous permit allocations) may be needed to encourage the region to participate in international action.

It is important to point out that these models simplify in several respects, as discussed at the beginning of this chapter. In particular, they assume optimising behaviour by economic decision-makers and do not incorporate market failures that result in unexploited energy-efficiency improvements with a positive social net present value ("free lunches"), even without any consideration of averted climate damages or carbon pricing. Bottom-up studies, such as those discussed in Chapter 3, argue that such opportunities are available. In addition, these models ignore the possibility that long run growth may increase as a result of climate change mitigation policies.

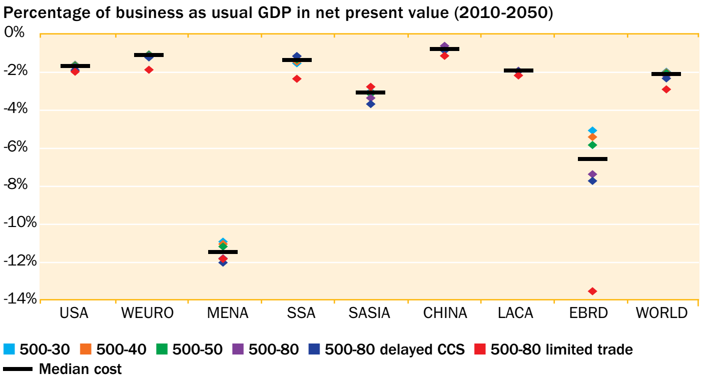
EBRD region-specific modelling using the WITCH model

To explore the potential macroeconomic and sectoral impacts of global climate change policies on the EBRD countries, the EBRD commissioned a study from the Euro-Mediterranean Centre for Climate Change using the WITCH integrated assessment model. WITCH is a macro-economic model whose distinguishing features are the modelling of endogenous technical progress in energy technologies and a game theoretic set-up that allows for multiple externalities, including innovation market failures due to knowledge spillovers across countries. The key features of the WITCH model are described in Box 2.1.

To account for the likely differentiated effects due to fossil-fuel resource endowments, the study split the EBRD region[25] into three sub-regions:

- new EU member states (EU-10): the nine EU members of the EBRD region and the Czech Republic
- Transition Economies Energy Exporters (TEEX), which are all net energy exporters[26]

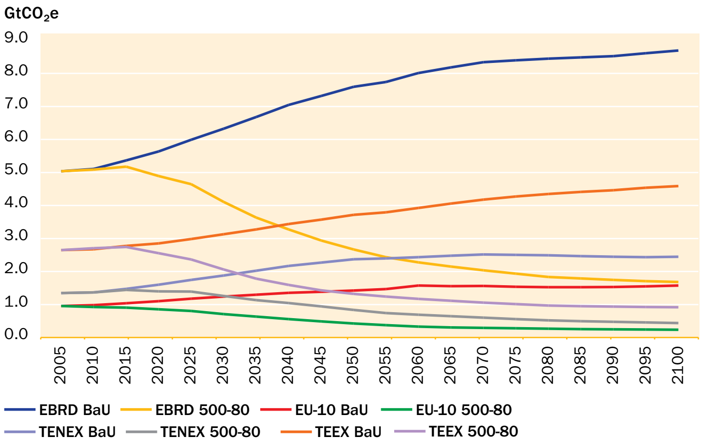
Chart 2.3
Estimated gross GDP loss ranges relative to business as usual



Source: WITCH and EBRD.

Note: The points denote mitigation scenarios with respect to the EBRD region's mitigation targets, delays in the availability of CCS technology and restrictions on carbon trading.
WEURO - Western Europe; MENA - Middle East and North Africa; SSA - Sub-Saharan Africa; SASIA - South Asia, including India; LACA - Latin America, Mexico and the Caribbean.
500-30, 500-40, 500-50, 500-80 - 30, 40, 50 and 80 per cent emission reduction target for the TEEX region only in the context of a global 500 ppm stabilisation target.
500-80 delayed CCS - a delay in the availability of CCS technology of 15 years.
500-80 limited trade - only 20 per cent of the carbon emission reduction can be imported from other regions and at least 80 per cent needs to be generated domestically in all world regions.
In all scenarios US, WEURO, EU-10, TENEX have an 80 per cent emission reduction target.
A discount rate of 5 per cent is used to derive the net present value.

Chart 2.4
Estimated emission reduction paths relative to business as usual



Source: WITCH and EBRD.

[23] The qualitative results are similar for Nordhaus' Eurasia region, which contains EBRD's Central Asia countries and some of the European ones, among others.
[24] For example, Knopf et al. (2009) and Leimbach et al. (2009).
[25] Bulgaria, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovak Republic, Slovenia.
[26] Azerbaijan, Kazakhstan, Mongolia, Russia and Turkmenistan.
[27] Albania, Armenia, Belarus, Bosnia and Herzegovina, Croatia, Georgia, Kyrgyz Republic, FYR Macedonia, Moldova, Montenegro, Serbia, Tajikistan, Turkey, Ukraine, Uzbekistan.
[28] Although slightly more lenient than the 450 ppm CO_2e often discussed in policy debates, the 500 ppm scenario provides a slightly less than 50:50 chance of keeping warming below 2°C. This is similar to most of the paths currently under consideration. The IPCC's "best guess" for the resultant global temperature increase

- Transition Economies Non-Exporters of Energy (TENEX): the remaining 15 countries of the EBRD region.[27]

The study examined a variety of scenarios to reflect a wide range of potential engagement by the EBRD region in international mitigation efforts. All scenarios assume a global mitigation target of 50 per cent reduction in emissions compared with 2005 by 2050, equivalent to a GHG concentration stabilisation at 500 parts per million of CO_2 equivalent (ppm CO_2e).[28]

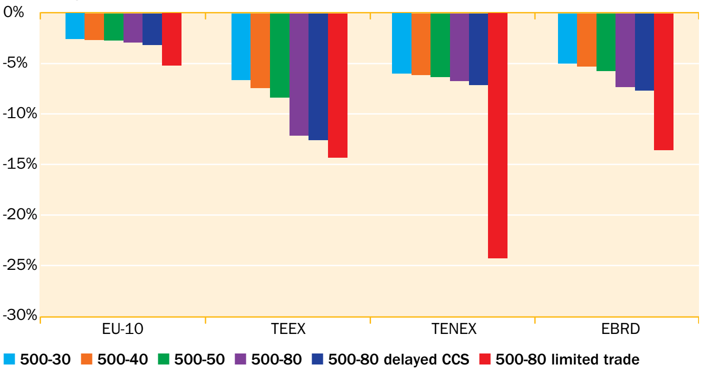
The scenarios explore the effects of various mitigation targets for the EBRD region, delays in the availability of technologies and restrictions on international carbon trading. The most restrictive scenario imposes a commitment on the EBRD region to reduce emissions by 80 per cent compared with 2005 by 2050 (on a par with G7 country commitments) and restrictions on carbon capture and sequestration (CCS) technology or carbon trade simultaneously.

The scenarios were run in the "cost effectiveness" mode to calculate the gross costs of climate mitigation, that is, without accounting for the benefits of avoiding climate damages. Thus ignoring avoided climate change impacts and avoided adaptation costs tends to overestimate the net regional mitigation costs. Intermediate scenarios allow for the variation of mitigation targets allocated to the TEEX region in the stringent 500 ppm scenario, whereas EU-10 and TENEX were assumed to have the caps appropriate for Kyoto Protocol Annex I countries.

The first result to note is that according to the WITCH model, aggressive decarbonisation is feasible. Global mitigation costs vary with global and regional mitigation targets, the availability of technologies and the limitations of carbon trading. These results are in line with findings in other top-down models, but are higher than what bottom-up models suggest.[29]

Chart 2.5
GDP costs under different scenarios

Percentage of business as usual GDP in net present value (2010-2050)



Source: WITCH and EBRD.
Notes: 500-30, 500-40, 500-50, 500-80 - 30, 40, 50 and 80 per cent emission reduction target for the TEEX region only in the context of a global 500 ppm stabilisation target.
500-80 delayed CCS - a delay in the availability of CCS technology of 15 years.
500-80 limited trade - only 20 per cent of the carbon emission reduction can be imported from other regions and at least 80 per cent needs to be generated domestically in all world regions.
A discount rate of 5 per cent is used to derive the net present value.

Chart 2.3 shows the range of estimated GDP losses across the scenarios examined for different regions, compared with the hypothetical business-as-usual case, i.e. no emission-reduction targets and no climate change.

The range of costs for different regions varies substantially more, reflecting a strong non-linear regional distribution of costs. The EBRD region also faces a wide range of potential costs under different scenarios. Within the region, costs tend to be lowest in the EU-10, higher in the TENEX countries and highest in the energy-based TEEX economies.

The costs comprise three main elements. First, the reduction in oil prices and oil production due to the global decline in oil demand hits the income of the EBRD region, because of the impact on the fossil-fuel-rich countries. Second, there are costs of decarbonising economies and utilising abatement opportunities – the costs that are conventionally included in top-down modelling exercises. These are higher in the more demanding scenarios. Third, sales of carbon market quotas may provide a benefit in the more lenient scenarios, but restrictions on cross-region carbon trading increase costs.

Another important source of cost that drives cross-regional variations is the change in the net carbon trading position of the EBRD region. In scenarios explored here under the 500 ppm global scenario, the EBRD region is a net importer of carbon offsets, shown in Chart 2.5. The 500 ppm scenario requires a significant departure from business as usual. Emission reductions need to start soon after 2015, with no overshoot allowed, to achieve the respective concentration objectives (Chart 2.4).

The model runs imply a drop in global oil consumption by at least 80 per cent with respect to business as usual and at least by 40 per cent with respect to 2005. This explains the high GDP losses in oil-exporting countries. In fact, there is a direct relationship between the size of the oil sector in GDP in the business-as-usual scenario and stabilisation policy costs. However, climate policy induces a moderate increase in oil extraction in the years before the cap becomes strongly binding. Over the long-term horizon, a fossil-fuel energy-based economy becomes increasingly uncompetitive in a low-carbon world economy.

Sensitivity analysis – alternative mitigation scenarios

The study examined a variety of scenarios to test the sensitivity of these results to three other important assumptions:

- the EBRD region's contribution to the global abatement effort – variations in the mitigation commitment of the TENEX and TEEX countries
- delays in the availability of CCS technology, which would permit the continued use of indigenous coal
- limitations in the scope for international emissions trading, which would allow high-cost regions to trade emission permits or offsets with low-cost regions in a cost-effective way.

The results are presented in Chart 2.5 and several conclusions can be drawn. First, there are clear cost convexities with respect to targets, technologies and carbon trade. Second, the widest

reported in the Fourth Assessment Report was 2.5°C, compared with 2.1°C for 450 ppm. See Bowen and Ranger (2009).

[29] Like other top-down models, WITCH does not allow for step improvements in energy efficiency through the correction of multiple market and policy failures, although it does consider how international innovation spillovers can be utilised. If the costs of decarbonisation are to be lower than estimated by models of this variety and more in line with those implied by bottom-up calculations, tackling those other failures will be crucial.

variation is generated by restrictions on carbon trading, which almost double the costs in percentage of GDP when all other parameters are held constant. Third, costs are non-linear in relation to the regional mitigation targets; this is most apparent for the energy-rich TEEX countries. Lastly, costs are larger for energy-based economies and increase the more decarbonised the world economy becomes. A more lenient mitigation target may have higher GDP costs in the TEEX region than an almost total decarbonisation of the EU-10 region in the ambitious global scenarios of 500 ppm.

The availability of CCS technology could affect mitigation costs in the transition region, given the abundant coal reserves there. In the main scenario, it was assumed that CCS would be available from the outset and meaningful scale deployment starts by about 2025. Delaying the arrival of CCS until 2040 would raise the price of emission allowances in 2025 by 17 per cent in the 500 ppm scenario. However, the relative penalty decreases over time. Overall, a delay in the deployment of CCS by 10 to 15 years would not hamper the ability of the EBRD region to comply with the low-carbon scenarios, but would increase costs.

Trading restrictions would affect the EU-10 and the TENEX region most heavily, as they are more actively involved in trading. TEEX would use most of its quotas itself, particularly under stringent emission-reduction and burden-sharing scenarios. However, oil exporters would be indirectly affected because delaying the use of international offsets also reduces global oil consumption. World regions that would have bought offsets would instead have to reduce emissions domestically and will further cut the use of fossil fuels.

Trade restrictions will also affect the global carbon price. In 2025 the price of emission allowances will be about 85 per cent lower than without trade restrictions. This is because the limit on global trading will affect the demand for allowances on the global market (from the world regions that have high marginal abatement costs) but not directly the supply of allowances (from the low-cost regions). The restrictions will decouple the carbon price from marginal abatement costs in all world regions.

Chart 2.6 summarises the economic impact of the different scenarios, providing a decomposition of the net present value of predicted economic losses to the EBRD region from 2005 to 2055. The overall GDP loss is split into foregone oil revenues, the costs of buying (or the profit from selling) carbon offsets, and the domestic costs of abatement (allowing for the benefits from international technology spillovers).

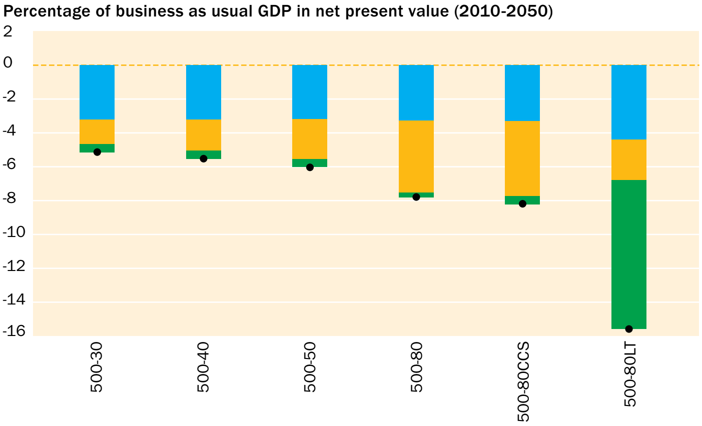
Chart 2.6 shows that the oil GDP loss is similar across scenarios. This follows from the fact that oil consumption is reduced significantly across all mitigation scenarios, given that global emissions are always significantly reduced. However, the economic impact of allowing international permit trading varies greatly across scenarios, given that net trading positions depend on regional levels of commitments. The domestic costs increase with the stringency of the mitigation goal, and are particularly high when carbon trading is restricted and the objective is ambitious, in which case they dominate the total policy cost. In the earlier periods (such as 2030), and for the milder scenarios only, the domestic costs are slightly negative because the benefits of the international technology spillovers outweigh the initially flat marginal abatement costs.

Table 2.1
The share of total GHG emissions in the EBRD region, world and OECD region

Source	EBRD	World	OECD
Total energy	82.4	64.4	81.6
Electricity production and heat	*38.2*	*28*	*34.2*
Manufacturing and construction	*12.4*	*11.9*	*11.4*
Transport	*9.6*	*12.2*	*20.9*
Other fuel	*11*	*8.5*	*12.1*
Fugitive emissions	*11.2*	*4*	*3*
Industrial processes	2.8	4.2	4.3
Agriculture	8.8	13.8	8.1
Land-use change and forestry	2	12.2	0.1
Waste	3.3	3.2	2.6
Bunkers	0.7	2.1	3.2

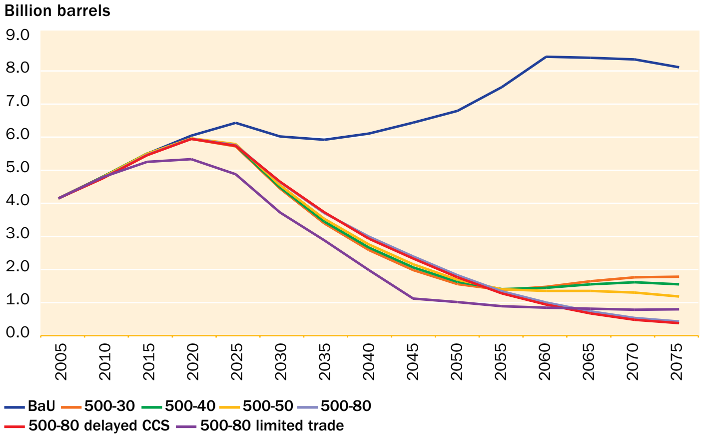
Source: World Resources Institute Climate Analysis Indicators Tool (WRI CAIT).[30]
Note: Bunkers include the use of fuel in international maritime transport and international aviation.

Chart 2.6
Decomposition of mitigation costs in the EBRD region



Source: WITCH and EBRD calculations.

Chart 2.7
Oil production in the EBRD region



Source: WITCH.

[30] http://cait.wri.org

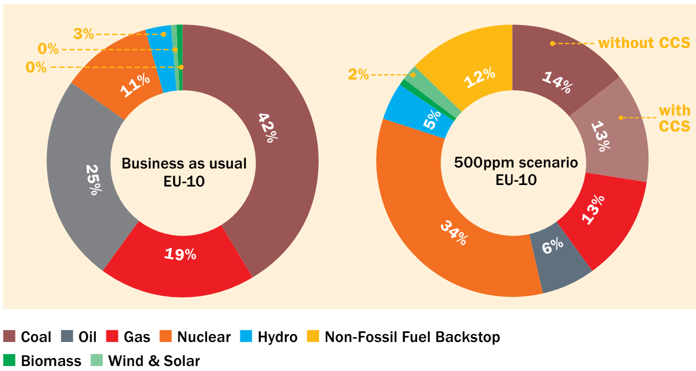
Impacts of mitigation policies by sector

If the EBRD region is to change to a low-carbon future, it will have to change its industrial structures and transform its technological underpinnings. Economies that no longer produce significant quantities of GHGs will use energy and land differently and will have different transport systems and construction practices. This will entail the reallocation of resources, guided by changes in relative prices. The precise pattern will depend on the pace of innovation in different sectors and the responsiveness of economies to the new incentives provided by climate change policy.

For some sectors, the changes will be minor, especially relative to all the other developments likely over the next 20 to 40 years. For consumers, consumption patterns are unlikely to be very different, although energy-intensive products are likely to increase in relative price. However, in transport, energy, buildings and other carbon-intensive sectors there will be substantial change akin to a new energy-industrial revolution (Box 2.2).

In the more aggressive mitigation scenarios, economies will have to substitute capital and labour for energy in producing final goods.

Chart 2.8.1
Share of total primary energy supply in 2050 under business as usual and 500ppm CO_2e scenario – EU-10



The main changes will be in energy systems. The largest share of GHG emissions in the EBRD region (as in the world as a whole) derives from the use of energy to provide electricity and heat (Table 2.1). This is particularly the case for the EU-10 and TEEX. The share accounted for by the use of energy in manufacturing and construction is also higher than average, especially in the TENEX region.

Energy for transport is also important, although noticeably less so (especially in TENEX) than in the developed countries of the OECD. Fugitive emissions (linked to gas pipeline leaks and the venting of associated gas) make a significantly larger contribution than they do in the rest of the world. Agriculture contributes fewer GHG emissions proportionally than in the rest of the world except in TENEX, while land-use change and forestry are also smaller contributors than in the world as a whole. The following sub-sections consider some of the transformations that will be necessary in the key sectors.

Changes in the energy mix

Decarbonisation requires that energy supply becomes less reliant on burning hydrocarbons, with increasing contributions from some mixture of renewable energy sources and nuclear power. It must be associated with CCS where it is difficult to find substitutes for fossil fuels. Decarbonisation is also likely to require a switch from primary energy use towards the production of electricity. Hence there will be more emphasis on the efficient design, operation and regulation of electricity grids. Oil production will be of less importance than under business as usual (Chart 2.7).

The second element of the transformation comprises a reduction in energy demand relative to incomes and output, so that the energy intensity of the economy is lower than it would otherwise have been. In the short term, this requires taking advantage of opportunities to raise efficiency at no (or negative) net cost. In the longer term, innovations with lower energy intensity will be needed, particularly in sectors with high energy use but also pervasively through economies. Subsequent sections consider some ways in which energy efficiency can be improved.

Chart 2.8.2
Share of total primary energy supply in 2050 under business as usual and 500ppm CO_2e scenario – TEEX

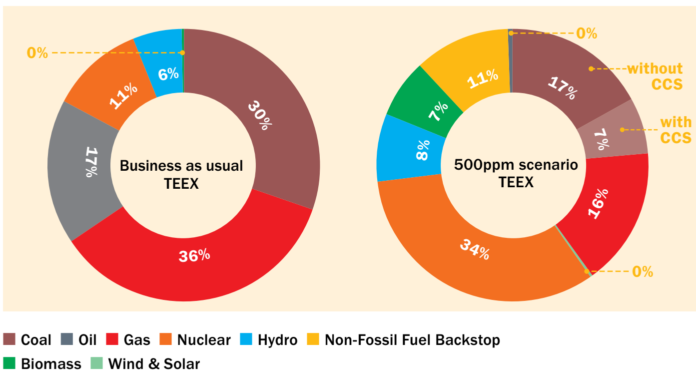
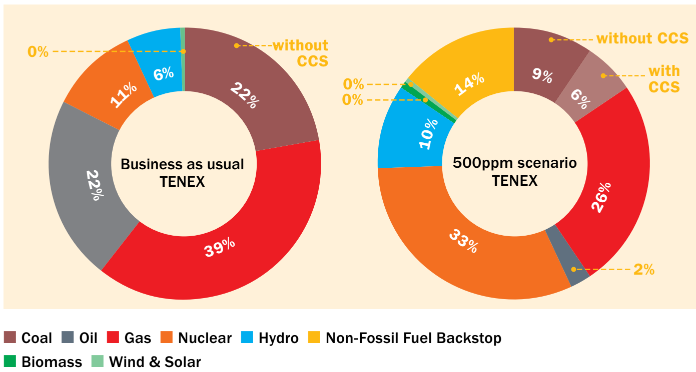


Chart 2.8.3
Share of total primary energy supply in 2050 under business as usual and 500ppm CO_2e scenario – TENEX



Source: WITCH.

In the simulations reported in the previous section, the importance of oil and other fossil fuels falls relative to the business-as-usual scenario, with significant implications for GDP, the domestic energy mix (Chart 2.8), employment and the allocation of investment.

Chart 2.8 demonstrates the impact of a demanding stabilisation target. For the EU-10, TEEX and TENEX regions, the chart shows the projected primary energy mix in 2050 under business as usual and under the 500 ppm target, with all transition countries taking on an 80 per cent reduction target.

Primary energy supply is much lower in the 500-80 ppm scenario (by 45 per cent, 39 per cent and 48 per cent respectively for EU-10, TEEX and TENEX). Oil supply is much lower, while renewables and nuclear power accounts for a much greater share. Coal's share is still significant, partly because of the use of CCS. Under business as usual, there is virtually no use of CCS, but in the 500-80 ppm scenario, much of the coal used is combined with CCS (29 per cent in TEEX, 39 per cent in TENEX and 48 per cent in the EU-10 by 2050).

In the WITCH study, conventional renewable energy sources may play a smaller part in decarbonisation over this time horizon than nuclear power, but backstop technologies are important. Biomass plays some part in decarbonisation in the TEEX region, where Russia in particular has scope to increase the use of managed forests, and hydroelectricity is a larger share of a smaller total supply. But the big increases in the contribution of biomass will arrive in the second half of the century. Gas declines a little in importance but still accounts for a major share. WITCH does not envisage a significant contribution from wind and solar power in TEEX and TENEX, even by the end of the century. Hence the WITCH model suggests that the route to decarbonisation in the EBRD region will be through the expansion of CCs, nuclear power and backstop technologies.[31]

However, other studies suggest that there is a greater potential from renewables, even in the short to medium term.[32] The new EU member states agreed targets for renewable energy by 2020 as part of their accession packages. Russia could increase the share of renewables in total power production from less than 1 per cent to over 6 per cent by 2030.[33]

The low-emissions scenarios will require aggressive policy action including, but not restricted to, strong carbon pricing. Otherwise, the scenarios with a larger contribution from renewables will be too costly compared with the alternatives. The replacement of obsolete plants (which has already happened in the new EU states as part of their preparation for EU membership) provides a good opportunity to improve energy efficiency in energy production sharply, as well as to adjust the mix of energy sources.

Industrial use of energy

EBRD countries, particularly those outside the EU, tend to have relatively carbon-intensive manufacturing, as Chart 2.9 indicates. To a certain extent, this reflects the composition of manufacturing, with a greater concentration on heavy industry and chemicals. Large improvements in energy efficiency in this sector could be achieved simply by replacing ageing plants and equipment with modern designs.

Changes in technology and the use of process by-products instead of conventional fuels have significant potential for negative-cost emission reductions in iron and steel (Box 2.3). The cement industry is another sector where huge improvements could be made cheaply or even at a profit. Russian cement production currently uses 50 per cent more primary energy per tonne produced than German cement production.

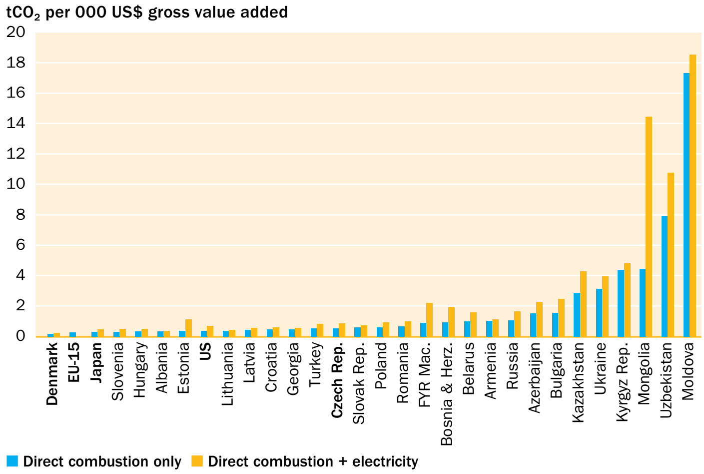
Aggressive climate policies around the world are likely to raise the relative prices of the most carbon-intensive industrial products and discourage their use. This makes it imperative that EBRD countries reduce the carbon content of currently carbon-intensive industrial products in which they have a comparative advantage. This will also mitigate the relative price increase. The most carbon-intensive products include mineral fuels, oil and distillation products, fertilisers, aluminium, paper, cement, inorganic chemicals, iron and steel.

A measure of "revealed comparative advantage" compares the share of a product in a country's gross exports with the share of the same product in the rest of the world's gross exports, using a measure running from 1 (when the given country is responsible for all of the product's exports) to -1 (when the country exports none of the product). Using this method, nine EBRD countries score more than 0.3 for fertilisers, 15 for iron and steel, 16 for cement, four for inorganic chemicals, six for mineral fuels and distillates, and eight for aluminium. Only in the paper industry is no EBRD country a major exporter.

Transport

Transport is the third-largest source of CO_2 emissions in the transition region after energy and industry, and emission levels have grown faster than in all other sectors in the past decade. Road transport accounts for 88.5 per cent of transport-related CO_2 emissions and air transport accounts for roughly 5.6 per cent. Some studies (for example, McKinsey, 2009b) suggest that without dedicated abatement measures, transport-related GHG emissions

Chart 2.9
Comparison of the carbon intensity of manufacturing



Sources: Vivid Economics (2010), using World Bank, UNESD and WRI data.
Note: Gross value added (GVA) is calculated on a market exchange rate basis. Black columns show comparators from outside the transition region. Data are unavailable for Serbia and Montenegro.

[31] From a practical perspective, additional policy and R&D efforts will be required to achieve such an outcome, as both nuclear and CCS currently face real challenges. Nuclear energy is expensive and requires very long preparation times. It also carries risks that need to be addressed and mitigated. CCS is still commercially unproven.
[32] UNDP (2007), for example, analyses the potential for solar power in Uzbekistan, particularly for off-grid applications.
[33] McKinsey (2009b).

Box 2.2 A low-carbon vision for 2030

By 2030 the world is in the midst of an energy-industrial revolution. The industrialised countries of the West, but also the new economic powers of Asia and Latin America, are systemically changing the way their economies work – from energy generation to transport, industry, buildings and agriculture. The EBRD countries are a part of this ongoing, economy-wide change.

The pace of change is fastest in the energy sector. By 2030, low-carbon options are the norm for new power-generation investment. Across the EU, which has expanded in south-eastern Europe, the average carbon emissions in power generation have been brought down by maybe 80 per cent compared to 2011. Elsewhere in the region the carbon intensity of electricity is coming down more slowly and many of the old fossil-fuel plants are still in operation.

The emission reductions are achieved through aggressive investment in renewable energy technology – both currently available technologies (mainly wind but also solar, biomass co-firing, hydro and geothermal) and through the introduction of backstop technologies that are currently only on the drawing board. In the EU, the better integration of the European power grid has helped fluctuations in supply and demand to be better managed. Many countries accustomed to nuclear power, and perhaps a few newcomers, are upgrading and renewing their nuclear capacity on the back of more stringent and strictly enforced environmental and nuclear safety regulations.

CCS for power generation was introduced more slowly than originally hoped, but pushed by regulatory support it has become the norm for new coal-fired capacity by 2030. Increasingly, CCS is also used for gas generation, although in 2030 this is still rare. CCS retrofits are limited to relatively modern plants. The advent of CCS has allowed fuel-rich countries to continue relying on indigenous coal resources. However, the mining industry has been through a process of deep restructuring to increase its efficiency and improve environmental, health and safety standards.

Residential energy efficiency in Central Europe has been boosted through large-scale building upgrades modelled on successful programmes in western Europe, and by 2030 the performance is on a par with the European average. “Zero carbon” is the standard for all new buildings. Richer households are exploring micro-generation options like roof-mounted solar photovoltaic panels, but with less generous support systems the penetration is smaller than, for example, in Germany.

In other parts of the region, progress in residential energy efficiency is slower, although energy price reforms have had a notable effect. The widespread use of district heating helps to boost energy efficiency, but there is a growing demand for decentralised solutions including heat pumps and biomass.

The transport sector in 2030 is in the midst of a technological shift away from traditional, petrol-powered cars towards electric cars, plug-in electric hybrids and backstop transport fuel (such as hydrogen fuel cells). In the EU member states the majority of new car sales are already electric. Elsewhere in the region, traditional motor vehicles still dominate but since 2011 their fuel efficiency has increased by more than 30 per cent, helping drivers to counterbalance the effect of higher oil prices. Some countries have introduced standards to blend petrol and diesel with sustainably grown biofuels, especially for lorries and vans, where electric solutions are not yet commercial. Railways are making a comeback throughout the region, and the fast, modern and quiet rolling stock of 2030 is a far cry from the musty trains of communist times.

The change in driving habits has had repercussions for the region’s automotive industry. Production lines, particularly in Central Europe, are now geared towards the new electric technology and the supply chain has made the necessary adjustments. The manufacture of light, long-lasting batteries has become an important new part of the industry. However, some of the better-known brands have disappeared as they failed to grasp the significance of the automotive revolution.

The move to a low-carbon economy is also felt in other parts of the manufacturing sector, with the supply chain for wind generation, CCS technology, smart grids, low-carbon heating systems, energy-efficient appliances, new building materials and energy-management solutions creating new sources of income and jobs. The forestry sector is taking advantage of a growing demand for sustainable biomass, both domestically and from abroad.

Heavy industry is still a mainstay of the economy in many transition countries. However, a concerted push to increase energy efficiency has transformed the sector. The competitive edge gained by early movers had forced the rest of the industry to follow suit, but in this sector too there have been high-profile factory closures among those that failed to keep up with the new industrial revolution.

Some pioneering factories are experimenting with CCS for industry. In 2030 this is still the exception, but the consensus is that, over the coming decades, it will become the norm. Meanwhile, scientists and engineers in the research division are experimenting with completely new production techniques and alternative products such as low-carbon cement.

Throughout the region, systemic change is helped by opportunities to monetise some of the carbon savings on the international carbon market and by a policy environment that facilitates, rather than hinders, low-carbon investment, resource efficiency and innovation.

The EBRD region has become an integral part of the global R&D efforts and it is at the forefront of several industries. Based on their abundance in natural resources, several EBRD countries build cutting-edge technologies compatible with the low-carbon economy, for example in steel with CCS or the use of biomass. Countries with a track record in car manufacturing develop strong leadership in transport technologies, for example electric cars.

Source: Vivid Economics (2010).

and fuel consumption in Russia could more than double by 2030, due to an expected 3.5 per cent annual increase in the number of vehicles on the road.

Energy efficiency needs in the transport sector are large. However, energy-efficiency policies and policy implementation lag significantly behind other sectors. Several barriers have been identified, including:

- limits (without additional climate change policy actions) to commercially viable low-carbon options in the transport sector
- a reluctance among policy-makers to curtail transport volumes, due to positive growth effects on the economy
- a lack of knowledge of and precedents for successful policy implementation, even in advanced economies.

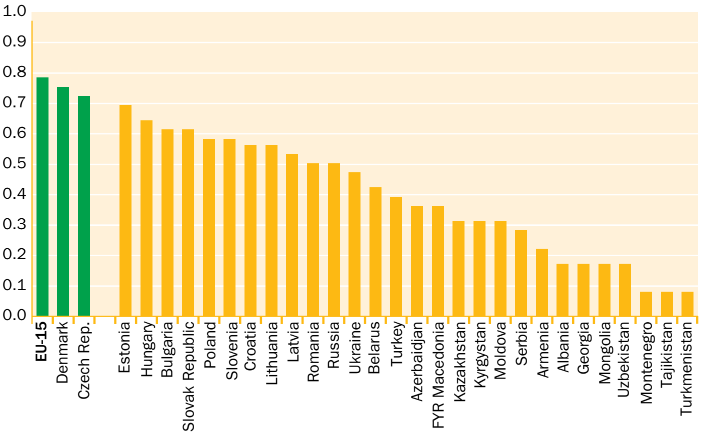
Nevertheless, public awareness of the problems and the demand for improved energy efficiency are growing.

Climate change policies can promote the fuel efficiency of light vehicles and slow down the shift from public to private transport. Tighter regulatory standards in the EU are expected to incentivise such changes, as they will influence the direction of automotive R&D. In addition, domestic fuel taxation in EBRD countries will be an important lever to encourage lower fuel consumption per mile and the development of less carbon-intensive fuels, such as biofuels.

Progress in the development and implementation of such policies can be gauged using an index of transport energy efficiency, shown in Chart 2.10. The index considers three core elements:

- policy and regulation, including the development of energy-efficiency strategies and policies at the national level, energy-efficiency standards and annual inspections for vehicles

Chart 2.10
Transport Energy Efficiency Index 2010



Source: COWI for EBRD.
Note: The Transport Energy Efficiency scores range from 0.0 to 1.0, with 0.0 representing a lack of institutions and market incentives to implement transport energy-efficiency solutions coupled with poor outcomes (high carbon and energy intensity and no or little use of energy-efficient modes of transport, vehicles and fuels). The scores were calculated based on survey results conducted by COWI in 2010 and transport and emission data.

- market incentives (a fuel taxation regime, financial incentives to use public transport, and the share of public transport in total passenger traffic)
- energy-efficiency outcomes (such as CO_2 emissions per passenger-km, CO_2 emissions per tonne-km).

The index reveals considerable variation among EBRD countries, but generally energy-efficiency efforts and outcomes are still at an early stage in the transition region. Most of the EU-10 states' scores are close to each other. Many of these countries have already adopted energy-efficiency strategies and policies, either at the national or municipal level. Many authorities have introduced vehicle- and fuel-based taxation, partly based on the "polluter pays" principle. Nevertheless, the level of efficiencies falls slightly below the EU-15 level, with room to improve awareness and policy effectiveness.

The south-eastern European countries lag behind in terms of policies and outcomes. Awareness remains low in the Commonwealth of Independent States (CIS) and there have been only a few cases where the government has actively pursued and implemented energy-efficiency policies in the transport sector. The capital and operational costs of using transport vehicles remain low and regulation of vehicle quality continues to be weak.

Buildings

One of the largest sources of emissions reductions from efficient climate change policy will be greater efficiency in heating buildings. McKinsey's study of low-carbon opportunities in Russia[34] identifies various changes that are estimated to be able to cut energy use by half, and emissions from the sector by 40 per cent. These changes include improvements in the insulation of the existing housing stock, the more widespread introduction of thermostats, and stricter efficiency standards for new construction.

Energy use per square metre in Russia is currently around twice that in Scandinavian countries with similar climates, so there is plenty of scope for improvement using known technologies. The challenge is to overcome the coordination and asymmetric information problems that inhibit residents and landlords from undertaking the improvements that could generate net benefits even without carbon pricing. This is one area where carbon pricing alone is unlikely to be a sufficient incentive and public intervention is likely to be necessary.

[34] See McKinsey (2009b).

Box 2.3 Climate change policy and the steel industry

The iron and steel industry is the largest industrial emitter of CO_2 in the world, with global emissions of about 2.8 Gt a year. Two production technologies are widely used: the integrated route comprised of blast furnaces and basic oxygen furnaces (BF/BOF), and electric arc furnaces (EAF).

In the BF/BOF process, iron ore is reduced in the blast furnaces by the use of coke and pulverised coal injection to form hot metal. This is then treated in a basic oxygen furnace to remove impurities with oxygen and produce steel. The EAF process uses primarily scrap metal, which is melted by very high-current electricity. But EAFs can also use Direct Reduced Iron, produced with coal or gas, as a substitute for scrap. Open-hearth furnace steelmaking (OHF) is a third, and older, steelmaking technology still in use in Russia and Ukraine, but increasingly obsolete.

About 85 per cent of the industry's CO_2 emissions derive directly from process and fuel combustion in primary steelmaking, which emits around 1.6-2.2 tCO_2 per tonne of steel (excluding coke/sinter-making). The remaining 15 per cent come from indirect emissions, mainly electricity consumption in EAF production.

Russia and Ukraine are significant steelmakers in the global context. Russia, with 64 Mt of crude steel produced in 2010, is the fourth-largest steel producer in the world, while Ukraine, with about 32.7 Mt per year, is the seventh largest. Their competitive advantage is based largely on access to raw materials, namely iron ore and coking coal. Prospects for the growth of the Russian and Ukrainian steel industries are good. This is based on the projected growth of their domestic economies (especially Russia's) and export markets, such as the Middle East. Furthermore, their competitive costs make them – along with Kazakhstan – two of the lowest-cost producers in the world.

Among the new EU member states, the largest steel producers are Poland (8 Mt per year, with good access to domestic coking coal) and Romania (4 Mt per year). The steel industry accounts for 32 per cent of exports of goods in Ukraine and the steel sector is one of the largest sectors in Bosnia, FYR Macedonia and Serbia.

Major efficiency improvements have been achieved in the Russian and Ukrainian steel industries. In Russia, CO_2 per tonne of steel produced was reduced from 2.6 in 1990 to 2.0 in 2008. The average energy performance is currently about 15 per cent lower than that of integrated steel works within the EU. But substantial opportunities for reducing CO_2 emissions per tonne remain. For example, both countries continue to operate open-hearth furnaces. In Russia this is because of the availability of relatively low-cost gas; in Ukraine it is because of the lack of finance for alternatives. These furnaces have scope for greater energy efficiency and higher emission reductions.

More effective recycling of waste gases provides a further opportunity to achieve international best practice in optimising energy use. However, good technical experience with traditional processes causes inertia in the sector, which remains a barrier to further technological change. At the same time, energy costs that are below international levels significantly dilute the potential economic benefits of such investments.

Government agreements in Russia and Ukraine under Annex I of the Kyoto Protocol do not, in practice, involve any restrictions on emissions from the steel industry. But steel companies can obtain carbon credits by achieving CO_2 reductions within the Joint Implementation scheme. In contrast, steel operations in the new EU member states within the Phase 3 of the EU Emissions Trading Scheme (ETS) will be granted allocations of rights to emit. These will be initially related to their immediate and medium-term prospects for output, and based on a benchmark reflecting the average performance at the 10 per cent of installations in the sector that were the most efficient in 2007 and 2008. This could mean that, above a certain tonnage, marginal tonnes produced will require the purchase of emissions permits.

EU-based steelmaking facilities subject to emissions restrictions may have to compete temporarily or permanently with steelmakers not subject to carbon pricing. This could give rise to "carbon leakage" – the relocation of output to jurisdictions with weaker carbon restrictions. Among all heavy industries, this is most likely to occur in the steel industry because of its combination of both high carbon intensity and trade intensity. In some circumstances, carbon leakage might actually increase global CO_2 emissions, if production is relocated to countries and plants with lower CO_2 efficiency. Various policy solutions have been proposed to address this potential distortion, including a border-carbon adjustment, a more generous system of free allocation of emission quotas for trade-sensitive industries, and sectoral agreements for emissions.

However, it is important not to overestimate the significance of extra costs under the EU ETS, especially if the additional costs related to emissions are under about €30 (about US$40) per tCO_2, or about €60 per tonne of steel. EU integrated steelmakers already experience a higher cost premium, due to higher input costs compared with competitors in Russia or Ukraine. This is offset by higher revenues per tonne, based on access to customers demanding higher valued-added products and technological experience in process and products. Moreover, EU steel producers are likely to be well placed to benefit from increased demand to transform the EU power and automotive sectors, from investments based on climate change policy. This will require higher quality and specialised steel products.

None of the foreseen efficiency improvements in primary iron and steelmaking are likely to transform the production process, which is intrinsically CO_2 intensive. Switching to electric arc steelmaking based on scrap is limited by the global availability of scrap. Other ironmaking processes, such as those based on direct reduction, still require gas or coal as an energy source.

Fundamental R&D is being undertaken on new processes that might radically reduce CO_2 intensity, mainly based on CCS technologies. At least one demonstration project in this area is likely to materialise in the next eight years. But the additional costs of CCS for iron and steelmaking will be significant – the IEA Technology Roadmap for CCS estimates additional costs of US$60 per tCO_2, or over US$100 per tonne of steel. Therefore, there are no immediate economic incentives for the iron and steel industry to adopt CCS.

Source: EBRD

Social implications of climate change policy

Are climate policies regressive?

Implementing climate policies through carbon pricing may have significant distributional effects for transition countries. One of the main concerns raised among policy-makers is that mitigation policies, by setting an explicit price on carbon and increasing energy costs, could be socially regressive and affect the poorest households disproportionately. There are no specific studies on the transition region, but findings from the empirical literature can be used to infer the potential distributional impact of mitigation policies, notably a carbon tax or price, in transition countries.

A carbon tax is likely to generate distributional effects by changing the product prices faced by households and by altering factor prices, thus affecting household incomes[35]. First, a carbon tax will raise the final price of fossil-fuel intensive products, such as natural gas, electricity, gasoline and heating fuel. This will affect consumers according to their spending on fossil-fuel intensive products. Since poorer households spend a higher share of their income on fossil-fuel intensive products, a carbon tax might be regressive.

Second, a carbon tax will affect the relative prices of the factors of production (labour or capital) used in carbon-intensive industries. The impact on factor prices will depend on how feasible and simple it is to substitute these production factors, and the relative factor intensity of carbon-intensive industries. A carbon tax will also increase returns from the factor that constitutes a better substitute for the polluting input.

Furthermore, a carbon tax will reduce the production of fossil-fuel intensive products. This will tend to reduce, to a relatively greater extent, returns from the factor intensively used in the sector. Carbon-intensive industries tend to be capital-intensive, so if capital is a better substitute for pollution than labour, a carbon tax might reduce wages. This will burden poor households particularly.

Most empirical studies on industrial countries conclude that climate change mitigation policies are likely to be regressive. Focusing on the impact of changes in relative prices on the real value of household spending, carbon pricing appears to be regressive partly because energy comprises a larger part of poorer families' expenditure.[36] In addition, the few empirical contributions focusing on sources of income suggest that a carbon tax could also be regressive by depressing (unskilled) wages when emission-abatement measures are capital-intensive.[37]

However, the empirical literature on developing countries depicts a slightly different picture. Some studies suggest that the distributional effects of climate change policies might be progressive[38], because the expenditure of low-income households is less sensitive to the price of energy-related commodities and a carbon price will favour unskilled rural workers.

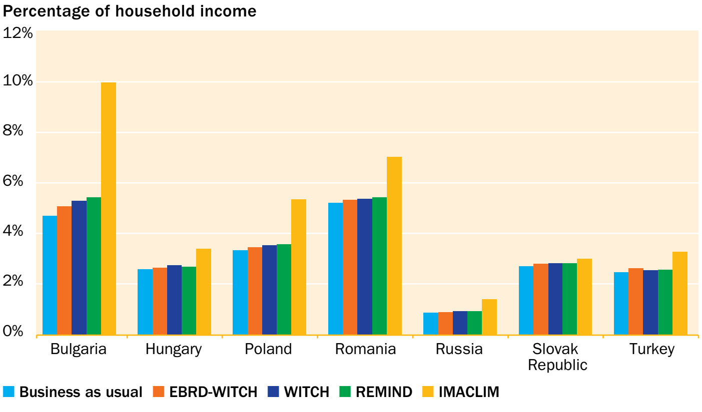
Although specific studies of the tax incidence of climate change policies in the EBRD region have not yet been conducted, it seems likely that the effects of climate change mitigation policies in the EBRD region will, on balance, be regressive. Access to electricity supply is widespread in the transition region, relatively energy-intensive technologies are used in industry and heating, and the share of labour employed in agriculture is, for most EBRD countries, closer to that in the OECD than is the share among developing countries.

Climate change policies and affordability

A narrower way of assessing the distributional impact of mitigation policies is to look at their effect on the affordability of household energy utility services. The World Bank (2009) defines affordability as households' ability to purchase an adequate level of utility services without suffering undue financial hardship. Affordability is usually measured by the affordability ratio – the share of income or expenditure allocated to a specific good or service.

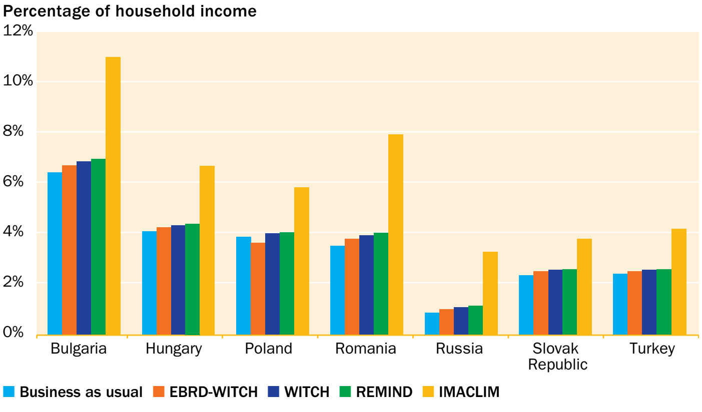
Moving to a low-carbon emission path may reduce the affordability of utility services: a positive carbon price would lead to higher prices for fossil-fuel intensive products, notably electricity and natural gas, thus tightening affordability constraints. However, anticipated energy-efficiency improvements, notably in housing, would ease affordability constraints by reducing the required consumption expenditures to achieve an adequate service level.

Chart 2.11
Affordability of electricity for the average household in 2020



Source: EBRD calculations.

Chart 2.12
Affordability of natural gas for the average household in 2020



Source: EBRD calculations.

[35] See Fullerton (2008) for a detailed review of the tax incidence literature.
[36] This conclusion emerges whether the studies are input-output table based, econometric or based on calibrated general equilibrium models. See respectively Symons (2000), Barker and Kohler (1998) and Hasset et al. (2009).
[37] See Fullerton and Heutel (2007) and Fullerton and Heutel (2010), who calibrate an analytical general equilibrium model for Japan and the US, respectively.
[38] For example Shah and Larsen (1992) and Yusuf and Resosudarmo (2008).
[39] The price projections for electricity and natural gas for each country under the baseline are obtained from Enerdata POLES. This is a partial equilibrium world model that estimates prices, taking into account projections of energy demand and supply by country.

By modelling the pass-through of carbon prices to the price of electricity and natural gas, it is possible to analyse the affordability of electricity and gas for both the average-income decile and the lowest-income decile of households. The analysis was carried out for six countries (Bulgaria, Hungary, Poland, Russia, Slovak Republic and Turkey) for energy- and carbon-price projections in 2020. Table 2.2 lists the four mitigation policy scenarios considered; a baseline scenario with no carbon price was also included.

In addition to the carbon price, the analysis also captures changes in consumption patterns in response to price changes and expected income dynamics.[39]

The main finding, shown in Charts 2.11-2.14, is that well-designed climate policies (including an international trade in emission permits) are not expected to generate major constraints on the affordability of electricity or gas for the average household in the selected transition countries. A carbon price in the range of US$10-25 per tCO_2 would only marginally increase the affordability ratio for the average household. Only a high carbon price, as in the IMACLIM projection, significantly alters the affordability of gas – in Russia, the projected affordability ratio triples whereas in Romania it doubles. It is important to note that even with such a high carbon price, the affordability ratio for gas remains relatively low in all countries except Romania and Bulgaria.

Although the patterns are similar in each country for the lowest decile households, the effects of carbon pricing are slightly more pronounced than for the average household, particularly for gas users. In the models, moderate carbon prices increase affordability ratios marginally, by less than one per cent in most of the selected countries. In contrast, high carbon prices increase the affordability ratio to double digits for most countries, with a more pronounced effect in gas once again.

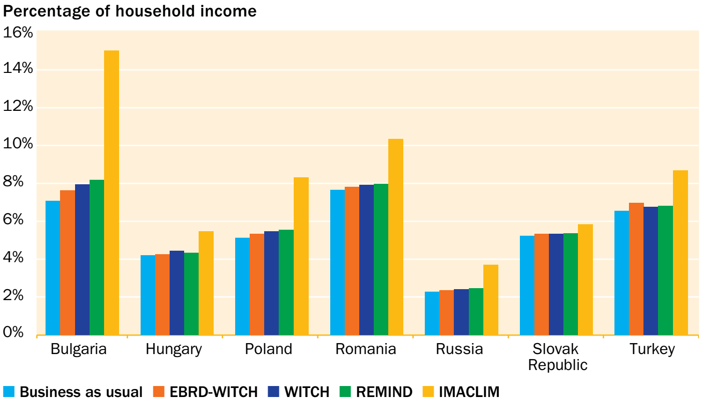
Given the relatively high affordability ratios for the poorest households, even under business as usual, there is a strong case for carefully crafting social protection policies to ensure that stringent climate policies do not impose undue hardship on the poorest households. However, as the affordability of energy for the average household is not likely to be severely affected by climate change policies, it is important to protect households in need rather than shield all households from the effects of carbon pricing, which would discourage more efficient energy use.

Table 2.2
Mitigation policies considered

Model	CO_2 price (US$/$tCO_2$)
Business as usual	0
EBRD-WITCH	11
WITCH	20
REMIND	25
IMACLIM	230

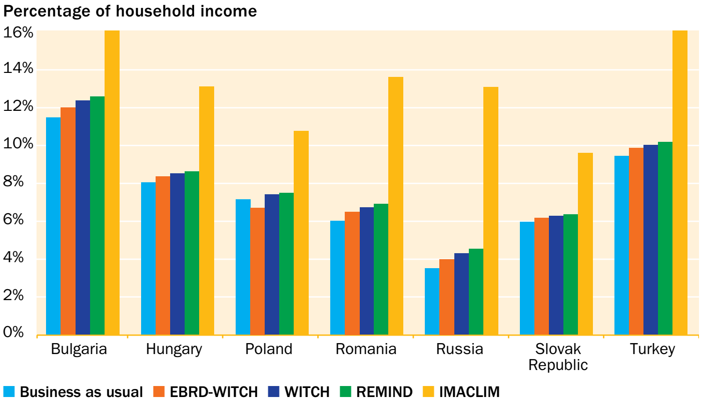
Notes: IMACLIM is a recursive, computable, general equilibrium model featuring inertia in the development and deployment of new technologies, agents' imperfect foresight, endogenous demand for goods and services, international trade of all goods and CO_2 emission permits. The model captures both micro- and macro-economic behavioural parameters. REMIND is an optimal growth model featuring inter-temporal trade and capital flows among world regions, and a detailed description of the macro-economy as well as the energy sector. This model combines the major strengths of bottom-up and top-down models. WITCH is an optimal growth model featuring endogenous technological change in the form of energy-efficiency improvements and technological breakthroughs, perfect foresight and international trade of CO_2 emission permits.

Chart 2.13
Affordability of electricity for the lowest decile household in 2020



Source: EBRD calculations.

Chart 2.14
Affordability of natural gas for the lowest decile household in 2020



Source: EBRD calculations.

Conclusions

Mitigation costs for the transition countries vary substantially with the ambition of the global and regional mitigation objectives, the availability and speed of new technology deployment, and the extent of international trade in carbon. For many transition countries, particularly oil and gas exporters, the legacy of an energy-based high carbon-intensity economy can cut both ways. On the one hand, there is a potential for significant emission reduction at very low economic costs, based on energy-efficiency gains. On the other hand, emission reductions that go way beyond these efficiency gains will require structural change both within and away from high-emissions sectors and global mitigation efforts will lead to a decline in global demand for fossil fuel based goods. For these reasons, macroeconomic models suggest that the costs of adjustment to low-carbon could be high for energy exporters, but relatively low for energy importers.

At the same time, decarbonisation also offers significant economic benefits. Some of these apply to energy producers and energy importers alike. In addition to the obvious gains from reducing the risks of calamitous climate change, these include technology spillovers associated with the development of alternative energy sources. In other cases, the benefits of climate change mitigation will apply particularly to resource-rich countries. This includes reducing the distortions associated with energy subsidies and inadequate regulation of energy production and distribution, and reaping the long-term growth benefits from diversifying away from the natural resource sectors. Climate change mitigation may generate strong incentives that help these economies battle their "resource curse". Hence, the countries that face the highest climate change mitigation costs over the medium term are also likely to benefit most from its consequences in the long term.

Climate change mitigation will entail structural changes in the EBRD economies. These will be largest in the energy sector, where fossil-fuel production will have to shift away from oil, productivity will need to improve, renewable energy sources and technologies must be developed and CCS deployed on a large scale. Some models suggest that the relative importance of nuclear power may have to increase, particularly in the more stringent emission-reduction scenarios. More widely, electricity produced in less carbon-intensive ways will have to be substituted for primary energy use by industrial and household users. Producers will need to explore opportunities for substituting labour and capital inputs for energy.

Elsewhere in the economy, the pace of energy-efficiency gains needs to be maintained or accelerated through improvements in the energy use of industry and buildings and the carbon performance of transport. There is scope for EBRD countries to narrow the gap with OECD countries in the energy efficiency of buildings and transport, where vehicle fuel economy has lagged. As several EBRD countries have relatively large manufacturing sectors, there is also the prospect of benefiting from the additional investment around the world in the "green" technologies that will be necessary to transform global energy systems. Exploiting this opportunity will be particularly important for those countries that will experience an adverse shift in their terms of trade because of the fall in demand for fossil fuels.

Climate change policies are also likely to have different effects on households at different income levels, particularly in the case of the implicit or explicit carbon pricing that will be necessary. However, analysis for the transition region also suggests that climate change policies will not significantly reduce the affordability of electricity, utilities and heating for the average household. In contrast, households in the poorest decile of the income distribution could face difficulties under high carbon prices. Hence climate change policies need to be developed hand in hand with social safety nets and labour market policies that support these households.

The main policy conclusion of the chapter is that while climate change mitigation will entail higher economic costs in the transition region than in advanced OECD economies, particularly in resource rich countries, ambitious mitigation measures are strongly aligned with the long term economic interests of the region. The end-result of successful mitigation efforts will be reduced resource dependency, and likely higher long term growth. Hence, responding constructively to the challenge of global climate change will accelerate structural transformation which, while costly, is ultimately desirable.

Proactive mitigation policies are the best way of containing mitigation cost. It is in the best interests of resource-rich countries to adapt production and exports to the lower global demand for fossil fuels and hence maintain economic competitiveness, rather than clinging to a production structure that is not well matched with the world's future needs. The faster the institutions and policy frameworks are created that will encourage new low-carbon production, the lower the total cost of mitigation.

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Effective policy is essential to facilitate the implementation of economy-wide emission reductions. "Marginal abatement cost" curves, which rank emission-reduction opportunities in increasing order of costs, can be used to analyse the impacts of general economic and specific climate change-targeted policies, and measures on the commercial viability of emission-reduction opportunities. Chapter 3 demonstrates how a portfolio of policies – energy pricing, improvements in the business environment, support mechanisms for renewable energy and carbon trading – can turn carbon abatement into a major investment opportunity in Russia and Turkey.

3

Effective policies to induce mitigation

Introduction

The carbon performance of a country is determined to varying degrees by its economic structure, geography, and its level of economic activity (see Chapter 1). However, carbon performance is also a function of policy. A mix of effective policies encourages carbon and energy efficiency, and can make low-cost emission-reduction investments commercially attractive to those who undertake and pay for them.

This chapter explores what policies are needed to make the emission-reduction trajectories of Chapter 2 a reality. The concept of marginal abatement cost (MAC) is used to demonstrate how the costs and profits of investments in carbon-abating projects are sensitive to policy choices. The results show what policies make a particular difference to investors. This is the case not just for targeted climate policies, such as carbon taxes, energy-efficiency standards or emissions trading schemes, but also for the broader economic policy context.

The analysis is applied in detail to Russia and Turkey. Both countries have unique emission-reduction challenges, which are arguably among the most testing in the EBRD region.[1] Yet the lessons that can be learned from these countries are relevant for the transition region as a whole. The historical emission trends in Russia are typical for former Soviet Union countries, where both energy use and carbon emissions rose fast in the 1980s, dropped sharply after the collapse of central planning and have recovered slowly over the past 10 years. In contrast, Turkey's energy use and greenhouse emissions have risen steadily over the last two decades. Even so, Turkey is much more carbon efficient than the former Soviet countries and is ahead of many transition countries in terms of pricing energy at cost-recovery levels.

Climate policies and outcomes

The debate on domestic carbon policies typically focuses on targeted climate policy instruments, such as economic incentives (including taxes, subsidies, cap-and-trade systems and tradeable green certificates) and administrative instruments (such as energy or emission-performance standards, products or process requirements) or their softer versions (such as energy-performance labelling or building certificates).[2] In a similar vein, the Stern review identifies three essential elements of climate change policy.[3] These include:

- carbon pricing (through taxes, trading or regulation)
- technology policy (e.g. research and development, demonstration, and market support to drive innovation)
- policies to remove barriers to behavioural change, particularly in relation to the take-up of opportunities for energy efficiency, changing preferences and entrenched behaviour.

However, there is a growing realisation that climate policies need to be integrated into broad development and economic policies. A sound macroeconomic environment can reduce country risk perceptions and reduce the financing costs for climate mitigation investments. Policies that reduce or eliminate subsidies to fossil fuels and energy-intensive economic activities will at the same time increase the opportunities for, and returns to, climate-mitigation activities.

Instead of pursuing a narrow policy goal of reducing emissions, policy integration offers opportunities to embed climate objectives into the aims of specific sectors that reflect the core objectives of a society, such as energy security or the quality of infrastructure services.

Policy integration has played a significant role in the success of the transition economies in meeting their Kyoto targets. As shown in chapter 1, making markets and prices work in formerly centrally planned economies has triggered massive economic restructuring and general improvements in efficiency. These have resulted in a partial decoupling of economic growth from carbon emissions.

Liberalised energy prices formed in competitive markets and cost-recovery tariffs for regulated energy services can improve the fundamentals for sustainable growth and provide incentives to use less energy and improve service quality. Conversely, persistent energy price subsidies make otherwise economically sound investments unattractive to investors. A poor business environment, resulting in steeper risk premiums and higher capital costs, can have a similar effect. This can offset the intended impacts of dedicated low-carbon policies, such as feed-in tariffs, carbon taxes and energy-efficiency regulations.

International policy instruments can financially enhance the effectiveness of national climate-friendly policies. Under the UN Framework Convention on Climate Change (UNFCC), finance may flow into countries through the flexible (carbon-finance) mechanisms of the Kyoto Protocol – Joint Implementation (JI), the Clean Development Mechanism (CDM) and International Emissions Trading. The transition region has so far exploited only a fraction of its potential for carbon-finance transactions. Public climate finance – distributed through bilateral or multilateral mechanisms – is available for technical assistance or less commercial activities.

Monitoring sustainable energy progress

The EBRD's Index of Sustainable Energy (ISE), introduced in 2008 and updated in 2010,[4] is a composite index of institutions, market incentives and outcomes relating to sustainable energy. The index tracks how targeted policies and generic reforms combine to achieve environmental outcomes.

[1] The specific features of Russia include its reliance on export of energy resources, vast territory with massive transport needs or harsh and diverse climatic conditions.
[2] OECD (2009).
[3] Stern (2007).
[4] For more details on the methodology and structure of the ISE, see www.ebrd.com/pages/research/publications/brochures/securing.shtml

Box 3.1 The Index of Sustainable Energy

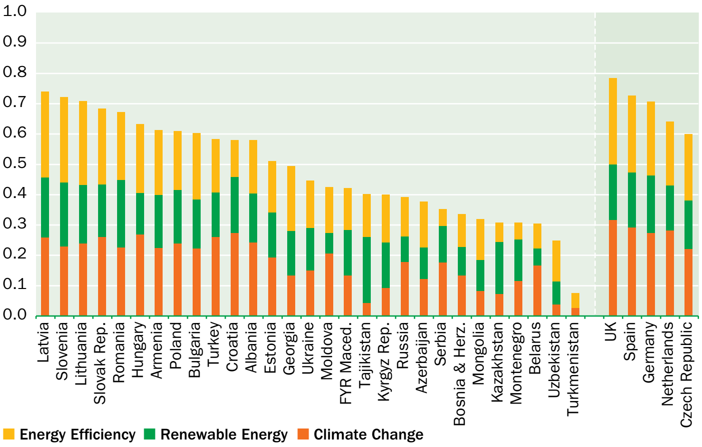
The Index of Sustainable Energy (ISE) rests on three pillars – institutions, market incentives and outcomes. These are applied to the three main areas of sustainable energy: energy efficiency (EE), renewable energy (RE) and climate change (CC). EE and RE refer to the energy use and energy supply in the economy. CC refers to climate-specific institutions and mechanisms, including international commitments to reduce country emissions, carbon-related taxes and emissions trading scheme, and the domestic institutions focused on climate policy. Each area is given equal weight in scoring.

Institutions – this metric captures the development of key institutions that enable and foster sustainable energy investment. Four main components of the institutional set-up are considered: laws (specific laws related to EE, RE and CC); agencies (their existence and assessment of their quality and functions); policies (their existence, extent, targets and sectoral regulations); and projects – the track record of sustainable energy and climate change project implementation in the country (implementation capacity).

Market incentives – this measure tracks pricing and other mechanisms that encourage energy savings, renewable energy generation and reductions in greenhouse gas emissions. Its main components are energy pricing (cost-reflective energy tariffs are a key driver of rational energy use); enforcement and waste (collection rates of electricity bills and transmission and distribution losses in the electricity system); renewable support mechanisms (tradeable certificate schemes and feed-in tariffs); and carbon taxes and emissions trading (cap-and-trade mechanisms and market-based carbon finance such as the Joint Implementation and the Clean Development Mechanism).[5]

Outcomes – measures of sustainable energy outcomes provide an indication of each country's room for improvement. The key measures are energy intensity, carbon intensity of GDP and carbon emissions per capita. Each is compared against world-leading countries and internationally accepted benchmarks.[6]

Chart 3.1
ISE scores across the transition region and relevant comparator countries



Source: EBRD.
Note: The data used for the index is the most recent available for each class of information: for institutions as of mid-2010, for energy use 2008 and carbon emissions 2007. The indicator ranges from 0 to 1. A value of 0 is the lowest in terms of sustainable energy (absence of institutions and market mechanisms coupled with the worst outcomes in terms of energy efficiency, renewable electricity generation, carbon footprint and carbon intensity). A maximum score of 1 denotes an ideal economy with strong sustainable energy institutions and market mechanisms, and which also ranks top in sustainable energy outcomes.

In so doing, it provides a snapshot of where each country stands in terms of institutions and market incentives, and the potential for improvements in sustainable energy outcomes compared with best practice (Box 3.1).

There is considerable variation in progress towards sustainable energy among countries in the transition region, but all EBRD and comparator countries have room for improvement.

The new EU member countries tend to score the highest within the EBRD region, reflecting institutional and policy reforms undertaken in the context of EU accession. Croatia and Turkey follow closely. Countries in the Eastern Europe and the Caucasus (EEC) region rank in the middle of the distribution, with higher scores in Armenia and Georgia. The weakest performers are the countries of the South Eastern Europe region (SEE) and the energy-rich countries of the former Soviet Union. Lastly, but equally importantly, the comparator-advanced EU countries score better on average than the new EU member states, but the gap between them and the advanced EBRD countries is much smaller than the gap between the most and least advanced of the EBRD countries.

The scores in energy efficiency and climate change are broadly comparable for the more advanced new EU member states. This is not surprising, as it reflects a better institutional setup, good market incentives and adoption of EU-wide policies. The comparator countries in western Europe are significantly more advanced than the EBRD countries in both energy efficiency and climate change. Outcome indicators in climate change – carbon intensity of GDP and carbon emissions per capita – are relatively poor in the transition region, but comparable with and often better than in the advanced EU countries, where high per-capita carbon footprints are the norm (see Chapter 1).

ISE scores for renewable energy are relatively low across all countries, including the comparator EU countries. Although the institutional setup is advanced in most EU countries, renewable energy outcomes are weak, reflecting the continuing strong reliance on fossil fuels to meet energy needs. Among the leading countries in the region, the relatively high scores are generated either by a mix of reasonably good institutions and market incentives with reasonably good outcomes (as in Romania), or strong institutional and market-incentive systems with a poorer outcome indicator (as in Poland). The relatively high scores in some less advanced EBRD countries (e.g. Albania and Tajikistan) are driven by high scores for renewable outcomes, as a result of exploitation of hydro resources in large plants. However, the institutional set-up for renewables is weak and no market mechanisms have been introduced to foster the renewables industry.

The relationship between the institutional framework and energy outcomes is complex. The creation of a suitable institutional environment does not lead immediately to improved outcomes, as changes occur over a relatively long time. Similarly, good outcomes as measured by the ISE may have arisen independently of the creation of sound institutions and policies, and should not necessarily be seen as evidence that all is well in the energy sector more broadly. Some countries may have a high share of renewable energy resources in the energy balance because of their location (and consequent abundance of hydro resources), despite having done little to strengthen their institutional framework.

[5] Joint Implementation and the Clean Development Mechanism are two flexible project-based mechanisms for emissions reductions allowed under the Kyoto Protocol.
[6] Outcome measures are not corrected for climate, economic structures or resource endowment.

Nevertheless, even with a simple snapshot of each of the indicators, breaking the ISE into institutional (institutions and market incentives) and outcome measures reveals several important findings (see Chart 3.2). First, the range of outcomes scores is extremely wide, with countries such as Albania, Georgia and Latvia scoring very highly,[7] even compared with advanced comparator countries. At the other end of the spectrum, Kazakhstan, Mongolia, Turkmenistan and Ukraine, as well as Bulgaria and Estonia, are among the least advanced, even by global standards. Second, it is clear that some countries in the region, particularly the new EU member states and a handful of others (e.g. Armenia, Moldova and Ukraine), have made substantial progress in establishing a supportive institutional framework and implementing effective price incentives to encourage sustainable energy outcomes.

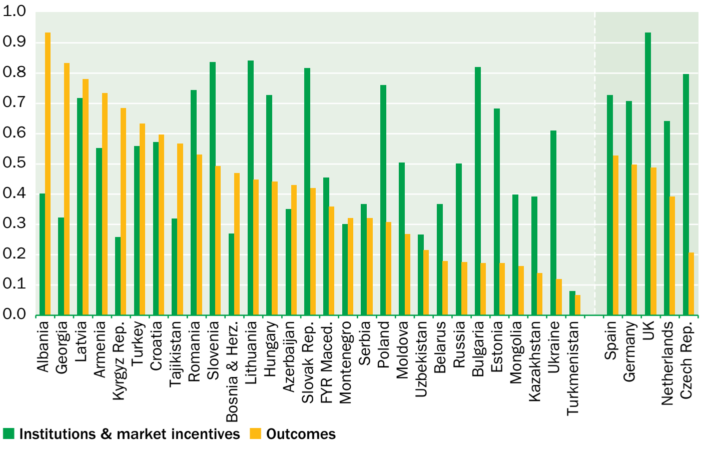
Third, there is a group largely composed of countries in the South-Eastern Europe (SEE) and the Central Asia and Mongolia (CAM) regions where both institutions and outcomes are poor. In these areas, institutions and incentives are not yet set up, and the poor outcome measures reflect the legacy of the Soviet economic model and its associated distortions in the energy sector.

Modelling the impact of climate policies

An effective way to assess the impact of policies on greenhouse gas emissions is to compare how policies affect the incremental cost of reducing emissions by one unit (known as the marginal abatement cost, or MAC).[8] This approach is applied in depth to two countries, Russia and Turkey. Limited information is also available for other countries.

A MAC curve is built from the bottom-up engineering assessment of the country-specific costs of reducing greenhouse gas emissions by one tonne for different technologies (or more broadly "measures") available in a country. Following this, the total volume of emissions

Chart 3.2
ISE decomposition: institutional structures (institutions and market mechanisms) versus outcomes



Source: EBRD.

Note: The data used for the index is the most recent available for each class of information: for institutions as of mid-2010, for energy use 2008 and carbon emissions 2007.

that can be realistically reduced in a country by each of these measures is estimated. The curve is constructed from individual rectangular blocks, each representing one specific abatement measure. The width of each block represents the incremental emission-reduction potential (in tonnes) relative to the reference high-carbon alternative.

The height of the block represents the incremental cost per tonne of implementing this emission-reduction measure relative to the reference high-carbon alternative. The typical cost formula is the annualised capital costs (and interests) over the lifetime of the assets plus the operational costs (including revenues, e.g. from energy savings). These costs are then compared with a reference scenario for each technology, yielding relative costs. The blocks are ranked from the lowest relative cost measures (on the left side of the graph) to the highest relative cost measures (the right side of the graph).

Most MAC curve tools calculate the cost of carbon-reducing investment projects from the perspective of a social planner, where costs are engineering resource costs, discount rates reflect the government cost of borrowing and investment risks are ignored. These models produce a very optimistic picture of a vast abatement potential that could be realised at no cost (or even at a profit) to society. However, because many of the abatement opportunities deemed to be money-saving are unlikely to be financially viable in the marketplace, societal-abatement cost curves have been viewed with scepticism by project developers and financial institutions.

In reality abatement is not achieved by governments, but by a myriad of private and public investors who have different perspectives from social planners. These investors pay taxes and receive subsidies, and they often pay less for energy than it costs society to extract fuels, convert them to a useful form of energy and deliver them to the point of use. Further complicating the picture, company- and project-related risks prevent firms from accessing capital on the terms the government enjoys when issuing treasury bonds. The actual costs experienced by market players are usually higher and include price distortions (taxes, fees and subsidies), transaction costs and several "hidden costs" related to sector- and technology-specific risks and barriers.

Recently some attempts have been made to conduct simple sensitivity analysis of abatement costs with respect to higher cost of capital, and to introduce some transaction costs into the formulas.[9] These efforts represent initial steps towards better representation of investment realities on the ground.

The analysis in this chapter deviates from the traditional societal perspective and goes well beyond simple sensitivity analyses. It is one of the first efforts to capture comprehensively the costs that different groups of investors actually face in the real marketplace, including consequences of policy interventions and market distortions. This makes it easier to study the effectiveness of various policies, which can be assessed by estimating the impact of different policy scenarios on the investors' costs and their expected willingness to invest.

[7] Two main factors account for this: (i) the large amount of renewable resources and the relative extensiveness of their use in large hydroelectric power plants (in Albania and Georgia, the share of electricity generated from renewable sources exceeds 80 per cent); and (ii) an economic structure with little energy-intensive industry.

[8] The analysis builds upon the modelling work from McKinsey for Russia and from NERA/Bloomberg New Energy Finance for Turkey.

[9] See, for example, McKinsey & Company (2009).

[10] The two modelling teams supporting this chapter have used slightly different concepts for the reference case (or reference baseline) in their modelling. In the McKinsey study for Russia, the reference baseline is based on the "natural" growth patterns of economic output by sector, which does take into account some efficiency improvements as new, more energy-efficient equipment and buildings gradually replace older

Investors' MAC curves should be interpreted carefully. Unit costs in the MAC do not represent the prices at which equipment or services can be purchased on the market. Nor do they represent the net present value of investments in the form that is used by firms in their feasibility studies or pricing models. The costs in MAC curves are *relative* and *incremental*, rather than absolute, costs. They are statistical averages rather than estimates that can be used to appraise specific investments. A positive cost of a mitigation measure indicates how much higher the cost of a given measure is than that of the more polluting reference measure that investors would normally choose. In other words, the height of the bar represents the price of carbon emissions at which a given measure becomes the preferred choice of investors relative to other, more carbon-intensive, alternatives. For negative cost measures (left-hand side of the graph), the height of the bar represents the cost advantage of investing in the abatement measure rather than the more carbon-intensive reference project.

The status quo scenario

The starting point of the policy analysis is a hypothetical baseline, which assumes that the policies that prevailed in Russia and Turkey in 2009 will remain in place and unchanged until 2030. In this status quo scenario, no new policies emerge to encourage energy efficiency, renewable energy or other emissions abatement. Where policies and measures are already in place, they are not strengthened and their effectiveness does not improve. Policies that have been declared but not yet implemented or not enforced are also ignored. As for all other policy scenarios, the abatement potential and costs of the status quo scenario are calculated against a reference case.[10]

The status quo scenario allows non-policy factors to evolve during the modelling period. One such factor that affects abatement costs and is allowed to change over time is technological progress. It is assumed that at the end of its economic life, currently employed equipment is replaced by new assets that are more efficient than the current vintage. Similarly, any new demand is assumed to be met through investment in new, more efficient equipment. In addition, abatement measures introduced in the status quo scenario are assumed to become more efficient and cheaper over time.

In short, the status quo represents current policies together with an assumption about how average emission intensities and technology costs will, by themselves, evolve from today until 2030. Some of the main policy drivers that affect abatement costs are reviewed next.

Policy variable I: investment risk

Investors have to identify, evaluate and mitigate a number of development, construction and operational risks. More capital can be raised at lower costs if these risks can be mitigated or avoided. A lower cost of capital translates into a lower cost of carbon abatement and a larger volume of profitable abatement investments, because abatement measures usually require additional investments compared to the high-carbon references, and are relatively capital intensive.

Most low-carbon projects are perceived as high-risk investments. To the extent that unsecure financing is provided, it is done with high interest rates, on short maturities and against a large equity cushion, unless creditors benefit from long-term power off-take agreements at guaranteed prices. This is the case for some renewable energy projects such as wind farms in the most stable jurisdictions that are extensively and successfully financed with long-term, relatively cheap debt capital. The viability of energy-efficiency investments, in particular small projects in the residential and small-and-medium-enterprises sectors, is hampered by high-risk related discounts applied by financial institutions and project sponsors to the potential savings. Generally, low-carbon projects are often dependent on an uncertain regulatory environment and are vulnerable both to increases in the cost of capital and regulatory inconsistency.

Overcoming these barriers requires dedicated policies, many of which reduce investment risks generally, not only for low-carbon investments. These include macroeconomic policies that support stable interest rates, prudent fiscal policies, fair and predictable regulations affecting business, a deep and competitive financial sector, an effective property rights regime, and an effective, rule-based judicial system.

Policy variable II: fossil-fuel prices

In a low-carbon economy, it is important to price energy at a level that covers the full economic cost of using the resources. This includes both direct costs and external costs borne by other parties, such as the cost of environmental damage. Cost-reflective prices provide incentives to use energy efficiently and to invest in energy-saving projects. Under-pricing of fossil fuels erodes the returns to energy-saving projects and makes clean energy less attractive to investors in comparison with carbon-emitting alternatives.

The Russian status quo scenario assumes that 2009 prices will remain frozen until 2030. This is not a likely scenario, but it helps to illustrate the potential climate-mitigation benefits of energy-pricing reforms that Russia has undertaken very recently and continuous to implement consistently, especially in the electricity sector.

By contrast, Turkey's 2009 prices are liberalised and already quite high. The model assumes that they will grow further in line with international trends, reflecting fewer distortions and a higher degree of openness in the Turkish energy market.

Policy variable III: transaction costs

Transaction costs encompass the costs of economic and administrative activities that are additional to the technical costs of an investment. The analysis distinguishes two distinct categories of transaction costs:

- **Project transaction costs.** These are associated with project preparation under standard financial structures and may include investment appraisal (e.g. time costs, consultancy fees, feasibility studies and overheads), procurement and legal costs (e.g. contracts, negotiation and finding vendors), compliance costs (e.g. permits and applications), and bribes.

- **Policy-induced transaction costs** (or trading transaction costs). These are costs that economic entities must bear to respond to

installations. In the NERA/Bloomberg New Energy Finance model used for Turkey, the reference case assumes zero technology progress – all assets are assumed to have fixed energy and emission intensities throughout the entire modelling period. In this sense, the reference baselines are not "business-as-usual" scenarios as applied in some studies, although the McKinsey approach is closer to this concept. The benefit of having such a conservative definition of reference baseline is that it avoids guessing what is "usual" in an uncertain world, and gives a useful benchmark against which the impact of existing and planned policies can be measured. On the other hand, the conservative reference improves the commercial viability of abatement measures in the status quo scenario.

policy interventions. They include a range of administrative costs associated with obtaining access to carbon finance, such as Joint Implementation projects in Russia and voluntary emission-reduction trades by Turkish firms. They also include the costs of obtaining government subsidies.

Average transaction costs in Russia are estimated at €7 per tonne of CO_2-equivalent (CO_2e) abated, with significant variations between measures. For smaller energy-efficiency projects, the transaction costs are estimated to reach €60 per tonne of CO_2e reduced; for large projects in industry or thermal power sectors, transaction costs account for a negligible fraction of underlying investments. Among policy-induced transaction costs, a preparation of a small Joint Implementation project may cost up to €40 per tonne of CO_2e reduced – almost four times more than the market price of a credit. Turkish project transaction costs are assumed to vary between 10 per cent and 30 per cent of capital expenditures.

Effective mitigation policies in Russia

The effect of policy interventions on Russian greenhouse gas emissions was analysed by comparing the status quo scenario and four bundles of policies against the reference case. The policy bundles build on each other and represent an increasing level of ambition to stimulate emission-reduction investments. Compared with the status quo, these policies increase the total volume of profitable[11] abatement investments and consequently the reduction in emissions that can be achieved by commercially attractive projects.

Status quo scenario

According to the previous study (McKinsey, 2009), the societally beneficial abatement potential in Russia – that is, the level by which emissions may be reduced in 2030 at no cost to society – is an astounding 50 per cent of 1990 emissions, or 567 million tonnes of CO_2e (Mt CO_2e).[12] This represents the minimum emission reductions that Russia should contemplate from a purely social-economic point of view, even before taking into account benefits of avoided negative impacts of climate change, avoided adaptation costs or local ancillary benefits such as the health benefits of reduced local air pollution.[13]

However, very little of this abatement will be delivered in Russia's current policy environment. The present study shows that under the status quo scenario, where current policies are frozen, Russia would barely meet its emission-reduction pledges under the Copenhagen Accord – a reduction of up to 25 per cent of annual emissions compared to 1990 levels by 2020.

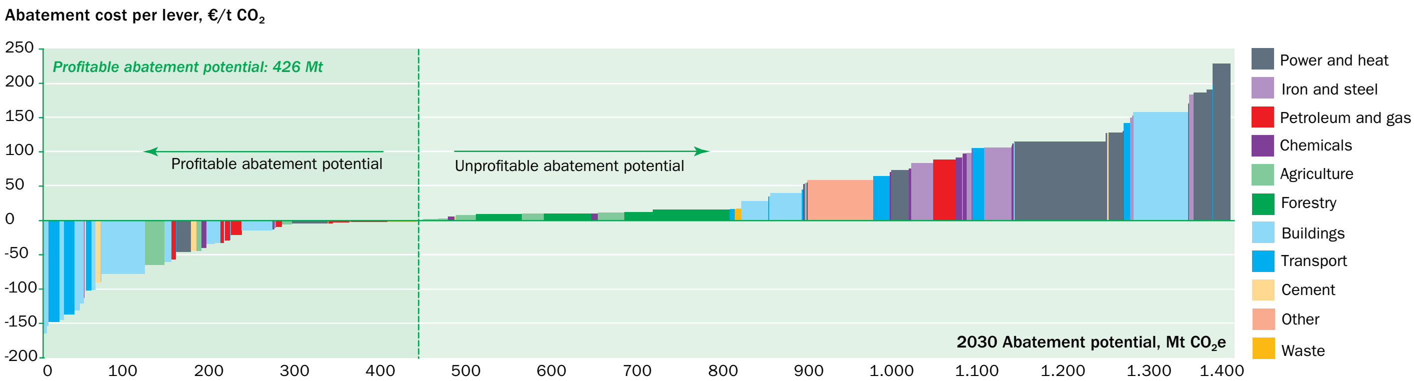
The status quo scenario assumes that the 2009 energy prices, taxes and subsidies (for oil, gas, electricity and heat) in different consumer classes remain in place. Other market conditions, including investment risks[14] and transaction costs, are also held constant. No renewable support or carbon price is introduced.

Chart 3.3 shows the MAC curve under the status quo scenario. It indicates a profitable annual abatement potential of almost 300 Mt CO_2e in 2020 and 426 Mt CO_2e in 2030, even with frozen energy prices and in the absence of any other energy and climate policies. This is not insignificant, but much lower than implied by McKinsey (2009). The assumption is that this is the abatement that would actually be implemented under the status quo.

The total investment needed to realise all profitable projects would amount to €57 billion over the period 2010–2030,[15] by which time savings of €118 billion per year would be realised. The savings would continue to be enjoyed beyond 2030 until the end of these investments' economic lifetime.[16]

The total emission-reduction potential of an estimated 1,409 Mt CO_2e – that is, summing profitable and non-profitable abatement opportunities represented in Chart 3.3[17] – could be achieved at the modest average cost of €32 per tonne of CO_2e. This reflects an average between the profitable opportunities on the left of Chart 3.3, and the costly opportunities on the right. At the margin, realising this full potential would be very expensive, with costs for the most expensive measures of almost €230 per tonne of CO_2e.

Chart 3.3
Status quo scenario for Russia



Source: EBRD on the basis of the Russian cost curve (McKinsey & Company, 2009).
Note: Abatement expected to be achieved under status quo is assumed to be equal to the sum of profitable abatement opportunities in this chart as indicated by the dotted line.

[11] "Profitable" measures in the MAC curve mean that over their lifetime these measures are cheaper than the alternative technologies that achieve the same economic output but with higher carbon emissions. In extreme cases such relatively profitable measures may not be profitable in absolute terms, but their high-carbon alternatives yield even higher losses.
[12] McKinsey & Company (2009).
[13] All these omitted benefits can significantly underestimate the social-economic return on low carbon investments in the societal MAC curves.
[14] Weighted average cost of capital is estimated between 20 per cent and 30 per cent for different measures.

Box 3.2 Why do profitable measures remain in the status quo scenario?

The scenarios run the simulations of the measures that would or could be implemented between 2010 and 2030. Their expected results should not be confused with the experience from the past, when framework conditions were even worse than assumed, even in the status quo scenario. There are a few reasons for the likelihood of "win-win" abatement measures in the status quo scenario:

- **External, non-policy factors,** such as technology progress or world energy prices, will improve the financial attractiveness of abatement over time.

- **Present policies** provide some incentives for profitable investment opportunities with climate change benefits; the EBRD portfolio of commercial energy-efficiency projects provides evidence that there were bankable project opportunities even under less than favourable conditions.

- **Market inertia and entrenched behaviours,** which means that market participants respond sluggishly to policy incentives. Long-term price elasticities of demand are always larger than short-term responsiveness. Models simulate the future expected behaviour until 2030. Over time, with improved availability of more efficient technologies and accumulated demonstration effects of groundbreaking projects, more abatement measures will attract investors, even in the absence of new policy incentives.

- **Residual barriers** not captured in the model through transaction costs and capital cost variables. Some non-price barriers, such as split incentives, legal barriers and access to capital, require additional interventions that cannot be meaningfully modelled in the MAC framework.

The chart indicates that by 2030, the largest improvements in emissions intensity that would occur naturally, without any new policies, are in thermal modernisation of commercial and residential buildings and cropland nutrient management in agriculture. This does not necessarily imply that every project in these sub-sectors would be commercially viable (for the reasons explained in footnote 10, as well as those highlighted in Box 3.2 left).

The results of the status quo scenario challenge financial institutions to structure adequate financial products that can harness commercially viable project opportunities, even within an unfavourable policy framework.

Policy mix 1: Economic and pricing reforms

The first bundle of additional policies covers the implementation of a series of policy reforms currently being contemplated or implemented in the area of electricity tariffs, gas tariffs and municipal services.

Since 2001 Russia has unbundled its vertically integrated electricity utilities, privatised parts of the generation, distribution and supply sectors, and put in place competitive market mechanisms that have stimulated investment. Wholesale prices were liberalised in a series of steps leading to full deregulation in January 2011. Household retail prices are still regulated and remain below the levels required to recover investment costs. Households, however account for approximately 15 per cent of total consumption, while prices for non-residential customers (i.e. 85 per cent of electricity consumption) are now fully liberalised, exactly in line with the announced schedule. The average prices of 2009 were maintained in the status quo scenario, but the economic and pricing reforms scenario assumes the full liberalization of both wholesale and retail electricity prices.

Reform in the gas market has been limited. Gazprom maintains an effective monopoly in the downstream sector, domestic tariffs are depressed and third-party access to the gas infrastructure network is constrained. An export tax on gas and oil products continues to work as a subsidy to domestic consumers. Gas price liberalisation is moving more slowly than electricity but nonetheless there have been significant price increases in recent years. There are plans to gradually liberalise domestic gas prices for industrial users although household tariffs are likely to remain subsidised until at least 2015. The economic and pricing reforms scenario assumes these planned measures are implemented successfully.

In municipal services, the federal legal framework allows for cost-reflective heat and water tariffs. However, various factors hamper tariff-setting at adequate levels in most municipalities. Tariffs are at or very close to full cost-recovery levels for some utilities, but the level of variation remains very high. Cross-subsidies for heat prices, while generally reduced compared with earlier years or even eliminated in certain utilities (e.g. Surgut and Yaroslavl), remain pervasive in others, particularly in remote areas. In addition, low payment-collection rates for heat remain a serious problem, even in Moscow. A large proportion of residential and many non-residential energy users continue to pay utility bills according to norms rather

[15] Here and thereafter, the investment figures are always provided as the sum of expected, undiscounted incremental capital expenditures needed to implement profitable abatement measures over the period 2010–2030 in real prices and exchange rates (as of 2005 Euros for Russia and 2009 Euros for Turkey).

[16] In this and the following charts the annual savings represent the net savings accumulated from all profitable projects in the last year of a period (usually given for 2030), undiscounted, that will accrue to these investments until the end of the economic lifetime of assets. It is not the integral of the left side of curve, which also includes capital costs.

[17] Here and thereafter the abatement potential is always annual for specific year (2020 or 2030) and irrespective when the measure itself was implemented during the period.

than metered consumption. In the economic and pricing reforms scenario, all municipal services are assumed to be priced at full cost-recovery level.[18]

In the economic and pricing reforms scenario, the fundamental shift is assumed in two key variables: energy prices and investment risks. The scenario assumes that, from the 2009 prices base, energy prices gradually increase to cost recovery levels: residential consumer prices increase by €13/bcm for gas, €14/MWh for electricity and €8/GCal for heat. Industrial prices increase by €11/MWh for electricity and €4/GCal for heat.

The complex set of policies described above is also assumed to reduce investment risk factors, so that the cost of capital would decrease gradually from the 20-30 per cent observed in the past to 9 per cent on average by 2030. Chart 3.4 illustrates the effect of these combined reforms. Profitable abatement opportunities in 2020 would reach 334 Mt CO_2e in 2020 and 547 Mt CO_2e in 2030, 28 per cent higher than under the status quo.

The total investments needed for profitable investments would amount to €145 billion in the period until 2030, but this would save €244 billion per year by 2030 and beyond. The total emission-reduction potential identified in the analysis could be achieved at a benefit (negative average cost to investors) of €9 per tonne of CO_2e. The marginal cost of the most expensive measures is still considerable but would drop to just under €94 per tonne of CO_2e.

The measures that are most responsive to the reduced risks and increased energy prices include basic and advanced thermal retrofitting of residential and commercial buildings, fuel efficiency improvements in passenger vehicles, and improved energy efficiency of industry. Capital intensive energy generation, such as nuclear and large hydropower plants would also reduce costs significantly as a result of lower cost of capital, although this would not make them commercially attractive to investors without additional support instruments.

While this package would fall well short of stabilising emissions in Russia, as we show below, it would exceed the pledge Russia made under the Copenhagen Accord and more recently in Cancún. Emissions would be 31 per cent below the 1990 level in 2020 and 26 per cent below the 1990 level in 2030.

This is not to say that this achievement would be effortless. Market-based energy pricing and sound economic policies are a win-win option for economic development and the environment, but entail significant adjustment costs, shifts in competitiveness between sectors, and the reallocation of labour and capital from high-emitting to low-carbon sectors. This requires a committed, skilled and consistent government that is willing to face short-term political challenges in order to complete reforms that would improve people's lives and make industry more competitive in the long term.

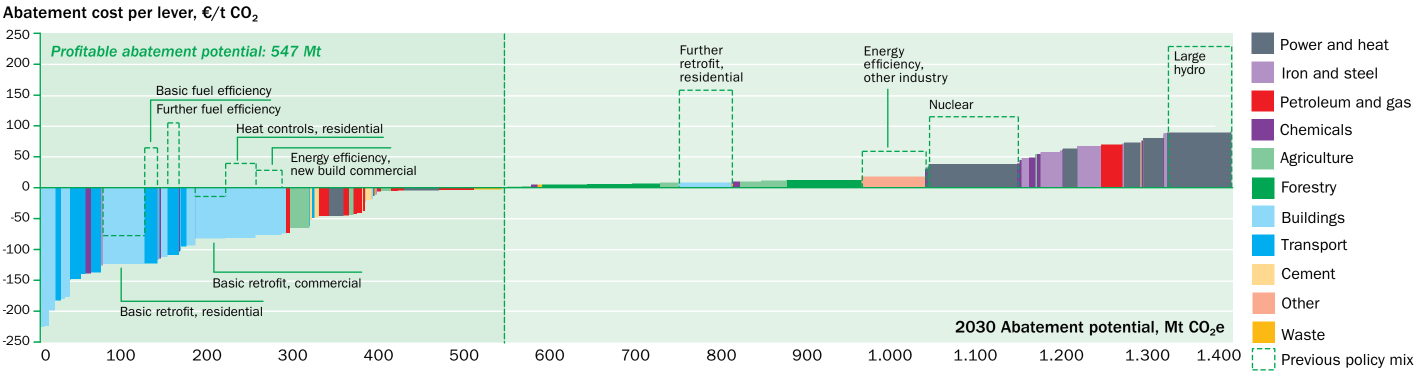
Policy mix 2: targeted energy-efficiency policies

The second policy bundle targets the transaction costs for energy-efficiency and low-carbon-power investments. These measures are added to the general reform steps considered in Policy mix 1.

Russia adopted an Energy Efficiency Law in November 2009, but implementing the pieces of secondary regulation stipulated by the Law, which number more than 90, will take time. The law envisages the gradual phase-out of certain energy-intensive products, energy-efficiency labelling for goods, and improved building standards. Consumer tariffs are to be differentiated depending on time and metered use. The targeted programme for energy efficiency was announced with earmarked funding of €17.3 billion.[19] In June 2008 President Medvedev signed a decree targeting a 40 per cent reduction in energy intensity (relative to 2007) by 2020. The government's energy strategy until 2030, approved in November 2009, makes energy efficiency a priority but only in the second stage of programme implementation.[20] The second policy scenario assumes that most provisions of the Energy Efficiency Law are implemented, and that this will result in an estimated 90 per cent decrease in the transaction costs of carbon-abatement projects.

Chart 3.5 shows the combined impact of economic reforms and energy-efficiency policies. The labelled and dotted-line bars indicate the measures that are most responsive to reducing transaction costs. The profitable abatement potential would increase to 610 Mt CO_2e.[21]

Chart 3.4
Economic and pricing reforms for Russia (Policy mix 1)



Source: EBRD on the basis of the Russian cost curve (McKinsey & Company, 2009).
Note: Labelled measures are those that are the most impacted by economic and pricing reform. The height of dotted line bars represents their cost in a status quo scenario.

[18] No assumptions about the protection of the most poor and vulnerable households is made here. Full cost pricing would require the establishment and proper funding of a social safety net for those affected above their affordability limits.

[19] Available at: http://energohelp.net/news.

[20] See *Energheticheskaya strategija Rossii na period 2030 goda*; www.minenrgo.gov.ru

[21] This result should be compared very cautiously with the 567 million tonnes of CO_2e Mt CO_2e that the McKinsey estimated in 2009 study as being in narrowly defined self-interest of Russia. Definition of self interest according to the McKinsey (2009) study does not include avoided costs of climate-change damages to Russia, avoided costs of adaptation or local co-benefits, such as health improvements due to the reduction of local air pollution. It is also difficult to consider McKinsey (2009) estimates as socially optimum emission-

The scenario leads to emissions that are 32 per cent below 1990 levels in 2020 and 28 per cent below 1990 levels in 2030.

The total profitable investment in the period 2010–2030 would increase to €220 billion. Net annual operational savings would increase to the level of €255 billion per year in 2030 and beyond.

The premium (negative average cost per tonne of CO_2e) of achieving the entire emission-reduction package analysed would increase from €9 to €12 in 2030, and the marginal cost of the most expensive measures would decrease to less than €85 per tonne of CO_2e.

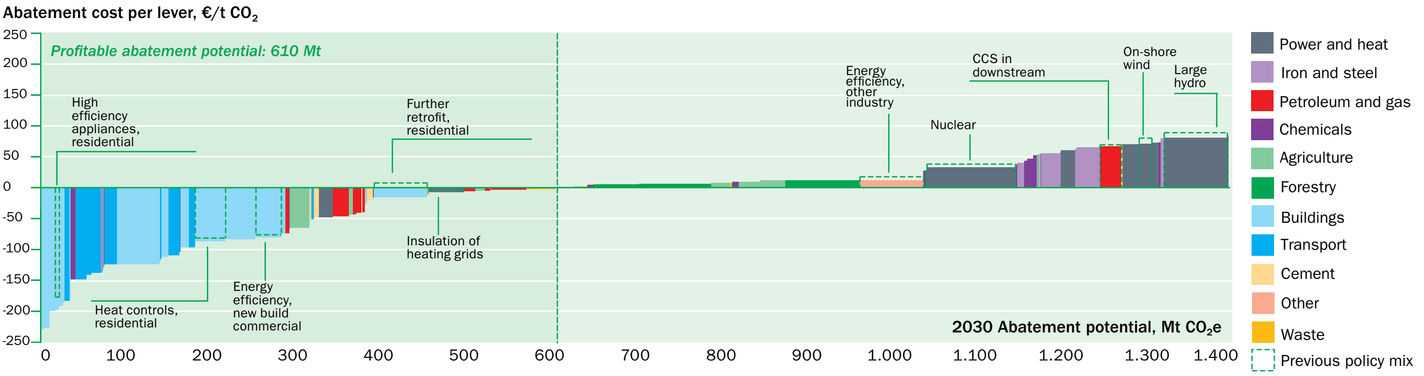
Policy mix 3: renewable support systems

The third policy bundle targets the renewable energy sector. Support for renewable energy is added to the previous policy mix of economic reform and reduced transaction costs for energy efficiency.

Russia's renewable energy sector is at an early stage of development, but institutional and regulatory mechanisms are emerging. Renewable capacity is confined largely to large Soviet-era hydro plants. Most of them are operated by RusHydro, a regulated but commercial company. The total installed capacity of RusHydro amounts to 25 gigawatts (GW), approximately 12 per cent of Russia's total installed capacity. In November 2007 the government approved an amendment to the Federal Law on Electricity, which outlines the general framework for the use of renewable energy sources. This includes possible mechanisms for renewable energy support, such as feed-in tariff premiums, subsidies for grid connection, and obligatory off-take by grid companies. As of today, the government approved three pieces of secondary regulation, which, along with other regulations, sets the target for renewable energy production at 4.5 per cent of total power production by 2020.

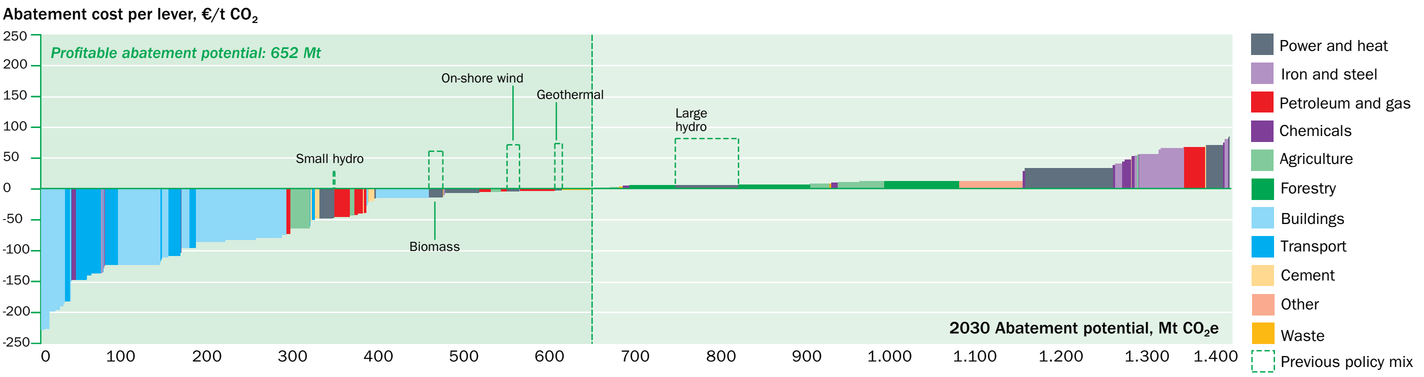
Adding a feed-in tariff premium of €30 per megawatt-hour (MWh) – €75/tonne of CO_2e – to the previous two policy bundles (economic and pricing reform and lower transaction costs) does not dramatically change the overall profitable abatement potential. It does, however, make a big difference for renewable energy. All forms of renewables, besides some large hydro facilities, would become commercially competitive (Chart 3.6). The abatement potential would increase by an additional 7 per cent to 652 Mt CO_2e.

Chart 3.5
Economic and pricing reforms and reduced transaction costs for Russia (Policy mix 2)



Source: EBRD on the basis of the Russian cost curve (McKinsey & Company, 2009).
Note: Labelled measures are those that are the most impacted by lowering transaction costs. The height of dotted line bars represents their cost in the previous scenario economic and pricing reforms, before transaction costs were lowered.

Chart 3.6
Economic reforms, reduced transaction costs and a feed-in tariff premium for Russia (Policy mix 3)



Source: EBRD on the basis of the Russian cost curve (McKinsey & Company, 2009).
Note: Labelled measures are those that are most impacted by feed-in tariff premiums. The height of dotted line bars represents their cost in the previous scenario with lower transaction costs, before the feed-in tariffs were applied.

reduction because it does not account for the macroeconomic long-run growth stimulus for example through diversification of economy away from over-reliance on resource extractive sectors. This concept of self-interest also omitted the expected international incentives.

The total investment into profitable emission reductions would increase to €247 billion up to 2030, and the net operational savings would be €255 billion per year in 2030 and beyond. The average surplus to investors for the total abatement package would increase to €18 per tonne of CO_2e. The marginal cost of the most expensive measures would remain at about €85 per tonne of CO_2e, as these are not activities affected by renewable energy policies. All renewable energy-generation technologies modelled would become commercially viable except large hydro, which is the most capital intensive.

The price premiums added to the wholesale electricity price simulated in this scenario would involve a financial transfer, from either electricity consumers or taxpayers to renewable power generators, of about €3.1 billion in the whole period until 2030. This would increase the wholesale power price by about 2.4 per cent on average in 2030.

Policy mix 4: carbon price

In the fourth policy bundle, a price is put on carbon emissions, in addition to the policy measures considered before. There are various ways to put a price on carbon (Box 3.3).

Russia has full access to carbon-finance mechanisms under the Kyoto Protocol, including Joint Implementation and international emissions trading between countries (so-called Assigned Amount Units trading), but has exploited only a fraction of opportunities so far. The necessary regulatory and institutional framework was developed late and is controversial for many market participants. The scenario assumes that over time Russia will establish a domestic emissions trading scheme linked to the European Union Emissions Trading Scheme (EU ETS), and projects not eligible under the domestic cap-and-trade system will participate more actively in the future international project-based carbon-market mechanisms (such as Joint Implementation or Sectoral Approaches). It is assumed that the regulatory and institutional framework to make active use of these mechanisms will be put in place, and that the domestic carbon price will rise to €40 per tonne by 2030. Alternatively, the same incentive effect could be achieved by an economy-wide carbon tax with this rate.

Box 3.3 Putting a price on carbon

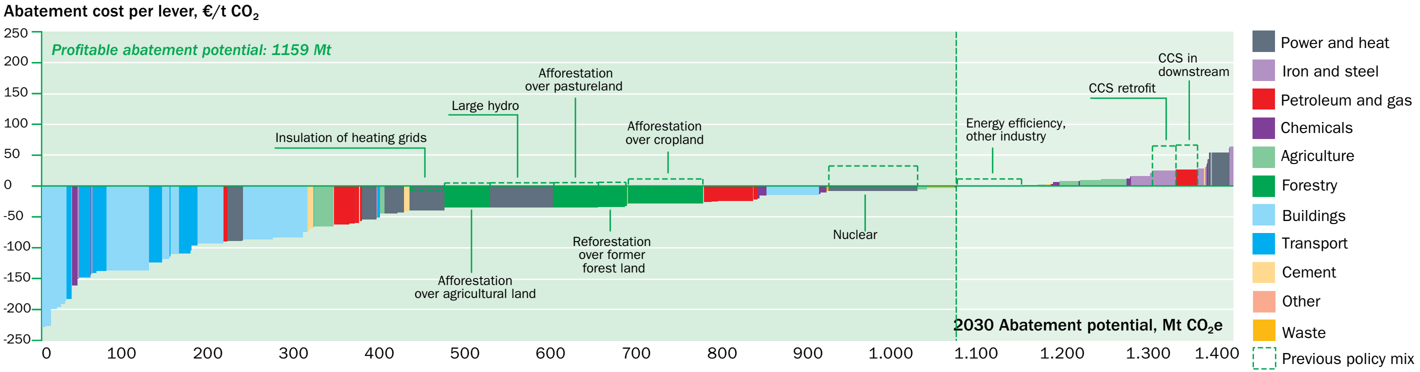
A carbon price can be established in many different ways. These include a cap-and-trade scheme, an emission tax, a carbon-offset mechanism, or penalties for non-compliance with emission standards. Although all these carbon-pricing instruments would have a similar effect on the incentives to invest at the margin, their impact on the ability to invest would differ. For example, revenues from a carbon-offset mechanism, such as Joint Implementation, or revenues from grandfathered emission allowances (meaning polluting firms are given emission permits for free) would transfer rents and cash to investors, enhancing their ability to invest.

However, carbon taxes or auctioned emission allowances would transfer money in the opposite direction – from project sponsors to the government. This is generally seen as more consistent with the "polluter pays" principle, but may also decrease investors' equity and hence their ability to raise debt to finance investments, unless governments establish credit-enhancement mechanisms or pay direct subsidies.

Command-and-control measures leave funds in the real economy but cause transfers between sectors. However, such administrative policies would increase the overall cost of abatement to the economy, because abatement efforts would not be allocated in a cost-effective way (as marginal abatement costs would differ from one plant to another). Our simulations show that the transaction costs of participation in carbon-market mechanisms would need to be dramatically reduced and additionality test-reviewed if they are to become investment instruments.

EBRD countries already apply various energy and product taxes, which can be further differentiated by their energy and carbon content in a revenue-neutral way. The EU member states of the EBRD region are already part of the EU ETS, the biggest and the most predictable carbon market to date globally. Belarus, Kazakhstan and Ukraine are already considering their own trading schemes, which would link up with the EU ETS. These and other countries may seek to benefit from sectoral approaches or new generation project-based credits that could succeed Joint Implementation and the Clean Development Mechanism.

Chart 3.7
Economic reforms, reduced transaction costs, a feed-in tariff and a €40 carbon price for Russia (Policy mix 4)



Source: EBRD on the basis of the Russian cost curve (McKinsey & Company, 2009).
Note: Labelled measures are those that are most influenced by carbon prices. The height of dotted-line bars represents their cost in the previous feed-in-tariff scenario, before the carbon price was introduced.

An economy-wide carbon price of €40 per tonne of CO_2e on the top of all previous policies would greatly increase the incentive to invest in low-emission projects. The commercially attractive abatement potential would increase by 78 per cent from 652 Mt CO_2e to 1,159 Mt CO_2e (Chart 3.7).

The total investment in profitable measures would increase to €424 billion in the period to 2030, and net annual operational savings would amount to €276 billion per year by 2030 and beyond. The average premium in the entire abatement programme would increase to €39 per tonne of CO_2e, and the marginal cost of the most expensive measures would decrease to €64 per tonne of CO_2e.[22]

A high carbon price would particularly increase the return to afforestation and reforestation activities. These do not benefit significantly from targeted policies in the other policy scenarios, but there is great potential. This potential could be realised if land use and forest carbon-sequestration credits become internationally tradeable under a future international climate agreement. Poland and Russia have proposed this in international negotiations.

Even a €40 carbon price would not lead to the commercial breakthrough of carbon capture and storage. Given the importance of this technology in both industry and the power sector, additional policy support may be warranted.

Comparison of scenarios

Sound economic policies have the biggest impact on investors' costs across sectors. An economy-wide carbon price has an equally powerful impact on the expected demand for investments (Chart 3.8). Reducing transaction costs and increasing renewable support again make a selected impact in the targeted sectors. However, their impact on the entire economy is mitigated because transaction costs account for a small fraction of the total cost in large emission-reduction projects, and feed-in tariffs affect a relatively small number of sectors.

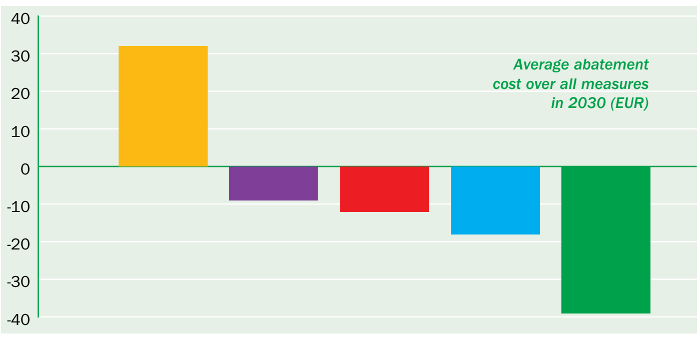
A price on carbon (€40 per tonne of CO2e) followed by sound economic policies (including energy tariff reform) are the most effective policies to stimulate emissions abatement. Reducing transaction costs and introducing feed-in tariffs for renewable energy would have a smaller impact on national emissions, although these policies are crucial for this sector, at which they are aimed (Chart 3.9).[23]

Status quo policies would keep Russian greenhouse gas emissions around 30 per cent below 1990 levels in 2020 and 23 per cent below 1990 levels in 2030 (see Chart 3.9). This is because new technologies that will naturally replace obsolete equipment and buildings will have higher efficiency and lower costs, and thus will become more financially attractive to firms and households. However, without additional policies, emissions would continue to rise relative to their 1998 low point.

General market reforms, such as the planned liberalisation of gas and electricity prices, would increase the potential for financially attractive abatement investments. If they were followed by a lowering of transaction costs and price support for renewable energy sources, this policy bundle would allow Russia to confidently meet its 25 per cent Copenhagen Accord pledge for 2020. The emissions would be kept 32 per cent below 1990 levels in 2020 and 29 per cent below 1990 levels in 2030. It would not, however, be sufficient to stabilise emissions; these would continue to rise, although at a slower pace.

Additional carbon-specific policies are needed to reverse a trend of growing emissions. Greenhouse gas emissions would fall 38 per cent below 1990 levels in 2020 and 45 per cent below 1990 levels in 2030. The incentive provided by a price for carbon emissions would mobilise sufficient commercially driven investments to steadily decrease Russia's carbon footprint below 2010 levels. This could happen through more active participation by Russian entities in the international carbon market, the introduction of a domestic emissions trading scheme, or an emissions tax.

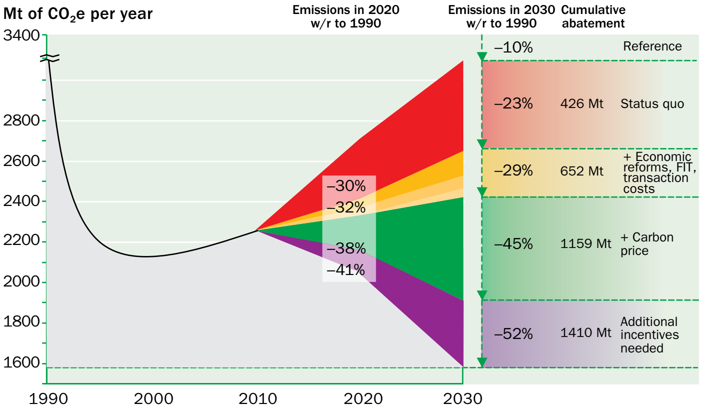
Chart 3.8
Average abatement costs for Russian investors in 2030 under different policies



Status quo · Policy mix 1 (+ economic reforms) · Policy mix 2 (+ low transaction costs) · Policy mix 3 (+ feed-in tariffs) · Policy mix 4 (+ carbon price)

Source: EBRD on the basis of the Russian cost curve (McKinsey & Company, 2009).
Note: The bars show the cumulative effects of the different policy scenarios.

Chart 3.9
Emission pathways under different policies in Russia



Status quo · Economic reforms, FIT, transaction costs · Carbon price · Additional incentives

Source: EBRD on the basis of McKinsey cost curve.

[22] This can be seen as an additional carbon price that would be needed to make this marginal abatement projects attractive to investors.

[23] The impact of investment subsidies (30 per cent of capital costs) was also simulated but was found to have a much weaker impact on expected demand for abatement investments than carbon price or economic reforms.

Effective mitigation policies in Turkey

The effect of policy on greenhouse gas emissions in Turkey was analysed by comparing the status quo with two alternative scenarios. In the planned policies scenario, any emission-reduction policies that are currently planned but not yet implemented or enforced are put in place. The enhanced policy scenario includes additional policies to promote a reduction in emissions.

Status quo scenario

The status quo assumes that over the next two decades, current policies and institutions continue as they are now. Only external factors may change, including technology costs and world market prices. These factors would influence emissions, as Turkey is a relatively open economy that is well integrated into the global market through trade and investment flows.

Unlike Russia, Turkish energy prices are allowed to grow and follow international trends,[24] as the Turkish energy market is less distorted, more open and more dependent on trade. Wholesale electricity prices and retail prices have been mostly liberalised. Demand for electricity is expected to continue its recent rapid growth by 5 per cent per year until 2030.

Consistent with government plans to expand the use of indigenous lignite reserves to reduce external energy dependency,[25] all proven lignite reserves are potentially available for electricity generation. However, none of the declared policies to promote the use of lignite or limit the use of gas will be implemented under the status quo scenario. Government support for the Akkuyu nuclear power plant is omitted from the projections, but privately and commercially financed nuclear developments are allowed.

The 1995 Renewable Energy Law is assumed to remain in place (a proposed amendment, published in January 2011, is considered in the planned policies scenario). Under the law, renewable plant operators can choose between selling electricity through the balancing market (thus taking a market-price risk), or at the fixed feed-in tariffs. For many years, balancing-market prices were consistently higher and most operators chose them over the feed-in tariff. The status quo assumes that investments in renewable energy will be driven mainly by relatively high prices on the wholesale market.

Reducing energy intensity is one of the Turkish Government's priorities, alongside security of supply and the sustainable development of the energy sector.[26] The 2007 Energy Efficiency Law sets out the principles and procedures for promoting energy efficiency across sectors. However, implementation regulation is yet to be adopted and institutions have yet to be set up. Similarly, Turkey has various policies to encourage energy efficiency in buildings, but they are not strictly enforced. Under the status quo scenario, current practice remains the norm.

As a non-signatory to Annex B of the Kyoto Protocol, Turkey is not eligible to participate in its flexible mechanisms. Carbon-finance projects in Turkey are instead developed under the Protocol's voluntary schemes, in which Turkey is one of the most active participants. However, because of rapidly decreasing sale volumes (from 7.5 Mt CO_2e in 2008 to 2.4 Mt CO_2e in 2009)[27] and falling prices, voluntary trading is not included in the status quo.

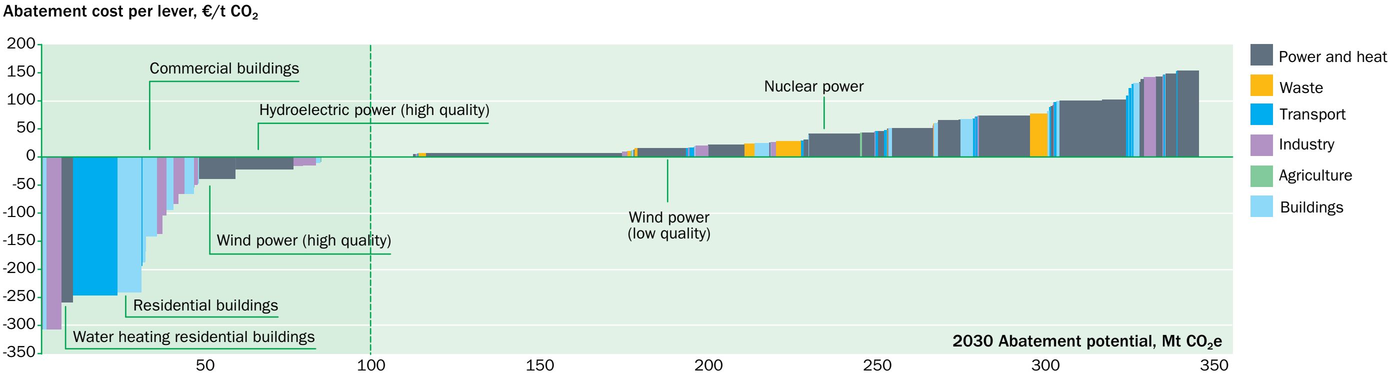
The emission-reduction potential that follows from these assumptions is shown in Chart 3.10. According to the MAC, an abatement potential in 2030 of around 111 Mt CO_2e is profitable to investors even without any energy and climate policies. Accounting for baseline emissions growth, this would imply emissions that are three times higher than in 1990, much of this due to an expanding power sector (Box 3.4).

Considering all the potential measures identified in the study, including those with a positive abatement cost, potential abatement could increase to 344 Mt CO_2e in 2030. Across the entire MAC curve, the average cost is around €1 per tonne of CO_2e.

Total incremental investments in profitable measures would amount to €45 billion in the period until 2030, and yield annual net savings of €15 billion by 2030 and beyond.

By 2030, the most attractive commercial investment opportunities would be in residential buildings, more efficient new passenger vehicles, new renewable power plants (hydro and wind), and more efficient new gas power stations.

Chart 3.10
Status quo scenario for Turkey



Source: EBRD on the basis of National Economic Research Associates (NERA) Economic Consulting and Bloomberg NEF.

[24] We use the IEA (2010a) World Economic Outlook forecasts of gas prices, which start from relatively low current levels and rise over the analysed period. Coal prices are also based on IEA projections, with an additional transport cost for Turkey. Lignite prices assume costs in Turkey will remain broadly at current levels (in line with IEA data) in real terms. Biomass prices start at current low levels, reflecting primarily traditional uses of the fuel and limited use in the power sector, but prices rise to reflect the expected increase in the international trade of biomass fuel as a low-carbon energy commodity. Wholesale electricity prices are modelled, with end-user power prices scaled up, based on historical retail costs.

[25] See Ministry of Energy and Natural Resources, Electricity Energy Market and Supply Security Strategy Paper, May 2009.

[26] Energy Strategy of the Turkish Government and Turkey's Ninth Development Plan (2007-13).

[27] Ecosystem Marketplace & Bloomberg New Energy Finance (2010).

Policy mix 1: currently planned policies

The first policy scenario considers major new policies that are planned or announced and are likely to have an effect on emissions. Where policies currently exist but are not well enforced (e.g. building standards), it is assumed that they are enforced more strictly.

The scenario assumes that the government achieves its 2023 target to reduce the share of gas in power generation from 50 per cent to 30 per cent.[28] At the same time, electric capacity is expected to approximately double. The 2023 target, driven by energy-security concerns about rising dependence on gas imports, is achieved in part through a switch to renewable energy and nuclear power.

The scenario assumes a strengthened feed-in-tariff policy to provide incentives to develop renewable power. New feed-in tariff rates, of between €5.5 per MWh for wind and small hydro to €10 per MWh for biomass and solar photovoltaics, will become effective in the first quarter of 2011 and are included in the planned policy scenario. Although the tariff levels will in several cases remain lower than expected wholesale prices, they provide a revenue floor during periods when wholesale prices are lower. This leads to a lower risk premium for the financing of renewables, thereby boosting their uptake. A further assumption is that the completion of an EBRD-financed interconnector between Turkey and Georgia allows Turkey to import hydropower from Georgia.

The scenario assumes support for the construction of Turkey's first nuclear power plant at Akkuyu, with a capacity of 4.8 GW, will begin in 2013, according to the government's contract with Rosatom of Russia. With the government offering price guarantees and setting up long-term funding for decommissioning and long-term waste disposal costs, the scenario allows for up to 15 GW of nuclear capacity by 2030.

With the removal of remaining electricity-price cross-subsidies, the price differential between industry and the residential and commercial sectors increases; residential and commercial prices increase and industrial prices fall by an equivalent amount.

The partial and delayed liberalisation of the gas market leads to somewhat higher gas prices from 2016 to 2020, as BOTAS, the incumbent company, is assumed to be able to exercise market power. Between 2020 and 2030 gas prices are assumed to rise in line with IEA (2010b) forecasts, with the import markets for gas opening and full liberalisation of the domestic gas market likely to keep the prices at world market levels.

Energy-efficiency regulations are strengthened, for example through information and energy-performance certification schemes and better enforcement of building regulations (including mandatory inspections). This leads to greater uptake of shared heating systems with higher efficiency, condensing boilers, insulation and heat meters.

The abatement potential that is profitable to investors increases to 166 Mt CO_2e in 2030, or by 49 per cent compared with the status quo scenario. This planned policy scenario (Chart 3.13) implies emissions that are 275 per cent higher than in 1990.

Total investments in profitable measures would amount to €69 billion in the modelling period until 2030, but these investments would yield net annual savings of €28 billion to investors by 2030 and beyond. Across the entire MAC the average benefit (negative cost) of all measures rises to €20 per tonne of CO_2e in 2030.

The greatest impact of the planned policies will be felt in the power sector, where the rapid expansion of nuclear power would displace a great deal of gas capacity (see Box 3.4). These policies would not fulfil the Turkish Government's aspiration to generate 30 per cent of electricity from renewable sources by 2030, including an additional 20 GW in new wind capacity and a doubling of the current hydropower capacity.

Outside the power sector, the planned policies would markedly increase the commercial viability of thermal modernisation and the installation of heating controls in residential and commercial buildings. The number of dwellings without appropriate insulation declines by almost half between 2010 and 2030, compared with a decline of 7 per cent in the status quo scenario. The total share of dwellings without any insulation is just under a quarter by 2030.

Chart 3.11
Planned policies scenario for Turkey

Source: EBRD on the basis of NERA and Bloomberg NEF.
Note: Labelled measures are those that are most impacted by planned policies. The height of dotted line bars represents their cost in the previous status quo scenario.

[28] See Ministry of Energy and Natural Resources, Electricity Energy Market and Supply Security Strategy Paper, May 2009.

Policy mix 2: enhanced policies

The enhanced polices scenario considers a range of additional measures that the authorities could designed to promote energy efficiency and reduce emissions. They are either at the early stages of consideration by the authorities or being promoted by different interest groups.

The feed-in tariff could be increased by a further €10–15 per MWh on top of the levels in the planned policy scenario. This would bring the feed-in tariffs above the expected wholesale power prices and match some of the more generous levels provided internationally.

There could be a more complete liberalisation of the gas market, with the early entry of major international rivals providing competition to BOTAS. This would have long-term benefits for consumers, reducing gas prices even before 2020.

In the status quo and planned policy scenarios, the limitations on gas and support for lignite-fired generation led to higher emissions. These constraints are removed in the enhanced policy scenario, so that there is no specified minimum or maximum deployment of these technologies. Instead, they are taken up according to their modelled financial attractiveness. Sufficient gas imports are available after the completion of the Nabucco and other gas pipelines or through a significant expansion of the liquefied natural gas market.

The scenario includes a price on carbon for the power and industry sector, which may be linked to the EU ETS. The price of allowances is assumed to be €40 per tonne of CO_2e in real prices (2010 Euro), which is consistent with recent industry forecasts that show strong fundamentals for €40 prices of EU ETS allowances in phase three (2013–2020). The sectors not eligible for the EU ETS – waste and coal mining, gas pipelines and agriculture – are assumed to benefit from credit-based carbon-finance mechanisms with a carbon price of €20 per tonne of CO_2e. This price difference is consistent with the analysts' forecast of a growing spread between EU allowance prices and the prices of international project-based credits.[29] The scenario adds the transaction costs of participation in carbon markets.[30]

Free provision of lignite to households is phased out and replaced with a more general policy that supports home heating or provide lump-sum income support. This allows for a gradual shift away from lignite to other fuels, according to their relative attractiveness depending on the characteristics of the relevant buildings.

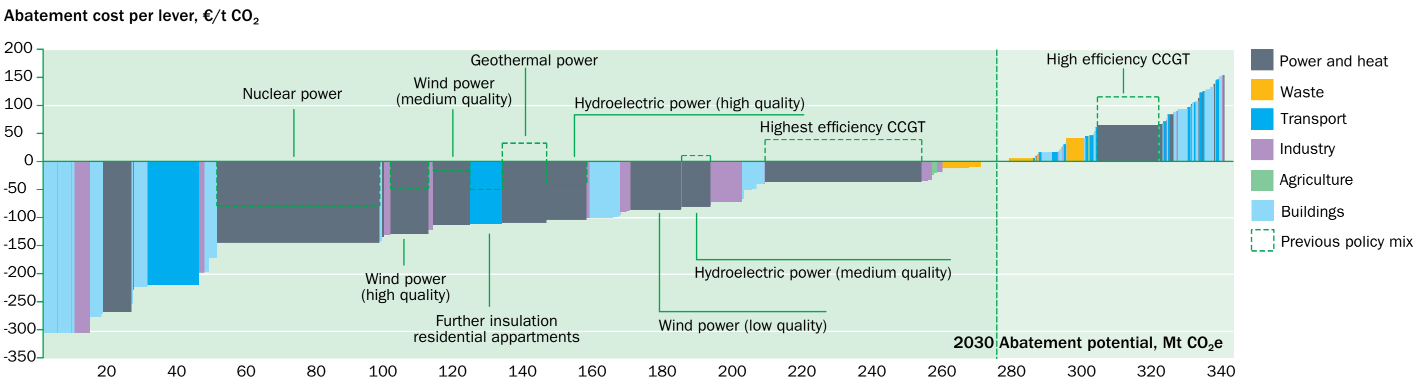
Additional requirements for alternative energy systems in buildings are included to reduce transaction costs, along the lines of EU Directive 2010/31 on the energy performance of buildings. Soft-loan programmes, supplier obligations, industrial benchmarking programmes and the expansion of commercial lending opportunities are assumed to reduce capital costs and the risks of household and industrial energy-efficiency measures, including insulation and solar or thermal hot-water heating.

The abatement potential that is profitable to investors increases to 276 Mt CO_2e in 2030, or by 54 per cent compared with planned policies (Chart 3.12). This would imply emissions increase by 163 per cent with respect to 1990 (Chart 3.13).

Total investments in profitable measures would amount to €100 billion in the period until 2030, but these investments would yield annual benefits of €40 billion to investors in 2030 and beyond. Across the entire MAC curve, the average benefit (negative cost) rises to €84 per tonne of CO_2e in 2030.

Enhanced policies will have the largest impact in the power sector if generous feed-in tariffs and carbon markets are available to spur renewable energy investments. Gas would become dominant among fossil fuels (Box 3.4). In the buildings sector, enhanced policies would promote insulation measures and the share of residential and commercial buildings with no insulation would fall to 20 per cent by 2030. Overall, there would only be a small shift in the fuel mix for heating by households compared with the planned policies scenario. Commercial buildings, however, would significantly reduce the use of coal for space heating. Finally, there would be a significant shift towards the use of more efficient lighting, particularly in residential dwellings.

Chart 3.12
Enhanced policies scenario for Turkey



Source: EBRD on the basis of NERA and Bloomberg NEF.
Note: Labelled measures are those that are most impacted by enhanced policies. The height of dotted line bars represents their cost in the previous planned policies scenario.

[29] Barclays Capital (2011), Make or Break: Carbon Market Outlook January, London.
[30] The €20 per tonne of CO_2e reflects the transaction costs and risk – it is a net price to primary credit developers.

Box 3.4 Case study: Policy impacts on the Turkish power sector

Power-sector development under status quo scenario
Under the status quo scenario, electricity production increases more than 2.6 times by 2030, but in the absence of incentives to reduce emissions, power-sector emissions more than triple as a result of the addition of significant coal and lignite capacity (as well as additional gas).

Gas-fired generation continues to be the lowest-cost option for new power plants during the period 2010–20, but the expected rising gas-import prices and constraints on available lignite combine to make hard coal the favoured source of new generation capacity beyond the 2020s.

By 2030, hard coal and gas provide similar shares of the total generation mix, with coal providing substantial baseload generation. There are also gradual additions of coal and lignite. Attractive wind power and hydropower sites are also developed, but not to the scale needed to meet ambitious government targets for renewables by 2023.

The resulting fuel mix broadly conforms to current government aspirations for fuel diversity, but in the absence of any significant expansion of renewables, this leads to a substantial increase in the overall emissions intensity of the power sector.

Impact of planned policies on power-sector development
The main difference between the planned policy scenario and the status quo is the addition of 15 GW of nuclear power – a result of underwriting of long-term contracts by the Turkish Government. By 2030 this would provide around one-sixth of Turkey's power generation. The expansion of nuclear power comes at the expense of gas-fired generation, due mainly to high projected gas prices after the 2020s. The policy support assumed under this scenario makes nuclear power viable. (This appears in the cost-effective portion of the MAC, with emission reductions relative to the reference case of over 50 Mt CO_2e by 2030.)

Planned policies do not lead to a significant additional expansion of wind power or hydropower. This is because the feed-in tariff levels for wind and hydro, although increased, remain below the modelled wholesale prices for electricity and are insufficient to make lower quality wind sites attractive. However, an additional 5 terrawatt hours of imported hydropower from Georgia are made available, with abatement of just under 3 Mt CO_2e. Overall, non-fossil sources of generation account for just under 40 per cent of generation by 2030.

Under this scenario, the total amount of abatement in the power sector at a zero carbon price is 92 Mt CO_2e in 2030. In addition, cost-effective investments in upgraded grid infrastructure help reduce transmission and distribution losses and provide additional emission reductions.

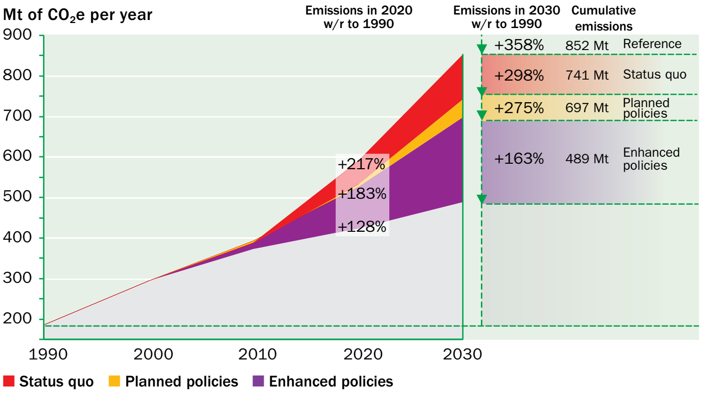
Enhanced policies impact on power-sector development
The enhanced policy scenario goes a long way towards significant decarbonisation of the Turkish power sector. Apart from the substantial contribution from nuclear power (also found in the planned policy scenario), there is a significant expansion of renewables on the back of generous feed-in tariffs and a substantial carbon price. By 2030, hydropower generation doubles to exploit its full estimated potential, while 30 GW of wind are added. Overall, 60 per cent of capacity and just over half of production come from non-fossil sources by 2030.

This is also a "high-gas" scenario. The strong carbon price and relaxed energy-diversity requirements make gas the preferred investment option relative to other fossil fuels. No new coal plants are constructed and the demand for gas increases in absolute terms compared with the planned policies scenario.

These developments substantially reduce emissions. Although generation increases by more than 2.5 times, emissions increase by no more than 50 per cent. Emissions are halved compared with the status quo.

Because all available hydropower and wind-power developments are rendered financially attractive, the cost-effective portion of the MAC is significantly larger in the enhanced policy scenario than in either the status quo or planned policy scenarios. By 2030, commercially attractive emission reductions in the power sector would increase to 120 Mt CO_2e relative to the reference case. In addition, cost-effective investments in upgraded grid infrastructure would help reduce transmission and distribution losses and provide additional emission reductions of 8 Mt CO_2e by 2030.

Chart 3.13
Emissions pathways under different scenarios in Turkey



Source: EBRD on the basis of NERA and Bloomberg NEF.

Comparison of the scenarios

If the Turkish economy grew by 5 per cent on average per year as projected over the period 2010–30, but remained stuck at its current carbon intensity, its emissions would reach 852 Mt CO_2e by 2030 (the reference case). However, the relative openness of Turkey's energy market will help to curtail emissions growth. Technological progress and energy prices that follow the global market under the status quo scenario could reduce 2030 emissions by about 111 Mt CO_2e compared with the static technology (reference) scenario. Technological improvements for new and replacement equipment bring greenhouse gas emissions down to 533 Mt CO_2e in 2020 and 741 Mt CO_2e in 2030 (Chart 3.13). However, this is still almost four times the 1990 level.

The implementation of policies that are already planned or being implemented would improve the commercial attractiveness of abatement projects and make emission reduction attractive for

a range of measures (Chart 3.14). Under the status quo, the average cost of abatement for the entire cost curve is €1 per tonne of CO_2e. Planned policies would turn this into a €20 surplus per tonne of CO_2e, limiting emissions to just 697 Mt CO_2e in 2030 – over three times the 1990 level.

Enhanced policies would harmonise Turkey's climate framework with the EU climate-policy package. This would make a big difference to overall emissions and the economics of emission reduction. The average premium of abatement for the entire cost curve would rise further to €83 per tonne of CO_2e, ensuring that emissions would not exceed 500 Mt CO_2e in 2030 (although this is still more than double 1990 levels). This suggests that in Turkey, even the most ambitious policy mixes simulated here could not ensure emissions would stabilise at 2009 levels, let alone 1990 levels.

Conclusions

Greenhouse gas emissions cannot be reduced without effective investments. This chapter explored the responsiveness of expected demand for emission-reduction projects to the policy environment in which they occur. This analysis focuses on incentives to invest, and as such complements the existing literature on the factors that influence ability to invest (e.g. access to finance), institutional barriers to investments, the macroeconomic consequences of mitigation actions (the focus of Chapter 2) and related social and political consequences.

The quantitative modelling conducted for Russia and Turkey indicates that a combination of a sound economic environment and targeted climate policies, could induce significant abatement investments. However, the 2009 policy framework in Russia and Turkey is shown to be patently insufficient, and if unchanged it would prevent countries from realising energy-efficiency measures that are in their self-interest, even without climate change.
In Russia and other former Soviet countries, the legacy of an industrialised but inefficient economy combined with an unfinished agenda of policy reforms leaves many low-cost emission-reduction opportunities still to be realised. The incentives to invest in climate-friendly projects in 2009 were greater in Turkey, primarily because of Turkey's earlier progress towards the market-based pricing of energy. The recent electricity pricing reforms and vigorously developing regulatory framework for energy efficiency in Russia will hopefully change the incentive structure, and this is captured in the scenario analysis.

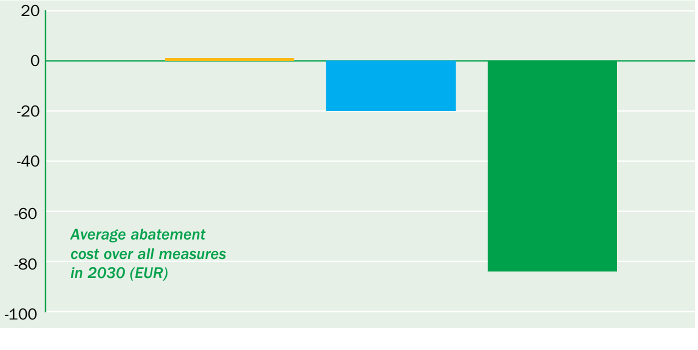
Under a status quo scenario, where the policy environment is effectively frozen at the 2009 level, Russia is likely to slow down emissions growth in the next two decades, emissions will continue to grow at a fast pace. Emissions growth under the status quo is likely to be even faster if remaining non-price barriers (not captured in this model) are included. A similar conclusion holds for Turkey, where emissions are expected to grow aggressively in the absence of counteracting policies.

Future abatement costs will rise more steeply in Turkey, because the country does not have a legacy of inefficient industrial development that would create vast opportunities for low-cost emission-reduction projects. Therefore, unlike Russia, Turkey will find it extremely challenging to even stabilise its emissions by applying the most ambitious climate policies during the modelling period. On the other hand, other studies show that the expected damages of climate change are going to be more severe in Turkey. This should increase self-interest to actively participate in domestic and global abatement efforts.

The policies required to facilitate emission reductions are often already planned and prioritised by governments. Many have already been approved but are being implemented slowly or are poorly enforced. Energy-efficiency standards and building regulations fall into this category.

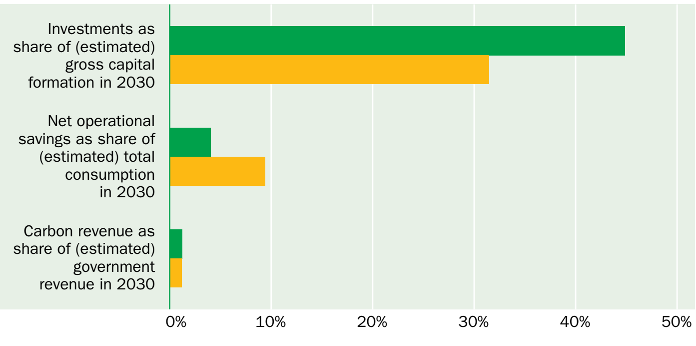
This analysis shows that many of the most powerful policies are not those specifically targeted at climate change, but are general economic reform policies that form part of the transition process and would bring wider economic benefits. Energy pricing, market liberalisation and a sound business environment that reduces investment risks are perhaps the most prominent examples.

Chart 3.14
Average abatement costs for Turkish investors in 2030 under different policies



Source: EBRD on the basis of NERA and Bloomberg NEF.
Note: The height of the bars represents the average for the integral of the entire curve (i.e. all measures available). The average abatement cost to investors starts from being positive with status quo policies and decreases to become a surplus with more ambitious policies applied.

Chart 3.15
Macroeconomic comparison



Source: EBRD on the basis of NERA and Bloomberg NEF.

Among carbon-specific measures, the most effective policy would be to put an economy-wide price on carbon. No alternative policy instrument can reasonably deliver a comparable scale of abatement investments. Without a high, economy-wide carbon price the demand for abatement investments will be weak in the future.

Carbon pricing is necessary but not sufficient for effective abatement. It must be complemented not only with economic and energy-pricing reform policies, but also with targeted support measures to nascent energy-efficiency and renewable-energy industries. Investors' responsiveness to price signals must be enhanced by a set of complex and specific interventions to remove institutional barriers and change entrenched behaviours, which are well documented in the literature and international experience. Various policy mixes are part of a comprehensive policy system of mutually reinforcing components and not all these mutual interactions could have been modelled here.

Chart 3.15 illustrates that under the most ambitious policies, including carbon prices, profitable carbon-abatement investments would become a core part of total investments in the economy, with almost half the gross capital formation in Turkey and above 30 per cent in Russia. The financial attractiveness of these investments would be higher on average in Russia than in Turkey; net operational savings compared to the reference would reach 10 per cent of total final consumption in Russia versus 5 per cent in Turkey. If a carbon price (a flat price of €40 per tonne of CO_2e in Russia and €20-40 in Turkey) is introduced as a tax or as auctioned emission permits, government revenue would increase by 1 to 2 per cent in both countries.

The results of the calculations should be interpreted carefully and should not be confused with cost estimates used in feasibility studies or pricing models. The costs in MAC curves are relative and incremental, rather than absolute, costs. They are statistical averages, rather then feasibility study figures and indicate the relative attractiveness of different abatement measures.

Achieving ambitious mitigation targets will not be effortless. The policies simulated here will provide effective signals to investors. Many are a win-win option for economic development and the environment. However, they entail significant adjustment costs, shifts of competitiveness between sectors, and the reallocation of labour and capital from high-emitting to low-carbon sectors. These are reflected in the economy-wide cost of climate change mitigation that was studied in chapter 2. The MAC model does not capture the impacts of these factors. However, like chapter 2 models - neither does it capture the economic benefits of avoided climate change damages, avoided adaptation costs or collateral benefits of climate mitigation policies, such as health benefits of reduced local air pollutants and lower resource dependence and higher long run growth in the current energy exporting countries.

As members of the international community, the transition countries will be under growing pressure to play their part in climate change mitigation in accordance with their "common but differentiated responsibilities".[31] The self-interest in curtailing global warming is likely to become stronger as knowledge of the harmful impacts of climate change and understanding of the co-benefits of abatement become more widespread in the region.

This self-interest may be further strengthened by negative and positive incentives introduced by the international community or bilaterally by the main trading partners. Probably the best that the advanced OECD countries, such as Canada, Japan and the US, and the EU could do is to adopt stringent emission caps so as to establish a predictable demand for emission allowances or low-cost offsets originated in the EBRD and developing countries that agree on monitorable ambitious abatement efforts.

The form in which a carbon price is introduced will have profound impact on investments. Some carbon prices will take cash away from investors; others will bring them additional revenues.

The design of international carbon markets or tax schemes may have significant impact on the ability of and incentives for these countries to implement ambitious climate policies. The transition region has under-used the potential of carbon markets in the past. In the future, however, the design of flexible international mechanisms may need to include provisions that would significantly reduce transaction costs and revise additionality tests. This would allow carbon finance to leverage abatement investments to a much larger scale in EBRD countries.

The interests of transition countries and the advanced market economies in seeking cooperative solutions to reduce global emissions and tackle climate change need to become aligned. The effective domestic policy mixes identified in this chapter, combined with the use of international carbon markets and other international policy instruments as both "sticks" and "carrots" could achieve this.

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Chapter Four
Political economy of climate change policy in the transition region

Implementing climate change policy poses difficult political economy challenges. What political economy dimensions are the most important? The type of political regime, the relative strengths of the carbon-intensive and low-carbon industry lobbies, the role of the independent media and civil society agents, and the public's broader political and economic preferences are all considered. Chapter 4 also analyses the interaction between the main political economy factors and the domestic climate policy outcomes, and demonstrates the political economy approach with case studies from Estonia, Russia and Ukraine.

4

Political economy of climate change policy in the transition region

Despite the advances made over the past two decades, many transition countries continue to be among the most carbon-intensive economies in the world. Where emissions have come down, it has primarily been the result of economic restructuring and reform (see Chapter 1). Only a few countries in the transition region – mainly those that have joined or are aspiring to join the EU – have begun to implement dedicated policies and measures to address the carbon emissions of their economies and thus contribute to global efforts to mitigate climate change.

Yet, as shown in Chapter 3, much stronger dedicated policies will be needed if transition countries are to reduce their emissions in line with international commitments. Consequently, it is critical to understand why the transition to a low-carbon growth model currently seems to be at best a marginal policy issue, and at worst actively opposed by politicians and the public in most of the transition region.

This chapter therefore focuses on the link between the structure of national economies – and hence the incentives that individuals and firms face with regard to their energy consumption choices – and aggregate national carbon output: the process of formulating the climate change mitigation *policies and measures* adopted by national governments to alter the incentives that shape individuals' and firms' energy choices. In particular, this chapter attempts to explain the key drivers of climate policy in the transition region, in order to highlight areas in which domestic and international policy-makers committed to combating global climate change can have a substantive impact on reducing carbon emissions in the transition region.[1]

The chapter draws on the larger literature on the political economy of reform to propose some hypotheses about the key obstacles to climate change policy in the EBRD region, sketching a stylised model of climate change policymaking in the region. It then asks whether there are in fact substantive differences between climate change policy in the transition region and the rest of the world, focusing on the following questions:

- When controlling for the differences between the transition countries' economies and the economies of the rest of the world, is climate change policy in the transition region less ambitious than in the rest of the world?
- Why is there not more ambitious climate change policy in the transition countries? What are the major political economy obstacles to the adoption of more ambitious climate policy in the region?
- Does the extensiveness of climate policy vary significantly across the transition countries? If so, what political economy factors might explain that variation?

How climate policies come about: a political economy approach

Why do some countries adopt ambitious climate change policies while others do not? The literature on the political economy of policymaking and reform suggests four sets of factors that are likely to be important. These relate to the international context, the structure of government, the degree of political accountability, and the characteristics of interest groups.[2]

First, the international context will affect how governments approach climate policy. The making of such policy can be thought of as a two-level interaction.[3] At the upper level, the world's governments interact strategically, each seeking to benefit from the global climate change regime while reducing their costs. Since there is no international authority with strong sanctioning power, this can be considered a "game" of voluntary contributions to a public good: climate stabilisation.[4] At the lower level, climate policies are formulated and implemented within each country by national governments once the international level is settled.

While the international bargaining game is important, this chapter focuses on the domestic level. We take international agreements as given and ask why some governments do far more than others to rapidly concretise and implement their international commitments. Under international agreements such as the Kyoto Protocol, countries do pledge to meet certain carbon-reduction targets. These pledges then serve as background to the game of domestic policymaking.[5]

Domestic policymaking depends in the first instance on the structure of government. Governments differ in the number of institutional veto players – or actors whose agreement is necessary for policies to be enacted – that they contain.[6] This depends on whether the parliament consists of two chambers, each with strong powers; whether there is a president; and whether the constitution is federal in the sense of granting veto-power over central policy to regional governments or their representatives. In addition, it will depend on the number of parties in the ruling coalition, since defection by a coalition member can preclude a bill's passage. The more veto players there are and the more divergent their views, the more difficult it is to change policy. One veto player, the agenda setter, gets to make the proposals to which other veto players respond. Hence, the identity of the agenda setter will also affect what policy is chosen.

The motivation of these veto players depends on the degree of political accountability. In democracies, parties and individual politicians in the government have reason to take into account the views of their constituents. The more responsive the democracy,

[1] In this chapter we use the terms 'climate change policy' and 'climate policy' interchangeably. Unless otherwise specified, we use these terms to denote policies designed to *mitigate* climate change (and thus global warming), as opposed to policies for *adaptation* to the impacts of climate change.
[2] See Roland (2000) for a general treatment of the politics of economic reform in transition countries.
[3] See Putnam (1988). For an application of the two-level game approach to climate policy, see Kroll and Shogren (2008).
[4] The literature since Olson (1965) has shown the outcome of such games to be far less determinate than originally thought. Many equilibria are possible, depending on the detailed structure of the game (see for example Bagnoli and Lipman 1989, Bergstrom, Blume and Varian 1986). But for some simple functional forms and assumptions, Olson's conjectures are confirmed. Most importantly, the public good is often undersupplied relative to the social optimum.
[5] We do, nevertheless, consider empirically whether membership in the EU is associated with more active climate

the more the preferences of the electorate will matter. The degree of responsiveness will depend on the electoral rules, but also on the degree of media freedom, which affects the accuracy and amount of information available to the voters. The ability of voters to extract accurate information from the media and other sources will depend on their level of education.

Finally, the characteristics of interest groups will also affect the outcomes of domestic policymaking. In part, the landscape of interest groups will simply reflect the underlying economic interests in the society, associated with the inherited economic structure. However, particular interest groups will be better organised in some places than others for historical reasons. Classic contributions to this literature suggest that the outcomes of policy will reflect the set of pressures – or bids – from competing interest groups.[7] Chart 4.1 outlines the relationships among these key actors, who drive the formation of climate policy by governments (represented as G1, G2 and so on).

Thinking about policy interactions in this way suggests a number of reasons why one country might pursue climate policy more actively than another. First, some countries are more dependent on carbon-intensive industries than others. If the income of the majority of the electorate depends on such industries, then one might expect democratic politicians to resist reforms that would threaten the livelihood of their constituents. If the benefits of developing clean industry exceed the costs of retiring heavy polluters, the voters could in principle be compensated. However, promises to do so may not be credible.

Even if the majority of voters do not depend on carbon-intensive industry, the carbon-intensive industry lobby can still achieve political influence disproportionate to the share of votes it can mobilise, as long as it is well organised. Thus, a strong presence of high-carbon industries may result in the effective blocking of reform.

However, other interest groups and issue-oriented lobbies such as environmental non-governmental organisations (NGOs) may balance the pressures of carbon-intensive industry, informing both the public and politicians about the benefits of climate policy.[8] Low-carbon industries may lobby for policies that support their activities.

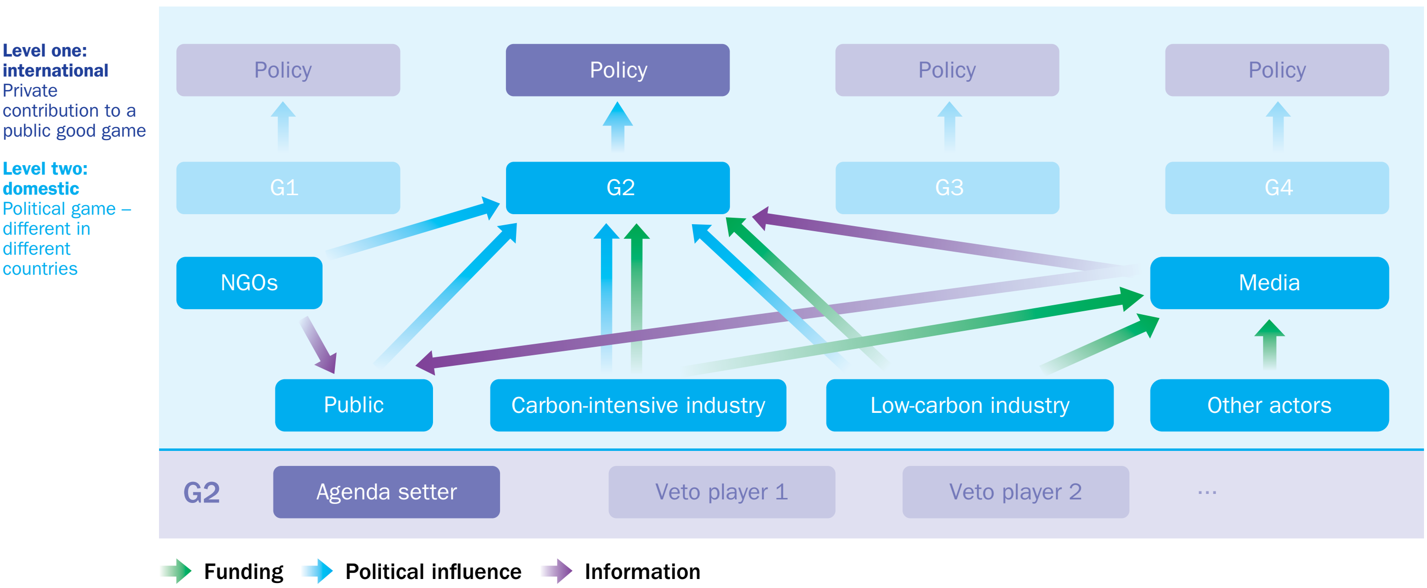
Indeed, the battle over climate change policies will in part be a battle of ideas. Supporters and opponents of climate policy will seek to inform – and sometimes to misinform – both the public and politicians on the causes of climate change and the costs and benefits of mitigation. Given this, a lot may depend on the sophistication of the general public – which in turn depends on the level of education – and on the extent to which the media are free and motivated to pursue the truth rather than to represent corporate or government interests.[9]

Public beliefs will also be shaped by history. In many transition countries, an abundance of fossil-fuel reserves coupled with an energy-intensive and wasteful industrial structure tends to be associated with a widespread assumption that energy use is less costly to society than it actually is. This may be another reason to expect slower reforms in countries where the energy-intensive sector is larger.

If the government is not democratic, then the paths of influence will tend to go directly from interest groups to government actors, with less influence by the public along the way. If the energy-intensive industry is well organised, it may succeed in blocking the implementation of climate policy commitments that benefit the public but are costly to entrenched interests.

The nature of the political regime may affect reform in one other way: by determining the time horizon of policy-makers. Preventing climate change has potentially huge long-term benefits, but also large short-term costs. If leaders are focused on winning the next

Chart 4.1
Stylised model of climate policy formation



policies. The norms and extra scrutiny associated with EU membership could plausibly motivate governments in the accession countries to demonstrate their commitment to the European approach.
[6] See Tsebelis (2002).
[7] See Olson (1965), Becker (1983), Grossman and Helpman (1994).
[8] See, for example, Botcheva (1996).
[9] See Snyder and Ballentine (1996) for a discussion of the battle of ideas – and the need to regulate free speech effectively – in the development of ethnonationalism in the post-communist region.

election (as in a democracy), or on avoiding an imminent coup (in an unstable autocracy), their regard for the future may be lower than that of the broader society. By contrast a (well-informed) autocrat who expects to remain in power for 20 years might take the threat of global warming more seriously.[10]

As should be clear from this discussion, most of the macro-variables likely to affect climate policy – democracy, press freedom, even the relative size of carbon-intensive industries – may have conditional or even conflicting effects. How economic structure, the extent of democracy and other factors influence countries' performance in climate change mitigation is therefore an empirical question. This is the subject of the following sections.

Measuring climate change policy

To understand the likely factors driving poor emission outcomes in many transition countries, it is important to understand to what extent and in which ways climate change policy in the transition region is substantively different from that adopted elsewhere in the world. However, while a number of international measures of climate change *outcomes* (such as emissions or carbon-intensity data) exist, there is no internationally comparative measure of climate change *policies and measures*. Policies and measures are based on, and embodied in, laws and institutions. We therefore constructed a globally comparative index: the Climate Laws, Institutions and Measures (CLIM) Index, or CLIMI.

Comparing the quality and depth of climate policies, measures, laws and institutions across a wide range of countries is no simple task. First, the range of government policies and measures that can influence climate change is vast.[11] It is therefore necessary to select, *ex ante*, from the set of government policies and measures those that are most effective in reducing carbon emissions and therefore mitigating global climate change.

A second major methodological problem relates to the availability of reliable data on climate change policies and measures that are comparable across countries. While there are a large number of country studies on the quality of individual countries' climate change policies, there are no available cross-country comparative assessments of climate change policies with global coverage.

We therefore chose to use the most systematic information on countries' climate change mitigation policies and measures available: National Communications to the United Nations Framework Convention on Climate Change (UNFCCC). The National Communications include detailed accounts of climate change adaptation and mitigation policies and measures adopted by national governments. All countries that ratified the Kyoto Protocol are required to submit National Communications. Developing countries submit National Communications only periodically, whereas developed economies (those listed in Annex I of the Kyoto Protocol) submit one every year.

Since 2005, 93 governments have submitted National Communications to the UNFCCC. In addition, in order to capture the largest and fastest growing emitters, we also include China, India, the Republic of Korea and South Africa, which all submitted National Communications prior to 2005, as well as the two missing transition countries, Azerbaijan and Turkey.[12]

There is an obvious benefit to using the National Communications: governments have a clear incentive to report all their climate change policies – or even to exaggerate them. To prevent misreporting based on exaggeration, the relevant policies were cross-checked with existing databases of climate change policies (such as the IEA and Climatico[13]), using national legislation as well as expert and UNFCCC country focal point consultations.

The components of the CLIM Index follow the standardised structure of the National Communications, which was designed to highlight the most important areas of climate change mitigation policies and measures. The CLIM Index therefore has 12 constituent variables grouped into four key policy areas:

- **International cooperation:** how quickly a government ratified the Kyoto Protocol and whether it developed institutional capacity to participate in the flexible mechanisms and host projects under Joint Implementation (JI) or the Clean Development Mechanism (CDM).[14]
- **Domestic climate framework:** this includes broad climate change laws and targets, and levels of institutional engagement in climate change (ministerial, independent committee and so on).
- **Sectoral fiscal or regulatory measures or targets:** these include targets and regulations in each of the sectors identified in the reports of the Intergovernmental Panel on Climate Change, apart from waste, as detailed in Table 4.1.
- **Cross-sectoral fiscal or regulatory measures:** these include carbon taxes and emission-trading schemes.

Most variables are scored on a 0/0.5/1 basis, apart from CDM/JI and Kyoto ratification. The policy areas, variables, scoring and weighting used in this analysis are reported in Table 4.1.[15]

Table 4.1
Components of the CLIM Index

Policy area	Policy area weight	Variable	Score	Sub weight
International cooperation	0.1	*Kyoto ratification*	0 to 1	0.5
		JI or CDM	0/1	0.5
Domestic climate framework	0.4	*Cross sectoral climate change legislation*	0/0.5/1	0.33
		Carbon emissions target	0/0.5/1	0.33
		Dedicated climate change institution	0/0.5/1	0.33
Significant sectoral fiscal or regulatory measures or targets	0.4	*Energy supply / renewables*	0/0.5/1	0.3
		Transport	0/0.5/1	0.13
		Buildings	0/0.5/1	0.07
		Agriculture	0/0.5/1	0.13
		Forestry	0/0.5/1	0.17
		Industry	0/0.5/1	0.2
Additional cross-sectoral fiscal or regulatory measures	0.1	*Cross-sectoral policy measures*	0/0.5/1	1

[10] Even the public may tend to overweigh the immediate future relative to the distant future in ways that are "time inconsistent" (O'Donoghue and Rabin 1999). However, we see no obvious reason why such tendencies would be more pronounced in some countries than others. For an application to the political economy of climate policy, see Hovi, Sprinz and Underdal (2009).

[11] For example, minimal energy-efficiency standards in residential building regulations can have a significant impact on carbon emissions, whether or not the consequence is intended. More broadly, Chapter 1 demonstrated that economic reforms associated with the transition process have had a substantial impact on emissions, even though the emissions consequences were not intended.

The CLIM Index thus offers a comparative assessment of the extensiveness and quality of climate change mitigation legislation, policies, measures and institutions in 95 countries around the world.[16] The Index includes all countries in the EBRD region and the EU, all large developing countries, many least developed countries and small island states, covering 91 per cent of global emissions and 73 per cent of the world's population.

Importantly, the Index does *not* include an assessment of outcomes, implementation quality or adaptation measures. Thus, it is possible that emissions may be on a rising trend in countries that have a high score on the CLIM Index. For example, China's industrial growth puts pressure on emissions, but its mitigation policies (which limit emissions that would not have occurred anyway) are increasingly ambitious. Thus, CLIMI measures the policies that countries *have adopted* to mitigate climate change, but does not provide an assessment of the quality of implementation of those policies. Instead, it relies on an assessment of the extensiveness of policy measures. Finally, CLIMI looks only at climate change mitigation; it does not look at either adaptation or broader environmental policies, which are likely to have different political economy mechanisms from those we identify.

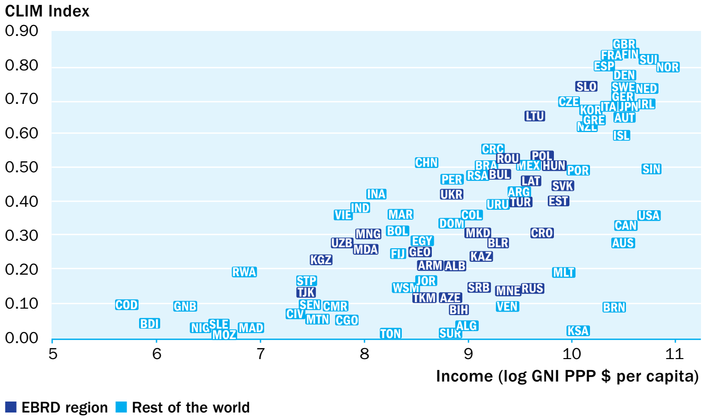
Table 4.2 report the results of the CLIM Index. Box 4.1 sketches out the key differences between the CLIM Index and the Index of Sustainable Energy (ISE), which was presented in Chapter 3.

The countries that score best on the CLIM Index tend to be northern European countries, mostly EU member states. The countries that score lowest on the CLIM Index tend to be low-income countries, predominantly located in sub-Saharan Africa, which have little pressure to reduce their relatively low emissions and low state capacity. Indeed, there is a clear correlation between countries' per capita income and the adoption of good climate change policies, as highlighted in Chart 4.2.

There is little correlation between countries' vulnerability to climate change and the adoption of climate change mitigation policies and measures. This reflects the fact that the countries most vulnerable to climate change tend to contribute little to the problem and hence focus their efforts on adaptation rather than mitigation.

There is significant variation among the transition countries, highlighted in dark blue in Table 4.2. Slovenia leads in 9th place globally while Bosnia and Herzegovina, ranked 83rd globally, lags

Chart 4.2
Correlation between per capita income and the adoption of good climate policies



Source: EBRD, World Bank.
Note: Data for 2007.

Table 4.2
Results of the CLIM Index

Rank	Country	CLIMI	Rank	Country	CLIMI	Rank	Country	CLIMI	Rank	Country	CLIMI
1	United Kingdom	0.801	25	Poland	0.496	49	Canada	0.316	73	Tajikistan	0.134
2	Finland	0.787	26	Mexico	0.486	50	Bolivia	0.296	74	Montenegro	0.133
3	France	0.783	27	China	0.485	51	FYR Macedonia	0.293	75	Turkmenistan	0.115
4	Switzerland	0.770	28	Hungary	0.483	52	Croatia	0.290	76	Azerbaijan	0.108
5	Spain	0.758	29	Singapore	0.468	53	Mongolia	0.288	77	DR Congo	0.091
6	Norway	0.749	29	Portugal	0.468	54	Egypt	0.267	78	Venezuela	0.090
7	Denmark	0.722	31	Brazil	0.464	55	Australia	0.265	79	Senegal	0.088
8	Sweden	0.701	32	Bulgaria	0.457	56	Belarus	0.262	80	Guinea Bissau	0.087
9	Slovenia	0.698	33	South Africa	0.456	56	Uzbekistan	0.262	81	Bahrain	0.086
10	Netherlands	0.691	34	Peru	0.437	58	Moldova	0.247	82	Cameroon	0.084
11	Ireland	0.667	35	Latvia	0.433	59	Georgia	0.238	83	Bosnia and Herzegovina	0.081
12	Germany	0.665	36	Slovak Republic	0.422	60	Fiji	0.233	84	Mauritania	0.071
13	Belgium	0.660	37	Indonesia	0.402	61	Kazakhstan	0.226	85	Cote d'Ivoire	0.064
14	Czech Republic	0.653	38	Argentina	0.401	62	Kyrgyz Republic	0.214	86	Congo	0.049
15	Austria	0.641	39	Ukraine	0.398	63	Armenia	0.201	87	Burundi	0.037
15	Italy	0.641	40	Estonia	0.383	64	Albania	0.199	88	Madagascar	0.029
17	Japan	0.636	41	Turkey	0.381	65	Malta	0.183	89	Niger	0.025
18	South Korea	0.629	42	Uruguay	0.369	66	Rwanda	0.182	90	Mozambique	0.023
19	Lithuania	0.615	43	India	0.358	67	United Arab Emirates	0.159	90	Saudi Arabia	0.023
20	Greece	0.608	44	Vietnam	0.345	68	Jordan	0.156	90	Algeria	0.023
21	New Zealand	0.602	45	Colombia	0.340	69	Sao Tome and Principe	0.143	93	Suriname	0.016
22	Iceland	0.561	45	United States	0.340	70	Samoa	0.142	93	Sierra Leone	0.016
23	Costa Rica	0.517	47	Morocco	0.339	71	Serbia	0.139	95	Tonga	0.011
24	Romania	0.497	48	Dominican Republic	0.319	72	Russia	0.134			

[12] For these two countries, we used a large number of sources to obtain the information that is normally provided in the National Communications. See Teytelboym and Steves (2011) for a description of these data sources.
[13] See Climatico Policy Monitor Baseline Report 2010; IEA Climate Change Database (http://www.iea.org/textbase/pm/index.html).
[14] See Dolsak (2009).
[15] Detailed explanations of the variables can be found in Teytelboym and Steves (2011), in which sensitivity analysis shows that the arbitrary choice of weights is justified as the ranking is usually preserved.
[16] We exclude Liechtenstein, Luxembourg, Monaco and San Marino.

Box 4.1 Comparing the ISE and the CLIM Index

The CLIM Index assesses only the extensiveness of policies adopted, and only in the particular area of climate change mitigation, and is global in scope. The Index of Sustainable Energy (ISE) assesses sustainable energy more broadly, including both policies and outcomes, and focuses primarily on the transition region.

Chart 4.1.1 plots the transition countries' scores on the ISE versus their scores on the CLIM Index. As one would suspect, the two indices correlate. This is not surprising because sustainable energy policies are also measured in the sectoral component of the CLIM Index. Most policies that promote energy efficiency and renewable energy also contribute to national efforts to mitigate climate change. Sustainable energy is reinforced through effective climate change mitigation measures. In addition, ISE has a climate change component, which may drive the correlation.

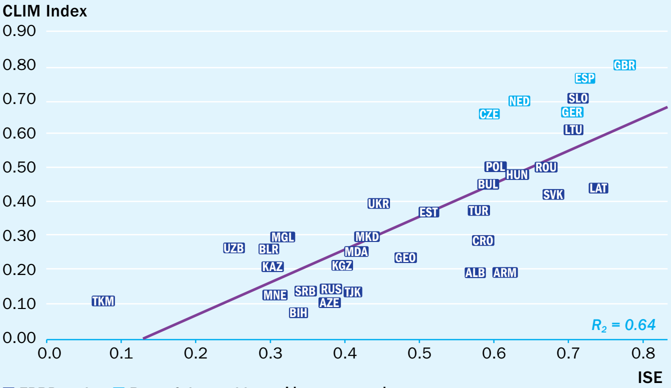
However, there are also important differences between the two indices. First, the CLIM Index has significantly broader country coverage, which allows us to make inferences about the determinants of individual aspects of climate change policy-making in the global context. Furthermore, the broader sample allows us to assess whether the relationship between the drivers of climate change mitigation policy have any regional specificity – and whether the transition countries are somehow "different" from the rest of the world in this regard.

Second, unlike the ISE, the CLIM Index does not combine policies and outcomes, focusing solely on climate change policies and measures.

Third, the CLIM Index assesses the existence of laws and regulations "on the books" as well as the existence of climate change institutions; it does not assess the effectiveness of those laws, regulations or institutions. This is important for understanding the political economy mechanisms underlying the adoption of mitigation measures, which are likely to be different from the political economy mechanisms underlying the adoption of, for example, energy-efficiency regulations. The CLIM Index therefore makes it possible to assess the impact of these policies and measures on actual carbon-emission outcomes.

Lastly, the CLIM Index covers all of the sectors of the economy that contribute to greenhouse gas (GHG) emissions – not just the energy sector. This is important for many developing countries, where the energy sector is not the largest contributor to GHG emissions.

Chart 4.1.1
The CLIM Index versus the ISE



Source: EBRD.
Note: Latest rankings.

well behind even the Commonwealth of Independent States (CIS) countries. Not surprisingly, the new EU member countries in Central and Eastern Europe and the Baltics (CEB) all score in the top half of the Index, although Estonia scores relatively poorly – worse than Ukraine, which leads the CIS countries by a large margin.

The remainder of the CIS countries are located within the third quartile globally, reflecting in part their energy-intensive economic legacies, but also a political economy setting that has not been conducive to effective climate change policies over the past twenty years. As Chart 4.2 shows, these countries have implemented significantly fewer climate change policies than would be expected given their levels of per capita income.

In the following section we explore in more detail the underlying drivers of the adoption of climate change policy – and the explanations for the relatively poor performance of the CIS countries in this regard.

Determinants of climate change policy

The CLIM Index can be used to analyse the relationship between climate change policies and measures – the outcome of interest – and the various aspects of the stylised model of climate policy-making outlined above. However, the stylised model by necessity oversimplifies what are in reality complex, and in many cases country-specific, political processes and decision-making calculi.

In the real world, some governments will be constrained by overwhelming public opposition to carbon-reduction policies – regardless of the hard economic facts – while in other countries the tide of public opinion will leave political leaders with little choice but to implement policy measures that are economically painful in the short run. In some countries, the influence of the carbon-intensive industry lobby will be channelled via opaque means or personal relationships, while in other countries the debate between carbon-intensive and low-carbon industries will take place in the public arena with open engagement by civil society and the independent media.

Given this complexity, we estimate a reduced-form statistical model, based on six major factors that the political economy literature identifies as likely to drive public policy on climate change:

- **Public knowledge of the threat represented by climate change.** Given the extent to which the government responds to public pressure, one would expect public knowledge of climate change to lead to stronger policies. The data used to measure this are taken from a 2009 Gallup poll, conducted in 175 countries, which asked people whether they see climate change as a threat, how much they know about climate change, and whether climate change is caused by human activity or is a natural phenomenon. However, because the public's understanding of climate change, as revealed in the survey, will itself also be influenced by national climate policies, so-called instrumental variable techniques will be required to understand this link (see below).

- **The level of democracy.** Democratic political systems are designed to transmit popular concerns and priorities into the policy-making process. In democratic countries where public

knowledge of climate change is high, one would expect climate policy to be ambitious. In contrast, if the public is opposed to climate policy because it may harm short-term economic prospects, democratic political systems may inhibit the adoption of ambitious policy in this area. Therefore, the direct effect of democratic systems on climate change mitigation policy could be either positive or negative. We employ the widely used Polity IV regime characteristics dataset for the year 2007 to measure the level of democracy.

- **The strength of the carbon-intensive industry lobby.** The political weight of the carbon-intensive industry lobby is simultaneously the most important determinant of climate change policies and measures, and the most difficult to measure. For the purpose of this analysis, the share of carbon-intensive industries – manufacturing, mining and utilities – in each country's Gross Domestic Product (GDP) was used as a rough proxy.

- **State administrative capacity.** Once political leaders have announced a course of policy action, the stated intention may or may not be translated into state policy. This will depend, at least in part, on the administrative capacity of the bureaucracy to draft regulations and laws, and submit them for legislative and executive approval. This factor is only implicitly addressed in the political economy literature, but might be important. Countries with strong democracies, free media and weak carbon-intensive industry lobbies might nevertheless have weak climate change policies because of insufficient capabilities to design and implement such policies – much less enforce them, an issue not dealt with in this chapter. The simple average of the World Bank's "Government Effectiveness" and "Regulatory Quality" Governance Indicators for 2007 was used to measure state administrative capacity.

- **Per capita and total CO_2 emissions.** There are two possible ways that per capita or total CO_2 emissions might affect climate change policy adoption. On the one hand, the countries with the highest CO_2 emissions per capita tend to be the highest income countries who have historically generated the most atmospheric carbon, and who are therefore expected to reduce their emissions more than countries with lower per capita CO_2. On the other hand, in countries with higher per capita CO_2 emissions, it is likely that introducing aggressive carbon emission-reduction targets will be resisted more fiercely by both individuals and firms. Countries that have lower total emissions may be more reluctant to cut emissions because their contribution to climate change is small and hence any decrease in emissions will only have a negligible effect on global emissions. We therefore test empirically what kind of impacts per capita and total CO_2 emissions have on the adoption of climate change policy.

- **International commitments.** In all countries the nature of internationally negotiated carbon emission-reduction targets will play a role in domestic leaders' and polities' cost / benefit deliberations on climate change policy innovation. We therefore control for ratification of the Kyoto Protocol, as well as the size of the emission-reduction target to which Annex I countries committed themselves. In addition, the most binding international commitments are entailed by membership in the EU, which we control for using a dummy variable in the regressions. We also use a dummy variable to test whether being a transition country has a significant effect on the adoption of climate change policy once other variables are controlled.

The determinants of public opinion on climate change

As mentioned above, the observed correlation between public knowledge of the threat posed by climate change and better climate policy could reflect causal effects in both directions. Better knowledge of the causes of climate change could both influence, and be influenced by, climate change policies. To see whether public information affects climate change policies, it is therefore important to focus on cross-country differences in public knowledge that are driven by factors unlikely to be influenced by climate policies, and that do not influence policies independently. Three possible factors are considered in this context:

- **Levels of tertiary education.** Higher levels of tertiary education produce a more sophisticated population, which is likely to be better informed about the scientific evidence on climate change. We use the latest data available from the World Bank's World Development Indicators.

- **Freedom of the media.** Independent and critical media play a crucial role in assessing and disseminating scientific findings, particularly in such vital areas as climate change. A free media is a key factor in shaping public understanding of climate change. We use Freedom House's Freedom of the Media index for 2007 for this issue.

Table 4.3
Determinants of knowledge of anthropogenic climate change

Dependent variable	Climate change a threat		Some knowledge of climate change		Much knowledge of climate change		Global warming caused by humans		Global warming has natural causes	
Model	A	B	C	D	E	F	G	H	I	J
Education	0.019	0.051	.208***	.184***	.345***	.338***	.146***	.180***	-.340***	-.394***
Media freedom	0.029	0.153	-.149***	-.210***	-.190**	-.291**	-0.068	0.028	.319***	-0.046
Vulnerability	-.386***	-.330***	-0.011	-0.032	0.411	-0.447	-.441***	-.416***	.711**	.763***
EU		0.08		-0.031		-.215*		0.064		-.596***
EBRD region		-.250***		.143**		0.061		-.202***		.363***
Number of observations	71	71	83	83	83	83	81	81	81	81
R^2	0.23	0.33	0.6	0.62	0.54	0.55	0.27	0.37	0.32	0.43

- **Vulnerability.** If a country is vulnerable to climate change, the population is more likely to be aware of climate change in general and its causes in particular. For this variable, we use the Climate Change Vulnerability Index 2011 compiled by Maplecroft, a risk analysis and mapping firm.[17]

Table 4.3 reports the results of the regression of various aspects of public opinion on climate change, as found in the 2009 Gallup poll, on the three independent variables listed above. The coefficients indicate whether countries with, respectively, a higher degree of education, more media freedom, and a greater vulnerability to climate change were more likely (positive coefficient) or less likely (negative coefficient) to agree with the statements described in the column headings.

As model A in this table illustrates, when controlling for the average level of education and for media freedom, the perception of climate change as a threat is driven almost entirely by a country's actual vulnerability to climate change.[18] Model B shows that the coefficient on a "dummy variable", which takes the value of 1 if a country is in the EBRD region and 0 otherwise, is negative and significant. This means that for similar levels of education, media freedom and vulnerability to climate change, the public in EBRD countries is significantly less aware of the threat posed by climate change than people in the rest of the world.

Models C-F show that people in countries with more widespread tertiary education and greater media freedom are more likely to state that they have knowledge of climate change. Countries' actual vulnerability to climate change has no significant effect here. In contrast, models G-H suggest that that awareness that global warming is caused by humans depends on education and country vulnerability, while media freedom makes no difference in this context. For similar levels of education and country vulnerability, this awareness is significantly weaker in the transition countries than in the rest of the world (model G).

The same pattern is visible in the inverse question (models I-J): people in more vulnerable countries and countries with more tertiary education are less likely to believe that global warming is a natural phenomenon. Controlling for levels of education and vulnerability, this belief tends to be less prevalent in EU countries and more prevalent in EBRD countries.

Political factors in climate change policy adoption

We now turn to this chapter's core question: what political economy factors drive the adoption of climate policy? We employ the two-stage least squares (2SLS) regression approach. This enables us to address the problem of reverse causation outlined in the preceding section and therefore make causal statements about the impact of public knowledge on climate change policy.

In the first stage, a regression along the lines of models G and H in Table 4.3, pooling the respondents who believe that global warming is caused by human activity, is used to construct predicted values of knowledge of climate change across countries. This constitutes a measure of climate change knowledge that is not influenced by climate change policies. In the second stage, this constructed variable as well as the remaining potential determinants discussed at the beginning of the section are then used to investigate the causes of cross-country variations in climate change policy. The results of this second stage regression, using the CLIM Index as the outcome variable, are presented in Table 4.4.

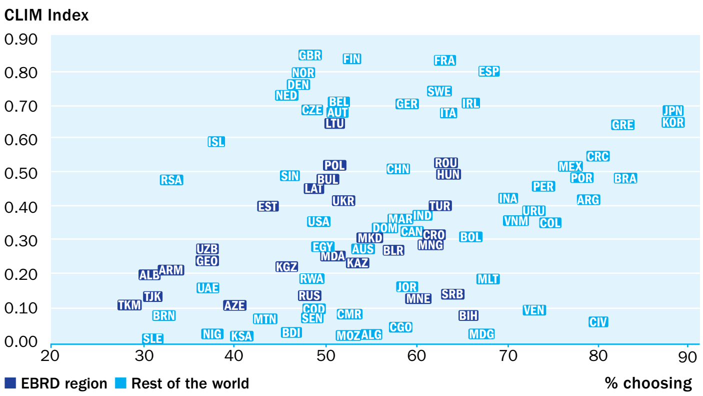
Model A shows that popular knowledge of climate change is positively associated with the adoption of more extensive climate change policies and measures, controlling for international commitments and per capita CO_2 emissions. This is illustrated graphically in Chart 4.3, which shows that countries where a larger proportion of the population believe that climate change is anthropogenic tend also to have more ambitious climate policies – and hence to score better on the CLIM Index.

Table 4.4 also shows that, controlling for international commitments and CO_2 emissions, democracy and state administrative capacity are not significant influences on climate change adoption. State administrative capacity is a significant predictor of active climate change policies only when Kyoto commitments and per capita CO_2 emissions are excluded from the regressions.

Table 4.4
Instrumental variables (2SLS) regression results

Dependent variable	Global Index of Climate Change Policies and Measures					
Model	A	B	C	D	E	F
Knowledge of climate change	3.012***	2.213*	2.254***	2.082**	2.087**	2.248**
Democracy		0.218	-0.230	-0.133	-0.0441	-0.156
Carbon intensive industry size			-0.687**	-0.730**	-0.942**	-0.871***
State administrative capacity			1.002**	0.682		0.562
Kyoto Protocol target	-2.319**	-2.119**			-2.806***	-2.708**
CO_2 per capita	0.237*	0.196*		0.0990	0.223**	0.139
Total CO_2 emissions	-0.0313	0.0168	0.0695	0.0501	0.0414	0.0453
EU	0.161	0.630**	0.389*	0.390**	0.430	0.393
EBRD region	0.315	0.294	0.494**	0.371*	0.148	0.307
Number of observations	75	71	77	71	71	71
R^2		0.326	0.411	0.440	0.459	0.434
Instrumented	*Knowledge of climate change*					
Instruments	*Media Freedom, Level of Education, Vulnerability*					

Chart 4.3
Knowledge of climate change and the CLIM Index



"Temperature rise is a part of global warming or climate change. Do you think rising temperatures are a result of...? a) human activities b) natural causes c) both"

Source: EBRD, Gallup.
Note: Data for 2006-9.

[17] We are very grateful to Maplecroft for sharing the aggregated results of their Climate Change Vulnerability Index 2011 with us for this analysis.
[18] The Maplecroft Climate Change Vulnerability Index is scored on a 1-10 scale, with 1 representing extreme vulnerability and 10 representing no vulnerability.
[19] The empirical finding that democracy is not a significant determinant of climate change policy adoption is consistent with the theoretical argument by Aumann, Kurz and Neyman (1983) that voting is irrelevant for pure (non-exclusive) public goods when resources are privately owned.
[20] While democracy and state administrative capacity are not significant, we leave them in as control variables to be sure that we are accurately capturing the effects of knowledge, the carbon-intensive industry lobby, per capita emissions and EU membership on climate change policy.

Similarly, models C and D show that EU members are significantly more likely to adopt climate change policies than non-EU members – until Kyoto Protocol commitments are controlled for.[19] Thus, Kyoto targets are of overriding significance for predicting cross-country variation in climate change policies, followed by EU membership and state administrative capacity.[20]

It is perhaps surprising that the level of democracy does not drive the adoption of climate change policies and measures, once we control for the other factors that influence the climate change policy-making process, including popular awareness of climate change. As we argued above, democratic political systems are intended to transmit popular concerns and priorities into the policy-making process. In the area of climate change policy-making, this appears not to be the case.

Perhaps the most important finding from this analysis is the strength of the carbon-intensive industry lobby as a factor holding back climate change policies (see in particular models E and F). This is illustrated in Chart 4.4, which plots countries' carbon emissions per tonne of CO_2 against their scores on the CLIM Index.

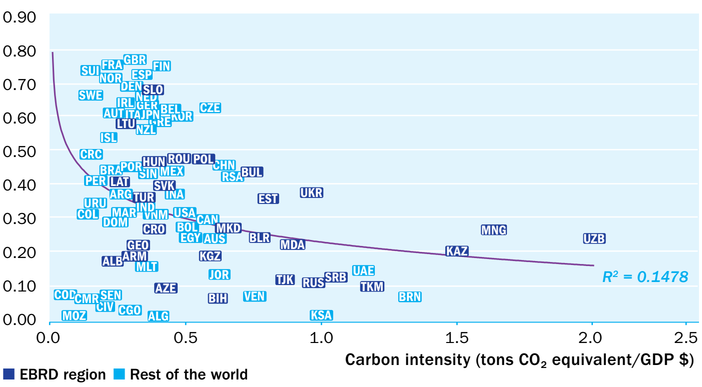
The final regression result, model F, summarises the main results from the analysis. Controlling for all other policy-influencing factors, including countries' CO_2 emission-reduction targets under Kyoto, reveals several findings:

- Popular knowledge of climate change is a powerful driver of climate change policy adoption. This is a very robust result. For every one per cent increase in public knowledge of the anthropogenic causes of climate change, there is a 2.25 per cent increase in countries' score on the CLIM Index.[21]

- The relative size of the carbon-intensive industry is significantly and negatively associated with climate change policy adoption.

- There is no clear evidence that the state's administrative capacity (at least as measured by the World Bank indicators) matters: states with low administrative capacity are just as likely to adopt climate change policies as states with high administrative capacity.

Chart 4.4
Carbon intensity correlated with the CLIM Index



Source: EBRD, IEA.
Note: Data for 2007. GDP in constant US dollars 2000 prices.

- EU member countries tend to adopt more assertive climate policies than non-EU members, although this effect is much less significant than countries' adoption of emission-reduction targets under the Kyoto Protocol.

- After taking account of these factors, climate change policies in transition countries do not appear to be different from those in the rest of the world.

This last conclusion – that the drivers of climate change policy in the transition region are the same as the drivers of climate change policy in the rest of the world – gives cause for optimism that the Soviet legacy of energy-inefficient production can be overcome, in time, through the appropriate reformulation of economic and fiscal incentives in the transition economies. However, the empirical relationships identified so far offer only limited guidance on how to achieve this.

The role of international commitments such as emissions targets in incentivising subsequent domestic policies suggests that there is a role for leadership in reformulating incentives. However, it is much more difficult to say how lobbies representing carbon-intensive sectors can be weakened, or public awareness can be developed. Factors such as level of education, vulnerability to climate change, and media freedom tend to evolve only very slowly over time. Press freedom can change more quickly – for instance, after coups or popular uprisings – but such events are relatively rare. None of these factors can explain the rapid acceleration in the adoption of climate change policies that has occurred over the past decade in many countries.

To unravel some of these more complex causal relationships – and in particular, to try to understand what provokes changes in governments' policy responses to the challenge of climate change in the transition region – we now turn to three case studies: Russia, Ukraine and Estonia. We focus in particular on the nature and role of veto players in those countries' political systems, and the ways in which these veto players have either blocked or facilitated the adoption of progressive policies to mitigate climate change.

[21] Thus, for example, if the level of public knowledge of climate change in Ukraine increased to the level seen in Italy, Ukraine's score on CLIMI would increase by 52 per cent – to be on par with New Zealand.

Case studies: climate change policy in the transition region

In this section we look in more depth at the domestic political landscape in three countries – Russia, Ukraine and Estonia – with very different economic structures, and levels of energy intensity of production. We specify who the key veto players are for each country – based on both *de jure* constitutional provisions and *de facto* sources of political authority – and where their ideal points on climate change policy lie. This requires judgments about the relative influence of different industries over various government institutions, for example the executive branch, upper and lower houses of parliament and so on, which we relate to the "carbon-intensive industry lobby" measurement used in the statistical analysis. We also highlight where carbon-intensive industries have formed a political coalition with the public (and perhaps the media) and those where the low-carbon industries are in coalition with the public (and perhaps the media).

We then identify the range of policy outcomes that all veto players would consider an improvement over the status quo, factoring in collective action and incentive problems at the international level. We identify within this range the point most preferred by the agenda setter, and then see how accurately this predicts the actual policy outputs of the different countries.[22] The relationships outlined in Chart 4.1 above are specified for each of these three countries in Charts 4.5.1-4.5.3.

Key veto players

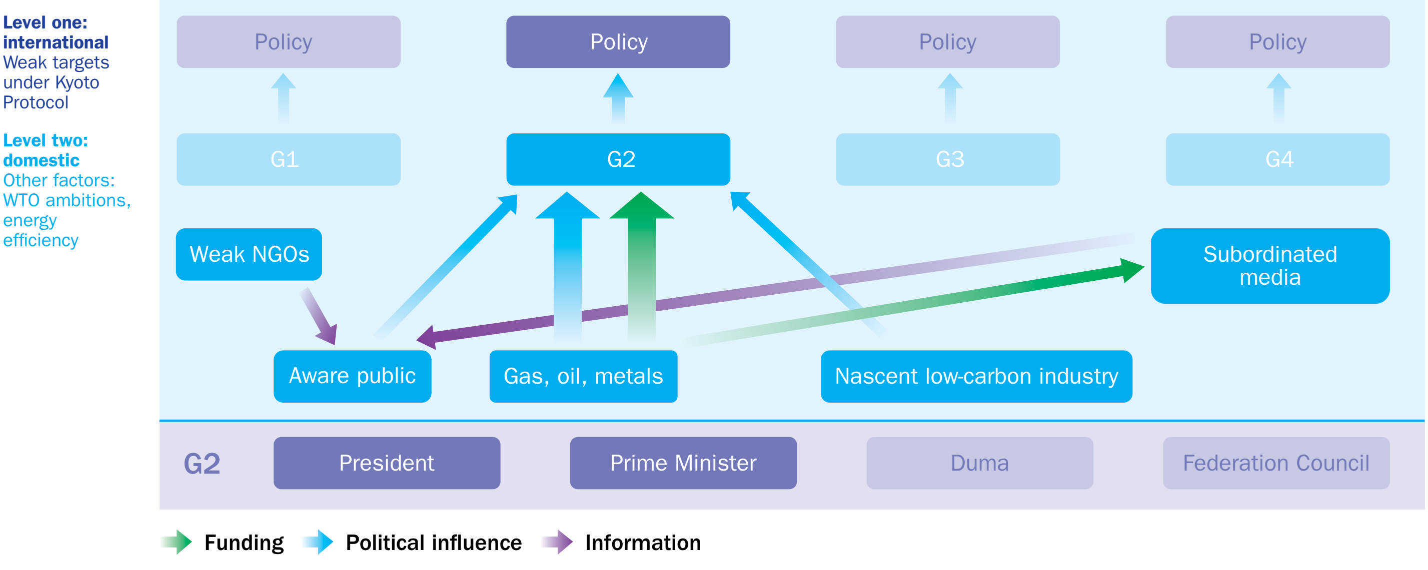
The Russian Federation today is a strong presidential republic in which the parliament has come to play a subordinate role. President Dmitri Medvedev and Prime Minister Vladimir Putin wield most of the political power and set the agenda for virtually all legislation. The lower house of parliament, the *Duma*, is dominated by the pro-Kremlin United Russia party, which is led by Mr Putin and supports most – if not all – of the government's legislative initiatives.

However, the Russian political system has evolved significantly over the past decade, altering the number and position of both official and unofficial veto players. Until the election of Mr Putin to the Presidency in 2000, the other major veto players included both the *Duma* and the upper house of parliament, the Federation Council. Until the early 2000s, Russia's regional governors also held situational veto player roles, as they were able to block the effective implementation of federal law at the regional level.

Since the abolition of direct elections for regional governors in 2004, they have become significantly less influential in this regard. The veto player landscape in Russia underwent another major shift in 2008 when Mr Putin transferred from the presidency to the premiership, thus *de facto* strengthening the government's veto player role. In short, there are currently in practice two veto players – the President and the Prime Minister – both of whom have agenda-setting power. The veto power of the President is mostly limited to the literal veto he can place on legislation, which can be overturned by a two-thirds majority.

Like Russia, Ukraine has gone through two major shifts in the constitutional distribution of political power over the past decade, which have resulted in a shifting kaleidoscope of veto players in the Ukrainian political system. Prior to the Orange Revolution of 2004, Ukraine was a strong presidential republic in which the President was the main agenda setter as well as the most powerful veto player. From 2006, when constitutional amendments took effect, Ukraine became a mixed presidential-parliamentary republic, in which the legislative branch acquired a number of executive functions, and the government and parliament became influential veto players in their own right. However, the new constitution also blurred the political prerogatives of the legislative and executive branches, resulting in a *de facto* multiplication of veto players across all branches of government, including the judiciary, which came to be used by competing political elites as a veto device.

Chart 4.5.1
Relationship among key actors on climate change policy in Russia



[22] This requires some subjective judgments but is nevertheless a powerful tool to illuminate the domestic political barriers to climate policy implementation.

With the election of Viktor Yanukovych to the Presidency in February 2010 and the subsequent formation of a pro-presidential government, these overlapping constitutional powers became less significant from a policy perspective as both executive and legislative branches were committed to the same policy agenda. In September 2010, the Constitutional Court ruled that the 2004 constitutional amendments were unconstitutional, which implicitly entails a reversion to the strong pre-Orange Revolution presidential regime.

In strong contrast to Ukraine, Estonia has a limited number of *de facto* veto players when it comes to climate change policy-making. Estonia has a unicameral parliament with a largely ceremonial Presidency, meaning that the government under the leadership of the Prime Minister is the agenda setter as well as the most influential veto player. However, unlike Russia, Estonia's electoral system is based on pure proportional representation (PR) with a large number of parties represented in parliament: while the electoral threshold is relatively high, at five per cent, the PR electoral system also provides an incentive to political party fractionalisation, and the two most recent parliaments (2003 and 2007) have had seven and six parties represented in them, respectively. This leads to often weak coalition governments and assigns opposition parties influential veto player roles in certain situations.

Media and civil society organisations

National television in Russia is largely subservient to the Kremlin when it comes to news coverage, almost never criticising the President or Prime Minister. Consequently, the media do not serve as an effective check on presidential or prime ministerial powers, and tends to funnel messages that have been pre-approved at the highest political levels to the Russian electorate. Although President Medvedev and Prime Minister Putin hold call-in shows with the public, most demonstrations against the government by civil society organisations are suppressed. Thus, the media and civil society today are not significant veto players.

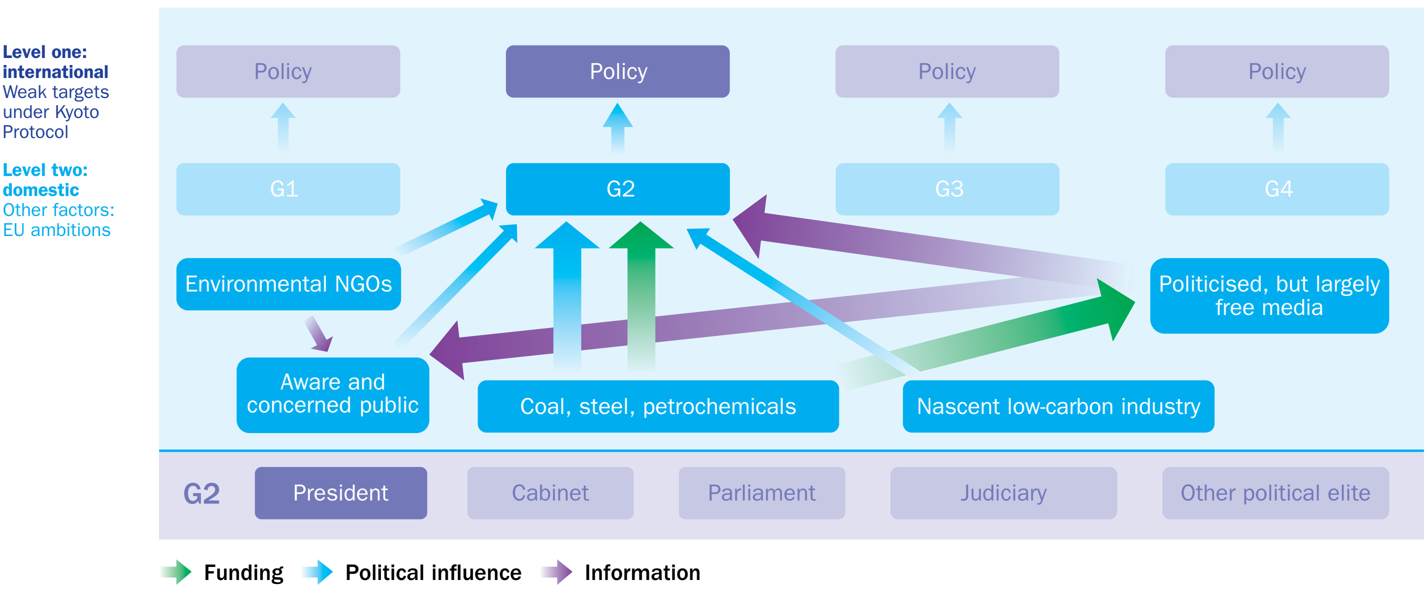
In contrast, the media in Ukraine are highly pluralistic and, particularly since the Orange Revolution, largely free from government interference. While oligarchic ownership has sometimes resulted in the extreme politicisation of some media outlets, these have not been necessarily in the service of the state or the incumbent political leadership. Likewise, in the aftermath of the Orange Revolution, campaigning civil society organisations, including environmental NGOs, rapidly grew in voice and effect within Ukrainian society. They have thus served as effective channels for the dissemination of information about the threat posed by climate change – and therefore the necessity for the Ukrainian government to undertake mitigating measures to help combat climate change.

The media in Estonia are pluralistic and independent, and a large segment is foreign-owned, which should facilitate the penetration of climate change knowledge into the social and political spheres. Moreover, the judiciary is both free from political interference and well-trained, which should likewise facilitate the adoption of EU norms and standards, including those related to climate change policy.

Public knowledge of climate change

Despite the political control of national television in Russia, almost half of all Russians (48 per cent) believe that global warming is a result of human activity. A similar proportion views it as a threat to themselves and their families. This may be caused, in part, by the extreme weather events that have affected European Russia in recent years, most recently in the form of record high temperatures and peat bog fires around Moscow in the summer of 2010. It probably also reflects the country's very high rate of tertiary education.

Chart 4.5.2
Relationship among key actors on climate change policy in Ukraine



The issue of global warming and the need for energy conservation, to the extent that it has been politicised at all, is one that President Medvedev has embraced. There is a growing awareness among the Russian population of the dangers of melting permafrost in Siberia and the vulnerability of Russian agriculture to climate change. Some attention has also been drawn to global warming issues by the popular environmental movement protests against a motorway through the Khimki forest near Moscow, as well as by previous campaigns to save Lake Baikal from industrial pollution.

The Ukrainian public is unusually well-informed about the threat of climate change; 78 per cent of the population claim to know something or a great deal about climate change and almost two-thirds worry that it might adversely affect their lives. The interesting mix of high public awareness and a relatively low CLIM Index score has produced the strongest disapproval of state policy in a worldwide sample of 80 countries: only 3 per cent of Ukrainians are satisfied with how seriously their government is taking climate change.

The Estonian public, by contrast with Ukrainians and to a lesser extent Russians, have the lowest public awareness of the causes and consequences of climate change in the EU.[23] Only 14 per cent of the population say that they know a great deal about climate change. Despite being a country with an extensive coastline, only 36 per cent of Estonians view climate change as a serious threat to their livelihoods. Nevertheless, the overwhelming majority of Estonians (83 per cent) do not believe that their government does enough to tackle climate change.

The carbon-intensive industry lobby

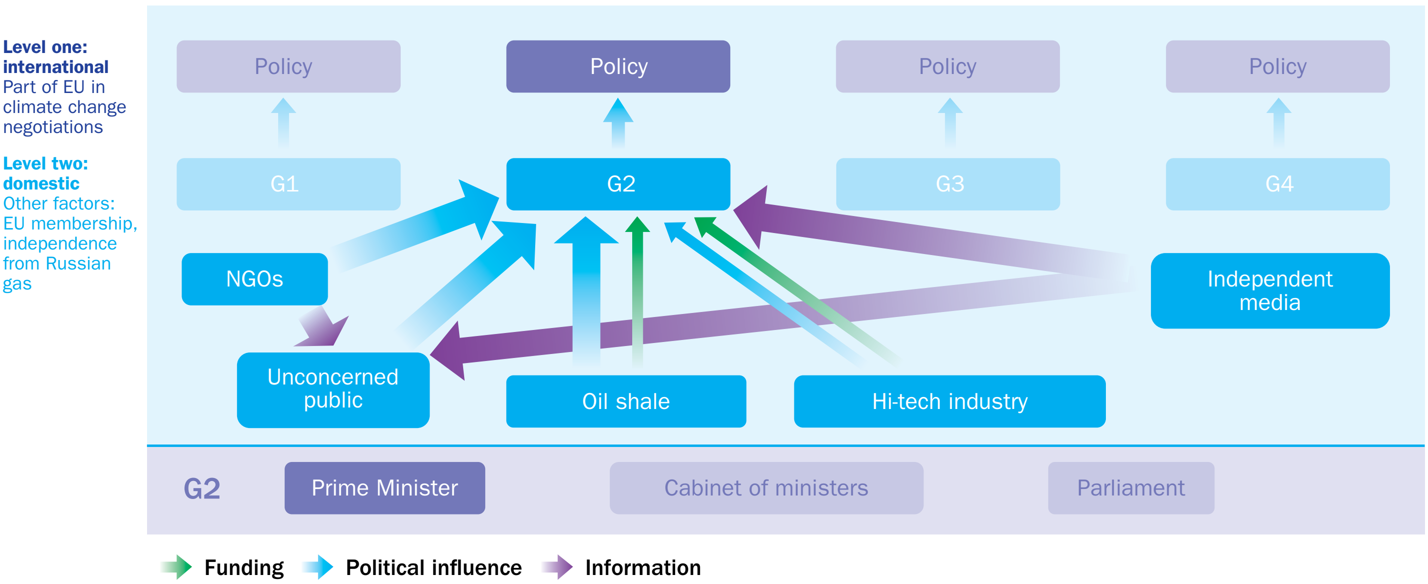
The carbon-intensive industry in Russia is extremely powerful, and has been since the onset of transition. Russia is the world's largest producer of natural gas and in 2009 became the largest exporter of oil. Moreover, the fossil-fuel industry has long enjoyed close links to the Kremlin: before his election, President Medvedev served as the Chairman of Gazprom, a state-owned energy company. Igor Sechin, the current chairman of another state energy company, Rosneft, also serves as Deputy Prime Minister.

Russia's largest and most powerful financial-industrial groups (FIGs) have concentrated interests in the metallurgical and other carbon-intensive industry sectors: gold, potash, steel, nickel and other heavy industry, to name but a few. The owners of these FIGs exercise significant influence on government policy. In comparison, Russia's low-carbon industry is negligible – a fact that the Russian government has acknowledged and proposes to address through support for the development of high-tech industry, such as the Skolkovo high-tech innovation hub.

The carbon-intensive industry lobby is also very powerful in Ukraine, with FIGs in the steel, coal and petrochemical refinery sectors exerting major influence on a succession of governments, predominantly through financial support for political parties and party leadership campaigns, but also through the placement of their subordinates in government positions, and through their ownership of the media. Although these players have not enjoyed the same veto powers that their counterparts in Russia have periodically exercised, they have served nevertheless as powerful influences – and at times constraints – on successive governments' climate change policy preferences.

In Estonia, despite having a modern service-based economy specializing in high-tech and high-value-added sectors, the carbon-intensive industry lobby is very influential. The explanation for this is due, at least in part, to Estonia's post-independence wariness of reliance on imports of energy, particularly gas, from neighbouring Russia. This has led to the large-scale commercial development of oil shale deposits, of which Estonia enjoys large reserves and from which it extracts 90 per cent of its domestic fuel energy. The oil shale industry also employs about one per cent of the Estonian work force, is significantly increasing its political clout in climate policy.

Chart 4.5.3
Relationship among key actors on climate change policy in Estonia



[23] While 72 per cent of Estonians claim to know something about climate change, only 44 per cent believe that climate change is caused by human activity – the lowest level in the EU, followed closely by The Netherlands (46 per cent), Denmark and Norway (47 per cent).

Climate change policy outcomes

Over the past two decades various officials in the Russian government have been hostile to any climate change legislation, some even arguing that a warming climate might in fact benefit Russian agriculture and tourism. The Russian Academy of Sciences includes several notable global warming sceptics, such as Khabibullo Abdusamatov. Some of them, such as Yuri Izrael, act as senior policy advisers in the government and favour geo-engineering solutions to climate change, rather than mitigation measures that might damage Russia's natural resources sector.

Prior to the UNFCCC summit in Copenhagen in December 2009, President Medvedev signed the Climate Doctrine, which was largely a political gesture as it contained no emission-reduction targets. Russia, despite being one of the most energy-intensive economies in the world, will effortlessly meet its Kyoto obligations under Annex I due to improvements in carbon performance over the past decade and the collapse of industry in the early 1990s.

However, by February 2010 President Medvedev's public statements on climate change began to match those of his Western counterparts.[24] He called on Russian legislators to expand the Climate Doctrine in the context of several recent pieces of legislation and presidential decrees.

Two key factors prompted President Medvedev's rhetorical shift: growing concern among the Russian population about climate change-induced extreme weather events and strong moral pressure from the other G20 leaders for Russia to join in multilateral efforts to reduce global CO_2 emissions. However, as its weak CLIM Index score shows, the domestic political game in Russia has resulted in few measures being enacted to mitigate climate change. These are mainly related to energy efficiency (Russia's Energy Strategy plans to reduce energy intensity by 1 per cent annually until 2030) and international agreements. For example, there has been strong political pressure on Gazprom to reduce gas-flaring, and there was a much-publicised ban on incandescent light bulbs in 2009 (which will take effect in 2014).

Ukraine is the top-ranked CIS country on the CLIM Index, on par with the lowest ranked EU-member transition country Estonia and significantly better than neighbouring Russia, which has a similar reliance on energy-intensive industry. This is surprising, given that public knowledge plays a significant role in driving the adoption of climate change policy and that carbon-intensive industry lobbyists have a strong deterrent effect. The differences are the result of Ukraine's adoption of the "National Plan on Approaches for the Implementation of the Provisions of the Kyoto Protocol," adopted in August 2005, and the establishment of the independent National Ecological Investment Agency.

Furthermore, the Ukrainian authorities have enacted laws on renewable energy (including wind energy targets and feed-in tariffs) and energy efficiency. And unlike in neighbouring Russia, the Ukrainian "Reforestation and Afforestation Programme 2010-2015" contain ambitious targets for carbon capture using land use, land-use change and forestry mechanisms.

Despite having a political structure that appears *ex ante* to be conducive to the introduction of ambitious climate change policy, Estonia has been relatively slow in adopting climate change policies and measures over the past decade. This can be seen in the country's score on the CLIM Index, where it ranks the lowest among the EU-10 countries, on par with Ukraine and Turkey.

The explanation for this lies primarily in the strength of the oil shale industry lobby, although the markedly *laissez-faire* approach that has dominated Estonian economic policy since the collapse of the Soviet Union has also played an important role. These factors are not independent of course: it is no coincidence that in a country that is otherwise fully open in terms of trade, investment and media, an overriding dependence on a carbon-intensive energy source is correlated with low levels of public understanding of climate change – nor that lack of policy action on climate change is the result.

This is particularly reflected in Estonia's comparatively poor performance with regard to the development of a national climate change framework: the country has not developed any cross-sectoral climate change legislation or established a dedicated governmental climate change institution for binding GHG emissions targets. While Estonia has implemented the minimal sectoral targets in the energy, transport and industrial sectors as required by EU legislation, the national leadership has been reluctant to move beyond these preliminary steps to formulate and implement broader cross-sectoral policies that might affect the price-competitiveness of the domestic shale oil sector.

This is, in some regards, surprising: for the past twenty years Estonia has been a pioneer in high-tech and information technology sectors. With its strategic location on the Baltic Sea coast, plentiful wind resources, a fully integrated Baltic electricity network and a serious deficit in energy supply – particularly since the closure of the Ignalina nuclear power plant in neighbouring Lithuania – Estonia risks losing out on an opportunity to develop renewable technologies and energy generation, and preserve the country's energy independence from Russia.

[24] See Charap and Safonov (2010) and Andonova (2008).

Conclusions

This chapter takes a political economy approach to explain why some countries adopt climate change mitigation policies and measures while others do not. Statistical analysis, together with a qualitative assessment of climate change policy-making in three transition countries, leads to a series of important conclusions.

We found that the level of democracy alone is not a major driver of climate change policy adoption. This is important as it means that there is no reason to assume that countries with weak or even non-democratic regimes are unable to make significant contributions to the global challenge of reducing carbon emissions. Expectations of contribution to global climate stabilisation by a given country need not, therefore, be limited by the nature of its political regime.

We also found that public knowledge of climate change is a powerful determinant of climate change policy adoption: countries in which the public is aware of the causes of climate change are significantly more likely to adopt climate change mitigation policies than countries in which public knowledge is low.

Public knowledge of climate change, in turn, is shaped by a number of key factors, including the threat posed by climate change in a particular country, the national level of education and the existence of free media. Democracy and free media tend to go hand-in-hand – there are few countries with free media but no democracy. Thus, the conclusion that democracy *per se* does not determine climate change policy does not mean that certain key aspects of democracy, such as free media, are not important drivers of policy adoption.

The focus, therefore, should be to try and penetrate closed information landscapes in order to promote public understanding of the urgent threat posed by climate change. Societies that are denied access to information about contemporary global events and risks, such as climate change, are not capable of mitigating or adapting to those risks.

Information asymmetries in many transition countries, particularly in disseminating information about the threat of climate change, are caused partly by the predominant role of the extractive sectors and carbon-intensive industries in many countries in the region. Our global analysis found that the relative strength of the carbon-intensive industry is a major deterrent to the adoption of climate change mitigation policies and measures, regardless of the level of democracy or the administrative capacity of the state.

It is hard to overcome the powerful influence of carbon-intensive industries. In many countries in the transition region, these industries are the largest export earners, the largest employers and the largest contributors to the national tax base. It comes as no surprise, therefore, that these carbon-intensive industries influence governments' approaches to climate change policy. Moreover, the carbon-intensive industries are unlikely to be replaced by low-carbon industry in a short enough timescale to make a difference to mitigating global climate change.

Therefore, it may be necessary to alter the incentives that the carbon-intensive industries are given and facilitate their transition from lobbyists against carbon-efficient production to lobbyists in favour of low-carbon production. Chapter 3 outlined efficient means to achieve this transition: energy price reform to encourage energy conservation, and new means of monetising carbon such as the introduction of international carbon trading mechanisms. These steps must be taken alongside broader improvements to the business environment to lower the cost of capital and thus make investment in long-term energy savings more attractive. Levers that will help governments implement such policies even in the face of initial domestic opposition include international emission reduction commitments, and information campaigns that increase public awareness of the long term benefits of climate change mitigation.

The pay-off for national political leaders in the transition region is clear: their national economies will gain a significant competitive edge in a global economy where there is increasing international pressure to reduce emissions. This in turn will enhance their political regime's domestic legitimacy. These steps – which are fully consistent with the "modernisation agenda" that has been laid out by the governments of many of the region's largest economies – would help to address the inherent economic weaknesses created by the lack of economic diversification and which were revealed by the recent global economic crisis.

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Abbreviations

BaU	Business as Usual
bcm	Billion cubic meters
BEEPS	Business Environment and Enterprise Performance Survey
BF/BOF	Basic oxygen furnaces
CAM	Central Asia and Mongolia (Kazakhstan, Kyrgyz Republic, Mongolia, Tajikistan, Turkmenistan, Uzbekistan)
CC	Climate change
CCGT	Combined cycle gas turbine
CCS	Carbon capture and sequestration
CDM	Clean Development Mechanism
CEB	Central Europe and the Baltic States (Croatia, Estonia, Hungary, Latvia, Lithuania, Poland, Slovak Republic, Slovenia)
CLIM	Climate Laws, Institutions and Measures Index
CO_2	Carbon dioxide
EAF	Electric arc furnaces
EBRD	European Bank for Reconstruction and Development
EE	Energy efficiency
EEC	Eastern Europe and the Caucasus (Armenia, Azerbaijan, Belarus, Georgia, Moldova, Ukraine)
EU-10	Nine EU member countries (Estonia, Bulgaria, Hungary, Latvia, Lithuania, Romania, Poland, Slovenia, Slovak Republic) of the EBRD region and Czech Republic
EU-15	Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom
EU ETS	European Union Emissions Trading Scheme
EUR	Euro
FIG	Financial-industrial group
FIT	Feed-in tariff
GDP	Gross domestic product
GHG	Greenhouse gas
Gt	Gigatonne
HDD	Heating degree days
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
ISE	Index of Sustainable Energy
JI	Joint Implementation
LSE	London School of Economics
MAC	Marginal abatement cost
Mt	Megatonne
NGO	Non-governmental organisation
NOx	Nitrogen oxide
OECD	Organisation for Economic Co-operation and Development
PCI	Pulverized coal injection
ppm	Parts per million
PPP	Purchasing power parity
PR	Proportional representation
R&D	Research and development
RE	Renewable energy
SEE	South Eastern Europe (Albania, Bosnia and Herzegovina, Bulgaria, FYR Macedonia, Montenegro, Romania, Serbia)
SO_2	Sulphur dioxide
toe	Tonne oil equivalent
TEEX	Transition Economies Energy Exporters (Azerbaijan, Kazakhstan, Mongolia, Russia and Turkmenistan)
TENEX	Transition Economies Non-Exporters of Energy (Albania, Armenia, Belarus, Bosnia and Herzegovina, Croatia, FYR Macedonia, Georgia, Kyrgyz Republic, Moldova, Montenegro, Serbia, Tajikistan, Turkey, Ukraine and Uzbekistan)
TPES	Total primary energy supply
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
US	United States
WITCH	World Induced Technical Change Hybrid Model

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