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Climate Change Policy for an Energy Efficient Europe

Original scientific paper

The World Energy Council study "European Climate Change Policy Beyond 2012" provides an overview of the EU climate and energy policy package and, more specifically, the further developments of its emissions trading system. Whereas EU policy covering the period to 2020 has well developed milestones and legislation, the future beyond 2020 is rather nebulous. This has severe implications on the investments in the energy sector and on research and development activities. Sustainability of investments not only necessitates consideration of environmental issues: also important are security of supply and affordability of energy. The World Energy Council study explores the main conclusions drawn from EU policy and the emissions trading system and outlines what shuld be the principal drivers of an economically and ecologically sustainable pathway for a European climate and energy policy.
Like all other regions and countries of the world, Europe faces an unprecedented dilemma flowing from the fact that climate change is a global problem. There can be no solution for Europe, irrespective of how generous Europe's contribution to solving the problem may be, unless there is an effective solution for the entire world. In other words, there can never be a sustainable European pathway unless there is a sustainable global pathway. Even if Europe's policies are cost-effective for Europe, they will not be cost-effective in climate change terms unless they contribute to cost-effectiveness globally.
Based on the World Energy Council study, this report provides some general background and statistical material about CO_2 emissions, identifies some important abatement technologies and their technical and economic potential, explores the current status of the EU climate policy and its possible future development and lays out the pathway to a climate friendly and energy efficient Europe. Energy efficiency in industry is expected to be major support to the EU climate policy.

Key words: *climate change, energy policy, energy efficiency, emissions trading scheme*

Introduction

The changes that our planet has undergone throughout its history are a result of natural factors like tiny changes in the Earth's path around the Sun, volcanic activity and fluctuations within the climate system. As the Sun's energy warms up the Earth, our

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planet radiates some of this heat back out towards space. Certain gases in the atmosphere act like the glass in a greenhouse, allowing the Sun's energy in, but preventing heat from escaping. Some greenhouse gases (GHG) are naturally present in the atmosphere (without them, the Earth's average temperature would be an unbearably cold –18 °C instead of the +15 °C it is today [1]). However, human activities, such as burning fossil fuels, cutting down rainforests and farming livestock, are releasing immense additional amounts of GHG into the atmosphere, enhancing the greenhouse effect and warming the climate [2]. Climate changes, as a result of natural factors and human activity, pose a serious threat to human lives, to economic development and to the natural world on which much of our prosperity depends.

The carbon dioxide (CO_2) is the GHG most commonly produced by human activities and is responsible for 63% of man-made global warming [3]. Other GHG (methane – CH_4, nitrous oxide – N_2O, chlorofluorocarbons – CHF and sulphurhexafluoride - SF_6) are emitted in far smaller quantities than CO_2, but they all trap heat more effectively than CO_2 does (CH_4 21 times, N_2O 310 times, CHF 10000-12000 times, SF_6 23000 times more effectively), making them also powerful contributors to global warming [4]. One of the main sources of CO_2 in the atmosphere is the combustion of fossil fuels – coal, oil and gas. Over the past couple of centuries, human societies have burnt ever increasing amounts of fossil fuels to generate electricity, heat buildings and transport people and goods, so that the atmospheric concentration of CO_2 since the Industrial Revolution increased by some 40% and it continues to rise (at the end of 2009 it reached 385 ppm and 391 ppm at the end of 2010). Smaller shares are accounted for by agriculture, producing mainly CH_4 and N_2O from domestic livestock and rice cultivation and by industrial processes, producing mainly fluorinated gases and N_2O. CH_4 emissions also come from waste disposal sites and waste-water handling, so that it is responsible for 19% of global warming from human activities. CHF and other industrial gases which deplete the Earth's protective ozone layer account for around 12% of global warming (although being phased out, these gases in some cases are being substituted by fluorinated ones, which can be even more powerful GHG, [3]). Emission sources of N_2O, which is responsible for 6% of man-made global warming, include nitrogen fertilisers, the combustion of fossil fuels as well as some industrial processes. Hence, a global warming potential is attributed to each GHG expressing the emission amount as CO_2-equivalent.

Global temperatures have risen by some 0.75 °C over the past 100 years, and the first consequences of climate change can already be seen worldwide. These impacts are predicted to intensify in the coming decades as the temperatures are rising [5]. The average global temperature is projected to increase further by anywhere between 1.1 °C and up to 6.4 °C over the course of this century unless the world takes action to limit the concentration of GHG in the atmosphere. An increase of 2 °C above the temperature in pre-industrial times (around 1.2 °C above today's level) is seen by scientists as the threshold beyond which there is a much higher risk that dangerous and possibly catastrophic changes in the global environment will occur. But even below this level climate change will have significant impacts [6]. Extreme weather events such as heat waves and floods pose a direct risk to the health and safety of people. Damage to property and infrastructure imposes heavy costs on society and the economy. Sectors that rely strongly on certain temperatures and precipitation levels, such as agriculture, forestry, energy and tourism, will be particularly affected. Climate change is happening so fast that many plant and animal species will struggle to cope. Warming of 1.5-2.5 °C beyond today's levels would put

as many as 20-30% of plant and animal species at increased risk of extinction [7]. Such a threat to the climate change beyond repair requires preventive global actions. However, many poor developing countries are among the most vulnerable to the climate change, but also have the least resources to cope with it.

The objective of the United Nations Framework Convention on Climate Change (UNFCCC), adopted in Rio in 1992, is to achieve the stabilisation of GHG concentrations in the atmosphere at a level which prevents dangerous anthropogenic interference with the climate system. The UNFCCC commits the Parties (both developed or Annex I and other or Non-Annex I countries) to implement national, and where appropriate, regional programmes containing measures to mitigate climate change. The countries are required to develop, periodically update, publish and report to the Conference of the Parties (COP) their national inventories of GHG emissions by sources and removals by sinks. At its first session (COP-1), the COP to the Convention concluded that the commitment by Annex I countries to aim at returning, individually or jointly, their emissions of CO_2 and other GHG to 1990 levels by the year 2000 was inadequate for achieving the long-term objective of preventing dangerous anthropogenic interference with the climate system, and agreed to begin a process to enable appropriate action to be taken for the period beyond 2000. This process resulted in the adoption of the well known Kyoto Protocol in December 1997.

The Kyoto Protocol provides for Parties to fulfill their commitments jointly, acting in the framework of and together with a regional economic integration organisation. To reach the goals defined in the Kyoto Protocol, with the least economical costs, three were introduced for the mandatory market: Clean Development Mechanism (CDM), Joint Implementation (JI), and Emission Trading (ET). The CDM and JI mechanisms are applied for projects which create a supply of emission reduction instruments, while ET allows those instruments to be sold on international markets. JI and CDM have lead to substantial emission reductions in developing countries. As long as targets are tailored to the level of economic development in countries, the instruments of JI and CDM would remain.

The energy sector, and electricity production in particular, is a major contributor to the global GHG emissions. Table 1 shows the electricity consumption per capita in certain countries or regions and the specific emissions connected with [8].

Table 1. Electricity consumption and related emissions of CO_2

Country	[kWh/capita]	[gCO_2 per kWh]	[tCO_2 per capita]	Population	[tCO_2 per year]
USA	14,606	573	8.37	$305 \cdot 10^6$	$2{,}533 \cdot 10^6$
EU-27	8,547	341	2.91	$497 \cdot 10^6$	$1{,}449 \cdot 10^6$
China	2,420	788	1.91	$1{,}332 \cdot 10^6$	$2{,}540 \cdot 10^6$
India	638	943	0.60	$1{,}149 \cdot 10^6$	$691 \cdot 10^6$
World	3,411	502	1.70	$6{,}705 \cdot 10^6$	$11{,}481 \cdot 10^6$

Evidently, in the emerging economies the specific emissions of the electricity production are high in comparison to industrialised countries, but the high electricity consumption in industrialised areas corresponds to lower specific emissions. The current

low level of electricity consumption in India or China, the land use, land use change and forestry lead to a low value of electricity-related emissions per capita. However, their energy consumption will change dramatically in the years to come.

Reducing GHG emissions is a financial burden for society. The energy sector in particular has a vested interest in fostering sustainable investments. The investment cycle necessitates a reliable and predictable long-term framework. Ensuring predictability for investments will speed up decisions for investments in low-carbon technologies and is thus necessary to reach the climate goals on schedule. The current recession also creates more pressure on economic efficient solutions for GHG abatement, and the least expensive solutions have to be considered first. However, since the global warming challenge is not an issue that can be solved within a short period, but certainly will take many decades because the climate change shows long-term effects, an interesting difficulty occurs: the benefits of the investments will not be experienced by the investors, but by their offspring. Nevertheless, the potential long term cumulated costs for doing nothing are higher than the estimated abatement costs [9]. Therefore, from a cost/benefit aspect, it will be cheaper to do the investments now, which means additional costs to develop the so-called climate friendly technologies. Consequently, it is important to provide sufficient incentives for investment leading to the replacement of old and carbon-intense processes by more efficient, low-carbon technologies.

The European climate policy

As the climate changes, extreme weather events like heat waves, droughts, heavy rain and snow, storms and floods are becoming more frequent or more intense in Europe and worldwide. Vulnerability to climate change varies widely across regions as shown in WEC study on the European climate policy [3]. European regions that are found particularly vulnerable to climate change include Southern Europe and the Mediterranean basin (due to heat and droughts), the Alps (due to rapid melting of snow and ice), coastal zones, deltas and floodplains (due to sea level rise, intense rainfall, floods and storms), as well as Europe's far north, the Arctic regions (due to increased global warming). The Mediterranean area is becoming drier, making it even more vulnerable to drought and wildfires. Northern Europe, meanwhile, is getting significantly wetter, and even winter floods could become common.

Given these facts and requirements of the UNFCCC and the Kyoto Protocol to the Convention, there is a need for thorough monitoring and regular assessment of EU GHG emissions so that the EU reduces greenhouse gas emissions by 8% below 1990 levels by 2008-2012. Looking at Europe's contribution to global GHG emissions, Europe's share is not only rather limited, but is actually decreasing. This decrease is due to both the substantial increase in emissions in other regions and the fact that Europe, or at least the EU-27, has in place abatement goals for GHG. In 2006, for example, energy supply and use was responsible for about 61% of the total GHG emissions [3]. The transport sector as second most important sector had a share of 19%, and the other sectors add up to a 20% contribution (fig. 1). CO_2 emissions in OECD countries rose by 16% in the period 1990-2005, while in developing and newly industrialized countries CO_2 emissions doubled in that time span of 15 years, while Russia and other non-OECD countries in Eastern Europe, by contrast, reported a decline in emissions of about one third. The share of OECD countries in global carbon emissions dropped from 53% in 1990 to 48% in 2005.

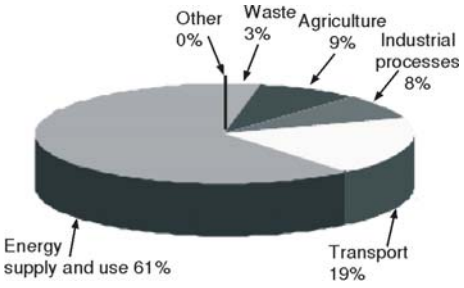

Figure 1. Sector contributions to total EU-27 CO_2 emissions in the year 2006

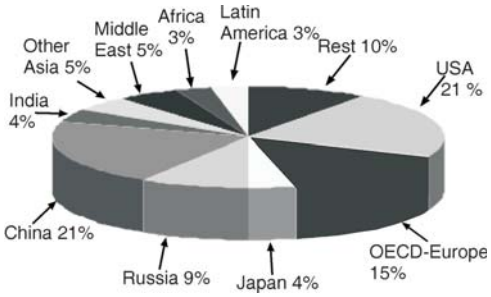

Figure 2. Energy related CO_2 emissions in the year 2006 world-wide

The EU's contribution is 14%, USA 21%, Middle East 5%, India 4%, China 21%, other Asia 5%, Russia 9%, Japan 4%, OECD-Europe 15%, Rest 10%, Africa 3% and Latin America 3%. A breakdown of energy related CO_2 emissions by countries and group of countries in 2006 is given in fig. 2 [3].

The climate challenge is global, but Europe is leading the way, although there is a need for other countries to act quickly in reducing their GHG emissions. In the EU-27 countries, total CO_2 emissions (without land use, land use change and forestry) fell from 5.6 billion tons in 1990 to 5.1 billion tons in the year 2006 [3]. This is to a large extent due to structural changes in the economy in Eastern European countries and a modernisation of power plants, which reduced the EU-27's share in global CO_2 emissions. In the following years, emissions have continued to rise in developing and newly industrialised countries in particular. China alone emitted 1 billion tons more of CO_2 in 2007 than in 2005, which means that China's carbon emissions have nearly tripled since 1990 (2.2 billion tons), reaching 6.1 billion tons in 2007. In the US, carbon emissions have likewise risen by 1 billion tons, *i. e.* by 20%, to 6.1 billion tons in the period 1990-2007. However, 2007 per capita CO_2 emissions in the US (20.5 tons) were four times higher than in China (4.7 tons), although China, with its 4.7 tons per capita, slightly overshot the global average per capita emission level for the first time in 2007 [10].

Climate change is a serious issue and a key consideration in any energy policy, but it is still one important issue amongst many. Climate change must be viewed as part of a comprehensive and balanced energy policy. In another regional study, the vulnerability of Europe with respect to possible energy crises was thoroughly investigated [11]. Additional work based on this study indicated that, to maintain low vulnerability, broad energy mix and affordable prices for the customers are essential. The study recommended to rely on climate-friendly technologies such as nuclear, clean coal and renewables, which is in line with GHG reduction goals, while at the same time ensuring a secure electricity supply [12]. The technological diversity also creates competition between the different climate-friendly technologies, competition crucial for affordable prices for the end-user.

The EU has long been committed to international efforts to tackle climate change and felt the duty to set an example through its policy-making at home. The EU has taken many climate-related initiatives since 1991, when it issued the first strategy to limit CO_2 emissions and improve energy efficiency. These include decisions to promote electricity from renewable energy, voluntary commitments by car makers to reduce CO_2

emissions by 25% and proposals on the taxation of energy products [11]. The EU and the Member States are jointly responsible for the fulfillment by the EU of its emission reduction by 8% below 1990 levels by 2008-2012, and before a country joins the EU, there are obligations common to all EU Member States (often referred to as "acquis") that have to transpose into its national legislation and implement from the moment of its accession.

At European level, a comprehensive package of policy measures to reduce GHG emissions has been initiated through the European Climate Change Programme (ECCP). The goal of the ECCP is to identify and develop all the necessary elements of an EU strategy to implement the Kyoto Protocol. Each of the EU Member States has also put in place its own domestic actions that build on the ECCP measures or complement them. Further development of the first ECCP (2000-2004) involved all the relevant groups of stakeholders working together. The second ECCP (ECCP II) in terms of emission reduction potential and cost-effectiveness was launched in 2005 to facilitate and support the actual implementation of the priorities identified in the first ECCP such as emissions trading, promotion of the use of bio-fuels and of combined heat and power (CHP) production, vehicle taxation, *etc*. [13].

Carbon market

Regional talks coming up in Europe have better chances of bringing consensus and action. However, having in mind that other regions are growing much faster in terms of economy and GHG emissions, it is also critical to do the first steps in this direction. A global value for GHG emissions, or at least a common value for the most relevant emitter regions, would help to trigger the needed investments. Hence, it is interesting to take a close look on the existing trading schemes in EU and around the world. Although the climate negotiations were held globally from its start, the use of market mechanisms like an Emissions Trading Scheme (ETS) have emerged locally. A lot of countries are implementing an emission market in order to fulfill their engagements to the Kyoto Protocol or their national targets.

The EU intends to work towards a gradual development of global carbon markets to support efforts of developed and developing countries to implement low-emission development strategies. The most effective climate change mitigation policy measure is international coordination to agree on a global price mechanism for carbon. Both in order to maximise cost-efficiency and to minimise economic distortions, a global carbon price is needed. This price provides an incentive to invest in climate-friendly technologies. Furthermore, a global carbon price will suppress any "carbon leakage" effects and guarantees a level playing field as well as avoiding protectionism in energy trade [14]. By broaden the participation to more regions, sectors and gases important steps will be taken as a transition to a global carbon market.

From an economic or market perspective, one has to distinguish between a mandatory market and a voluntary market. In contrast to the strict rules set out for the mandatory market, the voluntary market provides companies with different options to acquire emissions reductions. Typical for both markets is the trade with emission certificates, Certified Emission Reduction (CER), Emission Reduction Unit (ERU), and Verified Emission Reduction (VER). The last VER has the great advantage that the projects/activities are managed according to the quality standards set out for CDM/JI projects. Nations which have failed to deliver their Kyoto emissions reductions obligations can

purchase CER and ERU to cover their treaty shortfalls. Nations and groups of nations can also create local emission reduction schemes which place mandatory emission targets on entities within their national boundaries. Projects which are compliant with the requirements of the CDM mechanism generate CER, while projects which are compliant with the requirements of the JI mechanism generate ERU. The CER and ERU can then be sold through ETS. The demand for the CER and ERU being traded is driven by shortfalls in national emission reduction obligations under the Kyoto Protocol, and shortfalls amongst entities obligated under local emissions reduction schemes.

When the EU Emissions Trading System (EU-ETS) started in 2005, it gave rise to the European carbon market. This market covers the trading in EU allowances and other units that may be used for compliance under the EU ETS in the 30 countries that currently participate in the trading system (EU-27 plus Iceland, Liechtenstein, and Norway). In principle, anyone can trade in the carbon market, but currently the largest categories of traders are, on the one hand, energy companies and industrial companies that have obligations under the EU-ETS, and, on the other hand, financial intermediaries, such as banks, who often trade on behalf of smaller emitters and companies [15].

Presently a lot of systems valuing carbon emissions have been developed besides the Kyoto Protocol. They are more regional or national systems, but most of them are based on market schemes. A a cap is imposed on total emissions, and emissions permit units are mainly granted by free allocations which then can be traded. All these systems apply to states and to industrial installations. Besides the Kyoto Protocol itself, the existing and ongoing systems are covering around 3.7 billion tons of CO_2, of which about 200 million tons from the USA and 2.5 billion tons from countries having ratified the Kyoto Protocol [10]. The implementation of a federal emissions trading system in the USA in the coming years could enlarge considerably the coverage of the first initiatives from the States. The US system could cover about 5 billion tons at the beginning [10]. Up to now the EU trading system has been the dominant market, although the EU-27 only emits below 15% of worldwide emissions, a small portion which will decrease in the next decades towards the development of Asian countries.

On all the markets the price of the ton of CO_2 has been relatively modest and inferior or close to 10 US$/ton, except on the European market where the price has skyrocketed up to 30 €/ton at the beginning of 2006 [16]. Price volatility is due to the announcement of possible shortage on the market because of the limitation of free allocations in National Allocation Plans in Europe or, on the contrary, of possible large future contribution of allowances coming from the Kyoto Protocol Mechanisms. The present framework is still in evolution and the settlement of rules will heavily contribute to the average price equilibrium during the Kyoto period and beyond. Linking the existing regional schemes to a global scheme, would define a global value of CO_2. Consequently this would help to reduce GHG emissions in a more economic way, since the least expensive abatement methods globally would be used. In the long term, however, the price is likely to be governed by the cost of Carbon Capture and Storage (CCS) technology. CCS is a promising family of technologies that capture CO_2 emitted by industrial processes and store it in underground geological formations where it cannot contribute to global warming. Although the different components of CCS are already deployed at commercial scale, the technical and economic viability of its use as an integrated system has yet to be shown [17]. The EU, therefore, plans to set up a network of CCS demonstration plants by 2015 to test its viability, with the aim of commercial update of CCS by

around 2020 [18]. The global value for GHG emissions would also help to trigger the needed technology transfer.

Since the EU-ETS is the centrepiece of the EU climate change policy, from an EU perspective the establishment of other ETS and their linking to the EU-ETS is essential. Though the EU-ETS might serve as a model for other ETS, for example in the US, it is quite likely that there will be differences between schemes, but these differences be minor enough to allow the schemes to link up. Closely related to this discussion is the question of whether the World Trade Organisation (WTO) rules need to be changed. In their energy trade and investment policies governments should agree with the principle that carbon-related tax measures should, as far as possible, not interfere with, or inhibit, the transborder movement of energy, goods, services, capital, and people. Such taxes or border measures are not seen as being in conformity with the obligations set out in the GATT and the WTO agreements. In agreeing that urgent international action is needed on climate change, national GHG reduction policies must be fully GATT-consistent and avoid disrupting energy and energy product markets. Furthermore, any national carbon emission reduction scheme should not discriminate against foreign energy investments.

The EU climate and energy package

The EU needs to start the transition towards a competitive low carbon economy now, as the longer it waits, the higher the cost will be. As oil prices keep rising, Europe is paying more every year for its energy bill and becoming more vulnerable to price shocks, and starting the transition now will pay off. The low carbon economy can be built by further developing proven technologies that exist already today. In this transition, all economic sectors need to contribute, including agriculture, construction and transport. The EU is now putting forward a series of long-term policy plans in areas such as transport, energy and climate change. This should shape the EU's climate action helping the EU become a competitive low-carbon economy by 2050. The approach is based on the view that innovative solutions are required to mobilise investments in energy, transport, industry and information and communication technologies, and that more focus is needed on energy efficiency policies [19].

Revision and strengthening of the EU ETS is the key tool for cutting emissions costeffectively. The core of the EU climate and energy package comprises (1) a revision and strengthening of the EU ETS, (2) an "Effort Sharing Decision", (3) binding national targets for renewable energy and (4) a legal framework to promote the development and safe use of CCS. A single EU-wide cap on emission allowances will apply from 2013 and will be cut annually, reducing the number of allowances available to businesses to 21% below the 2005 level in 2020 [20]. The free allocation of allowances will be progressively replaced by auctioning, and the sectors and gases covered by the system will be somewhat expanded. The "Effort Sharing Decision" is governing emissions from sectors not covered by the EU ETS, such as transport, housing, agriculture, and waste. Under this Decision each Member State has agreed to a binding national emissions target for 2020 which reflects its relative wealth. The targets range from an emissions reduction of 20% by the richest Member States to an increase in emissions of 20% by the poorest. These targets will cut the EU's overall emissions from the non-ETS sectors by 10% by 2020 compared with 2005 levels. Binding national targets for renewable energy which collectively will lift the average renewable share across the EU to 20% by 2020 (more than double the 2006

level of 9.2% [20]). The targets will contribute to decreasing the EU's dependence on imported energy and to reducing GHG emissions

The EU Climate and Energy Package consists of a series of demanding climate and energy targets to be met by 2020, known as the "20-20-20" targets. These are (1) a reduction of GHG emissions in EU by at least 20% below 1990 levels, (2) 20% of EU energy consumption to come from renewable resources, and (3) a 20% reduction in primary energy use compared with projected levels, to be achieved by improving energy efficiency. This "climate and energy package" became law in June 2009. However, it does not address energy efficiency directly, but through the EU's Energy Efficiency Action Plan [21]. The EU is currently on track to meet two of those targets, but will not meet its energy efficiency target unless further efforts are made. The EU emissions, including international aviation, in 2009 were 16% below 1990 levels [22]. With full implementation of current policies, the EU is on track to achieve a 20% domestic reduction in 2020 below 1990 levels, and 30% in 2030. However, with current policies, only half of the 20% energy efficiency target would be met by 2020. If the EU delivers on its current policies, including its commitment to reach 20% renewables, and achieve 20% energy efficiency by 2020, this would enable the EU to outperform the current 20% emission reduction target and achieve a 25% reduction by 2020.

For transforming the EU into a competitive low-carbon economy in a cost-effective way, the EU's objective of cutting GHG emissions up to –95% of 1990 levels by 2050, the EU would achieve reductions in its domestic emissions by 80% by 2050 compared to 1990. This goal, Europe should achieve largely through domestic measures since by mid-century international credits to offset emissions will be less widely available than today, and any credits used would increase the overall emissions reduction beyond –80%. To achieve an 80% "domestic" reduction by 2050, cuts of the order of 40% and 60% below 1990 levels should be achieved by 2030 and 2040, respectively, while current policies are projected to reduce domestic emissions to only –30% in 2030 and –40% in 2050.

Figure 3 illustrates the EU way towards an 80% reduction of domestic GHG emissions by 2050 [21]. The upper projection in fig. 3 shows how domestic GHG emissions would develop under current policies. A scenario consistent with an 80% domestic reduction then shows how overall and sectoral emissions could evolve, if additional policies are put in place, taking into account technological options available over time [19]. This will require additional annual investment over the next 40 years equivalent to 1.5% of EU GDP (or 270 billion €) on top of overall current investment of 19% of GDP [20]. However, much or all of this extra investment will be recovered through lower import bills for oil and gas. These savings are estimated at 175-320 billion € a year. Moreover, this low carbon investment (in so called clean technologies, infrastructure such

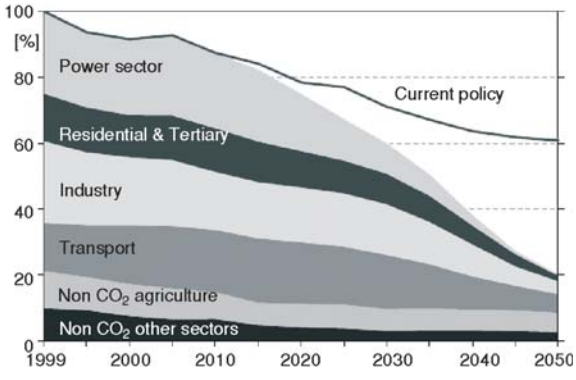

Figure 3. Towards an 80% EU domestic reduction of GHG emissions below 1990

as "smart" electricity grids and environmental protection) will have multiple benefits, as the fuel costs are paid largely to third countries, while investment creates value-added in the EU. Air pollution and its associated health costs would also be cut, so that total benefits from better air quality could reach up to 88 billion € a year by 2050 [20].

An analysis of different scenarios shows that domestic emission reductions of the order of 40% and 60% below 1990 levels would be the cost-effective pathway by 2030 and 2040, respectively [21]. In this context, it also shows reductions of 25% in 2020. Such a pathway would result in annual reductions compared to 1990 of roughly 1% in the first decade until 2020, 1.5% in the second decade from 2020 until 2030, and 2% in the last two decades until 2050. The analysis has also explored pathways for key sectors, looking at a range of scenarios assuming different rates of technological innovation and different fossil fuel prices. They produced largely convergent results with respect to the magnitude of reductions needed in each sector in 2030 and 2050 as indicated by the ranges presented in tab. 2 [21]. The development of sectoral policy options will have to go into greater depth on costs, trade-offs, and uncertainties.

Table 2. Sectoral reductions GHG emissions compared to 1990

Year	2005 [%]	2030 [%]	2050 [%]
Total reduction	–7	–40 to –44	–79 to –82
Sectors			
Power (CO_2)	–7	–54 to –68	–93 to –99
Industry (CO_2)	–20	–34 to –40	–83 to –87
Transport(CO_2)	+30	+20 to –9	–54 to –67
Residential and services (CO_2)	–12	–37 to –53	–88 to –91
Agriculture (non-CO_2)	–20	–36 to –37	–42 to –49
Other non-CO_2 emissions	–30	–72 to –73	–70 to –78

The power sector has the biggest potential for cutting emissions. It can almost totally eliminate CO_2 emissions by 2050, as shows fig. 3. Electricity could partially replace fossil fuels in transport and heating. Electricity will come from renewable sources like wind, solar, water, and biomass or other sources that are low in carbon emissions like nuclear power plants or fossil fuel power stations equipped with CCS technology, which allows CO_2 to be stored underground instead of emitted into the atmosphere. The share of these clean technologies in power generation could increase rapidly, from 45% today, to around 60% in 2020 and almost 100% in 2050 [23]. For this to happen the cap on emissions from the power sector under the EU ETS will need to be strengthened and considerable investment put into smart grids.

Electricity will play a central role in the low carbon economy as it can almost totally eliminate CO_2 emissions by 2050, and offers the prospect of partially replacing fossil fuels in transport and heating. Since electricity will increasingly be used in these two sec-

tors, overall electricity consumption would have to continue to increase. A wide range of existing technologies will need to be widely deployed, including more advanced technologies, that will continue to become cheaper and thus more competitive over time [24]. Given that the central role of electricity in the low carbon economy requires significant use of renewables, many of which have variable output, considerable investments in networks are required to ensure continuity of supply at all times. Investment in smart grids is a key enabler for a low carbon electricity system, notably facilitating demand-side efficiency, larger shares of renewables and distributed generation and enabling electrification of transport [25].

While emissions from transport are still increasing today, they could be reduced to more than 60% below 1990 levels by 2050, as evident from fig. 3. For passenger cars further improvements are needed in the fuel efficiency with traditional petrol and diesel engines. After 2025, a shift to plug-in hybrid cars and electric cars will allow CO_2 emissions from cars to be cut very steeply. Emissions from road, rail and inland waterways could thus be brought back to below 1990 levels in 2030, in combination with measures such as pricing schemes to tackle congestion and air pollution, infrastructure charging, intelligent city planning and improving public transport, whilst securing affordable mobility. Planes will be powered largely by biofuels and also heavy duty vehicles (lorries) will not fully shift towards electro mobility. Biofuels used should be sustainable to avoid increased pressure on biodiversity and an increase of GHG emissions through changes in land use.

Technological innovation can help the transition to a more efficient and sustainable transport system by increasing vehicle efficiency through new engines, materials and design, cleaner energy use through new fuels and propulsion systems, better use of networks and safer and more secure operation through information and communication systems.. Improved efficiency and better demand-side management, fostered through CO_2 standards and smart taxation systems, should also advance the development of hybrid engine technologies and facilitate the gradual transition towards large-scale penetration of cleaner vehicles in all transport modes, including plug-in hybrids and electric vehicles (powered by batteries or fuel cells) at a later stage. The synergies with other sustainability objectives such as the reduction of oil dependence, the competitiveness of Europe's automotive industry as well as health benefits, especially improved air quality in cities, make a compelling case for the EU to step up its efforts to accelerate the development and early deployment of electrification, and in general, of alternative fuels and propulsion methods, for the whole transport system.

Energy intensive industries will also make a large contribution by cutting emissions by more than 80% by 2050, as shown on fig. 3. Technologies used will get cleaner and more energy-efficient. In addition, a large-scale introduction of CCS technologies would be needed. This would require big investments of 10 billion € annually by 2040-2050 [26]. Installations that meet the GHG performance-based benchmarks will in principle receive all allowances they need, while those that do not meet the benchmark will have a shortage of allowances and the option to either lower their emissions or to purchase additional allowances to cover their excess emissions. However, if other developed countries and other major emitters of GHG do not take comparable action to reduce their emissions, certain energy-intensive sectors in the EU that are subject to international competition could be put at an economic disadvantage. Therefore, allocating emission allowances free of charge aims at limiting the costs for EU industries in relation to competitors outside of the EU. At

the same time, an absence of comparable action outside of the EU could lead to an increase in GHG emissions in third countries where industry is not subject to comparable carbon constraints, so-called "carbon leakage". To address these issues, industrial sectors that face international competition from industries outside the EU, which are not subject to comparable climate legislation, will receive a higher share of free allowances than those which are not at the risk of "carbon leakage" [11].

Emissions from houses and office buildings can be almost completely cut, by around 90% in 2050 [21]. Energy performance of buildings will be improved and "passive" housing technology will become mainstream for new buildings and old buildings will be retrofitted. Heating, cooling and cooking will be largely powered by electricity and renewable energy, instead of fossil fuels. Investments can be recovered over time through reduced energy bills.

As global food demand grows, the share of agriculture in the EU's total amount of emissions will raise to about a third by 2050, [21]. But reductions are possible, and it is vital to achieve these emission cuts in the agricultural sector as well (otherwise, other sectors will need to make a bigger reduction effort). Agriculture will need to cut emissions from fertiliser, manure and livestock and can contribute to the storage of CO_2 in soils and forests. But also changes towards a more healthy diet, with more vegetables and less meat can reduce emissions.

The effort would become greater over time as a wider set of cost-effective technologies becomes available for each of the sectors. A less ambitious pathway could lock in carbon intensive investments, resulting in higher carbon prices and significantly higher overall costs over the entire period. An early deployment of technologies, such as various forms of low carbon energy sources, CCS, smart grids and hybrid and electric vehicle technology, are of paramount importance to ensure their cost-effective and large-scale penetration later on. Full implementation of the EU Strategic Energy Technology (SET) plan requires an additional investment of 50 billion € over the next 10 years [19].

The EU ETS "cap" is the total amount of emission allowances to be issued for a given year under the EU ETS. Since each allowance represents the right to emit one tonne of CO_2 (or an amount of other GHG giving the same contribution to global warming as one tonne of CO_2) the total number of allowances, *i. e.* the "cap", determines the maximum amount of emissions possible under the EU ETS. The EU determined the "cap" for the year 2013 at 2,039,152,882 allowances, and this cap will decrease each year by 1.74%, which means the number of allowances will be reduced annually by 37, 435, 387 [11]. This annual reduction will continue beyond 2020, but may be subject to revision not later than 2025.

In contrast to the most common allocation methods in force since 2005 and until 2012, this new system applying from 2013 onwards will no longer have the unfair effect of providing more free allowances to the highest emitting installations. From 2013 onwards the system for allocating emission allowances will significantly change compared to the two previous trading periods (2005-2012). The emission allowances will be distributed according to the same rules across all EU Member States. Moreover, auctioning will be the rule for the power sector, which means that the majority of allowances under the EU ETS will not anymore be allocated for free. Since 2005 the EU ETS has covered only CO_2 emissions from power stations and other combustion plants, oil refineries, coke ovens, iron and steel plants and some other installations, but the scope of the ETS from 2013 will be extended to other sectors and GHG.

Long term policy outlook

Currently the world population is over 6,5 billion people and it is supposed to increase by one half to 9 billion people in 2050, and consequently, the energy needs will grow as the population an standard of living increase, particularly in the emerging economies [27]. This higher energy demand is regarded as the main contributor to future global GHG emissions. For example, if China doubles its per capita energy use, annual emissions will rise by +2,540 million tons CO_2, and if India doubles its per capita consumption, emissions will rise by +691 million tons CO_2. On the other hand, if EU gains 10% end customer energy efficiency, annual emissions will fall by –145 million tons CO_2, and if EU halves its specific emissions, total emissions will fall by –724 million tons CO_2,. However, if China doubles consumption but reaches actual EU-27 specific emissions, the emissions will fall by –342 million tons CO_2, while if USA reaches specific emissions of the EU-27 –1,034 million tons CO_2 [28]. This consideration shows the further impact of some growing economies based on their population.

The EU framework is dealing with the issue of sustainability and long-term effects of climate change that can not be dealt with at the national level alone. Climate change has long been recognised as one such long-term shaping factor, where coherent EU action is needed, both inside the EU and internationally. Whereas for the EU policy until 2020 some corner stones are defined and the legislative process has already started, the future beyond 2020 is rather sketchy. This has severe implications on the investments in the energy sector and on the research and development activities. Sustainability of investments not only necessitates consideration of environmental issues, but also security of supply and affordability of energy.

According to the Intergovernmental Panel on Climate Change (IPCC), the only way to solve the problem of climate change is to address it internationally [5]. Like all other regions of the world, Europe faces an unprecedented dilemma flowing from the fact that climate change is a global problem. There can be no solution for Europe, irrespective of its generous contribution to solving the problem, unless there is an effective solution for the entire world. In other words, there can never be a sustainable European pathway unless there is a sustainable global pathway. Even if Europe's policies are cost-effective for Europe, they will not be cost effective in climate change terms unless they contribute to cost-effectiveness globally [29].

The situation today is fundamentally different than at the end of 2008 when the EU unilaterally adopted its Climate and Energy Package. The EU has taken initiatives leading to the global transition to a low carbon and resource-efficient economy, which will also have multiple benefits for the EU [14]. At the UN Conference of the Parties in Copenhagen (COP-15), world leaders agreed that global average temperature should not rise more than 2 °C. Hence, the EU priority remains to achieve all the targets already set for 2020, while, in order to keep climate change below 2 °C, the longer term EU objective would be to reduce GHG emissions by 80-95% by 2050 below 1990 levels [21]. In line with the position endorsed by world leaders in the Copenhagen and the Cancun agreements, the countries representing more than 80% of global emissions have pledged domestic targets under these agreements. If and when implemented, these pledges would globalise climate change policies in the coming years. However, implementation of the pledges made since COP-15 would only achieve a part of the reductions needed, and the EU, with little more than 10% of global emissions, will not be able to tackle climate change on its own [21].

The forthcoming UNFCC discussions in Durban look unlikely to produce meaningful results without global commitments. If no firm global action is taken against climate change, temperatures might increase by more than 2 °C already by 2050, and more than 4 °C by 2100 [7]. In order to avoid this catastrophic scenario, science indicates that by 2050 global GHG emissions need to be reduced by at least 50% compared to 1990 [22]. In this way, the EU is taking a new initiative to stimulate international negotiations in the run-up to Durban on a wider strategy to deliver on the objective to keep the global average temperature increase below 2 °C compared to pre-industrial levels. When cooperating with its partners, the EU intends to take a comprehensive approach, intensifying bilateral and multilateral engagements on the broad range of aspects across different sectors that touch upon climate policy.

Conclusions

The European share on the global GHG emissions is constantly diminishing, while the emissions are globally still rising. However, an effective combat against climate change needs a global solution, and other important regions should move and establish their pathways, while Europe can show the way and demonstrate efforts. In order to combat climate change effectively, all large emitters must contribute, including the major developed and developing economies. Clear and realistic goals have to be defined so that provide an opportunity to decrease the global GHG emissions in order to slow the increase of the global temperature. Furthermore, appropriate goals for all major emitters will prevent the transfer of carbon-intense production to countries with no carbon constraints, so called carbon leakage.

By reducing the threat of dangerous climate change as part of ambitious global action, deep reductions in the EU's emissions have the potential to deliver benefits in the form of savings on fossil fuel imports and improvements in air quality and public health. To realise these milestones as cost-effectively as possible, and to maximise benefits for EU manufacturing industries, the implementation of the EU SET Plan is of crucial importance. A global value for GHG emissions would help to give incentives into low-carbon technologies and hence also in the necessary technology transfer. For modern climate-friendly technologies to be developed and implemented, a likely innovation centre is Europe. Implementing modern technologies in growing economies is also of benefit for the climate.

Any carbon reduction policy necessitates investments in low-carbon technology, which is still more expensive than any business-as-usual technology. Consequently, energy and energy related goods will show price increases. These price increases, however, are also incentives for the end-customers to use energy more efficiently and to change to alternatives with fewer emissions. In the energy and energy intensive industry, where investments are capital intensive, often subject to long permit application procedures found to last for more than a decade, it is crucial to have a clear understanding of what the regulatory conditions will be when the investments become fully operational.

Europe will mainly be part of the solution in terms of clean technology development. But, Europe on its own is not able to combat climate change and the cooperation with other regions is needed. The forthcoming negotiations on the post-Kyoto protocol to the UNFCCC offer the possibility for European climate policy to inspire a world commitment to preserve the global climate from changes beyond repair.

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Апстракт

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Климатска политика енергетски ефикасне Европе

Студија Светског Савета за енергију (*World Energy Council – WEC*), објављена 2009. године под насловом „Европска политика против климатских промена после 2012" пружа преглед интегралне климатске и енергетске политике Европске Уније (ЕУ) и даљег развоја Европске шеме трговине емисијама гасова са ефектом стаклене баште (*EU-ETS*). Политика ЕУ за период до 2020. године обухвата добро утврђене рокове и регулативу, али је за период иза 2020. године прилично неизвесна. То има озбиљне импликације по инвестиције у енергетски сектор, као и по истраживачке и развојне активности. Поред еколошких критеријума за одрживост инвестирања од значаја су и сигурност снабдевања и могућност да енергија буде плаћена. Студија WEC анализира главне закључке узведене из политике ЕУ и *ETS* и утврђује шта би требали да буду основни економски и еколошки одрживи покретачи климатске и енергетске политике Европе.

Као и остали региони и земље у свету, Европа је први пут суочена са дилемом произашлом из чињенице да су климатске промене глобални проблем. Стога га она сама не може да реши, ма колико велики био њен допринос, уколико не постоји глобални одрживи покрет у том правцу. Чак и када је европска политика у смислу климатских промена исплатива за Европу, она не би била исплатива глобално уколико не доприноси глобалној исплативости.

Полазећи од те (*WEC*) студије, овај рад обезбеђује опште основе и статистички материјал о емисијама CO_2, идентификује поједине важне технологије за смањење емисија и њихов технички и економски потенцијал, обрађује садашњи статус климатске политике ЕУ и њен могући будући развој ка климатски пријатељској и енергетски ефикасној Европи. Енергетска ефикасност у индустрији може да буде значајан ослонац климатске политике ЕУ.

Кључне речи: *промена климе, енергетска политика, енергетска ефикасност, шема трговања емисијама*

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