INTRODUCTION

Against the backdrop of agreement that global coordinated action is needed to prevent dangerous climate change,[1] individual countries are thinking through the implications of climate action for their economies and people. Some countries are already observing the impact of global warming on local weather and water supply. Others wish to position themselves as leaders in the ongoing international negotiations. With the expectation that a global price for carbon[2] will eventually be established, some countries may wish to push to the front on emerging clean technology industries and avoid 'stranded assets'—expensive long-lived infrastructure such as dirty coal-burning generators. Some simply want to inform policymaking on a key issue. Given that Poland ratified the Kyoto Protocol and hosted the December 2008 round of international climate negotiations,[3] 'carbon' mitigation is not a new issue for Poland. But with its obligations as a member of the European Union making that commitment more concrete, it is an opportune time to assess more thoroughly the complex economic impact of emissions mitigation by Poland, in particular the expected tradeoffs between reducing greenhouse gases[4] (GHGs) and sustaining economic growth and employment.

There is a broad consensus that the world is warming and that human activity is primarily to blame. Average global temperatures and sea levels are rising while the extent of Arctic sea ice, mountain glaciers, and snow cover is declining. The Intergovernmental Panel on Climate Change (IPCC) has concluded that warming of the Earth's climate system is unequivocal and that anthropogenic (human-made) greenhouse gas emissions, generated mostly by the burning of fossil fuels and deforestation and changes in land use, are to blame. The level of carbon dioxide (the most important GHG) in the atmosphere is already the highest concentration in the last 650,000 years (at 379 parts per million (ppm) in 2005 as compared with 280 ppm in the preindustrial era). Via the 'greenhouse effect', these high and rising levels of GHGs are projected to raise average global temperatures over the next 100 years by 1 to 6°C. [5] (See Box 1).

1 Climate change is defined as changes in the mean or variability of weather (generally, temperature, precipitation and wind) over a multi-year period, generally 20 or 30 years (following usage by the Intergovernmental Panel on Climate Change).

2 Note that throughout this report, the words 'carbon' and 'emissions' are used interchangeably as a shorthand for greenhouse gas emissions, usually measured in carbon dioxide equivalent (CO_2e) units.

3 Poland is a signatory to the 1992 United Nations Framework Convention on Climate Change (UNFCCC) and has ratified the 1997 Kyoto Protocol.

4 Greenhouse gases trap heat within the atmosphere, creating the greenhouse effect (warming of the atmosphere which would otherwise have a temperature of -19°C). In this report, GHGs refer to the anthropogenic greenhouse gases covered by the UNFCCC: carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O); and the F-gases (or halocarbons) covered by the Kyoto Protocol: hydrofluorocarbons, perfluorocarbons, and sulphurhexafluoride.

5 IPCC (2007), Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and A. Reisinger (eds.)]. Intergovernmental Panel on Climate Change, Geneva, Switzerland, 104 pp.

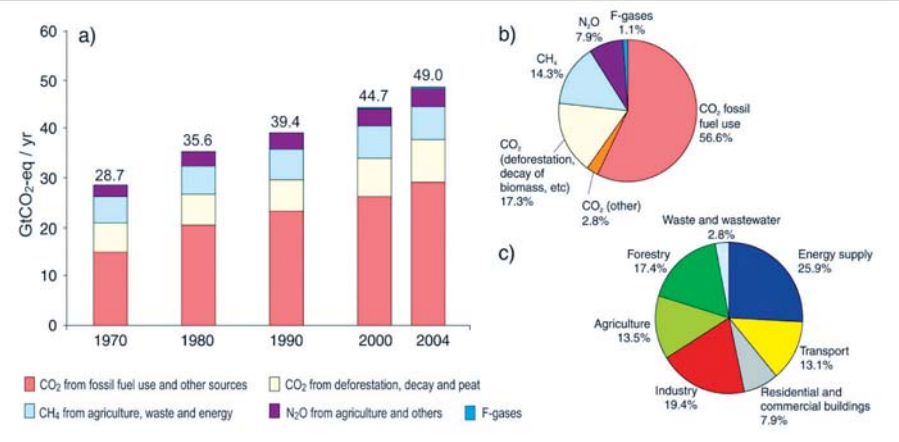
Box 1. The Intergovernmental Panel on Climate Change's (IPCC) Fourth Assessment Report

The Intergovernmental Panel on Climate Change (IPCC), established by the United Nations in 1988, assesses scientific information and environmental and economic consequences of climate change, in support of the United Nations Framework Convention on Climate Change (UNFCCC). This box summarizes key conclusions of their 2007 Assessment Report, which today appears conservative in its conclusions. According to its most recent Report, representing a consensus view among more than 2000 scientists worldwide on climate change, warming of the climate system is unequivocal, based on evidence from increases in global average air and ocean temperatures (especially over the last 50 years), widespread melting of snow, Arctic ice, and mountain glaciers (over the last 30 years or so), and rising global average sea level (over the last 50 years or so).

This global warming is being driven by rising atmospheric concentrations of greenhouse gases, in particular carbon dioxide. Human activities result in emissions of four long-lived GHGs: carbon dioxide (CO_2), methane (CH4), nitrous oxide (N2O) and halocarbons (a group of gases containing fluorine, chlorine and bromine that can destroy stratospheric ozone). Atmospheric concentrations of GHGs increase when emissions are larger than removal processes. The IPCC report notes that "global atmospheric concentrations of CO_2, CH4 and N2O have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values". From a pre-industrial level of 280 ppm, CO_2 concentrations were at 390 ppm in mid-2010. [1]

There is little doubt that human activity is the cause of higher GHG levels and, therefore, of climate change. "Global increases in CO_2 concentrations are primarily due to fossil fuel use, with land-use change providing another significant but smaller contribution. It is very likely [with a confidence level greater than 90 percent] that the observed increase in CH4 concentration is predominantly due to agriculture and fossil fuel use. The increase in N2O concentration is primarily due to agriculture."[2] Overall, human-made emissions rose 70 percent between 1970 and 2004 (see Figure 1), driven primarily by the energy supply sector.

Figure 1. Global annual emissions of greenhouse gases



Note: (a) Global annual emissions of anthropogenic GHGs from 1970 to 2004 (b) Share of different anthropogenic GHGs in total emissions in 2004 (c) Share of different sectors in total anthropogenic GHG emissions in 2004 (Forestry includes deforestation.) $GtCO_2$-eq is gigatonnes (billions of metric tons) of carbon dioxide equivalent, a common metric based on the differing warming influences of each GHG. Source: IPCC (2007), p. 5.

In the absence of additional climate mitigation policies, global GHG emissions are projected to increase by 25 to 90 percent between 2000 and 2030. Using a range of scenarios, world temperatures are projected to rise by between 1.1 and 6.4°C compared with 1980-99 (with a confidence level greater than 66 percent) while sea levels will rise by 18 to 59 cm during the 21st century (but with a high degree of uncertainty). Further, with a confidence level greater than 90 percent, there will be more frequent warm spells, heat waves and heavy rainfall; and with confidence level greater than 66 percent, there will be an increase in droughts, tropical cyclones and extreme high tides. Abrupt or irreversible impacts are possible, such as partial melting of polar ice sheets (which would cause meters of sea level rise); changes in ocean circulation such as the Gulf Stream; and, if global average temperature increase exceeds about 3.5°C, extinction of 40 to 70 percent of terrestrial species and widespread coral mortality in marine ecosystems.

Source: IPCC (2007).

1 Data from US National Aeronautics and Space Administration's Jet Propulsion Laboratory.
2 IPCC (2007), p. 5

Unfettered climate change will impose enormous costs unevenly distributed across countries, with developing countries faring the worst. As the World Bank's World Development Report 2010 has stressed, the projected rise in temperatures will create "a vastly different world from today, with more extreme weather events, most ecosystems stressed and changing, many species doomed to extinction, and whole island nations threatened by inundation".[6] A 2°C warming above preindustrial levels will cause more frequent and stronger extreme weather events, including heat waves, drought, flooding, and hurricanes; increased water stress in many world regions and especially in Africa and Asia; declining food production in many tropical regions as cereals become no longer cultivable in low latitudes; coastal erosion and aquifer salinization; and damaged ecosystems and biodiversity loss, including widespread dying off of coral reefs and shifting ranges for pests and diseases. These consequences will fall disproportionately on developing countries, with estimates of a 4 to 5 percent permanent reduction in annual income per capita in Africa and South Asia and a global average GDP loss of about 1 percent.[7]

While other parts of the globe will face the greatest harm, the countries of Central and Eastern Europe and Central Asia[8] face considerable threats from climate change. Rising temperatures and shifting precipitation patterns will aggravate winter floods and summer droughts and heat waves. Precipitation intensity is expected to increase across the region while water availability is projected to decrease everywhere but Russia. The rapid melting of the region's glaciers will reduce summer water availability, with severe impacts in irrigation-dependent Central Asia. Changes in sea level will affect the four major basins—the Baltic Sea, the East Adriatic and Turkey's Mediterranean coast, the Black Sea, and the Caspian—as well as the Russian Arctic Ocean, threatening low-lying areas such as, for example, Poland's heavily populated coast. Increased temperatures and changing hydrology are expected to generate substantial tree loss and degradation, the northward migration of pests, and the return of malaria to Europe.[9]

The international community has been negotiating a coordinated response to the threat of climate change for some time. Under the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC), industrialized countries and economies in transition (or 'Annex 1' countries under the UNFCCC) committed in 1997 to reduce greenhouse gas emissions by about 5.2 percent during 2008-12 compared to 1990. The UNFCCC climate summits in Copenhagen in December 2009 (Conference of the Parties or COP-15) and in Cancun in December 2010 (COP-16) aimed to make progress on post-2012 emission targets and their allocation. A 2 to 2.5°C increase in global temperatures above preindustrial levels by 2050 has been accepted as a target because it is considered achievable while also likely to prevent some of the most catastrophic potential effects of climate change, such as major increases in global sea level and disruption of agriculture and natural ecosystems. The stabilization of greenhouse gases at 450 ppm CO_2e (or carbon dioxide-equivalent),[10] which would provide a 40 to 50 percent chance of limiting the temperature rise to 2°C, requires emissions to be reduced by at least 50 to 85 percent in 2050 compared to 2000 levels and global emissions need to peak prior to 2020, according to the IPCC. Intermediate targets for 2020 have also been suggested, including an indicative range of 25 to 40 percent reductions compared to 1990 for developed and transition countries.[11]

The European Union has taken a proactive stance through its 'climate and energy package,' setting ambitious mitigation targets for its members for 2020 in advance of an international agreement. Following the European Council's decision for unilateral emissions reductions of 20 percent by 2020 at its March 2007 summit, the package of measures referred to as the '20-20-20 targets' was approved by the European Parliament in December 2008 and became law in June 2009.[12] By 2020, EU emissions are to be cut by 20 percent (or 30 percent if a global deal is reached); energy efficiency

6 World Bank (2009), World Development Report 2010: Development and Climate Change, p. 1.

7 World Bank (2009), p. 5.

8 Central and Eastern Europe and Central Asia includes: Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Georgia, Hungary, Kazakhstan, Kosovo, Kyrgyzstan, Latvia, Lithuania FYR Macedonia, Moldova, Montenegro, Poland, Romania, Serbia, Slovakia, Slovenia, Tajikistan, Turkey, Turkmenistan, Ukraine, and Uzbekistan.

9 Fay, Marianne, Rachel I. Block, and Jane Ebinger, eds. (2010), Adapting to Climate Change in Eastern Europe and Central Asia (World Bank).

10 GHGs differ in their warming influence (radiative forcing) on the global climate system due to their different radiative properties and lifetimes in the atmosphere. These warming influences may be expressed through a common metric based on the radiative forcing of CO_2. CO_2-equivalent emission is the amount of CO_2 emission that would cause the same time-integrated radiative forcing, over a given time horizon, as an emitted amount of a long-lived GHG or a mixture of GHGs.

11 IPCC (2007).

12 European Union (2008), The Climate Action and Renewable Energy Package: Europe's Climate Change Opportunity.

is to be increased by 20 percent; and 20 percent of energy used is to come from renewables.[13] Higher emission sectors are included in an EU-wide cap-and-trade system (the Emissions Trading Scheme) while other sectors face national targets only. Thus, EU members such as Poland already face specific obligations for climate action.

Poland faces a particular challenge in CO_2 mitigation because of its reliance on abundant domestic coal. 85 percent of Poland's GHG emissions come from the energy sector, and more than 90 percent of electricity comes from coal-fired power plants (which emit the highest levels of CO_2 per unit of electricity of any power generation technology, and roughly two to three times as much as equivalent gas-fired plants). Despite progress over the last two decades, Poland's economy remains twice as energy intensive as the EU average. Also, while emissions overall have fallen by near 30 percent since Poland's transition to a market economy began, those from the transport sector have grown by almost three-quarters (although they still constitute just over 10 percent of total emissions). There is understandable concern in Poland that a move towards a lower carbon economy will boost electricity prices, already amongst the highest in the region, which in turn will undermine welfare and profitability, with devastating effect on employment at home and competitiveness abroad. How costly will it be for Poland to move to a lower carbon path? What combination of energy efficiency, shifts in fuel for power generation, and other measures is most desirable? How steep is the tradeoff between carbon abatement and growth?

Through the Low Carbon Growth Country Studies Program, the World Bank has been supporting selected countries' work on lower carbon development paths. In 2007, the donor community asked the Bank to build on its experience in developing country-specific marginal abatement cost curves which aggregate the incremental costs of GHG mitigation measures relative to a business-as-usual scenario and the associated financing needs. The Bank was asked to assist in preparation of low carbon country case studies for Brazil, China, India, Indonesia, Mexico, and South Africa. These studies aim to integrate carbon abatement targets with objectives for economic growth and poverty alleviation. The Bank has been careful to ensure that these studies are client led, to help ensure the transition to implementation. As a result, each study has taken a different approach, appropriate to the client country and building on experience. This report on Poland draws on that ongoing experience but aims to go further in addressing the macroeconomic impact of a low emissions growth strategy by integrating 'bottom-up' engineering analysis with 'top-down' economy-wide modeling.

The rest of the report is organized along the following lines. The next section provides background on Poland's greenhouse gas emissions. Then section B sets out Poland's existing carbon abatement targets and key policy challenges related to GHG mitigation. The next section summarizes the innovative methodological approach used by the report. Section D discusses the methods and implications of constructing business-as-usual or reference scenarios. Section E provides the major findings from the first model, the engineering approach, on the costs of measures aimed at GHG mitigation for Poland. Section F explains how these findings are expanded and revised by incorporation into the first macroeconomic model. Section G provides an analysis of the economic impact through 2020 of mitigation measures within the constraints of EU policy arrangements. Section H examines the energy sector and how Section E's findings are enhanced by optimization of the structure of the energy sector. Section I takes a first look at the challenges of energy efficiency. Section J provides additional analysis of the transport sector. The last section provides some notes on additional issues and further work.

13 Renewable energy (or renewables) is energy which comes from natural resources such as sunlight, wind, rain, tides, and geothermal heat, which are renewable (naturally replenished).