The economic impact of the fight against climate change

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Introduction

The attention being given to the consequences of climate change, and environmental issues in general, has increased considerably in recent decades. This is particularly true of climate experts and policy-makers, but companies and households have also changed their behaviour in order to combat climate change. This issue has been the subject of numerous reports by esteemed researchers in a variety of fields (physicians, chemists, climate scientists, economists, sociologists, etc.). This article aims to depict the principle facets of this issue, focusing on the situation in Belgium as much as possible.

The first part of the article briefly presents the possible causes of climate change and their effects. The second part describes several aspects of climate policy in an international context, paying close attention to policy targets and instruments. The third part examines some key studies that quantify the impact of the fight against climate change on the Belgian economy. We identify the areas in which there is the greatest room for improvement, taking into account the structural characteristics of the Belgian economy. We formulate several conclusions in the fourth section, the most significant of which is that the fight against climate change not only has a cost, it also offers opportunities.

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1. Climate change

Global warming has received most of the attention in recent decades. The average global temperature has progressively increased over the past 35 years, such that the temperature in 2010 was about 0.8 °C higher than the average for the period 1951-1980. It is vital to understand the causes of this warming and its consequences in order to set an optimal climate policy. However, we still face a number of uncertainties.

The causes of global warming are still being debated, even though most scientists believe that the warming is very likely caused, to a material extent, by human activity. For example, the growing use of fossil fuels (coal, crude oil and natural gas), deforestation and agriculture are increasing the concentration of greenhouse gases in the atmosphere, amplifying the natural greenhouse effect, which is thought to be raising global temperatures. That being the case, several attempts have been made in recent decades to reduce world greenhouse gas emissions and thereby reverse an exponential trend.

The consequences of warming are shrouded in even greater uncertainty. There is (as of yet) no consensus as to how high temperatures will rise and what the impact will be on mankind and the environment. However, it is widely thought that coastal regions will lose land to the sea due to rising ocean levels. As warming speeds up, we are also likely to see a decrease in biodiversity, because certain animal and plant species will be unable to adapt quickly enough. One of the consequences that already appears to be happening is an increased frequency of extreme weather conditions. The resulting natural disasters are having a significant impact on agricultural production, the availability of drinking water, and public health. Not only do these disasters result in a loss of human life, they also destroy a portion of the production capacity and infrastructure of affected economies, undermining their growth potential. Because the direct consequences of global warming vary greatly from one region to the next, inequalities are likely to widen, which could result in large-scale migration.

Quantifying the impact of climate change is made even harder by the fact that the process is necessarily based on a number of technical assumptions. It is, thus, difficult to express some of the expected impacts in monetary terms. The loss of human life, the loss of biodiversity, migratory flows, and so on can be expressed in thousands of units, but must be translated into monetary terms. Furthermore, consequences vary greatly from one region to the next, so the aggregation method will influence the final outcome. Lastly, certain effects will be felt quickly, whereas others will only show up later on. The choice of the discount rate will thus influence the final result. The available total cost estimates for climate change are thus very diverse. Two estimates often cited are those of the Intergovernmental Panel on Climate Change (IPCC) and the Stern Review (2007). In 2007, the IPCC announced that if no action were taken to combat climate change, world GDP would eventually be 1 % to 5 % lower. By contrast, Stern claimed that, in a more comprehensive scenario, the total costs could reach 5 % to 14 % of world GDP per capita.

For Belgium, as for the rest of Western Europe, the consequences of climate change appear less dramatic at first glance than for certain other regions. A limited rise in the average temperature is even likely to benefit agriculture and the tourism sector. However, further out, more extreme weather conditions and rising sea levels will have negative consequences, especially for the Belgian coast. According to a recent study conducted in 2009 by reinsurer Swiss Re working with the University of Berne, the damage to the Belgian coast as a result of more violent storms and an expected 37cm rise in sea level by the end of the century will be three times greater than present damage [1]. Measures will have to be taken to better protect coastal regions. One possibility is to make dykes better able to resist superstorms. Other projects aim to raise several sandbanks using sand from maintenance dredging of waterways to prevent waves from breaking on the shore. But more violent storms and abundant rainfall could have serious consequences for the rest of Belgium as well, not just for farming and the insurance sector, but also for companies working in other sectors of the economy, and for households, whose buildings and machinery could be damaged. This is why authorities need to adapt land planning and construction regulations. Lastly, it is worth mentioning a certain number of impacts on public health (van Ypersele and Marbaix, 2004). For example, more frequent or intense heatwaves are resulting in more heat-related deaths in the over-65 population. Conversely, fewer very cold winter days tend to reduce the number of cardiovascular deaths.

Even though the direct effects of climate change will undoubtedly remain limited in Belgium, our country must join the global fight against climate change, not just out of solidarity with the developing countries that will be hit the hardest, despite the fact that they are not the source of much of the problem, but also because the effort could generate positive effects through lower energy consumption. Belgian companies will suffer a loss of competitiveness if they lower their energy costs less sharply than their principal competitors on international markets, which would be extremely detrimental for an open economy. Furthermore, using less crude oil and natural gas for energy purposes will free up resources for numerous other basic applications, such as plastics and fertilisers, which is notably in the interest of future generations. More judicious use of these natural resources is not only necessary because of global warming, but also from an ethical standpoint.

This article focuses principally on efforts to fight climate change by limiting greenhouse gas concentration in the atmosphere. However, even if greenhouse gas emissions were completely halted, global warming would continue due to the delayed effects of earlier emissions. At this point, it is important to take steps simultaneously to mitigate the unavoidable harmful consequences on the population, the economy and the environment. Because the effects of climate change vary greatly from one region to the next, the necessary mitigation efforts will also vary. Even so, there are several general measures worth mentioning, such as investing in water reservoirs, choosing plants suitable for farming, strengthening dykes, creating controlled flood areas, devising or altering emergency plans, etc.

2. Climate policy

The numerous uncertainties surrounding the causes and consequences of climate change are the reason why the international community has not reacted earlier and more radically to this ecological shock. Nevertheless, it has gradually become apparent that the impact may be extremely negative for many countries, and even irreversible

(1) A 37 cm rise in sea level corresponds to the IPCC's A2 scenario, which assumes a very heterogeneous world characterised by high population growth, slow economic development, and slow technological change.

in certain cases. Given the global nature of the ecological shock, the fight can only be waged through international agreements aimed at reducing greenhouse gas emissions, with the overall goal then translated into national plans.

2.1 International climate agreements

2.1.1 Emissions reduction targets

For international climate agreements to be reached, the mostly likely causes and consequences of climate change had to be clearly delineated. To this end, the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) created an international network of scientists, the Intergovernmental Panel on Climate Change (IPCC), in 1988. This group of experts was tasked with conducting a critical and objective analysis of the scientific, technical and socio-economic literature on climate change. The IPCC's mission was to inventory and evaluate the current state of climate change science, without carrying out its own research. Its work was to result in summary assessment reports upon which policy-makers could base their decisions. So far, the IPCC has released four assessment reports, in 1990, 1995, 2001 and 2007. A fifth report is scheduled for release in 2014. The IPCC has also published several supporting documents, such as special reports on particular issues and methodological reports.

The IPCC's first assessment report, published in 1990, was the basis of the United Nations Framework Convention on Climate Change (UNFCCC), signed in 1992 in Rio de Janeiro. The Convention sought to fight climate change caused by the greenhouse effect that is amplified by human activity. To do so, it was decided to stabilise concentrations of greenhouse gases in the atmosphere at a level that would prevent any dangerous disturbance to the climate system. Most of all, the Convention offered a general framework requiring industrialised countries to reduce their greenhouse gas emissions to 1990 levels by 2000, without specifying concretely how they should do so.

It was only after years of negotiations that the Parties to the UNFCCC reached an agreement in Kyoto in 1997 containing concrete targets for reducing greenhouse gas emissions. The Kyoto Protocol calls for signatory industrialised nations to reduce their average greenhouse gas emissions during the period 2008-2012 by at least 5 % overall relative to 1990 levels. The exact percentage reductions vary from one country to the next, as a function of economic potential, emissions levels and the goodwill of the countries in question. For example, the US was supposed to cut its emissions by 7 %, Japan by 6 % and the EU-15 by 8 %. However, the US never ratified the Protocol. For the other countries, the reduction targets are binding. If they do not reach their targets, they will be forced to make up the difference during the following commitment period (after 2012), with a surcharge set at 30 %. The Kyoto Protocol does not include emissions reduction targets for emerging countries such as China or India.

No binding agreement has been reached at the global level for the period after 2012. In January 2010, the industrialised nations and several developing countries – which together are responsible for more than 80 % of world greenhouse gas emissions – set concrete targets in the Copenhagen Accord that they hope to reach by 2020. However, these pledges are not legally binding. Furthermore, an analysis of these national targets shows that the joint effort to which these countries have committed will not be enough to keep global warming below the threshold of 2 °C above pre-industrial temperatures.

Despite the lack of an international agreement at the world level, the European Union's 2009 climate and energy package set a number of ambitious targets that it hopes to meet by 2020. For example, it plans to reduce greenhouse gas emissions in the EU by at least 20 % relative to 1990 levels. If other developed countries make a similar commitment, the EU will raise that reduction target to 30 %. Furthermore, the percentage of final energy

CHART 1 PRINCIPAL INTERNATIONAL CLIMATE AGREEMENTS

1988	Creation of the Intergovernmental Panel on Climate Change (IPCC)
1990	First IPCC Assessment Report
1992	UN Framework Convention on Climate Change – Rio de Janeiro
1995	Second IPCC Assessment Report
1997	Kyoto Protocol (targets for signatory industrialised countries for the period 2008-2012)
2001	Third IPCC Assessment Report
2007	Fourth IPCC Assessment Report
2009	European climate and energy package (targets for EU Member States for the year 2020)
2010	Copenhagen Accord (non-binding targets for the industrialised countries and some other nations for 2020)
2011	

consumption derived from renewable sources must be raised to 20 %, and at least 10 % of energy for transport must be produced sustainably. Lastly, it aims to increase energy efficiency by 20 %, but this target is not binding.

2.1.2 Evaluating ongoing efforts

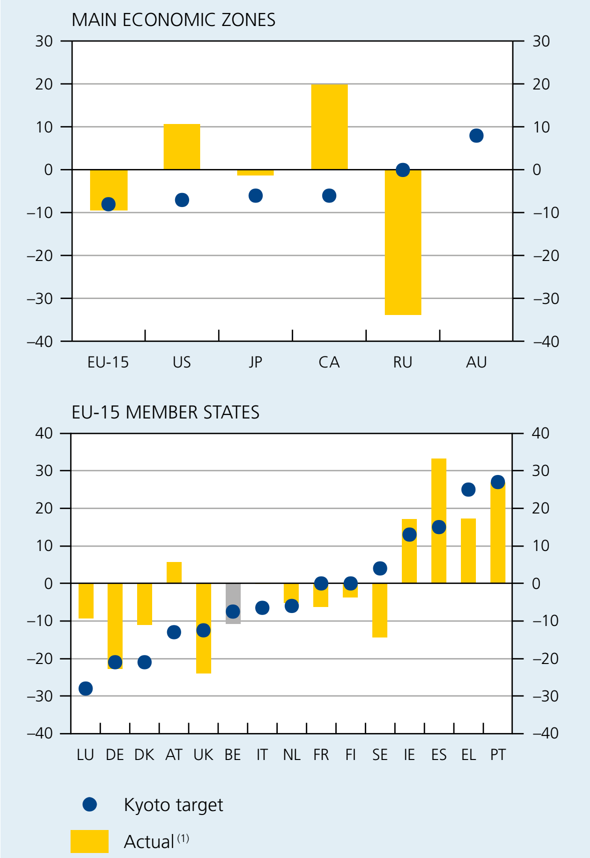
The Parties to the Convention on Climate Change must report annually on greenhouse gas emission volumes. The figures available up to 2009 inclusive show that results vary considerably among the largest countries. On the one hand are countries like the Russian Federation and Australia, whose average greenhouse gas emissions in 2008-2009 were significantly below the authorised level. These developments are partly attributable to changes in the economic structure of those countries, as the most polluting economic activities have grown less significant. Furthermore, modernisation of the industrial tool – in response to both environmental considerations and rising energy prices – has also played a role. Lastly, the reduction in emissions in 2009 is partly attributable to weaker demand for energy because of the recession. On the other hand are large countries like the US, Japan and Canada, whose average greenhouse gas emissions in 2008-2009 were well above the authorised level and who will have to step up their efforts considerably.

This observation is equally true of some emerging economies – which are, however, not party to the Kyoto Protocol. These countries have enjoyed robust economic growth, but have also risen quickly through the rankings of greenhouse gas emitters. According to the most recent figures from the World Resources Institute for 2005, greenhouse gas emissions have risen by respectively 101.3 % and 68.1 % in China and India since 1990. In 2005, these countries were respectively the biggest and fifth-biggest polluters in the world. At the same time, their per capita emissions remain very low compared with countries like Australia, the US and Canada, whose per capita greenhouse gas emissions are around 4.5 times higher, and compared with Belgium, whose per capita greenhouse gas emissions are around 2.5 times higher. While it is essential, in the post-Kyoto period, for more countries to commit to reducing their greenhouse gas emissions, in setting concrete targets it is necessary to take into account the “lag” exhibited by emerging countries.

The EU-15 countries are somewhere in the middle: average greenhouse gas emissions during the period 2008-2009 were 9.5 % below the base year, whereas the reduction target for the period 2008-2012 was only 8 %. However, it is important to remember that the reduction in emissions in 2009 was partly attributable to weaker demand for energy caused by the recession. In 2010, this decrease probably experienced a correction, and may have even been temporarily reversed. The EU-15 nevertheless appears to be on track to meet its target for the period 2008-2012.

CHART 2 KYOTO TARGETS AND ACTUAL GREENHOUSE GAS EMISSIONS

(change as a % relative to the base year)



Sources: UNFCCC, EC.
(1) Average emissions over the period 2008-2009.

However, it is worth pointing out that the Member States are not all producing the same results with respect to limiting greenhouse gas emissions. When the Kyoto Protocol was concluded, very different targets were set. For example, certain countries pledged to reduce their greenhouse gas emissions (Luxembourg, Germany, Denmark, Austria, the UK, Belgium, Italy and the Netherlands), whereas other Member States sought only to stabilise their emissions (France and Finland), and still others decided to cap the increase in their emissions (Sweden, Ireland, Spain, Greece and Portugal). Given the range of targets, it makes more sense to evaluate ongoing efforts by using the difference between average emissions during the period 2008-2009 and the countries' individual Kyoto targets. Based on this yardstick, Sweden and the UK have clearly had the best results. Both countries managed to lower their greenhouse gas emissions during the period 2008-2009 to a level more than 10 % below their Kyoto targets. France and Greece are also ahead of target by around 6 %. Conversely, Luxembourg and Austria were the weakest: their average emissions over the period 2008-2009 were more than 20 % higher than their Kyoto targets. Spain and Denmark also must intensify their efforts, given that their emissions were on average more than 10 % higher than their Kyoto targets.

With a 10.9 % reduction, Belgium's performance during the period 2008-09 was better than the targeted 7.5 %. While the result is partially attributable to the abrupt economic slump, which reduced energy consumption during the 2009 crisis, Belgium could easily meet its Kyoto target by 2012 without additional measures. According to the Federal Planning Bureau's economic outlook for 2011-2016, greenhouse gas emissions during the period 2008-2012 are expected to be 11 % lower on average than the 1990 level. Additional measures will, however, be necessary to meet the 2020 targets in the European climate and energy package. According to the Federal Planning Bureau, the biggest need for reducing emissions lies with energy-intensive industrial facilities, and significant efforts still need to be made in terms of renewable energy.

2.2 Climate policy instruments

In Belgium, jurisdiction over climate policy – covering the environmental, energy and transport fields – is currently split between the federal government and the three Regions. The fragmentation makes it more complicated to implement a national strategy to fight climate change, even though several coordinating bodies have been created to encourage dialogue and collaboration, ensure consistent policies and unlock needed synergies. For example, the National Climate Commission in 2009 developed the first National Climate Plan, which synthesises all of the measures taken by the various levels of government to meet the obligations of the Kyoto Protocol. This plan also lays the groundwork for a post-2012 strategy. It sets goals for six key sectors – optimise energy production, use energy rationally in buildings, work on industrial processes, develop sustainable modes of transport, encourage the sustainable management of agricultural and forest ecosystems, and step up waste management efforts – many of which are examined in greater detail in section three of this article.

Above all, a climate policy aimed at reducing greenhouse gas emissions must get economic agents (both producers and consumers) to modify their behaviour. To reduce greenhouse gas emissions, energy consumption will have to fall through increased energy efficiency, and the energy mix will have to change to include a lower percentage of carbon, which means reducing the use of coal and, to a lesser extent, crude oil in favour of nuclear energy, natural gas and/or renewable sources. In concrete terms, this means notably that companies will have to adapt their production processes and introduce new technologies, and that households will have to pay more attention to the sustainability of their purchases when making consumption and investment decisions.

There are several ways to encourage the needed behavioural changes. The various instruments can be split into two main categories: market instruments, which influence the relative prices of products (such as tradable emissions permits, environmental taxes and green subsidies), and non-market instruments. Among the second group, the principal instruments are regulatory, such as prohibitions or standards for certain goods and services. This group of instruments also includes measures aimed at promoting research into new technologies, and subsequently their development and spread, as well as measures aimed at informing and raising awareness among the population and companies.

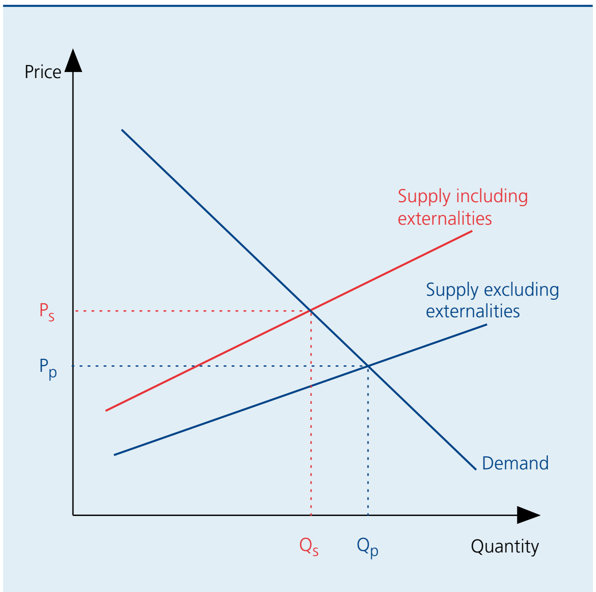
In general, climate policy consists in calibrating these instruments, taking into account numerous factors, particularly the manner in which greenhouse gases are emitted. If emissions are principally caused by economic sectors that are highly sensitive to price movements, the instruments that influence relative prices will be a good choice. Where this is not the case – notably in the transport sector – other instruments will have to be used, such as promoting innovation or improving public transport options. Social aspects must also be kept in mind. For example, most environmental taxes are regressive, as costs weigh proportionally more heavily on lower-income classes. However, they also generate receipts for public authorities that can be used, among other things, to lower the tax burden on labour (or certain categories of labour), support innovation or reduce the public debt. Lastly, environmental policy must not imperil the competitiveness of companies active on international markets. In this respect, it is important for environmental goals to be subscribed to by a very large number of countries, and that carbon leakage be avoided as much as possible. This occurs when companies decide to relocate some or all of their polluting production to countries with more lenient climate rules. According to a 2010 OECD estimate, carbon leakage would amount to around 12 % if the EU unilaterally imposed a 50 % reduction in emissions by 2050, whereas the number would be less than 2 % if all industrialised countries made similar commitments.

2.2.1 Market instruments that influence price

Market instruments that influence the relative prices of products are designed to internalise negative externalities. The private cost of producing or consuming a product is lower than the social cost, because the latter also includes external effects such as greenhouse gas emissions. The market price of the product (P_p) – obtained where demand meets the marginal private cost – does not take into account these externalities and will thus be lower than the optimal price from a societal standpoint (P_s), which results in excessive use of the product ($Q_p > Q_s$).

In the case of an emissions permit trading system, authorities issue a number of emissions permits for a certain period, which can then be traded. The limited overall quantity creates scarcity, which then, through market mechanisms, causes the price of emissions permits to rise. This encourages companies to reduce their emissions. The advantage of such a system is that the target for reducing emissions is set by the authorities. However, the carbon value varies over time, so companies have no certainty as to the additional costs engendered by emitting greenhouse gases. This uncertainty may diminish their willingness to invest in the development and use of new technologies. Furthermore, companies in this type of system have less incentive to reduce their emissions once the target is reached.

CHART 3 INTERNALISING ENVIRONMENTAL EXTERNALITIES



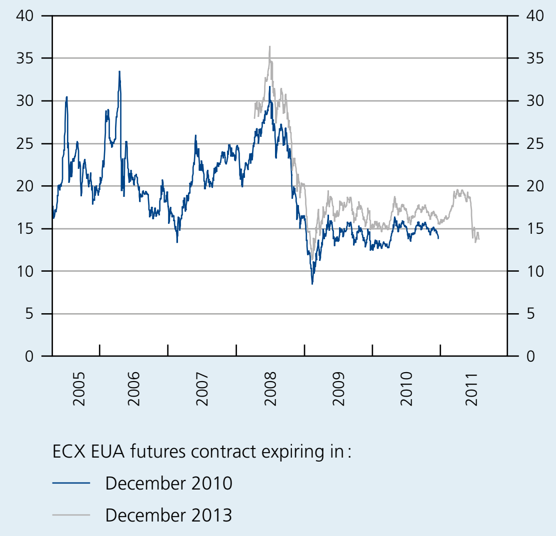
The market for tradable emissions permits must be deep enough and liquid enough for prices to correctly reflect the carbon value. Because such a market could not be created by most European countries acting individually, the EU Emission Trading Scheme (EU ETS) was launched in 2005. At present, some 11 000 energy-intensive installations compulsorily participate in the system. They consist chiefly of power plants, combustion plants, oil refineries, cokers, iron and steel works and plants producing cement, glass, bricks, ceramics, pulp and paper. These installations together generate around 40 % of the EU's greenhouse gas emissions.

In phase one (from 1 January 2005 to 31 December 2007), it was up to the Member States to determine the total quantity of emissions permits for their country and how to allocate them (mostly free of charge) among the individual installations by crafting a national allocation plan that had to be approved by the EC. Companies were required, after the year had ended, to turn in the emissions permits owed. If a company's emissions exceeded the number of permits it owned, it would have to pay a fine of € 40 for each missing emissions permit and turn in the owed emissions permits the following year. During phase two (from 1 January 2008 to 31 December 2012), the system is largely the same, but the number of emissions permits has been reduced and the fine for each missing permit raised to € 100. Furthermore, emissions rights can be carried over from one year to the next, which was not the case in phase one.

For phase three (from 1 January 2013 to 31 December 2020), the rules will be changed considerably. First of all, the number of emissions permits for the entire EU will be limited. It will be lowered each year by 1.74 %; the total number of emissions permits in 2020 will thus be 21 % lower than the amount issued in 2005. Second, a growing share of the emissions permits will be auctioned. However, activities that consume a great deal of energy and would thus experience a significant competitive disadvantage – implying the risk of carbon leakage – will still be initially allocated most of the emissions permits free of charge. The auction proceeds could reach, according to EC estimates, between € 30 billion and € 50 billion annually by 2020, depending on the permit price. Member States have agreed that at least half of this revenue will be used to fight climate change, both in Europe and in developing countries. Third, the air transport sector, international shipping, and the capture, transport and storage of CO_2 will be incorporated into the trading system. By contrast, small installations are to be excluded to keep administrative costs down, provided that the appropriate Member State applies equivalent environmental levies to those installations. Lastly, the fine per permit not received will be adjusted to euro area inflation annually.

The extent to which companies are prepared to make efforts to limit their greenhouse gas emissions depends principally on prevailing market prices. These need to be not only sufficiently high, but also relatively stable. To increase its energy efficiency, a company must make sizeable investments over a fairly long period. As uncertainties regarding the future carbon value increase, a company will be less temped to make the necessary investments and so will adopt a wait-and-see attitude. Until now, emissions permit prices have been very volatile. In the first year of the EU ETS's operations, this volatility may have been attributable to a lack of market liquidity, because too many emissions permits were granted. Prices then fell sharply when the figures on actual emissions were released in late April 2006. In following years, price trends were less volatile, although significant fluctuations continued. For example, the price of a futures contract maturing in December 2010 traded on the European Climate Exchange rose from a low of € 13.3 on 20 February 2007 to a peak of € 31.7 on 1 July 2008, or an increase of 138.4 %. Demand for emissions permits rose sharply over the period, with more coal being used to generate electricity in response to a rising oil price, resulting in higher CO_2 emissions. The carbon value then plunged following the economic and financial crisis, reaching a new low of € 8.4 on 12 February 2009. Subsequently, the market recovered somewhat and the price of a futures contract maturing in December 2010 fluctuated between € 12.5 and € 16.5. Longer contracts are a bit more expensive, but their prices exhibited comparable trends.

CHART 4 EMISSIONS PERMIT PRICES
(in € per tonne of CO_2 emissions)



Source : European Climate Exchange (ECX).

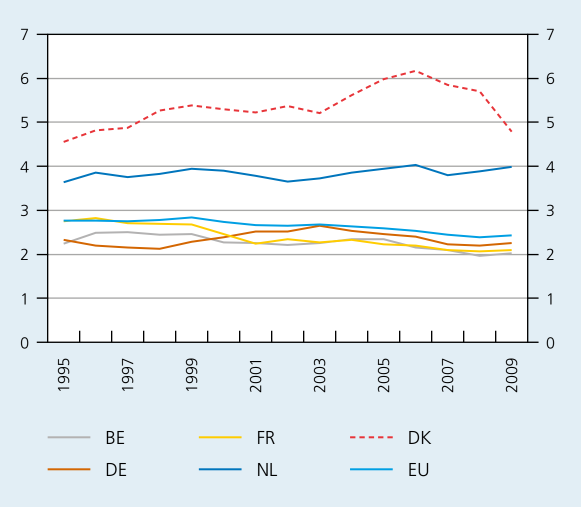
The EU ETS is the pre-eminent way to reduce emissions by industry and public utilities. However, Member States must also take steps to limit the greenhouse gas emissions of sectors not subject to the ETS (such as households, the transport sector and agriculture). One way of doing so is to levy environmental taxes. Unlike the emissions permit trading system, imposing an environmental tax offers no guarantees with respect to emissions reduction. The final outcome depends on the behaviour of producers and consumers. Environmental taxes also pose the disadvantage of offering less ability to differentiate between production and consumption locations and methods. On the other hand, a sufficiently high tax rate gives companies a permanent catalyst to develop and use new technologies. Once a new technology is adopted on a large scale, emissions reductions can thus be more pronounced than authorities' initial estimates.

For the EU, environmental tax receipts averaged 2.6 % of GDP over the period 1995-2009, but there were significant disparities among the countries. Belgian receipts were limited to 2.3 % of GDP on average, the second-lowest figure in the EU-15. Of its three principal neighbours, France and Germany also make little use of environmental taxes. In the Netherlands, on the other hand, environmental tax receipts have hovered around 3.8 % of GDP. Denmark is by far the leading country in this respect, with receipts averaging 5.3 % of GDP. The positioning of Denmark and the Netherlands is remarkable not only in terms of the average tax receipts over the period in question, but also in terms of their trends. Whereas EU environmental tax receipts have fallen by 0.4 % of GDP since 1999, they have been relatively stable in the Netherlands and even rose in Denmark until 2006, after which they fell sharply. But the development in environmental taxes is influenced by two factors : on the one hand, environmental tax rates, and on the other, consumption of the taxed good. A downward trend does not necessarily indicate that authorities have eliminated environmental taxes ; it may also be attributable to the fact that taxes are effective in reducing consumption of polluting products.

From a statistical standpoint, environmental taxes are generally split into three categories. The biggest group is taxes on energy. This category includes taxes on fuel

CHART 5 ENVIRONMENTAL TAX RECEIPTS

(as a % of GDP)



Source : EC.

used in transport, heating oil, natural gas, coal and electricity, along with CO_2 taxes. Between 1996 and 2009, these taxes trended downward in Belgium, as in the EU. However, this trend was temporarily interrupted in 2003-2005, when several structural measures were enacted to tie automobile transport costs to the use of the vehicle rather than its possession. During the period 2006-2008, however, energy taxes were again lowered in Belgium, principally due to application of the reverse ratchet system to petrol and diesel. Belgian energy tax policy has often proceeded by trial and error, and has in some cases lacked a long-term vision.

Apart from energy taxes, taxes on transport play a relatively important role. They include both the one-off tax paid when a vehicle is purchased and recurring charges, but not excise duties on petrol or diesel, which fall under energy taxes. The relative significance of transport taxes does not show a clear trend in any of the countries studied, although it has fluctuated significantly over time in the Netherlands and especially Denmark. Lastly, taxes on pollution and resources bring in much less. They include notably taxes on packaging, atmospheric pollution, waste and water use. However, it is this category that is the reason for the upward trend in environmental taxes as a percentage of GDP in Denmark.

To cover all the bases, it is worth adding that in addition to tradable emissions permits and environmental taxes, the category of instruments that influence the relative prices of products also includes environmental subsidies and tax deductions for green products. Such is the case with green certificates and cogeneration certificates, which stipulate a minimum guaranteed price, designed to encourage the production of green electricity and the cogeneration of heat and electricity. Furthermore, tax cuts for various energy-saving investments have been enacted for personal income taxes in Belgium. These investments include replacing old boilers, installing double-pane windows, and improving home insulation. Tax advantages are also granted for the purchase of environmentally friendly vehicles. Companies can also take advantage of tax incentives when they make certain energy-saving investments.

2.2.2 Non-market instruments

Correcting the price signal to include the external effects of greenhouse gas emissions will not, however, be enough to sufficiently lower these emissions. That is why non-market instruments must also be used. Regulatory instruments are the principal tools in this category. Authorities may decide, for example, to completely outlaw the use of certain pollutants, such as was the case with chlorofluorocarbons (CFCs). Their use was progressively banned by the Montreal Protocol. Incandescent light bulbs, as well, will gradually disappear from the EU between 2009 and 2012. Furthermore, authorities may impose standards for certain products. Ordinarily, this practice is also used at the EU level to avoid unfair competition. For example, Directives dealing with the ecodesign of energy-using products and energy-related products have established a framework for setting requirements designed to optimise the environmental performance of products throughout their life cycle without impairing their functional characteristics. Among the energy-using products targeted are, notably, domestic appliances, consumer electronics, lighting, office equipment, heating, air conditioning and ventilation systems, electric motor systems, pumps, fans, transformers and industrial ovens. The group of energy-related products includes, notably, windows, insulation materials and water-consuming products, such as shower heads and water taps. Lastly, there are also overall standards in terms of energy performance and insulation for new housing, which are intended to improve the energy efficiency of the housing stock (see below, section 3.2.2).

Given the extent of the actions needed, companies, households and authorities will also have to take part in the general trend toward significantly improved technologies or new technologies, especially for activities that generate the most pollution. The nature of the new technologies that will be needed to considerably reduce greenhouse gas emissions over the long term is such that the private sector will not be able to act on its own. What is needed is not marginal improvements to existing technologies, but rather a technological revolution that will substantially cut energy consumption without affecting economic growth and prosperity. Without sufficient support from authorities, private companies will be slower to want to develop such technologies. As a result, it would be technically impossible to meet ambitious environmental targets.

To begin with, these new technologies will not be profitable unless they can be used on a large scale. During the first phase of the innovation process (invention), costs are high and the likelihood of commercial success is low. Given this risk profile, it is often difficult for companies to find enough affordable financing from banks or on financial markets. As effective new technologies become more widely used, their costs decline during the marketing phase due to the learning curve and economies of scale. It is thus up to authorities to support research into new technologies, chiefly during the initial phase. In addition, authorities can pay an incentive to users of the new technology during this initial phase in order to reach critical mass more quickly.

Secondly, innovation can be viewed as a public good, in the sense that once the new technology has been developed, the knowledge is shared with other companies. Other companies can thus build on that knowledge, which increases the likelihood that the innovation will be effective. However, the drawback of this situation is that the economic benefits of the investment in new technologies do not all accrue to the (first) innovating company. Thus, the company is not assured of being able to profit sufficiently from its investment down the road, which may dissuade it from taking such big risks. This is yet another argument for authorities to provide financial assistance to companies trying to develop new technologies.

For companies that emit a great deal of CO_2, R&D and innovation are naturally important. As long as they manage to reduce their emissions at a price lower than the carbon value, they will be getting a good deal. But for other companies as well, eco-innovation can be a powerful catalyst. Given that climate change is a global problem, the world market for eco-innovations is very large. The idea is to seize such opportunities as quickly as possible and to be among the first movers in this vast market.

Innovation in general and eco-innovation in particular now occupy a central place in the EC's Europe 2020 strategy and in the OECD's green growth strategy. In Belgium as well, innovation plays a major role in Wallonia's Marshall Plans and in Vlaanderen in Actie's Pact 2020. Organisational and financial support will be available for cooperation agreements between companies, research centres and training centres and it will be easier to establish innovative new companies.

Lastly, authorities can also do a lot to help raise the awareness of companies and households on climate change issues. Targeted information campaigns can show how far we have to go in certain areas and present the actions that can or must be taken, along with what forms of public assistance are available.

3. Impact of the fight against climate change on the Belgian economy

The economic impact of the fight against climate change can be analysed using several approaches. The first consists in using an econometric model to simulate the macroeconomic consequences of the targets imposed by the European climate and energy package. Section 3.1 presents the results of two of these studies. We can also take a more descriptive approach focused on the methods used to reduce greenhouse gas emissions. Using this approach, we will look successively at the decrease in energy intensity of certain activities (section 3.2), the increasing use of renewable energy (3.3) and, as a last resort, CO_2 capture and storage (3.4).

3.1 Macroeconomic impact of the European climate and energy package

Estimating the impact of the fight against climate change on the Belgian economy requires to formulate a number of hypotheses. For example, it is important first of all to create a baseline scenario describing the likely trend in energy consumption assuming no change in (climate) policy. To this end, it is necessary to formulate working assumptions regarding population trends, the number of households, economic growth and commodity prices. One must then develop several scenarios under which it is possible to meet the targets of the European climate and energy package. The results of these simulations can then be compared against those of the baseline scenario to determine the impact of the fight against climate change.

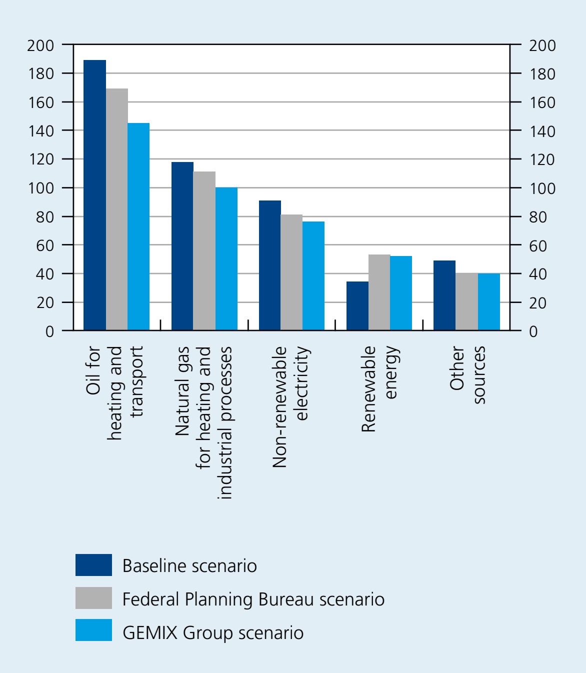
3.1.1 Impact on energy consumption

The Bank does not have a model that allows us to quantify the impact on the Belgian economy of the fight against climate change. The Federal Planning Bureau, however, has already conducted several simulations in this respect. According to Bossier *et al.* (2008), the targets of the

European climate and energy package will have a twofold impact on Belgian energy consumption. First of all, the introduction of carbon pricing is expected to push up energy prices and thereby reduce final energy consumption by a total of 5.7 % in 2020 compared with the baseline scenario. Secondly, the energy mix is expected to shift in favour of a lower carbon content. In this case, the carbon value will influence the relative prices of the various energy sources, and the explicit target for renewable energies will also play a role. The principal energy sources that will be significantly lower than in the baseline scenario are oil demand for heating and transport, and non-renewable electricity consumption, by respectively 10.6 % and 11.5 %. Natural gas consumption for heating and industrial processes would also be more limited, but the 5.5 % drop relative to the baseline scenario is less pronounced. This is attributable notably to the fact that industry has already substantially improved its energy efficiency and significant additional economies will only be possible by extensively adapting industrial processes, which is not possible with current technology. Compared with the baseline scenario, renewable energy consumption would be around 50 % higher, but would still only represent 11.6 % of total final energy consumption in 2020.

CHART 6 IMPACT OF THE EUROPEAN CLIMATE AND ENERGY PACKAGE ON FINAL ENERGY CONSUMPTION IN BELGIUM IN 2020, ACCORDING TO DIFFERENT SCENARIOS

(in TWh)



Source : GEMIX Group (2009).

In its 30 September 2009 report, the GEMIX Group argued that it would be possible to lower final energy consumption by 14.5 % relative to the baseline scenario. The additional decrease is principally due to the oil demand for heating and transport and the natural gas demand for heating and industrial processes. To meet these targets, it is advisable to pursue a particularly aggressive policy with respect to energy efficiency, emphasising building insulation, improving public transport, increasing multimodal transport, and clean vehicles (see below, section 3.2).

As already pointed out in section 2.1.2, energy consumption fell significantly in 2009 due to the economic crisis, which invalidated the baseline scenario presented above. The updated version of Bossier *et al.* (2011) accounts for the impact of the crisis, and assumes stronger population growth and higher energy prices. The study also takes into consideration certain energy-saving measures enacted in 2008 and 2009. While the principal results of Bossier *et al.* (2008) are confirmed, the needed energy savings represent only 1 % in the new study, compared with 6 % in the previous version. It is principally natural gas consumption and, to a lesser extent, oil consumption that will need to be reduced still further. The results of the two studies are comparable with respect to renewable energy sources.

3.1.2 Impact on economic activity and employment

The macroeconomic impact of the fight against climate change has a number of aspects, including direct costs linked to the actions taken at the national level to reduce greenhouse gas emissions, which include investment in renewable energies and energy-efficient technologies, higher energy prices and the costs of adapting to changing energy consumption, as well as the direct costs of using the flexibility mechanisms that allow to meet targets for emissions reductions and renewable energies abroad. According to the estimates of Bossier *et al.* (2008), the total direct costs for Belgium will amount to 0.86 % of GDP in 2020 [1]. The macroeconomic consequences for the Belgian economy, however, also include feedback effects. Whereas new technology investments represent a cost for the companies that make them, they will also generate revenues for the companies that make the purchased products. In addition, authorities will have additional resources (from environmental taxes and emissions permit auctions) that they can inject into the economy. The total

(1) According to the updated version of Bossier *et al.* (2011), the total direct costs would represent only 0.3 % of GDP. This study, however, does not include the new estimate of the macroeconomic impact of the European climate and energy package, at least with respect to the scenario considered here for the reduction of greenhouse gas emissions by 20 % by 2020, and for that reason it is not considered in this section.

impact of the fight against climate change will consequently be smaller.

Bossier *et al.* (2008) calculated that in 2020, GDP would be "only" 0.45 % lower than in the baseline scenario, even if authorities choose not to use the additional proceeds to stimulate the economy. The rise in energy prices will hurt individuals' purchasing power, thus slowing consumption. Business investment will fall more sharply due to the drop in production. Whereas exports will also be slightly lower, this decline will be offset by a considerably drop in imports, so net exports will make a positive contribution to GDP. The decrease in activity will also have an impact on employment, which will be 0.35 % lower than in the baseline scenario.

According to this study, the negative impact on the Belgian economy may be mostly offset if authorities use their extra receipts to reduce employers' social security contributions. This would spread the charges more evenly among the production factors of labour, capital and energy. Furthermore, employment would benefit from the lower labour charges : according to this study, it would even be higher than in the baseline scenario. As a result, the negative impact on private consumption will be almost cancelled out. Under this scenario as well, business investment would remain lower than in the baseline scenario, but the difference would be reduced by half. The total negative impact on GDP would be lowered to 0.07 % in 2020.

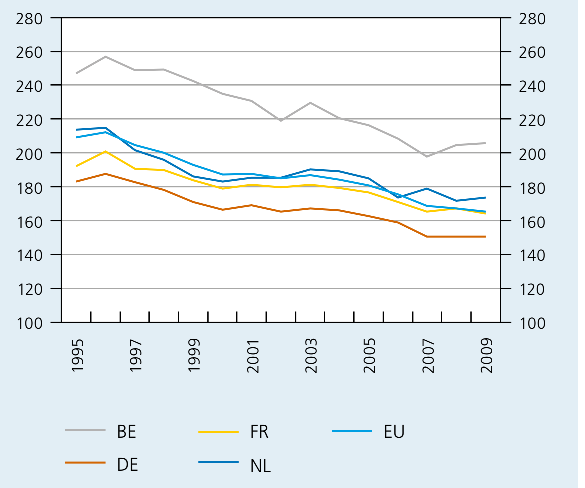
According to a recent study by the EC, support for innovation may also be a stimulant that can offset the costs generated by the fight against climate change. Conte *et al.* (2010) analyse the impact of this fight for the entire EU. They look at five scenarios, which vary in the extent to which authorities redirect their additional receipts. The least favourable result in terms of GDP and employment is when authorities decide to use their additional receipts to reduce a flat-rate tax. If authorities lower the tax on earned income, employment in the EU in 2020 would be higher than in the baseline scenario, even though GDP would still be a bit lower. The latter is no longer the case in the other scenarios, in which 10-20 % of additional public receipts are used to subsidise innovative projects (environmentally friendly or not) and the remaining additional receipts are used to lower the tax burden on labour. In these scenarios, employment would be less strongly stimulated than in the second scenario, but in 2020 it would still be 0.2 % higher than in the baseline scenario, and GDP would also be slightly higher than in the baseline scenario.

Even though the results of such model-based simulations depend heavily on the underlying working assumptions, these studies clearly show that the fight against climate change will not necessarily cause a contraction in economic activity. At the same time, it appears that not all sectors of activity or companies will be affected to the same extent. For example, the simulations cited above indicate slower activity principally in the energy sector (at least in the segment using fossil fuels) and transport sector (except rail transport). Conversely, we see strong growth in the sectors that meet the needs of a more environmentally friendly economy. Another task for authorities is to prepare for and guide, as much as possible, the shifts arising in the economic structure. In this respect, we principally have in mind making sure that job-seekers have the qualifications to meet the (new) needs of companies.

3.2 Decrease in energy intensity

Over the past 15 years, the energy intensity of the Belgian economy has definitely trended downwards, but it remains particularly high. In 2009, overall energy intensity – defined here as the ratio of gross energy consumption to GDP in volume terms – was 206 TOE per million euro in Belgium, whereas it was between 150 and 175 TOE

CHART 7 OVERALL ENERGY INTENSITY (1)
(in TOE per million euro)



Source : EC.
(1) Calculated as the ratio between gross energy consumption and GDP in volume terms.

(1) The tonne of oil equivalent (TOE) is a unit of account for the amount of energy that a primary energy source represents and is more or less equal to the net calorific content of a tonne of crude oil. The units of primary energy sources other than oil are converted into tonne of oil equivalents using conversion coefficients.

per million euro in the principal neighbouring countries and the EU[1]. A country's overall energy intensity is influenced by numerous factors, such as economic structure, the average age of the building stock and capital stock, weather conditions, population density, standard of living and transport infrastructures. It is calculated using gross energy consumption and is thus influenced by final energy production methods due to differences in performance[1]. When comparing energy intensity across countries, it is thus important to remember that these differences are not only a function of efficiency.

3.2.1 Energy intensity in industry

The impact of the economic structure can be partially eliminated by analysing energy intensity at the level of the major economic sectors. Energy intensity in this case is defined as the ratio between final energy consumption and the value added of each economic sector. This measure indicates that in recent years, Belgian industry has already made considerable headway. Between 2001 and 2009, its energy intensity fell by a total of 26.8 %. Much of this downward trend is the result of voluntary agreements that many industrial companies signed with regional authorities to increase their energy efficiency. These companies have made a commitment to be among the global elite in terms of energy efficiency by 2012. In exchange, the authorities have pledged not to impose additional obligations in terms of energy savings or CO_2 reduction. Furthermore, the three Regions have put their full weight behind support for cogeneration technology, which involves producing both electrical energy and thermal energy using the same primary energy source. Similarly, the creation of an authorisation policy based on the "best available techniques" has helped increase energy efficiency in industry.

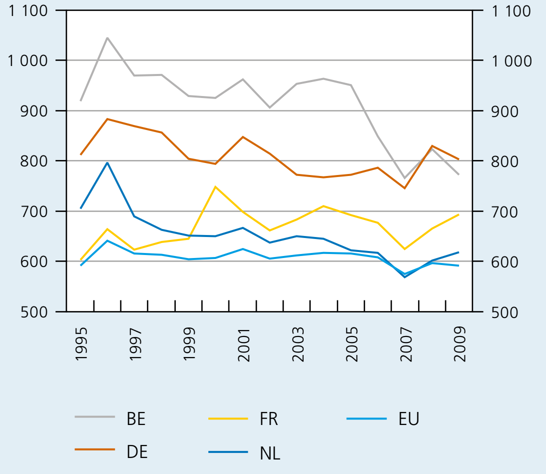
Even though this process has helped close the gap vis-à-vis the three principal neighbouring countries, Belgium still lags behind considerably, notably due to differences in industrial specialisation. For example, in 2008 the most energy-intensive industries – iron and steel works, metallurgy and non-ferrous metalworking, non-metallic minerals and chemicals and petrochemicals – represented 37 % of the value-added of Belgian industry, compared with just 27 % in Germany and France. Furthermore, these industrial sectors also exhibit large differences that influence installations' energy consumption. For example, the Belgian steel sector specialises in oxygen steel-making, which is produced using iron ore, whereas many other countries have more electric steel-making, which uses scrap metal. Given that the two production processes and types of steel are totally different, their energy consumption is not comparable. Even though the industry could still opt for technologies that use energy more efficiently, the principal contribution will probably not come from this sector, at least in the current state of the technology.

3.2.2 Residential energy consumption

One of the areas in which energy efficiency could still improve considerably is energy consumption by Belgian individuals for domestic purposes (heating, lighting and electrical appliances). Over the period from 1999 to 2005, this consumption was significantly higher than those of the three principal neighbouring countries and the EU. In 2006 and 2007, energy consumption fell sharply, although without closing the gap completely.

This relatively high energy consumption is partly attributable to the fact that existing housing in Belgium is fairly old and tends not to be renovated extensively until the arrival of a new owner. This is why many old residences have only single-glazing windows and inadequate roof insulation. Moreover, Belgium's housing stock includes a relatively large number of single-family homes and a relatively small number of apartments, which generally results in higher energy consumption for heating. Similarly, the share of social rental housing in the total

CHART 8 ANNUAL ENERGY CONSUMPTION FOR DOMESTIC PURPOSES
(in TOE per capita)



Source : EC.

(1) Gross energy consumption includes the primary energy sources used (principally solid fuels, oil, natural gas and nuclear power). Final energy consumption is obtained after the primary energy sources have been transformed into usable forms of energy (principally refined oil products and electricity). Energy transformation and transport generate losses, primarily linked to the efficiency of the electric power plant.

housing stock in Belgium, and in Germany, is considerably lower than in France or the Netherlands, where public authorities can increase the energy efficiency of those residential buildings. By contrast, the owners of housing that is rented out privately are less inclined to invest in energy efficiency because it is the tenant who pays the energy bills. Lastly, the consumer price of heating oil and natural gas is lower in Belgium than in the three principal neighbouring countries because excise duties are much lower(1). As a result, the price signal is not strong enough to encourage Belgian households to practice rational residential energy consumption. Given that in Belgium, circumstances are unfavourable to sparing energy consumption for domestic purposes, all interested parties (individuals, authorities and companies) must redouble their efforts to increase the energy efficiency of housing (and buildings in general).

Directive 2002/91/EC on the energy performance of buildings notably sets out the requirements in terms of energy efficiency for new construction and renovation projects, for both residential buildings and non-residential buildings such as offices and commercial space. In this context, Belgian regulations on energy performance impose a higher limit for the E value of new construction, a measure of a building's energy consumption defined as the ratio between the theoretical energy consumption of the building and a benchmark value(2). The energy consumption calculation is based on several building characteristics, such as compactness, choice of energy source, windows and thermal insulation. These standards are increasingly strict. As at 1 September 2011, the limit was set at E80 in the Flanders Region and Wallonia. In the Brussels-Capital Region, it was set at E70 for housing and E75 for offices.

Given the weak percentage of renovated buildings, it is nevertheless evident that the existing housing stock can do the most to improve energy performances. A first stage will involve stimulating energy consulting activities by certifying energy experts who will then be in a position to perform inspections to measure the energy performance of buildings and identify areas where improvement is possible. Introducing an energy performance certificate for existing buildings – giving potential buyers and renters information regarding a home's energy efficiency – is another step in this direction. The introduction of energy labelling for home appliances is also raising consumer awareness of the environment.

(1) For more information, see Baugnet and Dury (2010).

(2) This benchmark value is calculated using the building's surface area of heat loss (interior and exterior separation constructions that result in a loss of heat), protected volume (rooms actually lived in and heated) and ventilation flow rate (a fixed function of the protected volume).

The incentives cited above will make consumers more conscious of the potential economies. However, financial incentives are also necessary. Such incentives include, on the one hand, measures to increase the cost of products whose consumption is undesirable, and, on the other hand, measures to reduce the cost of products that limit energy consumption. For example, authorities may increase excise duties on heating oil, natural gas and electricity, raising consumer prices of these energy sources and encouraging households to limit their consumption. Relatively low excise duties are principally attributable to the fact that spending on energy represents a fairly significant portion of low-income households' budgets, and higher excise duties are thus heavily regressive. To alleviate this impact, authorities can devise offsetting measures to raise the incomes of the less fortunate without reducing the dissuasive effect of higher energy costs.

Furthermore, there are currently numerous incentives and tax deductions for renovation work to improve a home's insulation or for individuals buying energy-saving appliances. For many households and companies, it is not easy to know which incentives they qualify for or who to apply to in that context. Thus, it would be helpful to simplify the range of incentives and conditions for receiving them. In addition, authorities must be sufficiently selective in handing out incentives. For example, when choosing which products to support, they need to take into consideration the cost-effectiveness of the measure. Furthermore, the individuals and companies who qualify for the incentive must be more carefully selected. For example, inadequately insulated buildings should be disqualified from the tax deduction for installing solar panels. Another possibility consists in planning specific financing options for low-income households (low-interest bank loans, assistance from an outside investor, etc.).

Generating substantial energy savings over the medium term will require greater efforts in innovation. Currently, several Belgian companies already specialise in developing and selling innovative materials that improve the energy efficiency of buildings. For example, the FEB (2010) notably mentions as specialty areas the production of polyurethane insulation materials and applications limiting energy loss or excessive heating due to plate-glass windows. In addition, energy-efficient appliances are needed. In this respect as well, progress have been considerable, notably with the development of heat pumps, thermal solar water heaters, condensing boilers and micro-cogeneration. It is imperative that the workers installing this equipment receive enough continuing training for them to ensure that the new appliances operate properly and as efficiently as possible. It is also important to improve professional training in the energy-efficiency renovation sector and to adapt to new materials and new technologies. Applications in the ICT field can also encourage significant energy savings; these include sensors that automatically trigger switches or time switches that operate electrical appliances and heating systems.

3.2.3 Energy consumption for road transport

Alongside residential energy consumption, road transport represents a significant component of final energy consumption. According to a McKinsey study (2009), consumption of fuel per passenger-kilometre in 1990 was significantly higher in Belgium than in France, the Netherlands and the EU-25. Germany had an even worse score in this respect. However, Germany has significantly reduced its consumption of fuel, and by 2005 was well ahead of Belgium. Given that the Belgian fleet of vehicles is relatively efficient from an energy standpoint, in part because of the significant share of diesel engines, Belgium's poor standing is notably due to the fact that the number of passengers per vehicle is lower than in other countries, and to the fact that trips generally cover short distances in urban areas, which involves a relatively high use of fuel. Furthermore, consumer diesel and petrol prices, like heating oil and natural gas, are relatively low in Belgium because lower excise duties are levied on these products. So for transport as well, the price signal is too weak to encourage individuals and companies to adopt more rational energy consumption habits.

Limiting goods and passenger transport is thus a key concern. There are several examples of measures that can limit the transport of persons: increased development of public transport (in terms of supply, punctuality and price), expanded infrastructure for bicycles and encouragement of carpooling and teleworking. As for merchandise, promoting inland waterway and rail transport appear to be the principal tools. In this respect, much attention is being devoted to multimodal goods transport, which favours rail, maritime, river and canal transport, with only initial and terminal shipments taking place over roads. In addition, more efficient or more intelligent road transport may limit the number of empty or half-empty trucks on the road and reduce trips during rush hours.

If there are acceptable alternatives, an increase in excise duties on diesel and petrol can lead individuals and companies to limit their consumption, encouraging them to choose transport options that pollute less. Given that the emissions released by road transport are heavily influenced by the frequency of traffic jams, it is also possible to imagine a tax per kilometre driven that would vary depending on the road followed and the time of the trip to discourage driving during rush hours. It is also important for the fleet of vehicles to be more environmentally friendly and reduce its emissions. For example, authorities are giving tax breaks to encourage buyers to purchase greener (and more expensive) vehicles. Today, the focus is on technical improvements to the fleet of conventional vehicles: equipping them with particulate filters or start-stop systems. Eventually, the biggest energy savings will come from wider use of electric or hybrid vehicles. In this area as well, certain Belgian companies have already gained considerable knowledge. Before such vehicles become widespread, it will be necessary to install needed infrastructure, notably for recharging electric batteries.

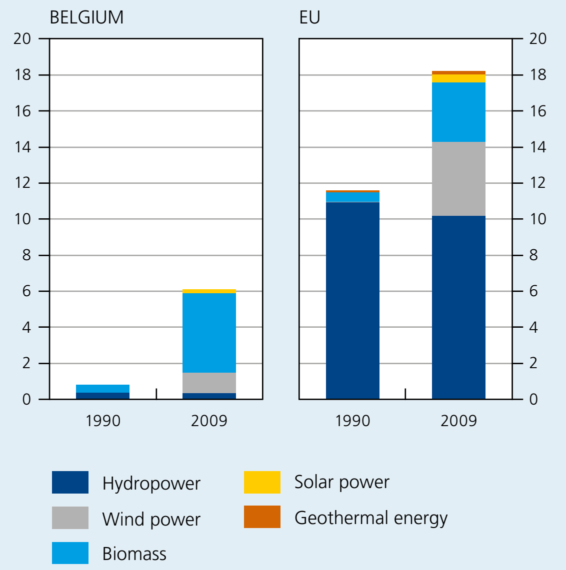
3.3 Investment in renewable energy

Given that the energy intensity of economic activities cannot be reduced indefinitely, the share of renewable energies in total consumption must also be increased. With respect to renewable energy sources, the EU has set itself the target of reaching a proportion of 20 % of gross final energy consumption by 2020. Belgium must attain a proportion of 13 %, one of the weakest national targets in the EU. This target notably takes into account Belgium's high population density, limited number of sunlight hours, the relatively flat slope of its rivers and its limited coastline length, all of which mean that the country has fewer possibilities to create facilities that produce solar, wind, hydraulic or tidal power.

Even so, this target is ambitious for Belgium. In 2005, the share of renewables in its gross final energy consumption was only 2.2 %. This proportion climbed to 3.3 % in 2008. The pace of growth is thus much too slow for the country to reach the 13 % target by 2020. According to the Federal Planning Bureau, with current policies we will reach a proportion of only 7.5 % in 2016, which is less than the 8.6 % set out in the national renewable energy action plan that was submitted to the EC. As a result, considerable additional efforts will be needed to reach the ultimate goal. The delay may be partially erased by further reducing final energy consumption or by taking advantage of the option to promote efforts abroad.

The available figures on green electricity as a share of overall electricity consumption show that the production of renewable energy in Belgium has been growing only recently. In 1990, only 0.8 % of overall electricity consumption was produced from renewable energy sources, whereas the EU average was 11.6 %. At over 50 %, Austria and Sweden are the leaders in this respect. Starting in 1999, however, the share of renewable energy in Belgium began to increase due to the use of biomass, and reached 6.1 % in 2009. Even so, the lag relative to

CHART 9 SHARE OF GREEN ELECTRICITY
(as a % of overall electricity consumption)



Source : EC.

the EU average remains considerable, given that the share of electricity produced from renewable energy sources was 18.2 % of overall electricity consumption at that point. Both in Belgium and in the EU, the rise is chiefly attributable to the success of biomass (wood, municipal waste and biogas) and wind power ; the share of geothermal and solar power remains very low.

In light of Belgian particularities, the greatest potential for growth lies with biomass and wind power. Each of these options, however, comes with a caveat. The power plants that produce thermal or electrical energy using biomass can pose an ethical problem from a sustainability standpoint. Increased use of these plants creates growing tension between agricultural land used to feed the population and land used for energy purposes. The same problem arises with the production of biofuels. In both cases, massive production of biomass is dangerous for the local environment. Furthermore, significant demand for certain types of biomass can threaten the food supply for a portion of the world population, either indirectly via an increase in food prices, or directly via inadequate food production. These problems result principally from the first generation of biomass (wood, sugar cane, corn, palm oil, rapeseed oil), and are less of an issue with the second generation (biodiesel, refined alcohol, materials produced from biomass as part of a chemical process, used frying oil, animal fats). Work is currently being done on a third generation of biomass, produced using specially prepared organisms such as algae which can contain more than 30 % oil. Many experts believe that algae are a good way to satisfy world demand for biomass and energy. However, years of research are still needed before they can be cultivated intensively, profitably and sustainably. The algae used as a source of biofuel are unlikely to arrive on the market before 2020. Another problem linked to the spread of small-scale biomass processing facilities lies in their emissions of fine particulates and nitrogen oxides (NOx), which need to be tightly controlled.

As for wind power, Belgium has principally invested in offshore wind turbines over the past few years. At present, two offshore wind farms are already partially operational. The farm located on the Bligh Bank generates 165 MW of power, which will double in the years ahead to reach 330 MW. The Thornton Bank farm currently produces only 30 MW, but will be expanded to 325 MW. When both wind farms are entirely operational, they will represent estimated annual electricity production of around 2 TWh, which is enough to supply 650 000 households with green electricity. Furthermore, authorities have already granted a concession for a wind farm on the Bank With No Name in the North Sea. Many Belgian companies are participating in these projects. Their highly specific expertise has enabled them to earn worldwide recognition. The FEB (2010) notably cites the following specialties : dredging and maritime construction, engineering and wind turbine components.

In this respect as well, a comprehensive vision is indispensable because there is already a capacity problem now. The electricity generated by offshore wind farms must travel via the Elia high-voltage grid, which is already expected to operate at full capacity until its planned expansion in 2014. Due to the high-voltage grid's limited capacity, other renewable energy projects in the country's interior will go nowhere, even though they complement offshore projects : they could supply the electric grid when there is not enough wind. The development of renewable sources of energy thus requires increased investment in a suitable electricity distribution grid able to handle the massive flows that could arise due to the fluctuating nature of renewable energy. The problem resulting from the intermittent nature of wind power can notably be resolved by linking the offshore wind farms amongst themselves. As a result, periods of no wind and peak demand could be handled better and the average performance of the farms improved. In December 2009, Belgium, Denmark, Germany, France, Ireland, Luxembourg, the Netherlands, the UK and Sweden signed a cooperation agreement to develop such an offshore grid in the North Sea and the Irish Sea. Furthermore, it will be important to adapt Belgian high-voltage infrastructure to bidirectional power flows to capture the electricity generated in a decentralised manner by wind and solar facilities, and what could be supplied by electric vehicles. It is thus imperative to further research the applications of smart grids in order to manage unstable supply and consumption of electricity. There are other problems: offshore wind energy projects often run into financing difficulties due to the size and risk profile of such investment. In addition, certain initiatives have trouble with environmental regulations: certain projects, for example, must be built further offshore, which makes them more complex, most costly, and thus less appealing.

3.4 Carbon capture and storage

For certain (industrial) companies, it is very difficult, and in some cases unprofitable, to reduce CO_2 emissions by using other energy sources or a production process that pollutes less. Another possibility for these companies is carbon capture and storage. This solution will become more appealing the more ambitious emissions reduction targets become. Research is currently being done into local-level carbon extraction, which is essential for Belgian steel- and cement-makers. However, the principal problem is carbon storage. In this field, as well, Belgium is not well positioned. The Campine is the only region where storage is possible, but the suitable land is already being used for seasonal natural gas storage. As an alternative, some have suggested certain mine shafts in Wallonia, but several additional geological studies would be necessary. Thus, it will be important to invest in a pipeline to transport CO_2 for offshore storage under the North Sea or transport it by boat to other locations. For example, there is a project in Norway to extract carbon from the Sleipner field's natural gas before storing it in a subsea aquifer layer.

Carbon extraction and capture techniques on a local scale are particularly energy-intensive. Existing technologies would result in a performance loss of around 10 %. Similarly, investment in the necessary infrastructure will be extremely large. Lastly, it is important not to lose sight of the legal aspects. However, this technique may also hold promise for the fight against climate change, because it provides a way to continue using coal, which is vitally important for fast-growing emerging countries such as China. At the same time, this technique must not be an impediment to initiatives aimed at reducing energy intensity and increasing the use of renewable energy sources.

Conclusion

The fight against climate change is a major challenge for the world. With respect to Belgium, the ability to reduce its emissions is somewhat limited by its economic structure, given its energy-intensive industries and significant logistical role. As for renewable energy production, its options are also more limited than other countries', given Belgium's geographic and climate characteristics.

The situation calls for a collective effort to meet the emissions reduction target. Private households will have to realise that current consumption habits are not sustainable. In concrete terms, the areas where the most progress is possible are energy efficiency for housing and private transportation. Individuals need to understand that if everyone helps, even a modest individual contribution can make a big difference. When making consumption and investment decisions, individuals will have to give more weight to environmental considerations, which assumes that there are sufficient environmentally friendly alternatives and that energy ratings and ecolabels are sufficiently clear.

Either spontaneously or in response to measures taken by public authorities, many companies have already done much to improve their energy efficiency. These efforts need to be continued and stepped up. Furthermore, companies have a crucial role to play in terms of innovation. They need not only to invest in scientific research, but also to do a better job of employing the resulting technological advances. Climate change is a global concern. There is thus a very large market for the new technologies needed to deal with it. The global dimension of the problem, however, also means that competition from foreign companies is particularly fierce. Thus, it is in the interests of Belgian companies to gain a foothold in the immense global market for eco-applications as soon as possible to maximise the profit to be had from a first-mover advantage.

The contribution of authorities, lastly, involves encouraging and supporting indispensable behavioural changes in the private sector. Companies and individuals need incentives to take the steps that will reduce energy consumption, and these come in a variety of forms: information and awareness campaigns, financial incentives and regulations. Furthermore, it will help to offer more alternatives to current pollution-causing activities. In this respect, authorities can do their part by supporting innovation and providing needed infrastructure (for example, with respect to public transport and renewable energy). In addition (local) authorities can provide an example of rational energy consumption, and sustainable energy production and mobility. Lastly, they must make sure to invest adequately in education and training so that new technologies can be used, and guide the structural changes in the economy as best they can.

The fight against climate change will clearly involve significant costs for the world economy. However, investment in developing low-emissions products and production process offers prospects in terms of innovation, economic activity, sustainable growth and employment. Energy efficiency will truly be a decisive factor for the competitiveness of the European and Belgian economies. In addition, it will be to our companies' advantage to conquer the global eco-innovation market as quickly as possible. In certain areas – such as dredging, wind power, engineering, building materials and basic materials for hybrid and electric vehicles – several Belgian companies have already acquired significant expertise and are now the principal suppliers in their niche. To hold on to and strengthen this position, companies, along with research centres and federal and regional authorities, must absolutely place greater importance on fundamental research. At present, this is already the case with biomass, biofuels, nuclear energy and waste treatment. Moreover, it will be necessary to strengthen collaboration among all parties concerned in order to strive for excellence with a common vision.

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