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Topic 4

# The Impact of Climate and Energy Policies on the Public Budget of EU Member States

Final Report
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Project Leader: Pippo Ranci
Research Coordinator: Luis Olmos
Research Team: Maria Grazia Pazienza
Sophia Ruester
Martina Sartori
Marzio Galeotti
Jean-Michel Glachant

Project Advisors: Christian von Hirschhausen
Pantelis Capros



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## Executive Summary

In March 2007, the European Council decided on a new integrated climate and energy policy designed to combat climate change, reduce import dependence and increase the competitiveness of the internal energy market. Two years later, a set of Directives, which are part of the by now well-known "20-20-20 Package" entailing the reduction in greenhouse gas emissions, increasing renewable energy and decreasing energy consumption through energy efficiency measures by 20% by the year 2020, was approved.

In the current context where public budgets are overstretched due to the economic crisis, there is a need to understand the effect of new climate policies on public revenues and expenses. The transition to a low-carbon energy system can create new sources of public funds (i.e. carbon pricing) but at the same time will imply an increase in certain State expenses (e.g. support to RD&D). It will also affect existing revenue streams such as a reduction in excise taxes from fossil fuels, whose size is not negligible in various Member States. Besides, climate policies generally impose a constraint on production and consumption decisions in the economy, which may well create efficiency costs. Therefore, a depressing impact on economic growth might be expected in the short-term, which may overshadow the stimulating effect of the increase in innovation subsidies. The net effect of any such simultaneous changes on main macroeconomic variables is, in any case, highly conjectural.

We estimate the impact of new policies targeting EU 2020 climate objectives on the fiscal balance of Member States in the year 2020. The policies whose effect we consider are those whose implementation has been decided from the year 2009 onward, i.e. carbon taxes applied in non-ETS sectors and additional support payments and energy efficiency regulations increasing the penetration and development of clean technologies. Through back-of-the-envelope calculations, we determine the effect of the application of these policies on public budgets by computing and comparing public revenues and expenses under a Baseline and an Enhanced Policy package. We investigate the level of both direct effects of new climate policies on public budgets and, in an approximate way, indirect effects resulting from changes in the use of resources triggered by these policies.

**Section 2** briefly introduces the main assumptions on which our analysis is based. The social cost of replacing high-carbon products with low-carbon ones is assumed to be equal to the costs incurred by industries when abating carbon. Based on this assumption, we estimate the isolated impact that changes in the use of resources by economic agents will have on national GDPs. We do not consider changes made to policies other than climate policy ones. Hence, any recycling of revenues or the sourcing of expenses resulting from climate policies are not taken into account; welfare (or distributional) effects are not treated. Given the uncertainty about future levels of carbon abatement cost, we consider three different possible futures corresponding to three different cost levels. Based on available information in the literature and making use of simplifying assumptions, we derive the level of carbon prices to be applied in each future both when new climate policies are in place and when they are not.

In **Section 3**, we discuss both in qualitative and quantitative terms how new and more ambitious policies can directly impact national public budgets. The direct effects considered include carbon pricing and the increase in subsidies to RD&D targeting low-C technologies. The first effect clearly dominates the second. Net public revenues in the year 2020 directly generated by climate policies applied in the Baseline scenario range between €52 and 123bn for the EU-27 as a whole depending on the carbon abatement cost level considered. Net incremental public revenues resulting from the application of new policies in an Enhanced Policy scenario range from a maximum of €71 bn (0.55% of the EU-27 GDP) in the case of high abatement costs, down to a negative value of €10 bn (-0.06% of GDP) if abatement costs are low. Reaching a given objective in terms of emission reductions requires the application of higher carbon prices the higher carbon abatement costs are. This would result in higher revenues from carbon taxes and from the auctioning of ETS allowances, and therefore a more positive change in the net public budget given a level of innovation subsidies.

**Section 4** investigates the indirect impacts that new climate policies have on public budgets. First, we calculate the effect that the reduction in fossil fuel production and consumption levels will have on revenues from excise taxes and subsidies provided to these fuels. Second, we estimate changes in public revenues and expenses resulting from the effect that new climate policies have on the level of economic output. Both types of effects are relevant, though changes in State revenues associated with those in GDP is probably the main factor in explaining differences among countries. Computed net indirect impacts range from an overall decrease in net revenues of about 0.03% of the EU-27 GDP when considering low carbon abatement costs to a decrease of about 0.23% for high abatement costs.

**Section 5** provides the aggregate impact of all direct and indirect effects of new climate policies on State budgets in 2020. For the EU-27 as a whole and given our assumptions, additional net public revenues of about €12.6bn (0.09% of the EU-27 GDP) can be expected if abatement costs are at the medium level of the considered range. This makes a non-negligible impact which is nevertheless much lower than the impact of changes in main macroeconomic variables over time on public accounts.

Additional revenues from carbon pricing and the decrease in revenues from excise taxes on fossil fuels and general taxes are the main factors contributing to the overall impact, though differences among countries are mainly related to differences in carbon pricing revenues. Additional net revenues increase with the share of emissions produced in non-ETS sectors and decrease with the extra reduction in GHG emissions achieved. The size of changes in State revenues (both if these changes are positive and if they are negative) is positively correlated with the carbon intensity of the economy.

Countries most significantly affected by new climate policies are those with higher carbon-intensity and lower than the EU average GDP/capita ratios. Impacts in those cases can exceed 1% of their GDP. On the other hand, the large economies in the EU are marginally affected. We assess the sensitivity of these results to assumptions made on the impact of the decarbonization of the economy on GDP growth and the changes in carbon prices caused by new climate policies for different levels of carbon abatement costs. The nominal value of results is quite sensitive to these assumptions but differences among countries are much more robust.

Finally, **Section 6** concludes.

## Introduction

The transition to a low-carbon energy system will impact both sides of a country's budget, i.e. revenues (via e.g. changes in the composition of taxes or tax levels) and expenditures (via transfer payments or direct investments). In the current context, where public budgets are overstretched due to the economic crisis, there is a pressing need to understand the implications of climate policies on the fiscal situation. Climate policies increasing public revenues could help to reduce the State debt, while policies significantly increasing public expenses could be difficult to implement.

This report investigates the medium-term, isolated impact on public budgets of EU Member States of climate and energy policy instruments implemented from the year 2009 on. We focus on both the average level of the net revenues obtained from new climate policies and on the differences among Member States in these net revenues. Both depend on national industry and energy sector structures as well as on the level of ambition of national climate policy targets set. We aim to determine if climate policies will significantly alter the fiscal balance of single countries and that of the EU-27 as a whole, and which structural variables are mainly driving this impact.

To combat climate change and reduce energy import dependence, in March 2007 the European Council agreed on **climate and energy targets** to be met in the mid-term (2020), namely a// a reduction of EU greenhouse gas (GHG) emissions by at least 20% with respect to 1990 levels;[1] b// meeting at least 20% of EU energy consumption using renewable resources (RES); and c// the reduction of EU primary energy use by at least 20% compared with projected levels. The "**climate and energy package**" supporting the achievement of these targets came into law in 2009.[2] This package includes both a strengthening of policy tools already available in 2009 and the implementation of new instruments. It mainly stands on three pillars: a// a revision and strengthening of the emissions trading system (ETS; Directive 2009/29/EC); b// an Effort Sharing Agreement governing GHG emissions from sectors not covered by the EU ETS (Decision 406/2009/EC); and c// binding national targets for renewable energy which collectively will raise the average RES share across the EU to 20% by 2020 with a sub-target of a 10% share in the transport sector (Directive 2009/28/EC).

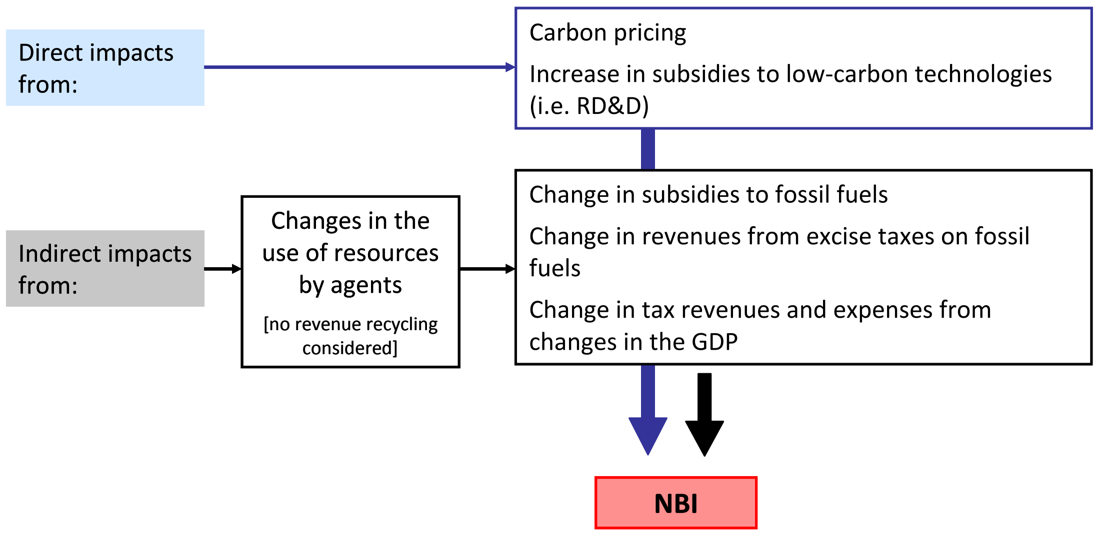
Assessing the impact on State budgets of new energy policy instruments facilitating the achievement of the above presented targets is clearly a very relevant issue both for analytical and policy purposes. This type of analysis would be interesting in ordinary times, but it is of extreme importance in periods of high debt such as these ones. This challenging task appears not to have been dealt with before. New policies will directly impact public budgets by generating new revenue and expenditure flows. A government will obtain additional revenues from carbon pricing and face an increase in expenditures associated with direct public support to research, development, and demonstration (RD&D) targeting low-carbon (low-C) technologies. In addition, most climate policy instruments will affect the decisions of individual economic agents on the use of resources, and therefore the economy at

1 The EU leaders offered to step this emission reduction target up to 30% provided that other major emitting countries in the developed and developing worlds commit to a global climate agreement. Negotiations on such an agreement are ongoing.

2 Whereas there are mandatory targets in place for RES and GHG emissions, the 20% target of a decrease in primary energy use is not yet legally binding. The climate and energy package does not address energy efficiency and energy savings explicitly, even though creating some indirect pressure to reduce energy consumption. However, in December 2010, the European Parliament voted for a binding energy saving target of at least 20% by 2020. Early in 2011, the EU is expected to publish (after several delays) the new Energy Efficiency Action Plan.

large, thus indirectly affecting State budgets. Those indirect effects are harder to predict, but they include changes in State revenues and expenses caused by the impact of climate policy on the economic output, both level and sectoral composition, prices and inflation, production and consumption, unemployment and interest rates. Particularly relevant for the present purposes appears to be, besides the impact via output changes, the change in State revenues from excise taxes on fossil fuels and in State expenses on subsidies for fossil fuels, resulting from the required decrease in the production and consumption of these fuels. Figure 1 summarizes all direct and indirect effects of climate policy on public budgets considered in our analysis.

**Figure 1**: Summary of direct and indirect impacts of climate policy on public budgets




Source: Own depiction

Quantitatively assessing the consequences of the EU climate and energy package for public budgets calls for simulating the general equilibrium of the economy of these States with the help of a sophisticated dynamic model. Such a model should allow for a sectoral and regional disaggregation together with a detailed description of the tax system and of public budget items. However, such a tool is quite difficult to come by: not even the suite of models (primarily PRIMES and GEM-E3) that has generated the scenarios for the EU package impact assessment exercises seems to possess those features, at least as far as the description and working of the public finance side of the economy are concerned. Short of that, and given the limited time horizon to carry out the present analysis, we have adopted a simpler, more direct, approach.

Making use of publicly available data on the future equilibrium of the energy sector of Member States, we have determined through back-of-the-envelope calculations the difference between net State revenues in the target year 2020 in two situations: a **Baseline** scenario, which only considers those climate policies that were first implemented, and a more ambitious **Enhanced Policy scenario** considering additional, more recent legislation. The analysis presented in EC (2009) is the only detailed enough, publicly available study simulating the future evolution of the energy system in Europe while treating separately all EU-27 countries. Thus, the policy scenarios considered in our analysis need to be those in the aforementioned work, where the general equilibrium of the system has been computed through simulations of the PRIMES and GEM-E3 models.[3]

The Baseline scenario mainly includes a strengthened Emission Trading Scheme (ETS) and different energy efficiency regulations. These policies seem unlikely to be able to achieve 2020 climate policy objectives alone. The Enhanced Policy scenario, in contrast, includes policies already applied in the Baseline scenario plus others whose implementation has been decided after the year 2009 to ensure the achievement of the 2020 climate and energy policy objectives. Extra policies considered include mainly carbon taxation in non-ETS sectors to comply with emission reduction objectives within the Effort Sharing Directive, support to deployment measures aimed at achieving objectives within the Renewable Directive, and additional energy efficiency regulations. As explained below, unless excise taxes on fossil fuels are also in place, carbon prices of the level computed in EC (2009) seem unlikely to trigger the reduction in the consumption of fossil fuels required to meet the 2020 targets. This together with the lack of information in EC (2009) on climate policies applied at the national level have led us to assume that carbon prices applied in these two scenarios complement instead of replace excise taxes on fossil fuels (energy taxes), which have been deemed to be of the same level as those currently applied.

3 The level of current taxes and subsidies related to climate policy, as published in Pazienza et al. (2011), has been used to compute the absolute value of the corresponding State revenues and expenses both in 2009 and in 2020. The latter has been compared to the incremental impact of new climate policies on the public budgets of Member States in 2020 to assess the relevance of this impact.

Due to the fact that policy scenarios compared are not far one from the other, the resulting differential impact of policy on the public accounts is necessarily small. The decision to limit the comparison to the Baseline and Enhanced Policy scenarios was due both to the mandate for the present report and to the information available and accessible within the short time given. We have understood this mandate as a clarification of the possible negative development that may affect public accounts in a transition to low-C technologies. This implies studying the impact of new measures which have been or have to be taken by Member States as a result of the basic climate policy decisions made by the Council in 2007 and put in practice in the 2009 Directives. When complying with this mandate, we relied on existing information and specifically on accessible databases and model simulations.

The report is structured as follows. Section 2 summarizes the main modeling assumptions based on which we conducted this analysis. Section 3 discusses direct impacts of climate policy on State budgets, while Section 4 is devoted to indirect impacts. Section 5 analyzes the overall Net Budget Impact of additional climate policies applied in the Enhanced Policy scenario. The results of different sensitivity analyses are also presented therein. Finally, Section 6 concludes.

## 1. Central Assumptions

The simulation exercises presented in EC (2009) assume an evolution of main macroeconomic and demographic variables that is common to both policy scenarios explored therein. In other words, authors assume that the application of more stringent energy policies does not affect these variables. In reality, however, economic variables such as the GDP are likely to be influenced by policies applied, since different policies should lead to different levels of GHG emission reductions, clean technology deployment and energy efficiency (see also Annex V). Changes in economic output in turn indirectly affect State revenues and expenses, as we discuss in more detail in Section 4. Therefore, we have made an estimate of the impact that differences in the use of resources by economic agents between the Baseline and Enhanced Policy scenarios shall have on national GDPs. We have partially based this estimate on carbon abatement costs to be incurred by Member States in the two policy scenarios. Given that there is no information in EC (2009) on carbon abatement costs incurred in each scenario, we have made our own estimates based on carbon prices reported in this study.

Carbon prices considered in EC (2009) are in the low range of those projected in the literature. Apart from this, the future evolution of variables driving carbon abatement costs and carbon prices, namely fossil fuel prices and clean technology development rates, is highly uncertain. Therefore, besides the carbon prices reported in EC (2009) and our estimate of the corresponding carbon abatement costs, we are considering two alternative sets of abatement costs corresponding to two alternative possible future situations where the cost gap between high and low-C technologies is larger than that assumed in EC (2009).

For each of these two alternative futures we have estimated carbon prices in the Baseline and Enhanced Policy scenarios assuming that differences in abatement costs among the different futures and scenarios considered will lead to the same nominal differences in carbon prices. Given that climate policy objectives must be met regardless of the level of abatement costs, we have assumed that all other energy system variables are common to all carbon abatement cost futures. The full analytical framework employed in our analysis is given in Annex V.

In order to estimate the future impact of climate policies on State revenues and expenses, one must first make an assumption on which policies will be financed from general tax revenues in 2020 (and will thus directly affect the public budget) and which will be financed through surcharges in consumer tariffs (and will therefore *not* directly affect the public budget). We have assumed that climate policy expenditures will be financed in the same way as they are today in most systems (the most common option today is assumed to be adopted by all systems in 2020). Thus, we are assuming that support to electricity generation from RES and investments in clean technology related infrastructure is directly or indirectly financed through consumer tariffs and is therefore not affecting the budget of European countries.[4]

We aim to compute the isolated impact of climate policies on public budgets. Therefore, we do not consider governments' use of funds obtained from climate policies, nor do we consider where public funds spent on climate policies are obtained from.[5] Consid-

4 Support for electricity generation from RES is provided in almost all MSs and its size is non-negligible. The Council of European Energy Regulators estimates that electricity support expenditure in 16 MSs (including all the large ones, hence approximating the total EU-27) reached €13.67 bn in 2009 (CEER, 2011, table 4), which represents approximately 0.1% of total GDP of these countries. Only a small share of such support expenditure is financed via the state budget. The main instruments are: (a) pass-through on electricity prices, (b) surcharges on the electricity transport tariff, (c) public service obligations imposed on electricity producers which indirectly impact electricity prices. The amount of such expenditure is highly variable among MSs and changing in time; its variations in the future may then be even larger than the overall net impact of new climate policies on the public budget of some MSs calculated in our report. The cost laid on consumers is not a tax, yet it is a legal obligation which may be seen as a substitute for taxes. The loss of competitiveness in electricity consuming industries may feed social pressure for the burden being moved to the state budget.

5 However, existing legislation includes already different requirements. Thus, for example, Directive 2009/29/EC includes

ering the recycling of net public revenues would involve redesigning Member States' fiscal policy, which is out of the scope of our analysis. Besides, the overall impact on public budgets of changes made to all policies (climate and non-climate related) should be zero. Net public revenues from any policy must be reinvested through other policies somewhere else in the economy, while net expenses have to be financed through an increase in revenues or debt, or a decrease in other public expenses.

# 2. Direct Impact of Climate Policies on Member States' Public Budgets

Adopting new climate policies involves creating new revenue and expense flows for the public sector. This section discusses from a qualitative and quantitative point of view the direct impact of new, more ambitious, policies supporting the achievement of EU 2020 climate objectives on the public budget of EU Member States. Policies considered are carbon pricing and the increase in subsidies to RD&D targeting low-C technologies. Changes in subsidies to the deployment of low-C technologies and investments in new infrastructures needed for their integration into the system are not taken into account, since we expect that they will be (mainly) financed by consumers rather than by national governments (maybe with some contributions from EU funds in specific projects of regional interest; see also CEER, 2011). For each of the two policies considered, we first describe its direct impact and how we have modeled it and second we present and discuss numerical results obtained.

clear provisions for the use of revenues from auctioning GHG emission allowances. At least 50% of these should be devoted to finance climate policy support payments and subsidies.

## 2.1 Carbon Pricing

We first provide a summary of existing legislation affecting carbon pricing policies. We then describe the modeling carried out; finally, we provide numerical results of carbon pricing revenues for both policy scenarios in 2020.

### 2.1.1 Legislation Affecting Carbon Pricing

An EU-wide cap and trade system was introduced in 2003 in order to drive down GHG emissions in certain sectors of the economy, namely power generation and energy-intensive industries. From 2012 on, emissions in the air transport sector will also be subject to this scheme. The mandatory target for the reduction of GHG emissions in the EU by 20% in 2020 with respect to 1990 levels has been split into two sub-targets: a reduction of 21% in emissions in those sectors covered by the ETS and one of 10% with respect to 2005 levels for emissions in the non-ETS sectors.[6]

The 2009 climate and energy policy package strengthens legislation on the reduction of emissions and extends the coverage of the **ETS** substantially. The new Directive 2009/29/EC considers: i) a longer

6 The cost-effective solution (i.e. minimization of the sum of abatement costs across all sectors) in a first best setting would imply a comprehensive ETS covering all emission sources of the considered economy and establishing a uniform price. However, real-world settings call for second best solutions. Market failures including e.g. initial tax distortions, market power, knowledge spillovers, uncertainty, or high transaction costs might provide a strong rational for the partitioning of the emission market into ETS and non-ETS. For more details and an evaluation of the economic impacts of EU climate policies see Böhringer et al. (2009). Rogge and Hoffmann (2010) discuss the impact of the ETS as policy instrument on sectoral innovation. For the role of fiscal instruments supporting climate policy see e.g. Kosonen and Nicodème (2009) or Cansino et al. (2010). Glachant et al. (2010) provide an in-depth discussion on challenges for policy making originating from the EU energy policy aiming to achieve various objectives at the same time, i.e. functioning markets, security of supply and sustainability.

time horizon (2020 taking explicitly into account the longer-term target to keep the increase in the global temperature below 2°C), ii) a single EU-wide cap on emission allowances from 2013 on, iii) the stepwise replacement of the free allocation of allowances by auctioning, and iv) an enlarged list of activities and GHGs covered by the ETS.

The direct impact of cap-and-trade systems on public budgets depends on the maximum amount of allowed emissions as well as on the procedure used to allocate emission allowances. Decision 2010/634/EU sets the total EU-wide amount of allowances at **€2,039 million for 2013**. This cap will decrease by 1.74% per year; a review of this factor shall be done in 2020. Full auctioning should be the rule from 2013 onwards for the electricity sector with free allocation of allowances to facilities used for district heating/cooling as well as to high-efficiency cogeneration used for heating/cooling. For other ETS sectors than power production, a transitional system will be put in place involving the auctioning of 20% of the allowances in 2013. This share will increase linearly resulting in 70% of allowances auctioned in 2020. See Box 1 for details on the allocation of allowances to Member States and Neuhoff et al. (2008) for an in-depth discussion about the role of auctioning within the EU-ETS.

Regarding **non-ETS sectors**, carbon emission reduction targets have been centrally set within the Effort Sharing Agreement. No decision has been however made at the EU level on the regulatory mechanisms to be applied to meet the reduction targets. Thus, the decision on the climate policy instruments to implement has been left to Member States, though carbon taxes are expected to play a major role. The proposal of a new Energy Taxation Directive (EC, 2011b) provides a framework for the adoption of a tax comprising both an energy component (similar to the excise taxes currently applied) and a GHG emissions component. Minimum carbon tax levels of €20/t $CO_2$ are proposed for several energy products. Apart from this, five European countries have already imposed a specific tax on the $CO_2$ content of energy products (see Table 1). Scandinavian countries introduced this special tax in the 1990s on the basis of the Commission proposal for a common taxation on $CO_2$, which has never been approved by the Council. After a long debate in 2009, Ireland introduced a new carbon tax as a component of a general package of fiscal consolidation. For an in-depth discussion of the composition of (environmental) taxes in EU Member States see Pazienza et al. (2011).

**Table 1**: Existing carbon taxes in EU Member States

| | Rate on emission (per t $CO_2$) | Petrol | Gas oil | Kerosene | Heavy fuel | GPL | Natural gas | Coal and coke | Elec-tricity |
|---|---|---|---|---|---|---|---|---|---|
| **Denmark** | DKK 120 (€ 17) | x | x | x | x | x | x | x | x |
| **Ireland** | € 15 | x | x | x | x | x | x | | |
| **Slovenia** | € 16 | | x | | x | x | x | x | |
| **Finland** | € 20 | x | x | x | x | | x | x | |
| **Sweden (*)** | € 109 | x | x | x | x | x | x | | |

(*) Standard rate mainly for households and services; lower rates apply to industry.
Source: National Ministries of Finance

2.1.2

**Box 1: Allocation of allowances**

In the third allocation period National Allocation Plans are not needed anymore; Article 10 of Directive 2009/29/EC provides detailed guidelines on the auctioning of allowances from 2013 on. Member States are responsible for the auctioning of the allowances that are allocated to them. In particular:

– 88% of the allowances to be auctioned are to be distributed among Member States according to their historical emissions under the EU ETS, i.e. according to their shares within the "verified emissions under the Community scheme for 2005, or the average of the period from 2005 to 2007, whichever one is the highest";

– The remaining 12% are to be distributed according to the economic strength of countries and their achievements under the Kyoto Protocol.

### 2.1.3 Basic Assumptions and Conceptual Analysis

Carbon pricing policies assumed to be in place in 2020 have been chosen taking into account existing legislation as well as policy instruments likely to be implemented until that time. Concerning ETS sectors, we have considered an EU-wide cap on emissions, full auctioning of allowances in the electricity sector and auctioning of 70% of total allowances dedicated to non-electricity sectors. Concerning GHG emissions originating from non-ETS sectors, we have assumed that they will be subject to a uniform carbon tax across all Member States and sources of emission. We have further assumed that Member States will obtain additional revenues from the VAT applied both on the sale of emission allowances and on top of any form of carbon tax.[7]

7 The treatment of revenues from carbon pricing with respect to VAT in the future is not completely clear as to date. VAT details are different in different countries and few MSs have auctioned allowances so far. The UK started auctioning (and also trading between private entities) subject to the standard VAT rate. However, after a short period the country decided for a zero-rated system. This was linked to serious VAT fraud. France recently opted for an exemption regime. However, any trading of allowances will be subject to VAT. Therefore, our assumption of applying VAT to auctioning revenues can be regarded as an appropriate approximation of total additional VAT revenues.

As pointed out above, the literature review we have conducted on projections of carbon prices in 2020 consistent with the achievement of EU climate objectives suggests that EC estimates of carbon prices are on the lower bound of expected price levels (EC, 2009). Carbon prices typically reported are between €20 and €40/t $CO_2$ (see e.g. Broek et al., 2011; Kempfert and Truong, 2007; CCC, 2008; Gorina, 2009). Also EC (2011b) proposes carbon taxes for selected energy products at a level of €20/t of $CO_2$. Given this evidence and the fact that the future evolution of several factors conditioning carbon abatement costs are highly uncertain, we have considered in our analysis, together with carbon prices in EC (2009) and our estimate of the corresponding carbon abatement costs, two alternative sets of carbon abatement costs corresponding to two alternative possible future situations where the cost gap between high- and low-C technologies is larger than that assumed in EC (2009).

Reaching a pre-determined level of emissions requires applying higher carbon prices, both in the ETS and non-ETS sectors, the higher abatement costs are. Therefore, we have assumed that abatement costs are positively correlated with carbon prices. On this basis, nominal differences in carbon abatement costs among the futures considered for them have been deemed to translate into the same nominal differences in carbon prices. Differences in carbon prices between the two policy scenarios in each future have been deemed common to all futures considered.[8] Table 2 presents the levels of carbon prices considered in each future and scenario.

Computations have been carried out considering a uniform carbon price for all emissions charged. In the Enhanced Policy scenario, this price reflects the weighted average of the carbon prices applied in ETS and non-ETS sectors. In the Baseline, this corresponds to the allowance price applied in the emission trading scheme. State revenues from carbon pricing in each scenario have been computed as the volume of emissions charged (which also depends on the scenario) times the corresponding uniform carbon price. For each of the carbon abatement cost futures considered, the direct impact of new policies on carbon pricing revenues in 2020 has been computed as the difference between carbon pricing revenues in the corresponding Enhanced Policy- and Baseline scenarios.

Calculations have been conducted for both the EU-27 as a whole and every single Member State. Revenues comprise auction revenues, where we distinguish between electricity and non-electricity sectors, carbon taxes and VAT.

8 This implies that the proportion of the average carbon price between the Enhanced Policy scenario and the Baseline changes.

### 2.1.4 Numerical Results

Total carbon pricing revenues for the EU-27 as a whole range between about €50bn (representing 0.35% of the overall GDP) when considering low carbon abatement costs and €200bn (representing 1.4% of the GDP) for high abatement costs (see Figure 2) in the Enhanced Policy scenario. Table 3 provides, for the EU as a whole and for each Member State, nominal values of carbon pricing revenues in the Baseline scenario and revenues in the Enhanced Policy scenario additional to those in the Baseline for the different carbon abatement cost futures. The latter is expressed both in monetary terms and as a percentage of GDP. A graphical representation of these results is provided in Annex III, Figure 5.

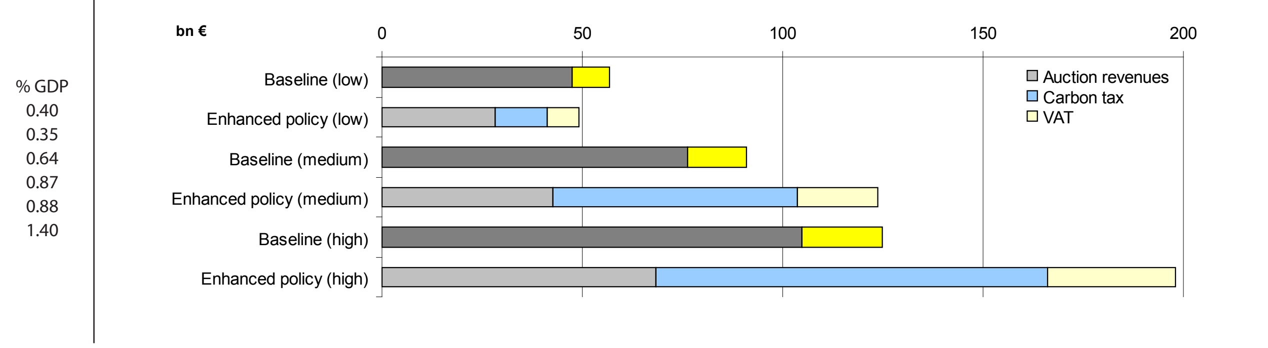
**Direct public revenues from carbon pricing differ substantially across the carbon abatement cost futures**. The higher carbon abatement costs are, the larger and more positive the difference between revenues in the Enhanced Policy and Baseline scenarios is. For low abatement costs, additional revenues in the

**Table 2:** Assumptions on carbon price levels for the different scenarios

| | Baseline | Enhanced Policy |
|---|---|---|
| | Input data on 2020 carbon emissions and projected GDP from EC (2009) | |
| **Low carbon abatement cost** | ETS auction price of €25/t $CO_2$<br>No carbon tax for non-ETS sectors | Uniform price of €10/t $CO_2$ - weighted average of prices published in EC (2009) -for ETS (€16.5/t $CO_2$) and non-ETS sectors (€5.3/t $CO_2$) |
| **Medium carbon abatement cost** | ETS auction price of €40/t $CO_2$<br>No carbon tax for non-ETS sectors | Uniform price (weighted average of prices in ETS and non-ETS sectors) of €25/t $CO_2$ |
| **High carbon abatement cost** | ETS auction price of €55/t $CO_2$<br>No carbon tax for non-ETS sector | Uniform price (weighted average of prices in ETS and non-ETS sectors) of €40/t $CO_2$ |

Source: EC (2009) for low carbon abatement costs; own assumptions for medium and high abatement costs

**Figure 2**: Revenues from carbon pricing for the EU-27 in 2020 [bn € and % GDP]




Source: Own calculation

Enhanced Policy scenario from carbon taxes applied in non-ETS sectors cannot outweigh foregone ETS auction revenues resulting from the fact that GHG emission levels and prices applied are lower than in the Baseline. The base of emissions on which carbon prices are applied is lower in the Enhanced Policy scenario because emission reductions achieved are larger. Additionally, more ambitious regulations in this scenario targeting both the deployment of clean generation and an increase in energy efficiency lead to a lower carbon price for the ETS sector. All this taken together results in revenues in the low carbon abatement cost future being lower in the Enhanced Policy scenario than in the Baseline for most EU countries. It should, however, be noted that *nominal* carbon pricing revenues in both scenarios are significant (€57bn in the Baseline and €49bn in the Enhanced policy for the EU-27).

Given that the difference between uniform carbon prices in both policy scenarios has been assumed to be the same for the three abatement cost futures, the ratio of carbon prices in the Enhanced Policy scenario to that in the Baseline rises with the cost of abating carbon. As a consequence, extra revenues from carbon pricing in the Enhanced Policy scenario become positive in most cases for medium abatement costs and are substantial for high abatement costs.

**The impact of carbon pricing on State revenues also differs across Member States**. The main factors behind differences among countries are the share of carbon emissions in non-ETS sectors, the extra reduction in emissions achieved in the Enhance Policy scenario, and the carbon intensity of the economy. Given that *non-ETS emissions* only pay a charge in the Enhanced Policy scenario, the larger the share of these emissions is in a country, the larger the public revenues from carbon pricing are in the Enhanced Policy scenario relative to the Baseline. Hence, those countries with a high relative level of non-ETS emissions (e.g. Austria, Hungary, Luxembourg, and Latvia) show high additional revenues in the Enhanced Policy scenario under medium and high abatement costs. The opposite is true for countries like Bulgaria and Estonia featuring a share of ETS emissions in 2020 of more than 60% – a value significantly above the EU average of 46%. It is worth noting that 8 of the 12 new Member States exhibit higher than the EU-27 average shares of GHG emissions covered by the ETS.

Another factor affecting differences among Member States is the *reduction of GHG emissions* taking place in the Enhanced Policy scenario with respect to the Baseline. The larger this difference the lower the extra revenues in the Enhanced Policy scenario will be. Estonia and Finland, for example, show differences

**Table 3**: Direct impact of carbon pricing on State revenues in 2020

| | Revenues Baseline | | | Difference Enhanced Policy scenario - Baseline | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | M€ | | | M€ *(% of GDP)* | | | | | |
| Carbon abatement cost | Medium | Low | High | Medium | | Low | | High | |
| EU-27 | 90,841 | 56,776 | 124,907 | 32,910 | 0.23 | -7,275 | -0.05 | 73,096 | 0.52 |
| Austria | 1,323 | 832 | 1,819 | 1,049 | 0.34 | 123 | 0.04 | 1,977 | 0.64 |
| Belgium | 2,152 | 1,345 | 2,959 | 1,167 | 0.30 | -17 | 0.00 | 2,352 | 0.60 |
| Bulgaria | 1,794 | 1,121 | 2,467 | -110 | -0.32 | -448 | -1.29 | 228 | 0.66 |
| Cyprus | 189 | 118 | 259 | 62 | 0.28 | -17 | -0.08 | 142 | 0.63 |
| Czech R. | 3,174 | 1,984 | 4,364 | 537 | 0.35 | -499 | -0.32 | 1,574 | 1.02 |
| Denmark | 1,042 | 651 | 1,433 | 513 | 0.21 | -29 | -0.01 | 1,056 | 0.43 |
| Estonia | 633 | 396 | 871 | -117 | -0.76 | -189 | -1.23 | -44 | -0.29 |
| Finland | 1,549 | 968 | 2,130 | 117 | 0.06 | -302 | -0.15 | 536 | 0.27 |
| France | 4,469 | 2,793 | 6,145 | 7,843 | 0.37 | 2,132 | 0.10 | 13,554 | 0.63 |
| Germany | 20,468 | 12,793 | 28,144 | 2,865 | 0.11 | -3,459 | -0.13 | 9,189 | 0.34 |
| Greece | 2,844 | 1,777 | 3,910 | 327 | 0.11 | -509 | -0.18 | 1,163 | 0.40 |
| Hungary | 1,142 | 714 | 1,570 | 919 | 0.80 | 111 | 0.10 | 1,727 | 1.50 |
| Ireland | 983 | 614 | 1,351 | 926 | 0.42 | 149 | 0.07 | 1,703 | 0.77 |
| Italy | 9,704 | 6,065 | 13,343 | 4,012 | 0.24 | -579 | -0.03 | 8,602 | 0.51 |
| Latvia | 134 | 83 | 184 | 224 | 1.29 | 60 | 0.34 | 389 | 2.24 |
| Lithuania | 399 | 249 | 548 | 186 | 0.61 | -15 | -0.05 | 387 | 1.28 |
| Luxemb. | 170 | 106 | 233 | 227 | 0.48 | 52 | 0.11 | 401 | 0.85 |
| Malta | 64 | 40 | 88 | 4 | 0.05 | -13 | -0.19 | 20 | 0.29 |
| Netherl. | 3,938 | 2,462 | 5,415 | 1,306 | 0.21 | -364 | -0.06 | 2,975 | 0.47 |
| Poland | 10,205 | 6,378 | 14,031 | 745 | 0.18 | -1,998 | -0.49 | 3,488 | 0.86 |
| Portugal | 1,243 | 777 | 1,710 | 588 | 0.33 | -45 | -0.02 | 1,220 | 0.68 |
| Romania | 2,651 | 1,657 | 3,646 | 961 | 0.71 | -212 | -0.16 | 2,135 | 1.58 |
| Slovak R. | 1,152 | 720 | 1,585 | 133 | 0.18 | -206 | -0.28 | 472 | 0.64 |
| Slovenia | 497 | 311 | 684 | 153 | 0.35 | -51 | -0.12 | 356 | 0.81 |
| Spain | 7,713 | 4,821 | 10,605 | 3,621 | 0.28 | -287 | -0.02 | 7,529 | 0.59 |
| Sweden | 793 | 496 | 1,090 | 790 | 0.21 | 138 | 0.04 | 1,443 | 0.38 |
| UK | 10,408 | 6,505 | 14,311 | 3,855 | 0.16 | -800 | -0.03 | 8,510 | 0.36 |

Source: Own calculation

in emissions clearly above the EU-27 average and are among the countries where revenues in the Enhanced Policy scenario compared to those in the Baseline are lowest. The opposite is true for e.g. Luxembourg, Hungary, or Latvia.

Finally, one can observe that revenues from carbon pricing increase with the *carbon intensity* of the economy, since these revenues are larger the larger emissions paying a charge are. However, revenues in the Baseline may be larger or smaller than those in the Enhanced policy scenario. Therefore, higher carbon intensity levels are associated with larger absolute values of the difference between revenues in both scenarios, but this difference may be positive or negative. Most of the countries whose public revenues are significantly altered by the application of new carbon pricing policies have carbon-intensive economies.

Some of them, like Estonia, experience a large decrease in their public revenues, while those of others like Hungary are significantly increasing. Finally, there are some carbon-intensive economies like Poland or Romania where public revenues may increase or decrease substantially depending on the level of carbon abatement costs considered.

## 2.2 Public Support to Clean Technology RD&D

Substantial additional RD&D activities are required in order to achieve the ambitious target of limiting global warming to a maximum of 2°C above pre-industrial levels. An adequate portfolio of existing and new clean energy technologies will not develop spontaneously. Reasons for this are as follows: i) the current EU ETS does not provide a sufficiently high, credible and predictable future carbon price trajectory, ii) it is unlikely, and probably also undesirable, that innovators capture a large fraction of market benefits from innovation activities targeting clean technologies; and iii) there is high uncertainty about future market revenues from the exploitation of new clean technologies. Thus, there is a need for direct public support for innovation.

Developing new clean technologies requires both supporting their development in the earlier stages of the innovation chain and their deployment afterwards. *Deployment* subsidies in most EU countries are currently financed through energy tariffs paid by consumers, i.e. they are support payments not to be categorized as subsidies in their classical definition. They do not directly affect public budgets, while their indirect effect on public revenues and expenses through their impact on decisions by consumers is difficult to estimate. Therefore, deployment subsidies are not considered in our analysis. Annex II provides a discussion of subsidies to the deployment of clean technologies.

There are three main types of policy instruments that can directly mobilize public funds to support early clean innovation (i.e. the *development* of immature clean technologies): public loans/guarantees, public equity, and subsidies. The direct impact of these instruments on public budgets is related to the amount of public funds mobilized and whether these must be reimbursed. Public costs are therefore highest for subsidies and lowest for loans, which are most probably paid back by innovators together with the agreed interest rate. Public equity investments offer the State the opportunity to earn substantial revenues if the innovation company is successful in the market. For an in-depth discussion on the optimal choice of financing instruments to support low-C RD&D see Newbery et al. (2011).

### 2.2.1 Basic Assumptions and Conceptual Analysis

Clean technologies to be supported can be classified into two main groups: supply side technologies and those increasing the efficiency in the use of energy. Both will be discussed jointly. However, it has to be noted that many energy efficiency measures are already cost competitive and, therefore, do not need direct financial support but instead the removal of existing barriers to their application (see also EC, 2006a; Stern, 2006; Parry et al., 2010).

We have estimated the direct impact on public budgets of the increase in direct public support to clean energy innovation that should take place in the Enhanced Policy scenario with respect to the Baseline as the difference between the non-refundable clean RD&D investments by Member States in the two scenarios. Public national RD&D investments in each scenario have been estimated according to the level of ambition of technology development objectives that we have assumed for this scenario. Innovation policy in the Baseline has been deemed not to be focused on the achievement of short- and long-term climate policy objectives, while the support to the development of clean technologies in the Enhanced Policy scenario should be conducive to the achievement of 2050 objectives (see also Jones and Glachant, 2010).

According to most recent estimates (see Eurostat, 2010), public contributions to clean RD&D by large countries (the main EU contributors) can be considered proportional to their GDP. Therefore, we have assumed that each country will contribute an amount of innovation subsidies that is proportional to its economic size.

Both fossil fuel prices and the rate of development of clean technologies should probably influence the level of innovation subsidies to be provided. However, the overall amount of innovation subsidies has been assumed to be common to all carbon abatement cost futures. Determining the relationship between subsidies and factors driving carbon abatement costs was not possible in the context of our study. Besides, differences among innovation subsidies for the different carbon abatement cost futures should, in any case, be much lower than differences among other public revenues and expense streams.

### 2.2.2 Numerical Results

As already explained, we have assumed that RD&D investments in the Enhanced Policy scenario should not only lead to the achievement of 2020 objectives but should also pave the way for the achievement of long-term 2050 objectives.[9] Therefore, clean innovation investments in the Enhanced Policy scenario should be in line with SET plan needs for the time period up to 2020. Total funds devoted annually to RD&D addressing SET plan technologies were €3.33bn in 2007, of which €1.105bn were public funds provided by Member States (EC, 2009d). The level of funds devoted to low-C technologies should triple during the next years if priority actions, as identified within the different Industrial Initiatives of the SET plan, are to be realized. The overall amount of funds that should be invested in the development of SET plan technologies over the coming decade (2010-2020) has been estimated at a level of about €74bn (EC, 2009d). Hence, total annual funds needed amount to about €10bn. If the fraction of public funds remained at current levels, Member States' governments should spend €3.3bn annually. However, most probably the relative size of private contributions will decrease. Therefore, public innovation funds provided by governments will probably have to amount to at least €5bn per year.

Innovation policy applied in the Baseline scenario is expected to be less ambitious than that in the Enhanced Policy scenario, since long-term global policy objectives are deemed not to be achieved in the former. Hence, public expenditures on low-C RD&D in the Baseline scenario should be between those in the period 2007-2009 and those projected in the Enhanced Policy scenario for 2020 (i.e. between €1bn and €5bn per year). Thus, the difference between public national RD&D investments in the two scenarios should be between zero and €4bn. We have taken the average of these two extreme values, i.e. €2bn (equaling 0.014% of the 2020 EU-27 GDP), to carry out our computations.

We have assumed that incremental innovation subsidies represent the same fraction of the GDP in all countries. Thus, most important contributors turn out to be those countries with the highest GDP in 2020, namely Germany, France, the UK, Italy and Spain.

9 The level of investments in clean innovation that would be needed to achieve only the shorter-term objectives would be substantially lower; technologies strictly required to meet 2020 targets are to a large extent already in the market.

Table 4 provides innovation subsidies by each country in the year 2020 in the Baseline scenario and extra subsidies to be provided in the Enhanced Policy scenario. Results are expressed in monetary units. Public costs associated with the increase in innovation subsidies in the EU-27 are non-negligible but modest compared to other revenue and expense streams, like public funds resulting from carbon pricing. This together with our assumption that contributions from countries are in proportion to their economic size results in innovation expenses not changing significantly the budget balance of any country.

**Table 4**: Increase in subsidies to clean technology RD&D in 2020

| | GDP in 2020 | RD&D subsidies Baseline | Difference Enhanced Policy scenario - Baseline |
|---|---|---|---|
| | [bn€] | [M€] | [M€] |
| EU-27 | 14,164.0 | 3,000.0 | 2,000.0 |
| Austria | 310.4 | 65.7 | 43.8 |
| Belgium | 389.5 | 82.5 | 55.0 |
| Bulgaria | 34.7 | 7.3 | 4.9 |
| Cyprus | 22.5 | 4.8 | 3.2 |
| Czech Republic | 154.2 | 32.7 | 21.8 |
| Denmark | 245.9 | 52.1 | 34.7 |
| Estonia | 15.4 | 3.3 | 2.2 |
| Finland | 201.4 | 42.7 | 28.4 |
| France | 2,144.4 | 454.2 | 302.8 |
| Germany | 2,723.6 | 576.9 | 384.6 |
| Greece | 290.6 | 61.6 | 41.0 |
| Hungary | 114.8 | 24.3 | 16.2 |
| Ireland | 221.7 | 47.0 | 31.3 |
| Italy | 1,678.7 | 355.6 | 237.0 |
| Latvia | 17.4 | 3.7 | 2.5 |
| Lithuania | 30.3 | 6.4 | 4.3 |
| Luxembourg | 47.3 | 10.0 | 6.7 |
| Malta | 6.8 | 1.4 | 1.0 |
| Netherlands | 637.9 | 135.1 | 90.1 |
| Poland | 406.1 | 86.0 | 57.3 |
| Portugal | 179.6 | 38.0 | 25.4 |
| Romania | 135.0 | 28.6 | 19.1 |
| Slovak Republic | 73.3 | 15.5 | 10.4 |
| Slovenia | 44.0 | 9.3 | 6.2 |
| Spain | 1,285.2 | 272.2 | 181.5 |
| Sweden | 380.3 | 80.5 | 53.7 |
| UK | 2,373.0 | 502.6 | 335.1 |

Source: EC (2009) for GDP in 2020; remaining numbers own calculation

## 2.3 Overall Direct Impact of New Policies on Public Budgets

Revenues from carbon pricing are much larger than the remaining direct revenues and expenses of Member States related to climate policy. Thus, changes in carbon pricing revenues in the Enhanced Policy scenario with respect to the Baseline represent also the major part of the direct impact of new climate policies on public budgets. Net direct revenues from climate policy are expected to increase with the level of carbon abatement costs. Net revenues computed for the Baseline scenario and the year 2020 range between €52 and €123bn for the EU-27 as a whole. According to the assumptions made, net incremental revenues in the Enhanced Policy scenario are also expected to increase with the level of carbon abatement costs from -€10bn at the EU level for low costs (-0.06% of GDP) to +€71bn for high costs (0.55% of GDP). Public budgets in those countries with a higher carbon intensive economy are expected to be more affected than budgets in those where carbon emissions are relatively lower. Direct net public revenues are expected to increase with the application of new climate policies in those countries with high shares of emissions coming from non-ETS sectors and where additional emission reductions required to comply with policy objectives are not very significant.

We have focused on major direct impacts of climate policies on public revenues and expenses. Not all possible effects have been considered. Some major costs associated with climate policy, like those of infrastructure investments or clean deployment subsidies, are expected to be directly paid by energy consumers. Other State revenues and expenses, like direct government investments into green products/services via, for example, public procurement programs or support policies targeting industries suffering from the turn to a green economy are expected to be of a minor size. Others like the cancellation of the reduced VAT currently applied on energy products are quite uncertain, at least in the 2020 horizon.

Table 14 below provides EU-27 and national figures for each of the individual effects of policies on public budgets, including direct ones, assuming medium carbon abatement costs. Results therein are expressed as a percentage of the GDP of the corresponding economy.

# 3. Indirect Impact of Climate Policies on Member States' Public Budgets

Besides creating new public revenue and expense streams, climate policies also affect the decisions of economic agents on the use of resources. Therefore, these policies also indirectly affect the public budgets of Member States. Assessing indirect impacts in a comprehensive way requires using complex general equilibrium models that consider the interdependencies that exist at a global level between the different activities in the economy. We have not used such a model in our analysis, but instead have computed the indirect effect of climate policies on the public budget by means of simple back-of-the-envelope calculations. Therefore, we have focused on a few main indirect effects.

The effects considered are of two main types. First, we assess in Section 4.1 the effect that the reduction in the level of fossil fuel production and consumption triggered by climate policy has on public revenues generated by excise taxes charged on these products and public expenses due to on-/off-budget subsidies granted to them. We then estimate those changes in public revenues and expenses resulting from the effect that climate policies have on the overall economic output. Changes in the level of the GDP driven by climate policies are discussed in Section 4.2, while the relationship between those and the public budgets is assessed in Section 4.3.

Climate policy effects not considered include changes to tax revenues resulting from the partial substitution of revenues from general (not excise) taxes applied on fossil fuel expenses by revenues from taxes applied on investments in cleaner and energy efficient equipment and the associated infrastructure. Note that excise taxes are explicitly considered in our analysis. We do not discuss either the effect that the expected increase in the labor intensity of the economy resulting from the partial replacement of high-C industries with low-C ones will have on unemployment levels and related transfer payments.

## 3.1 Changes in State Revenues and Expenses related to the Production and Consumption of Fossil Fuels

In this section, we discuss the effect that a reduction in the production and consumption of fossil fuels caused by new climate policies is expected to have on public budgets. First, we consider the impact of new climate policies on direct subsidies granted to fossil fuels; second, we analyze the impact of these policies on revenues from excise taxes.

### 3.1.1 Common Assumptions

As already pointed out in Section 2, the evolution of the use of fossil fuels has been assumed to be the same for the three different levels of carbon abatement costs we have considered. In reality, changes to fossil fuel prices and technology development rates affect the use of different fossil fuels. However, quantitative values of the variables characterizing the market equilibria of the different national systems in the two considered policy scenarios, including disaggregated fossil fuel production and consumption levels, have only been computed in the literature for low carbon abatement costs, see EC (2009). Therefore, we had to assume that fossil fuel production and consumption quantities reported in EC (2009) for the Enhanced Policy and Baseline scenarios are also representative of market equilibria when carbon abatement costs are higher than those assumed by the European Commission.

### 3.1.2 Subsidies to Fossil Fuels

#### Introduction and common assumptions made

Reducing GHG emissions entails a reduction in the production and use of fossil fuels. This may be induced by a decrease, or the abolition of subsidies to those products. This would represent a direct effect of climate policy on public budgets. However, we have adopted a more conservative approach assuming instead that per-unit subsidies will remain unchanged. Despite the fact that the size of subsidies for high-C products and technologies is not negligible in some Member States, their cancellation is a politically sensitive issue. Therefore, in this section we only consider those changes to public revenues and expenses that are related to climate policy driven changes in the level of use and production of fossil fuels. These represent an indirect effect of climate policies on public budgets.

Publicly available information on the level of subsidies currently paid by individual Member States is very scarce. Thus, we have allocated the global amount of on- and, non-hidden off-budget subsidies currently provided in the EU to individual countries proportionally to some specific subsidies paid by these countries. Then, we have extrapolated figures so obtained for the year 2020 based on the expected evolution of fossil fuel production and consumption in the Baseline and Enhanced Policy scenarios (data from EC, 2009).

Subsidies provided to high-C sectors are typically classified into on-budget and off-budget subsidies.[10] We discuss changes in each of these two types of subsidies separately.

### On-budget subsidies for fossil fuels

#### Basic assumptions and conceptual analysis

Our analysis takes as input data the level of overall EU subsidies reported in EEA (2004). EU-15 on-budget subsidies to fossil fuels amounted to €6.6bn in 2001 (with €6.4bn provided to solids and €0.2bn to oil and gas). We have also taken as input data information in the GTAP 7.1 database on the net value of output subsidies within the EU in 2004 disaggregated by fossil fuel and Member State. However, separating output subsidies from energy taxes within the GTAP database is not possible strictly speaking.

Based on data published by Eurostat and EC (2009), we have estimated implicit excise tax rates applied in the year 2008 as the ratio of total revenues in each country from energy taxes applied on each fuel in that year to the level of gross consumption of this fuel. Table 5 shows that taxes paid on oil and gas are much larger than those paid by coal. Besides, both the GTAP Database and EEA (2004) show that net output subsidies received by coal are much larger than those received by other fossil fuels. Therefore, we have assumed that only coal output subsidies are relevant and that these are largely proportional to net output subsidies in the GTAP Database. Output subsidies received by other fuels have been deemed zero. Then, we have allocated overall fossil fuel on-budget subsidies granted in 2001 to individual countries proportionately to national figures on net coal output subsidies in 2004, while on-budget subsidies received by other fuels have been assumed to be zero.

We have divided the overall amount of on-budget subsidies to each fuel within each country in 2001 by the local level of production of this fuel in the same year to compute the level of local per-unit, on-budget subsidies to this fuel. Assuming that this value remains constant over time, we have computed the overall amount of on-budget subsidies to this fuel expected to be paid by each individual country in 2020 in the Baseline and Enhanced Policy scenarios by multiplying the corresponding level of national per-unit-subsidies with the projected levels of local production of this fuel. Production data for the year 2020 have been obtained from EC (2009).[11] Finally, the impact of new climate policies implemented in the Enhanced Policy scenario on on-budget subsidies to fossil fuels has been calculated as the difference between on-budget subsidies computed for the two scenarios.

10 For a more detailed overview on the relevance of subsidies in the energy sector see Pazienza et al. (2011).

11 In order to take into account the fact that some countries have stopped producing coal since 2004 while EC (2009) still predicts a non-zero level of production in them in the year 2020, we have cross-checked the levels of coal production in EC (2009) with carbon production figures by country in the year 2009 from IEA (2010). If the latter reports that no coal production took place in a country in 2009, the projected level of production in the year 2020 for this country has been set to zero regardless of the corresponding value in EC (2009).

**Table 5**: Implicit tax rates on main fossil fuels

| [M€/1000 toe] | Coal and coke | Mineral oils | Natural gas |
|---|---|---|---|
| Belgium | 0.007 | 0.16 | 0.003 |
| Bulgaria | 0.001 | 0.21 | - |
| Czech R. | 0.003 | 0.31 | 0.005 |
| Denmark | 0.049 | 0.32 | 0.125 |
| Germany | 0.000 | 0.31 | 0.027 |
| Estonia | 0.000 | 0.27 | 0.008 |
| Ireland | - | 0.26 | - |
| Greece | 0.003 | 0.17 | - |
| Spain | - | 0.18 | - |
| France | 0.001 | 0.27 | 0.006 |
| Italy | 0.003 | 0.29 | 0.035 |
| Cyprus | - | 0.10 | |
| Latvia | 0.006 | 0.27 | - |
| Lithuania | 0.006 | 0.16 | - |
| Luxembourg | - | 0.31 | 0.004 |
| Hungary | - | 0.28 | 0.008 |
| Malta | | 0.09 | |
| Netherlands | 0.002 | 0.21 | 0.076 |
| Austria** | - | 0.29 | 0.044 |
| Poland | - | 0.26 | - |
| Portugal | - | 0.20 | 0.000 |
| Romania | 0.001 | 0.18 | 0.003 |
| Slovenia | 0.000 | 0.28 | 0.004 |
| Slovak R. | 0.000 | 0.26 | 0.001 |
| Finland | 0.016 | 0.24 | 0.022 |
| Sweden | 0.012 | 0.33 | 0.087 |
| UK | - | 0.34 | 0.007 |

** Gas figure in Austria includes coal and electricity

Source: Computation based on EC and Eurostat data. These implicit tax rates are a rough approximation of energy related tax policy of Member States.

### Numerical results

Numerical results on the level of on-budget subsidies provided in the Baseline scenario in each country, as well as on the increase in these subsidies in the Enhanced Policy scenario with respect to the Baseline, are shown in Table 6. Figures for the Baseline are provided in monetary units, while incremental ones are provided both in monetary units and as a percentage of the respective country's GDP. Countries not listed are deemed not to pay any on-budget subsidies to fossil fuels, either because local production of coal, which is the only fossil fuel heavily subsidized, is negligible (or zero) in 2020 or because fossil fuels are not subsidized (IEA, 2010). Given that these numbers correspond to State expenses, negative values in the "Impacts on the public budget" column indicate a decrease in State expenses, i.e. an increase in net revenues.

Numerical results obtained mainly depend on unit subsidies computed for each country and on the expected evolution of its coal production. Germany is the country paying the highest subsidies to the coal industry both in absolute terms and in per unit of production. In addition, according to EC (2009) its production of coal is projected to be higher in the Enhanced Policy scenario than in the Baseline in 2020. Thus, the amount of subsidies paid within this country is expected to increase by €90M with the implementation of tighter climate policy. Significant subsidies are also paid in Spain, Poland and the UK. These countries show a small decrease in coal production in the Enhanced Policy scenario compared to the Baseline. Therefore, a small decrease is also expected in the overall level of subsidies paid in them. The public budget impact of new climate policies for the EU-27 is positive (representing an increase in on-budget subsidies) but negligible relative to GDP (0.0006%).

The removal of subsidies to fossil fuels within the EU in the Enhanced Policy scenario would have a much larger impact on public budgets than that computed here. In this case, the reduction in public expenses would equal the amount of subsidies paid in the Baseline scenario in 2020, i.e. €3.35bn at the EU level, or 0.024% of the EU-27 GDP.

### Off-budget subsidies

#### Basic assumptions and conceptual analysis

As explained in detail in Annex V, "non-hidden", off-budget subsidies are deemed to directly affect net revenues, since, to a large extent, they involve a change in taxes levied on some products (a reduction in VAT applied, for example). Therefore, off-budget subsidies result, in many cases, in a reduction of tax revenues. The so-called "hidden" subsidies are not subsidies

**Table 6**: Changes in fossil fuel on-budget subsidies

| | On-budget subsidies [M€] | | Impact on public budget in 2020 (Enhanced Policy - Baseline scenario) | |
|---|---|---|---|---|
| | **Baseline (2009)** | **Baseline (2020)** | **[M€]** | **[% of GDP]** |
| EU-27 | 4,570 | 3,349 | 87 | 0.00060% |
| Bulgaria | 0.44 | 0.45 | -0.08 | -0.00024% |
| Czech Republic | 0.82 | 0.75 | -0.01 | -0.00001% |
| Germany | 4,813 | 3,093 | 91 | 0.00333% |
| Poland | 76 | 66 | -0.25 | -0.00006% |
| Spain | 188 | 159 | -0.56 | -0.00004% |
| UK | 40 | 29 | -2.81 | -0.00012% |

Source: Own estimation

from a legal perspective, since they are financed through an increase in tariffs paid by consumers, thus not directly affecting public accounts. These include in most countries support payments to renewable generation. We are not considering this form of support payments in our analysis.

It must be pointed out that, despite not being subsidies, support payments to clean technologies financed through energy tariffs, which include a large share of the subsidies to renewable generation, worry many (including the European energy regulators). Concerns are related to the fast growth of these support payments, and consequently of energy tariffs. This increase in tariffs does not reflect an increase in the cost of energy that a free market would deliver. It rather has the nature of a burden imposed upon consumers, which they cannot avoid by switching suppliers. Thus, from an economic point of view, support payments are not far different from a tax. The option to finance feed-in tariffs through general taxes is being currently discussed in several countries (e.g. in Spain), with proponents building on the argument that environmental benefits from low-C energy do not only affect electricity consumers (see also CEER, 2011).

Our analysis of the impact of new climate policies on off-budget subsidies is based on data provided by EEA (2004) and IEEP (2007). According to the former report, overall off-budget subsidies for fossil fuel consumption in 2001 equaled €15.1bn (with €6.6bn to solids and €8.5bn for oil and natural gas). IEEP (2007) provides figures on the implicit subsidies in 2004 resulting from the application of reduced VAT rates on fossil fuel consumption by households, as shown in Table 7.

Due to the lack of additional information on the distribution of off-budget subsidies by country, we have assumed that overall fossil fuel off-budget subsidies paid by countries are proportional to those corresponding to the application of reduced VAT rates to household energy consumption. Using this criterion we have allocated the overall amount of subsidies paid in the EU in 2001 to individual Member States. Using data on fossil fuel consumption in 2001 from EC (2009) we have computed the level of subsidies paid per unit of fuel of each type consumed in each country and have assumed that these remain constant over time. We then have computed the amount of off-budget subsidies paid by each country in 2020 for each type of fossil fuel and each policy scenario as the expected level of consumption of this fuel in this country and scenario, as reported in EC (2009), times the fuel-specific per-unit-subsidy in the country. The total impact of new climate policies on off-budget subsidies is calculated as the difference between the overall levels of these subsidies in both scenarios.

### Numerical results

Numerical results concerning the impact of new climate policies on off-budget subsidies within the EU are shown in Table 8. We provide the level of off-budget subsidies paid to each main type of fossil fuel within each country and in the EU as a whole both in the years 2009 and 2020 in the Baseline scenario. These results are given in monetary units. Besides, we provide the increase in subsidies to each type of fuel in the Enhanced Policy scenario with respect to the Baseline, also in monetary units. Finally, we provide, both in monetary units and as a percentage of GDP, the overall increase in off-budget subsidies to fossil fuels in each country and in the EU as a whole. Negative increases in subsidies represent a reduction in State expenses and correspond therefore to positive impacts on the public budget. Data is provided only for those countries that subsidize the use of fossil fuels.

**Table 7**: Implicit subsidies from reduced VAT rates applied to households' energy consumption

| M€ in 2004 | Solid fuels | Fuel oil | Natural gas | Total by country |
|---|---|---|---|---|
| Belgium | 6.7 | - | - | 6.7 |
| Estonia | 0.5 | - | - | 0.5 |
| Greece | - | - | 4.3 | 4.3 |
| Hungary | 1.2 | - | - | 1.2 |
| Ireland | 11.5 | 30.6 | 52.9 | 95 |
| Italy | 0.3 | - | 114.2 | 114.5 |
| Luxembourg | - | 2.7 | 12.5 | 15.2 |
| Portugal | - | 26.5 | 39.0 | 65.5 |
| UK | 45.3 | 54.4 | 1907.8 | 2007.5 |
| **EU-25 total** | **65.5** | **114.2** | **2130.7** | |

Source: IEEP (2007)

**Table 8**: Impact of changes in fossil fuel off-budget subsidies

| | **Off-budget subsidies** [M€] | | | | | | **Difference** [Enhanced Policy - Baseline scenario] | | | **Total impact** [M€] | **Total impact** [% GDP] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Baseline (2009) | | | Baseline (2020) | | | | | | | |
| | Solids | Oil | Gas | Solids | Oil | Gas | Solids | Oil | Gas | | |
| **EU-27** | **6,004** | **418** | **9,101** | **5,745** | **424** | **7,051** | **-999** | **-13** | **-700** | **-1,711** | **-0.012%** |
| Belgium | 399 | - | - | 439 | - | - | -30 | - | - | -30 | -0.008% |
| Estonia | 44 | - | - | 48 | - | - | -5 | - | - | -5 | -0.033% |
| Greece | - | - | 27 | - | - | 45 | - | - | -9 | -9 | -0.003% |
| Hungary | 97 | - | - | 91 | - | - | 0.29 | - | - | 0.29 | 0.0003% |
| Ireland | 998 | 123 | 221 | 1,100 | 133 | 263 | -150 | -5 | -68 | -223 | -0.101% |
| Italy | 0.04 | - | 517 | 41 | - | 566 | -4 | - | -51 | -55 | -0.003% |
| Luxemb. | - | 13 | 76 | - | 13 | 91 | - | -0.45 | -6 | -7 | -0.014% |
| Portugal | - | 89 | 256 | - | 85 | 251 | - | -2 | -75 | -78 | -0.043% |
| UK | 4,388 | 194 | 6,805 | 4,027 | 193 | 5,835 | -810 | -5 | -490 | -1,304 | -0.055% |

Source: Own estimation

The level of off-budget subsidies in each scenario depends on the expected evolution of fossil fuel consumption in each country and the level of VAT rates applied on it. Off-budget subsidies in 2020 are projected to be lower for solids and natural gas than those in 2009 (the total decrease in fossil fuel subsidies projected equals 14.8%), while subsidies for oil are expected to increase slightly. Subsidies in the Enhanced Policy scenario are expected to be lower than those in the Baseline for all fossil fuels. Due to the fact that in most Member States fossil fuel use is not subject to reduced VAT rates, the overall budget impact of new climate policies at EU level (€1.7bn) represents a small fraction of EU-27 GDP (0.012%). However, this impact is still much larger than the one computed for on-budget subsidies.

Significant reductions in subsidies relative to GDP are expected in Ireland and the UK in the Enhanced Policy scenario. This is mainly due to the fact that the consumption of all fossil fuels is heavily subsidized in those two countries (VAT rates applied on fossil fuels are low). Other countries where the impact is expected not to be negligible are Portugal and Estonia.

In Portugal, significant per-unit subsidies are granted to oil and gas. In Estonia, the level of coal consumption in the Enhanced Policy scenario is expected to be significantly lower than that in the Baseline in absolute terms (the carbon intensity of its economy is quite high). In Italy per-unit subsidies to natural gas are high (see Table 7), but the reduction in natural gas consumption in the Enhanced Policy scenario compared to the Baseline is not substantial (-9%). Thus, the impact of the change in off-budget subsidies on the Italian public budget is negligible in relative terms. Hungary is the only country showing an increase in expenses that can, nevertheless, be considered negligible. This is mainly due to the fact that the consumption of coal, the only fossil fuel that is subsidized in that country, is expected to increase slightly when implementing tighter policies while that of other fossil fuels is expected to decrease, though not significantly (the emission reduction objective for Hungary is not very ambitious).

For the remaining countries per unit subsidies resulting from reduced VAT rates applied on fossil fuels are low. Then, the resulting changes in off-budget subsidies are expected to be also low. Additional figures on subsidies to high-C products are reported in Annex III.

### 3.1.3 Excise Taxes on Fossil Fuels

#### Basic assumptions and conceptual analysis

The application of new climate policies in the Enhanced Policy scenario will typically result in lower consumption of fossil fuels and will therefore prompt a decrease in State revenues from excise taxes levied on these products. As already mentioned in the Introduction, carbon prices applied on fossil fuels have been taken to be additional to excise taxes, which we have assumed to remain unchanged over time regardless of the climate policies applied. In other words, excise tax levels in 2020 in both policy scenarios are the same as those in 2008, the most recent year for which official data are available.

We are aware that a reform of energy taxation is being currently discussed. This will probably involve a modification of existing excise taxes. However, the structure and level of future energy taxation remains unclear. Besides, carbon tax levels considered in our analysis, which are based on those reported in EC (2009) and other studies in the literature, seem not to be high enough to achieve the decrease in the use of fossil fuels (mainly oil) needed to meet the 20-20-20 objectives if excise taxes are not in place.[12]

Instead of considering excise tax rates properly speaking, we have considered implicit energy tax rates as displayed in Table 5. We have used implicit tax rates instead of statutory excise duties because there are significant differences across Member States in the level of excise duties applied on each type of use and consumer of a certain fuel (EC, 2010). Implicit tax rates allow us to make a rough but reasonable and easy to compute estimate of the level of fiscal pressure on each fossil fuel.

Oil is the most heavily taxed fossil fuel in all European States, with sizable differences among tax levels in different countries. In the UK, Sweden, Denmark,

12 Fossil fuel consumption levels in the Baseline and Enhanced Policy scenarios in EC (2009) do not seem compatible with the replacement of excise taxes on fossil fuels with carbon taxes of the value reported in this study for the Enhanced Policy scenario. Revenues from excise taxes projected for 2020, assuming that the level of these taxes remains unchanged, are much larger than those from carbon pricing for carbon price levels reported. This implies that the average level of fossil fuel excise taxes per unit of carbon content is larger than that of carbon prices. Thus, replacing the former with the latter is unlikely to result in a reduction in oil consumption, which is the fuel currently most heavily taxed. However, oil consumption in the Enhanced Policy scenario is lower than that in the Baseline. This requires the application of some form of energy taxes in addition to carbon taxes reported.

**Table 9**: Changes in excise taxes applied on fossil fuels

| | Revenues from excise taxes in 2008 from fuel (Baseline)[M€] | | | Revenues from excise taxes in 2020 from fuel (Baseline) [M€] | | | Impact of fuel Enhanced Baseline in 2020 [M€] | | | Total impact on public budget (Solids +Oil + Gas) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Solids | Oil | Gas | Solids | Oil | Gas | Solids | Oil | Gas | [M€] | [% GDP] |
| EU-27 | 505 | 171,007 | 9,624 | 464 | 166,369 | 9,630 | -47 | -5947 | -900 | -6,894 | -0.05 |
| Austria | - | 4,035 | 374 | - | 3,842 | 407 | - | -105 | -89 | -194 | -0.06 |
| Belgium | 34 | 3,751 | 50 | 37 | 3,583 | 55 | -3 | -135 | -7 | -145 | -0.04 |
| Bulgaria | 7 | 977 | - | 7 | 1,036 | - | -1 | -26 | - | -27 | -0.08 |
| Cyprus | - | 254 | - | - | 227 | - | - | -10 | - | -10 | -0.05 |
| Czech R. | 48 | 3,237 | 43 | 42 | 3,638 | 44 | - | -65 | -4 | -69 | -0.04 |
| Denmark | 167 | 2,452 | 561 | 133 | 2,316 | 537 | -18 | -50 | -54 | -122 | -0.05 |
| Estonia | - | 296 | 6 | 0.09 | 331 | 7 | - | -17 | - | -18 | -0.12 |
| Finland | 91 | 2,234 | 88 | 80 | 2,039 | 86 | -9 | -123 | -12 | -144 | -0.07 |
| France | 6 | 23,965 | 254 | 5 | 21,779 | 262 | -1 | -1,043 | -52 | -1,096 | -0.05 |
| Germany | 33 | 35,797 | 2,314 | 32 | 32,041 | 2,355 | -1 | -691 | -217 | -910 | -0.03 |
| Greece | 22 | 3,037 | - | 22 | 2,974 | - | -2 | -165 | - | -166 | -0.06 |
| Hungary | - | 2,117 | 100 | - | 2,353 | 100 | - | -36 | -8 | -44 | -0.04 |
| Ireland | - | 2,217 | - | - | 2,407 | - | - | -97 | - | -97 | -0.04 |
| Italy | 50 | 21,366 | 2,557 | 57 | 20,523 | 2,799 | -5 | -1,428 | -253 | -1,686 | -0.10 |
| Lithuania | - | 422 | - | 0.61 | 767 | - | - | -7 | - | -7 | -0.02 |
| Luxemb. | 1 | 416 | - | 0.15 | 517 | - | - | -34 | - | -34 | -0.07 |
| Latvia | - | 952 | 5 | - | 565 | 6 | 3 | -11 | - | -8 | -0.05 |
| Malta | - | 78 | - | - | 53 | - | - | -2 | - | -2 | -0.03 |
| Netherl. | 14 | 6,626 | 2,571 | 17 | 6,408 | 2,341 | - | -101 | -114 | -215 | -0.03 |
| Poland | - | 6,901 | - | - | 8,264 | - | - | -375 | - | -375 | -0.09 |
| Portugal | - | 2,713 | - | - | 2,578 | - | - | -68 | - | -68 | -0.04 |
| Romania | 4 | 1,993 | 33 | 5 | 2,266 | 31 | - | -67 | -2 | -69 | -0.05 |
| Slovak. R | - | 1,088 | 5 | 0.43 | 1,195 | 5 | - | -73 | - | -73 | -0.10 |
| Slovenia | - | 823 | 3 | 0.32 | 1,033 | 4 | - | -64 | -1 | -65 | -0.15 |
| Spain | - | 12,454 | - | - | 13,306 | - | - | -368 | - | -368 | -0.03 |
| Sweden | 27 | 4,603 | 100 | 27 | 4,322 | 11 | -9 | -175 | -46 | -231 | -0.06 |
| UK | - | 26,208 | 559 | - | 26,005 | 479 | - | -612 | -40 | -652 | -0.03 |

Source: Own estimation

Germany, Luxembourg and the Czech Republic taxes on oil are highest (> 0.3 M€/1000 toe), while in Malta, Cyprus, Lithuania, Belgium, Greece, Romania and Spain implicit tax rates are relatively low (< 0.2 M€/1000 toe). Regarding other high-C products, coal and natural gas implicit tax rates are negligible in almost all cases, with the exception of those in Denmark, Sweden and the Netherlands (only for natural gas).

Incremental revenues from excise taxes in the Enhanced Policy scenario amount to the difference between fossil fuel consumption in 2020 in both policy scenarios times the implicit tax rates calculated for the year 2008.

### Numerical results

Numerical results on changes in public revenues from excise taxes on fossil fuels resulting from new climate policies are shown in Table 9. This includes the level of revenues from taxes applied on each main type of fossil fuel within each country and the EU-27 as a whole both in the year 2008 and in the year 2020 in the Baseline scenario. These revenues are expressed in monetary units. Besides, we provide the increase in revenues from excise taxes applied on each type of fuel in the Enhanced Policy scenario with respect to the Baseline. Finally, we include also, both in monetary units and as a percentage of the GDP, the overall decrease in revenues from excise taxes on fossil fuels in each country and in the EU as a whole. Negative numbers represent a reduction in revenues from excise taxes (a decrease in revenues) while positive ones represent a revenue increase.

Given that oil is the most heavily taxed type of fuel, decreases in overall revenues are mainly due to a decrease in oil consumption. The overall EU-27 decrease in revenues from excise taxes due to the application of new policies is about €6.9bn (0.05% of the GDP). Revenues from excise taxes in 2020 in the Baseline scenario are €5bn lower than those in 2009 (-2.74% change in revenues). However, in some countries revenues from oil taxation are higher in 2020 than in 2009. This is the case of ten "new" Member States (i.e., Bulgaria, Czech. Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, and Slovenia) plus Ireland and Spain. Most of these countries had low GDP per capita levels and economies with a low carbon intensity in 1990 (having a low level of industrialization). In the following years these countries experienced high economic growth at the expense of increasing their emissions. Taking this into account, 2020 GHG emission reduction objectives for these countries have been set to allow them to have a higher level of emissions than in 1990.

Differences among countries in the incremental revenues from excise taxes in the Enhanced Policy scenario can be explained in terms of the expected evolution of oil consumption in both scenarios and implicit tax rates on oil in each country. Slovenia, Estonia, Italy and Slovakia show the largest decreases in tax revenues in the Enhanced Policy scenario in terms of percentage points of their GDP (> 0.1%). Italy and Slovakia are expected to experience large decreases in oil consumption in the Enhanced Policy scenario (the decrease in revenues and oil consumption in Italy is the largest in Europe). Large decreases in tax revenues to be experienced by Estonia and Slovenia are due both to the fact that their level of oil consumption decreases substantially in the Enhanced Policy scenario and to the fact that excise rates applied in these countries are high. Countries, like Luxembourg, where excise taxes are very high also tend to experience large decreases in revenues with the application of tighter climate policies.

Lithuania and the Netherlands are the two countries expected to experience the lowest decrease in revenues from excise taxes in the Enhanced Policy scenario. In both countries, both the reduction in oil consumption due to the application of new policies and excise taxes applied are deemed to be low. Results obtained are represented graphically in Annex III.

## 3.2 Stand-Alone Impact of New Climate Policies on the Output of the Economy

### 3.2.1 Basic Assumptions and Conceptual Analysis

The implementation of climate policy instruments will affect decisions made by economic agents and, therefore, the allocation of resources to economic activities. This will certainly alter the composition and size of the global output of the economy (GDP). In our analysis, we focus on estimating the change in the level of GDP that will result from new policies applied within the Enhanced Policy scenario. We have identified three main changes in economic activities brought about by these policies. First, high-C products and services will be replaced by those low-C ones that are already technologically available. Second, Member States will obtain revenues and incur expenses from the application of new climate policies. In each country, climate policies will entail budget revenues coming from certain economic activities and expenditures in favor of other activities. This will alter the value of economic production. Finally, the development of new clean technologies will have to be publicly supported to comply with long-term climate policy objectives.

In the remainder of this section we discuss each of these three components in turn and describe the modeling we have carried out. Other effects of climate policy on GDP, like for instance the expected increase in the latter resulting from the improvement of climate conditions, can be assumed not to be sizable within the time horizon considered in our analysis.

### A- Impact of the decrease in GHG emissions

Reducing GHG emissions involves allocating fewer resources to high-C products and services. These will be partially replaced by lower-C ones. However, a large fraction of low-C products and services are not yet cost competitive. In other words, market agents are not willing to buy and/or sell them because their market value per monetary unit of resources (endowment) is deemed to be lower than that of high-C products in the short-term. Note that relevant budget impacts of the use of high-C products related to their negative effects on the environment, as well as some other benefits brought about by the use of low-C products, will most probably only materialize in the medium- to long-term. As a result, and also in line with various estimates in the literature, the level of economic growth will, at least transitionally, decrease compared to the business-as-usual scenario (BAU). Hence, the total system output (market value of all products and services) will be negatively affected in the short- to medium-term by the decarbonization of the economy (see also Pissarides, 2008; Acemoglu et al., 2010). In the long-term, the efficiency of the economy may increase due to the adoption, induced by the existing restriction on carbon emissions, of cleaner, more energy efficient, technologies whose economic potential is higher than that of traditional, fossil-fuel-based, ones. Box 2 highlights a few considerations to take into account when assessing the GDP impact of policies focused on the decarbonization of the economy.

The economic impact of the shift from high- to low-C products will depend on the type of products/services replaced and those replacing them. Our analysis does not make use of a complex simulation model able to take into account all the existing economic interdependencies among activities. Thus, we have assumed that the decrease in the level of the overall economic output resulting from the shift to low-C products roughly coincides with the level of costs incurred by industries when abating carbon. In other words, we have computed the GDP impact of the additional reduction in GHG emissions taking place in the Enhanced Policy scenario as the overall extra carbon abatement costs incurred in this scenario.[13]

13 The increase in production costs of an economic activity 'A' resulting from a shift to lower-C end products is equal to the change in the market value of inputs to this activity. Products 'I1' no longer used as an input to this activity (i.e. those no longer used as intermediate products) can now be sold as end products or be used as inputs to other economic activities being at the margin leading to an increase in the overall market value of end products in the economy (GDP). At the same time, new inputs 'I2' to activity 'A' become intermediate products in this activity and can, therefore, no longer be sold as end products or be used as inputs to other activities, thus leading to a decrease in the GDP.
Carbon abatement costs incurred in activity 'A' may lead to an increase in the price of the final products of this activity. However, assuming that exports and consumer savings remain unchanged,

**Box 2: Approaches to macro-economic consequences of climate policy**

It is important to highlight that the discussion of the effect of climate policies on the economy always has to be regarded within the analytical setting applied. First, as already discussed above, revenue recycling can mitigate welfare losses resulting from the shift to low-C products through a reduction in previously existing distortionary taxes (see Goulder, 1995; Sandmo, 2000; Weizsäcker and Jesinghaus, 1992; Pissarides, 2008; Andersen and Ekins, 2009). Thereby, alternative mechanisms of recycling can lead to different impacts of climate policy on GDP (see e.g. Cambridge Econometrics, 2008; Andersen, 2009; Lutz and Meyer, 2010).

Second, short-term GDP effects of climate policy differ from long-term effects. In the short-term, wages and the demand for energy can be deemed almost inelastic and the set of technologies available is given. As a consequence, increases in production costs stemming from carbon pricing will translate into higher prices and result in a reduction of both the output and demand in the system, which will result in a lower and less efficient employment of production factors and, therefore, in a lower system output. In the longer-term, however, part of these effects will fade out. Wages and demand will adapt to the new situation. The former will fall triggering an increase in labor supply, while the latter will shift to cleaner, less energy-intensive goods, which, together with direct public financial support, will drive an increase in the competitiveness of low-C technologies.

Finally, several factors like the substitutability of inputs to production processes or the design made of environmental regulation may affect the long term effects of this regulation on public budgets and the economy as a whole. The reader is referred to Acemoglu et al. (2010) and Porter and van der Linde (1995) to get further discussions on these issues.

However, estimating the GDP impact of climate policies according to carbon abatement costs incurred has some limitations. Future abatement costs are typically computed assuming that emission reductions will take place in an efficient way, i.e. taking advantage of the most economical abatement opportunities available. This does not consider the fact that climate policies applied aim to deploy selected technologies that are less mature than other clean ones.[14] Besides, abatement costs incurred in a system do not take into account the loss of competitiveness of the economy resulting from the increase in the price of local production. Given the limitations of the approach here considered, and the wide range of estimates in the literature on the medium-term impact that the shift to

the increase in end consumer expenses on products from activity 'A' needs to be cancelled out by a decrease in their expenses in other products. Then, one may assume that the GDP change resulting from an increase in the price of end products in activity 'A' is zero.
Overall, given optimal production decisions, the shift from high- to low-C products within activity 'A' should lead to a net decrease in the market value of end production equal to the difference between the market value of 'I2' and 'I1', i.e. the carbon abatement costs incurred in 'A'.

14 According to static economic efficiency principles, emission reduction targets for both types of sectors should be set such that abatement is consistent with the existence of a unique carbon price reflecting the overall system marginal abatement cost. However, authorities are expected to support the installation and use of RES generation technologies to engender learning by doing. Then, energy efficient technologies in non-ETS sectors (many of which are already cost competitive) will be used to a lesser extent than what is economically efficient from a short-term perspective. Thus, on average, unit carbon abatement costs, and prices, incurred in ETS sectors are expected to be higher than those in non-ETS sectors.

low-C products will have on the output of the economy, in Section 5 we analyze the sensitivity of the overall impact of new climate policies on the budget of Member States to changes in the GDP impact of the decarbonization of the economy.

Taking into account local emission abatement opportunities expected to exist in 2020, industry and academia have published estimates of carbon abatement costs for various EU countries as well as the EU as a whole. Unit abatement costs will, of course, depend on the amount of carbon already abated, since the cheapest opportunities tend to be exhausted first. Hence, carbon abatement costs typically are represented in the form of curves providing their evolution with the overall amount of carbon already abated (Marginal Abatement Cost Curves, or MACC). We have made use of the MACCs available in the literature[15] to estimate, for each EU country, the unit cost of reducing carbon emissions in the Enhanced Policy scenario with respect to those in the Baseline. Unit costs in a country have been obtained as the average value of the MACC for this country between those points corresponding to carbon emissions abated in the Baseline and Enhanced Policy scenarios. The overall cost of the extra amount of carbon abated in the latter can be computed as this unit cost times the size of the reduction in emissions.

Given that MACCs were not available for all EU countries, we have clustered Member States into three groups, i.e. low, medium and high carbon abatement cost countries, and computed a single 2020 unit abatement cost value for each of these groups. Countries have been allocated to these groups according to the carbon intensity of their economy projected for the year 2020 in EC (2009).[16] Table 10 shows the values of the unit carbon abatement costs considered in our analysis for countries whose economy has a high, medium and low carbon intensity. Separate values have been estimated for each of the three possible future situations that we have envisaged regarding the general evolution of carbon abatement costs.

15 Relevant works include Mckinsey UK, 2009; HM Government, 2009; Stern Review, 2008; Mckinsey Sweden, 2008; Mckinsey Germany, 2007; Gracceva and Ciorba, 2008; Stankevicute et al., 2007; Morris et al., 2008; Kitous and Criqui, 2009; Mckinsey Poland, 2008; Mckinsey CZ, 2008; and Cleto et al., 2007.

16 Note that, generally speaking, countries where carbon intensity is high are the ones where abating further amounts of carbon is cheaper because they typically have not exhausted yet the most economical abatement opportunities.

### B- Impact of State revenues and expenses

We are examining the isolated effect of climate policies on public budgets, considering neither any recycling of State revenues from these policies, nor the sourcing of funds injected into the economy through them. Thus, revenues obtained correspond to funds that are not given any economic use in our analysis, while climate policy related expenses allow the States to finance extra economic activities.

If both revenue neutral climate policies and revenue or expense generating ones are to achieve emission reduction objectives, the overall carbon content of economic activities taking place under these two types of policy regimes should be the same. Then, the set of economic activities that State revenues are drained from (taking place under revenue neutral policies but not under the policy regime considered here) need to have the same overall carbon content as the set of extra activities financed through State expenses (taking place under policies of the type considered here but not under revenue neutral policies). This implies that the carbon content of activities being the source of State revenues, or being financed by public expenses, should decrease with the absolute value of net State revenues. Thus, for example, if policies applied only produced State revenues or expenses, the carbon content of these activities should be zero.

**Table 10**: Different future trends of unit carbon abatement costs for different country types

| | Unit carbon abatement cost trend [€/$tCO_2$] | | |
|---|---|---|---|
| | High | Medium | Low |
| High carbon intensity [> 0.5 $tCO_2$/k€ output] | 30 | 15 | 0 |
| Medium carbon intensity | 55 | 40 | 25 |
| Low carbon intensity [< 0.25 $tCO_2$/k€ output] | 75 | 60 | 45 |

Source: Own assumptions

Aiming to make a conservative estimate of the impact of climate policy on GDP, and given that, according to the discussion above, the productivity level of activities is positively correlated with their carbon content, we have assumed a value of one for the capital-output ratio of activities being affected by the existence of State expenses or revenues. This value, which is clearly below the average capital-output ratio of productive activities, may be deemed representative of the productivity of clean activities. Then, the change in the level of the output of the economy caused by the existence of State revenues and expenses associated with climate policy can be considered to be equal to the net amount of State revenues with opposite sign.

### C- Impact of the development of new clean technologies

The short-term social value (or contribution to economic output) of clean innovation publicly funded can be assumed to be zero if technologies being supported are not mature enough to be used in the short-term and knowledge produced cannot be applied at that same time in other fields either. In this case, all public innovation investments can be deemed to represent a short-term efficiency loss. In the long-term, of course, clean RD&D leads to the availability of more efficient technologies to meet system needs, besides their value originating from the reduction they cause in the carbon footprint. Public support of innovation represents an important and necessary means to trigger socially beneficial research activities which are not conducted spontaneously by the private sector due to market failures at stake (see e.g. Martin and Scott, 2000; Foxon, 2003; and Hall and Lerner, 2009).

Not being productive in the short-term, public expenses on clean innovation result in a short-term reduction in the output of the economy with respect to the situation where all climate policy State expenses finance activities with a capital-output ratio of '1', as assumed in Section B. This GDP reduction is equal to the level of public innovation expenses. For the sake of simplicity, we have assumed that public support of innovation is neither replacing private innovation investments, nor triggering further private investments beyond those that market agents would already be willing to afford in the absence of any public support.

### 3.2.2 Numerical Results: Overall Impact of Climate Policy on GDP

Authors in EC (2009) predict a GDP increase for the EU-27 as a whole of above 20% in the period 2010-2020, i.e. from €11,386bn in 2010 to €14,164bn in 2020. We have computed the impact of new climate policies on the GDP in 2020 for each of the three different future carbon abatement cost trends considered (see Table 11). Overall EU-27 GDP changes range between 0.02% (an almost negligible increase) for low abatement costs and -0.43% for high abate-

**Table 11**: Overall impact of new climate policies on the GDP

| | GDP in 2020 | Medium abatement cost | | Low abatement cost | | High abatement cost | |
|---|---|---|---|---|---|---|---|
| | [bn€] | [bn€] | [%GDP] | [bn€] | [%GDP] | [bn€] | [%GDP] |
| EU-27 | 14164.0 | -29.0 | -0.20 | 2.5 | 0.02 | -60.4 | -0.43 |
| Austria | 310.4 | -0.8 | -0.25 | -0.1 | -0.02 | -1.5 | -0.48 |
| Belgium | 389.5 | -0.9 | -0.24 | -0.1 | -0.02 | -1.8 | -0.46 |
| Bulgaria | 34.7 | 0.0 | 0.07 | 0.4 | 1.02 | -0.3 | -0.88 |
| Cyprus | 22.5 | 0.0 | -0.22 | 0.0 | 0.05 | -0.1 | -0.49 |
| Czech Republic | 154.2 | -0.4 | -0.26 | 0.4 | 0.27 | -1.2 | -0.79 |
| Denmark | 245.9 | -0.4 | -0.15 | 0.0 | 0.00 | -0.7 | -0.30 |
| Estonia | 15.4 | 0.1 | 0.47 | 0.2 | 1.01 | 0.0 | -0.08 |
| Finland | 201.4 | -0.2 | -0.08 | 0.2 | 0.09 | -0.5 | -0.25 |
| France | 2144.4 | -6.2 | -0.29 | -1.9 | -0.09 | -10.5 | -0.49 |
| Germany | 2723.6 | -2.6 | -0.09 | 2.2 | 0.08 | -7.3 | -0.27 |
| Greece | 290.6 | -0.4 | -0.14 | 0.3 | 0.11 | -1.1 | -0.39 |
| Hungary | 114.8 | -0.7 | -0.57 | 0.0 | -0.04 | -1.3 | -1.10 |
| Ireland | 221.7 | -0.9 | -0.42 | -0.3 | -0.14 | -1.5 | -0.70 |
| Italy | 1678.7 | -2.7 | -0.16 | 0.7 | 0.04 | -6.2 | -0.37 |
| Latvia | 17.4 | -0.2 | -0.95 | 0.0 | -0.23 | -0.3 | -1.67 |
| Lithuania | 30.3 | -0.2 | -0.52 | 0.0 | 0.06 | -0.3 | -1.09 |
| Luxembourg | 47.3 | -0.2 | -0.33 | 0.0 | -0.06 | -0.3 | -0.61 |
| Malta | 6.8 | 0.0 | -0.06 | 0.0 | 0.14 | 0.0 | -0.25 |
| Netherlands | 637.9 | -0.9 | -0.14 | 0.3 | 0.04 | -2.0 | -0.32 |
| Poland | 406.1 | -0.7 | -0.16 | 1.7 | 0.43 | -3.0 | -0.75 |
| Portugal | 179.6 | -0.6 | -0.35 | -0.1 | -0.06 | -1.1 | -0.64 |
| Romania | 135.0 | -0.8 | -0.62 | 0.2 | 0.16 | -1.9 | -1.40 |
| Slovak R. | 73.3 | -0.1 | -0.14 | 0.2 | 0.30 | -0.4 | -0.59 |
| Slovenia | 44.0 | -0.1 | -0.22 | 0.1 | 0.19 | -0.3 | -0.62 |
| Spain | 1285.2 | -3.2 | -0.25 | -0.1 | -0.01 | -6.2 | -0.49 |
| Sweden | 380.3 | -0.6 | -0.16 | -0.1 | -0.03 | -1.1 | -0.29 |
| UK | 2373.0 | -5.4 | -0.23 | -1.6 | -0.07 | -9.2 | -0.39 |

Source: Own calculations

ment costs. The GDP impact of not considering any recycling of public revenues from climate policies and that of using low-C products instead of high-C ones are much more relevant than short-term efficiency losses associated with public innovation investments.

The overall GDP impact is largely in inverse proportion to the level of carbon abatement costs. This is coherent with the fact that both State revenues from carbon pricing, which are the main component of net State revenues, and the cost of the shift to low-C products are proportional to the level of carbon abatement costs. Differences among the GDP impacts experienced by different countries can be mainly explained in terms of their net State revenues from new policies, which are, in turn, dominated by the extra revenues from carbon pricing to be obtained by countries in the Enhanced Policy scenario. Those countries getting the largest extra revenues from carbon pricing when implementing the full 2020 policy package are the ones whose economic output is decreasing to the largest extent in the Enhanced Policy with respect to the Baseline scenario. Thus, Latvia, Romania, Hungary and Lithuania are experiencing GDP reductions of -0.95%, -0.62%, -0.57% and -0.52%, respectively, when considering a medium level of abatement costs. On the other hand, those countries whose extra revenues from carbon pricing in the Enhanced Policy scenario are lowest are also the ones whose GDP is expected to experience the largest increase (positive). Thus, Bulgaria and Estonia are experiencing GDP increases of 0.07% and 0.47% of their GDP, respectively, in the medium abatement cost future.

As discussed in Section 3, incremental State revenues from carbon pricing depend mainly on the carbon intensity of the economy, the share of GHG emissions from non-ETS sectors and the level of additional reductions in emissions taking place in the Enhanced Policy scenario. The larger the carbon intensity of the economy is, the larger the absolute value of extra revenues from carbon pricing in the Enhanced Policy scenario. However, this increase may be positive or negative. The larger the share of emissions from non-ETS sectors in total emissions, the more positive incremental State revenues are in the Enhanced Policy scenario, while the larger the reduction in GHG emissions in this scenario, the more negative incremental revenues should be.

Reductions in the GDP growth originating from the shift to low-C products are in direct proportion to unit abatement costs and the amount of emissions abated. The effect of the carbon intensity of the economy on carbon abatement costs is mixed because emission reductions to be achieved tend to increase with it (with some exceptions like the Czech Republic or Hungary), but unit carbon abatement costs tend to decrease. Affluent countries whose economies already have medium-to-low carbon intensity may still be asked to achieve significant emission reductions leading to large local abatement costs (examples are the UK and Finland). Additional figures graphically representing results obtained are provided in Annex III, Figure 6.

Before proceeding, it is necessary to stress that the numbers just discussed have to be regarded as highly speculative. Properly assessing changes in overall GDP induced by climate policies would require a detailed general equilibrium model, and even in that case results would be "model-dependent". Our results rest on a few, ad hoc, albeit reasonable, assumptions. This makes carrying out sensitivity analysis a mandatory task. A word of caveat is therefore in order.

## 3.3 Impact of Climate Policy Driven Changes in GDP on Tax Revenues and State Expenses

### 3.3.1 Conceptual Analysis and Modeling of the Impact

This section discusses the effect that changes in GDP growth, and hence changes in the level of economic output, caused by new policies will have on public budgets. The base of most taxes, as well as the average tax rate, will change with the GDP. Main taxes affected include VAT and excise taxes applied on products and services, corporate taxes, income taxes and social security contributions. Analogously, the number of recipients of certain State subsidies and social expenses, as well as the average level of expenses incurred per recipient, is expected to change with a change in GDP. Main expenses affected include subsidies for unemployed people and possibly also pension payments.

We have collected official data on the elasticities of State revenues and expenses with respect to GDP. Percentage changes in State revenues and expenses

**Table 12**: Impact of climate policy driven changes in the GDP on State revenues

| | State revenues from taxes as % of GDP (2009) | GDP elasticity of State revenues | Medium abatement cost | | Low abatement cost | | High abatement cost | |
|---|---|---|---|---|---|---|---|---|
| | [%] | [p.u.] | [bn€] | [%GDP] | [bn€] | [%GDP] | [bn€] | [%GDP] |
| EU-27 | 39.2 | | -11.7 | -0.08 | 0.7 | 0.00 | -24.0 | -0.17 |
| Austria | 42.8 | 0.96 | -0.3 | -0.10 | 0.0 | -0.01 | -0.6 | -0.20 |
| Belgium | 44.3 | 1 | -0.4 | -0.11 | 0.0 | -0.01 | -0.8 | -0.21 |
| Bulgaria | 33.3 | 0.961 | 0.0 | 0.02 | 0.1 | 0.33 | -0.1 | -0.28 |
| Cyprus | 39.2 | 1.14 | 0.0 | -0.10 | 0.0 | 0.02 | 0.0 | -0.22 |
| Czech Republic | 36.1 | 0.99 | -0.1 | -0.09 | 0.1 | 0.10 | -0.4 | -0.28 |
| Denmark | 48.2 | 1 | -0.2 | -0.07 | 0.0 | 0.00 | -0.4 | -0.15 |
| Estonia | 32.2 | 0.88 | 0.0 | 0.13 | 0.0 | 0.29 | 0.0 | -0.02 |
| Finland | 43.1 | 0.92 | -0.1 | -0.03 | 0.1 | 0.04 | -0.2 | -0.10 |
| France | 42.8 | 0.98 | -2.6 | -0.12 | -0.8 | -0.04 | -4.4 | -0.21 |
| Germany | 39.3 | 0.97 | -1.0 | -0.04 | 0.8 | 0.03 | -2.8 | -0.10 |
| Greece | 32.6 | 1.07 | -0.1 | -0.05 | 0.1 | 0.04 | -0.4 | -0.14 |
| Hungary | 40.4 | 1.02 | -0.3 | -0.23 | 0.0 | -0.02 | -0.5 | -0.45 |
| Ireland | 29.3 | 1.14 | -0.3 | -0.14 | -0.1 | -0.05 | -0.5 | -0.23 |
| Italy | 42.8 | 1.17 | -1.4 | -0.08 | 0.4 | 0.02 | -3.1 | -0.19 |
| Latvia | 28.9 | 0.89 | 0.0 | -0.24 | 0.0 | -0.06 | -0.1 | -0.43 |
| Lithuania | 30.3 | 0.9 | 0.0 | -0.14 | 0.0 | 0.02 | -0.1 | -0.30 |
| Luxembourg | 35.6 | 1.14 | -0.1 | -0.13 | 0.0 | -0.02 | -0.1 | -0.25 |
| Malta | 34.5 | 1.04 | 0.0 | -0.02 | 0.0 | 0.05 | 0.0 | -0.09 |
| Netherlands | 39.1 | 1.01 | -0.3 | -0.05 | 0.1 | 0.02 | -0.8 | -0.12 |
| Poland | 34.3 | 0.91 | -0.2 | -0.05 | 0.5 | 0.13 | -0.9 | -0.23 |
| Portugal | 36.7 | 1.08 | -0.2 | -0.14 | 0.0 | -0.02 | -0.5 | -0.25 |
| Romania | 28 | 0.961 | -0.2 | -0.17 | 0.1 | 0.04 | -0.5 | -0.38 |
| Slovak Republic | 29.1 | 0.88 | 0.0 | -0.04 | 0.1 | 0.08 | -0.1 | -0.15 |
| Slovenia | 37.3 | 0.96 | 0.0 | -0.08 | 0.0 | 0.07 | -0.1 | -0.22 |
| Spain | 33.1 | 1.09 | -1.1 | -0.09 | 0.0 | 0.00 | -2.3 | -0.18 |
| Sweden | 47.1 | 0.94 | -0.3 | -0.07 | -0.1 | -0.01 | -0.5 | -0.13 |
| UK | 37.3 | 1.1 | -2.2 | -0.09 | -0.6 | -0.03 | -3.8 | -0.16 |

Source: Own calculation

resulting from changes in GDP caused by new climate policies have been computed as the aforementioned percent changes in GDP times the elasticities of State revenues, respectively State expenses. Data on revenue and expense elasticities have been obtained from EC (2006) for all EU countries but Bulgaria and Romania. Elasticities for these two countries have been assumed equal to the average of those for the remaining "new" Member States.

### 3.3.2 Numerical Results

Estimates on the evolution of GDP in the EU reported in EC (2009) suggest that State revenues will increase by about 24% in the period 2010-2020 (assuming that State revenues are proportional to GDP). State revenues and expenses may nevertheless experience some variations related to climate policies applied and their impact on GDP. Values computed in our analysis for the impact of changes to GDP driven by new climate policies on State revenues and expenses are shown in Table 12 and Table 13, respectively. These tables also provide the level of fiscal pressure in each country (State revenues within each country as a percentage of GDP) as well as values of State revenue and expense elasticities employed. Expenditure elasticities consider mainly unemployment-related effects.

**Table 13**: Impact of climate policy driven changes in the GDP on State expenses

| | State revenues from taxes as % of GDP | GDP elasticity of State expenses | Medium abatement cost | | Low abatement cost | | High abatement cost | |
|---|---|---|---|---|---|---|---|---|
| | [%] | [p.u.]* | [bn€]** | [%GDP] | [bn€]** | [%GDP] | [bn€]** | [%GDP] |
| EU-27 | 39.2 | | 1.4 | 0.01 | -0.3 | 0.00 | 3.1 | 0.02 |
| Austria | 42.8 | -0.08 | 0.0 | 0.01 | 0.0 | 0.00 | 0.1 | 0.02 |
| Belgium | 44.3 | -0.16 | 0.1 | 0.02 | 0.0 | 0.00 | 0.1 | 0.03 |
| Bulgaria | 33.3 | -0.056 | 0.0 | 0.00 | 0.0 | -0.02 | 0.0 | 0.02 |
| Cyprus | 39.2 | -0.02 | 0.0 | 0.00 | 0.0 | 0.00 | 0.0 | 0.00 |
| Czech Republic | 36.1 | -0.02 | 0.0 | 0.00 | 0.0 | 0.00 | 0.0 | 0.01 |
| Denmark | 48.2 | -0.3 | 0.1 | 0.02 | 0.0 | 0.00 | 0.1 | 0.04 |
| Estonia | 32.2 | -0.05 | 0.0 | -0.01 | 0.0 | -0.02 | 0.0 | 0.00 |
| Finland | 43.1 | -0.21 | 0.0 | 0.01 | 0.0 | -0.01 | 0.0 | 0.02 |
| France | 42.8 | -0.12 | 0.3 | 0.01 | 0.1 | 0.00 | 0.5 | 0.03 |
| Germany | 39.3 | -0.27 | 0.3 | 0.01 | -0.2 | -0.01 | 0.8 | 0.03 |
| Greece | 32.6 | -0.04 | 0.0 | 0.00 | 0.0 | 0.00 | 0.0 | 0.01 |
| Hungary | 40.4 | -0.03 | 0.0 | 0.01 | 0.0 | 0.00 | 0.0 | 0.01 |
| Ireland | 29.3 | -0.16 | 0.0 | 0.02 | 0.0 | 0.01 | 0.1 | 0.03 |
| Italy | 42.8 | -0.04 | 0.0 | 0.00 | 0.0 | 0.00 | 0.1 | 0.01 |
| Latvia | 28.9 | -0.05 | 0.0 | 0.01 | 0.0 | 0.00 | 0.0 | 0.02 |
| Lithuania | 30.3 | -0.03 | 0.0 | 0.00 | 0.0 | 0.00 | 0.0 | 0.01 |
| Luxembourg | 35.6 | -0.04 | 0.0 | 0.00 | 0.0 | 0.00 | 0.0 | 0.01 |
| Malta | 34.5 | -0.02 | 0.0 | 0.00 | 0.0 | 0.00 | 0.0 | 0.00 |
| Netherlands | 39.1 | -0.42 | 0.1 | 0.02 | 0.0 | -0.01 | 0.3 | 0.05 |
| Poland | 34.3 | -0.17 | 0.0 | 0.01 | -0.1 | -0.02 | 0.2 | 0.04 |
| Portugal | 36.7 | -0.09 | 0.0 | 0.01 | 0.0 | 0.00 | 0.0 | 0.02 |
| Romania | 28 | -0.056 | 0.0 | 0.01 | 0.0 | 0.00 | 0.0 | 0.02 |
| Slovak Republic | 29.1 | -0.04 | 0.0 | 0.00 | 0.0 | 0.00 | 0.0 | 0.01 |
| Slovenia | 37.3 | -0.13 | 0.0 | 0.01 | 0.0 | -0.01 | 0.0 | 0.03 |
| Spain | 33.1 | -0.16 | 0.2 | 0.01 | 0.0 | 0.00 | 0.3 | 0.03 |
| Sweden | 47.1 | -0.19 | 0.1 | 0.01 | 0.0 | 0.00 | 0.1 | 0.03 |
| UK | 37.3 | -0.05 | 0.1 | 0.00 | 0.0 | 0.00 | 0.2 | 0.01 |

* Only unemployment expenses deemed to be affected. ** Assuming State expenses equal revenues.

Source: Own calculation

Changes in State revenues are in direct proportion to increases in GDP driven by new climate policies and to revenue elasticities with respect to the latter. Revenue elasticities are typically close to unity, even though they tend to be smaller for the ten "new" Member States than within the EU-15. Therefore, differences among countries in the impact of policies on State revenues are close to be proportional to differences among the GDP impacts of these policies. When considering medium future carbon abatement costs, overall State revenues in Europe are expected to decrease by about €12bn, or about 0.08% of the EU-27 GDP in 2020, due to the effect of new climate policies on economic output. The largest increases in revenues are obtained for Bulgaria and Estonia, whose GDP increase is also the largest. Thus, when considering low abatement costs, Bulgaria and Estonia experience increases in their State revenues in the Enhanced Policy scenario equal to 0.33 and 0.29% of their GDP, respectively. This amounts to about 1% of their overall State revenues. The opposite occurs in countries like Hungary or Latvia, whose GDP growth experiences a relevant decrease as a result of the application of new policies. As a consequence of climate policy driven changes to its GDP, Hungary State revenues are expected to decrease by 0.45% of its GDP in the Enhanced Policy scenario when carbon abatement costs are assumed to be high. This represents a reduction of about 1% of its total State revenues. Those of Latvia are expected to decrease by 0.43% of its GDP, or about 1.5% of total State revenues. Countries with higher than one revenue elasticity are generally those applying progressive taxes, while those with low revenue elasticities typically are applying flat rate taxes that result in regressive tax schemes.

The impact of GDP changes caused by new climate policies on State expenses depends on the level of the GDP impact of new policies and the value of State expense elasticities, which varies significantly across the countries. Those countries whose expenses increase more due to the application of new climate policies in the Enhanced Policy scenario are either: i) those whose GDP elasticity of expenses is more negative, like the Netherlands or Denmark; ii) those whose GDP decreases the most in the Enhanced Policy scenario with respect to the Baseline, like Latvia; or iii) those that have a negative and significant expense elasticity and whose GDP decreases substantially in the Enhanced Policy scenario, like Romania, Ireland, France or Sweden. Increases in State expenses resulting from climate policy driven changes to GDP range from -0.02% of its GDP for Bulgaria (a decrease in costs), if carbon abatement costs are low, to 0.05% of its GDP for the Netherlands if abatement costs are high. Thus, they are expected to be substantially lower in absolute value than changes in State revenues just discussed.

Obviously, State revenues will decrease and expenses increase to a larger extent the higher carbon abatement costs are. Additional figures are provided in Annex III, Figure 7 and Figure 8.

## 3.4 Overall Indirect Impact of New Policies on the Budget

Among the indirect impacts of climate policy on public budgets, the most relevant is probably the change in revenues stemming from the effect that climate policies have on the level of the output of the economy. The net indirect impact of new policies amounts to -0.13% of the EU-27 GDP (a decrease in net public revenues) when carbon abatement costs (CACs) considered are medium within the range possible. According to the assumptions we made, the higher CACs are, the larger the decrease in public revenues, and therefore the indirect impact of climate policies, should be. Net indirect impacts computed range from a decrease in net revenues of about 0.03% of the EU

GDP for low CACs to a decrease of about 0.23% of the EU GDP for high CACs. Those countries, like Latvia, Hungary or Romania, experiencing the largest decrease in their GDP due to new climate policies are also the ones suffering the largest and more negative indirect impact of these policies on the budget (representing a decrease in net State revenues of between 0.2 and 0.3% of their GDP).

Short of the proper modeling tools, we have not considered some presumably non-negligible indirect impacts of new climate policies on public budgets. We are only providing an incomplete picture of all indirect impacts occurring. Although indirect impacts are typically second-order effects relative to direct impacts, our figures may probably be over- or underestimating true overall indirect impacts. Table 14 in Section 5.2 provides EU-27 and national figures for each of the individual effects of policies on public budgets including indirect ones. Results in Table 14 are expressed as a percentage of the GDP of the corresponding economy.

# 4. Net Budget Impact of New Policies

In this section we add the results of our calculations of direct and indirect effects of policies on public revenues and expenses to obtain the overall impact of the strengthened climate policy package on public budgets in the year 2020. Following the same structure of the analysis carried out before, we first provide a brief description of the procedure followed to compute the Net Budget Impact (NBI) of new climate policies and then discuss the quantitative results. Finally, we present results obtained when assessing the sensitivity of the NBI of new policies with respect to: i) the impact of the decarbonization of the economy on GDP growth and ii) the relationship between carbon prices applied in the two policy scenarios considered.

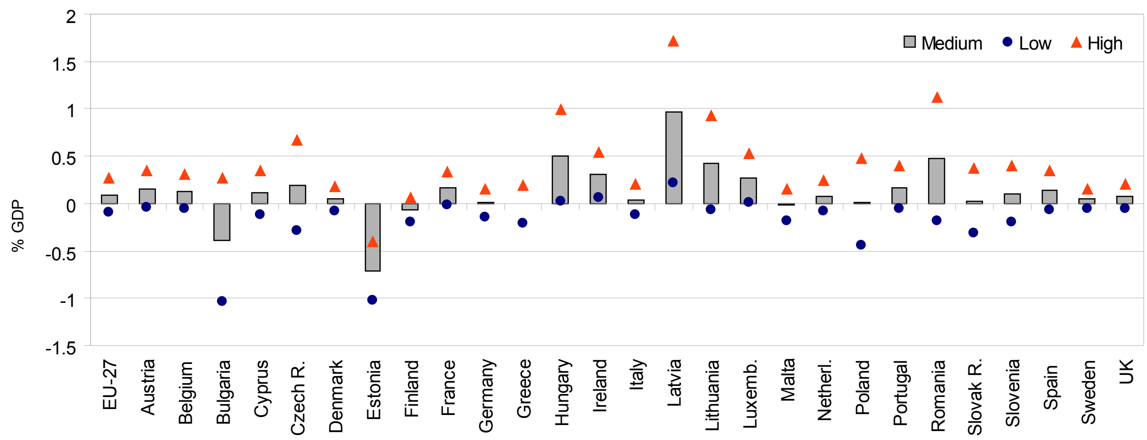
## 4.1 Computation of the Net Impact of New Climate Policies on Public Budgets

We have computed the overall impact of new climate policies on public budgets by adding up all individual direct and indirect effects discussed above. We did not consider any revenues or expenses from climate policy not affecting State budgets. Thus, infrastructure investments and the cost of deployment of low-C technologies (commonly financed through the regulated part of energy tariffs) have been left out. We have also left out some effects whose size cannot be estimated without the use of complex simulation models. The main unaccounted for effect probably is the partial replacement of public revenues from general (other than excise) taxes applied on fossil fuels by those from general taxes on investments on clean energy equipment and the associated infrastructure. We are not considering either the potential increase in labor intensity associated with the growth of green industries (see for instance Berndes and Hansson, 2007; Lehr et al. 2008; Mathiesen et al., 2011; Dalton and Lewis, 2011).[17]

As already discussed in Section 4.2, net public revenues from the application of new climate policies and extra costs incurred in the enhanced Policy scenario to abate carbon and develop new clean technologies must be added up to compute the change in GDP caused by these policies, which in turn affects State revenues and expenses. Hence, NBI figures presented in this section have been taken as an input for the analysis in Section 4.2.

17 Some authors state that long-term positive effects of the decarbonization of the system on employment critically depend on the establishment of a strong export market for innovative clean products (Wei et al., 2010). Furthermore, labor supply might increase due to the depressive effect of the implementation of climate policy instruments on real income. Marginal workers will have a higher incentive to work as a reaction to the increase in the price of goods (see also Pissarides, 2008).

**Figure 3**: Net Budget Impact of new policies




Source: Own calculation

## 4.2 Numerical Results

Table 14 shows the NBI of new climate policies for the EU-27 as a whole and for each Member State in the medium carbon abatement cost future. It also includes figures for each of the individual effects of policies on the budget (both direct and indirect). Table 15 compares the net impacts of these policies on public budgets in the three different carbon abatement cost futures considered in our analysis, expressed both in monetary terms and as a percentage of GDP. Finally, Figure 3 graphically represents numbers shown in Table 15.

Changes in fossil fuel prices or the rate of development of technologies leading to an increase in carbon abatement costs result in an increase in the level of carbon prices as well. As explained above, we have assumed that the resulting increases in carbon prices in the Enhanced Policy and Baseline scenarios are of the same size. Carbon prices in the Enhanced Policy scenario are expected to be lower than those in the Baseline due to the provision in the former of further support to the deployment of RES and other clean technologies. Thus, higher carbon abatement cost levels lead to a higher ratio of the carbon price in the Enhanced Policy scenario to that in the Baseline. Consequently, and given that the amount of GHG emissions is supposed to be the same in all carbon abatement cost futures, extra revenues from carbon pricing in the Enhanced Policy scenario, and therefore also the NBI of new policies, is more positive the higher carbon abatement costs are.

At EU-27 level, the NBI of new climate policies in terms of GDP ranges from -0.1% for low abatement costs (corresponding to a decrease of 0.25% in overall public revenues) to 0.27% for high abatement costs (corresponding to an increase of 0.7% in public revenues). At the country level, values of the NBI, also expressed in terms of the GDP of the corresponding country, range from -1% in the low abatement cost future for Bulgaria and Estonia (corresponding to a decrease of 3% in the State revenues in these countries) to 1.7% of the GDP in the high carbon abatement cost future for Latvia (corresponding to an increase of almost 6% in its State revenues). The impact of new policies on the public budgets of main EU economies tends to be marginal and positive. Thus, NBI values

**Table 14**: Computation of the Net Budget Impact of additional climate policies implemented in the Enhanced Policy scenario [medium carbon abatement costs]

| | Direct impact | | Indirect impact | | | | NBI | |
|---|---|---|---|---|---|---|---|---|
| | Carbon pricing | Subsidies for RD&D low-C technologies | Impact of GDP changes on State revenues | Impact of GDP changes on State expenses | Excise taxes on fossil fuels | Subsidies for fossil fuels | | |
| | [%GDP] | [%GDP] | [%GDP] | [%GDP] | [%GDP] | [%GDP] | [bn€] | [%GDP] |
| EU-27 | 0.23 | -0.01 | -0.08 | -0.01 | -0.05 | 0.01 | 12.6 | 0.09 |
| Austria | 0.34 | -0.01 | -0.10 | -0.01 | -0.06 | 0.00 | 0.5 | 0.15 |
| Belgium | 0.30 | -0.01 | -0.11 | -0.02 | -0.04 | 0.01 | 0.5 | 0.13 |
| Bulgaria | -0.32 | -0.01 | 0.02 | 0.00 | -0.08 | 0.00 | -0.1 | -0.38 |
| Cyprus | 0.28 | -0.01 | -0.10 | 0.00 | -0.05 | 0.00 | 0.0 | 0.12 |
| Czech Republic | 0.35 | -0.01 | -0.09 | 0.00 | -0.04 | 0.00 | 0.3 | 0.20 |
| Denmark | 0.21 | -0.01 | -0.07 | -0.02 | -0.05 | 0.00 | 0.1 | 0.05 |
| Estonia | -0.76 | -0.01 | 0.13 | 0.01 | -0.12 | 0.03 | -0.1 | -0.71 |
| Finland | 0.06 | -0.01 | -0.03 | -0.01 | -0.07 | 0.00 | -0.1 | -0.07 |
| France | 0.37 | -0.01 | -0.12 | -0.01 | -0.05 | 0.00 | 3.5 | 0.16 |
| Germany | 0.11 | -0.01 | -0.04 | -0.01 | -0.03 | 0.00 | 0.2 | 0.01 |
| Greece | 0.11 | -0.01 | -0.05 | 0.00 | -0.06 | 0.00 | 0.0 | -0.01 |
| Hungary | 0.80 | -0.01 | -0.23 | -0.01 | -0.04 | 0.00 | 0.6 | 0.51 |
| Ireland | 0.42 | -0.01 | -0.14 | -0.02 | -0.04 | 0.10 | 0.7 | 0.30 |
| Italy | 0.24 | -0.01 | -0.08 | 0.00 | -0.10 | 0.00 | 0.7 | 0.04 |
| Latvia | 1.29 | -0.01 | -0.24 | -0.01 | -0.05 | 0.00 | 0.2 | 0.97 |
| Lithuania | 0.61 | -0.01 | -0.14 | 0.00 | -0.02 | 0.00 | 0.1 | 0.43 |
| Luxembourg | 0.48 | -0.01 | -0.13 | 0.00 | -0.07 | 0.01 | 0.1 | 0.27 |
| Malta | 0.05 | -0.01 | -0.02 | 0.00 | -0.03 | 0.00 | 0.0 | -0.02 |
| Netherlands | 0.20 | -0.01 | -0.05 | -0.02 | -0.03 | 0.00 | 0.5 | 0.08 |
| Poland | 0.18 | -0.01 | -0.05 | -0.01 | -0.09 | 0.00 | 0.1 | 0.02 |
| Portugal | 0.33 | -0.01 | -0.14 | -0.01 | -0.04 | 0.04 | 0.3 | 0.17 |
| Romania | 0.71 | -0.01 | -0.17 | -0.01 | -0.05 | 0.00 | 0.6 | 0.47 |
| Slovak Republic | 0.18 | -0.01 | -0.04 | 0.00 | -0.10 | 0.00 | 0.0 | 0.03 |
| Slovenia | 0.35 | -0.01 | -0.08 | -0.01 | -0.15 | 0.00 | 0.0 | 0.10 |
| Spain | 0.28 | -0.01 | -0.09 | -0.01 | -0.03 | 0.00 | 1.8 | 0.14 |
| Sweden | 0.21 | -0.01 | -0.07 | -0.01 | -0.06 | 0.00 | 0.2 | 0.05 |
| UK | 0.16 | -0.01 | -0.09 | 0.00 | -0.03 | 0.06 | 1.9 | 0.08 |

Source: Own calculation

**Table 15**: Net Budget Impact of new policies [low, medium and high carbon abatement costs]

| | State revenues | NBI | | | | | |
|---|---|---|---|---|---|---|---|
| | | Low carbon abatement costs | | Medium carbon abatement costs | | High carbon abatement costs | |
| | [%GDP] | [bn€] | [%GDP] | [bn€] | [%GDP] | [bn€] | [%GDP] |
| EU-27 | 39.2 | -13.6 | -0.10 | 12.6 | 0.09 | 38.7 | 0.27 |
| Austria | 42.8 | -0.1 | -0.05 | 0.5 | 0.15 | 1.1 | 0.35 |
| Belgium | 44.3 | -0.2 | -0.06 | 0.5 | 0.13 | 1.3 | 0.32 |
| Bulgaria | 33.3 | -0.4 | -1.04 | -0.1 | -0.38 | 0.1 | 0.27 |
| Cyprus | 39.2 | 0.0 | -0.12 | 0.0 | 0.12 | 0.1 | 0.35 |
| Czech Republic | 36.1 | -0.4 | -0.28 | 0.3 | 0.20 | 1.0 | 0.67 |
| Denmark | 48.2 | -0.2 | -0.08 | 0.1 | 0.05 | 0.4 | 0.17 |
| Estonia | 32.2 | -0.2 | -1.02 | -0.1 | -0.71 | -0.1 | -0.41 |
| Finland | 43.1 | -0.4 | -0.19 | -0.1 | -0.07 | 0.1 | 0.06 |
| France | 42.8 | -0.2 | -0.01 | 3.5 | 0.16 | 7.2 | 0.34 |
| Germany | 39.3 | -3.8 | -0.14 | 0.2 | 0.01 | 4.2 | 0.16 |
| Greece | 32.6 | -0.6 | -0.20 | 0.0 | -0.01 | 0.6 | 0.19 |
| Hungary | 40.4 | 0.0 | 0.03 | 0.6 | 0.51 | 1.1 | 0.99 |
| Ireland | 29.3 | 0.1 | 0.06 | 0.7 | 0.30 | 1.2 | 0.55 |
| Italy | 42.8 | -2.1 | -0.12 | 0.7 | 0.04 | 3.5 | 0.21 |
| Latvia | 28.9 | 0.0 | 0.22 | 0.2 | 0.97 | 0.3 | 1.72 |
| Lithuania | 30.3 | 0.0 | -0.07 | 0.1 | 0.43 | 0.3 | 0.93 |
| Luxembourg | 35.6 | 0.0 | 0.01 | 0.1 | 0.27 | 0.2 | 0.52 |
| Malta | 34.5 | 0.0 | -0.19 | 0.0 | -0.02 | 0.0 | 0.16 |
| Netherlands | 39.1 | -0.5 | -0.08 | 0.5 | 0.08 | 1.5 | 0.24 |
| Poland | 34.3 | -1.8 | -0.44 | 0.1 | 0.02 | 1.9 | 0.48 |
| Portugal | 36.7 | -0.1 | -0.06 | 0.3 | 0.17 | 0.7 | 0.40 |
| Romania | 28.0 | -0.2 | -0.18 | 0.6 | 0.47 | 1.5 | 1.12 |
| Slovak Republic | 29.1 | -0.2 | -0.31 | 0.0 | 0.03 | 0.3 | 0.37 |
| Slovenia | 37.3 | -0.1 | -0.20 | 0.0 | 0.10 | 0.2 | 0.40 |
| Spain | 33.1 | -0.9 | -0.07 | 1.8 | 0.14 | 4.4 | 0.34 |
| Sweden | 47.1 | -0.2 | -0.06 | 0.2 | 0.05 | 0.6 | 0.15 |
| UK | 37.3 | -1.2 | -0.05 | 1.9 | 0.08 | 4.9 | 0.21 |

Source: Own calculation

for these economies in terms of their GDP range from -0.14% for Germany in the low CAC future to 0.34% for France and Spain in the high CAC one.

As already explained in Section 4.2, the overall NBI of climate policy is clearly dominated by revenues from carbon pricing (namely the trading of emission allowances in ETS sectors and the levy of carbon taxes in non-ETS ones). Thereby, the NBI of new policies is positively correlated with the level of extra revenues from carbon pricing in the Enhanced Policy scenario. We have also argued that extra carbon pricing revenues obtained in this scenario mainly depend on the carbon intensity of the economy, the share of emissions produced in non-ETS sectors, and the reduction in GHG emissions taking place in the Enhanced Policy scenario with respect to the Baseline. The effect of these three variables on the NBI can be summarized as follows: The larger the carbon intensity of the economy, the larger the absolute value of the NBI. However, the latter could be positive or negative. Thus, the carbon intensity of the economy is highly and positively correlated with the absolute value of the NBI. Besides, the larger the share of non-ETS GHG emissions and the lower the reduction in GHG emissions in the Enhanced Policy scenario, the more positive the NBI. Thus, the share of non-ETS emissions is highly and positively correlated with the NBI, while the reduction in GHG emissions in the Enhanced Policy scenario is negatively correlated.

In countries like Bulgaria or Estonia, where the share of non-ETS emissions is low, the carbon intensity of the economy is very high and reductions in GHG emissions taking place in the Enhanced Policy scenario are very large, the impact of new policies in the strengthened policy package on the NBI is very large and negative. When abatement costs considered are at a medium level, the NBI of these policies in Bulgaria represents -0.4% of its GDP, while in Estonia it represents -0.7%, or about -1% and -2% of their total State revenues, respectively. On the other hand, those countries with a large share of non-ETS emissions, economies with relatively high carbon intensities and experiencing low to very low decreases in GHG emissions in the Enhanced Policy scenario face very large and positive impacts of additional climate policies on the public budget. This is the case, for instance, of countries like Latvia or Hungary. The NBI of new climate policies in Latvia in the medium abatement cost future amounts to 0.97% of its GDP, or about 3.5% of its total State revenues, while in Hungary it represents 0.5% of the GDP, or about 1.25% of its State revenues.

Finally, there are other combinations of the aforementioned explanatory variables also leading to large positive public budget impacts. This is the case of Romania, where the share of non-ETS GHGs is medium to low and the decrease in emissions in the Enhanced Policy scenario is medium to high. Despite this, carbon pricing revenues in this scenario are larger than in the Baseline when we assume medium abatement costs. Then, due to the fact that the carbon intensity of the Romanian economy is high, the NBI of climate policy is large and positive. When considering medium carbon abatement costs, Romania experiences one of the biggest positive impacts of new policies on the public budget in the whole EU. Its budget surplus increases by almost 2%, or 0.46% of the country's GDP. When carbon abatement costs considered are low, the NBI impact of new climate policies in this country becomes negative and also large in magnitude.

On the whole, countries whose budgets are more significantly affected by policies, either positively or negatively, are those whose economies have a high carbon intensity, which tend to be also the less developed ones (they have a more traditional industry). Whether their public budgets are positively or negatively affected depends mainly on the proportion of carbon in ETS and non-ETS industries and the size of the additional reduction in carbon emissions to be achieved through new policies. The budgets of large, more developed countries in the EU tend to be only slightly affected by new climate policies.

Differences among large EU economies can be mainly explained in terms of the proportion of ETS emissions in them. Germany is the country whose public budget is most negatively affected by new policies because as much as 55% of local emissions there are expected to come from ETS sectors in the year 2020. NBI values for Germany range between -0.14% and 0.16% of its GDP depending on abatement costs. On the other hand, France is experiencing the largest increase in net public revenues because only 23% of total emissions there are produced in ETS sectors. NBI values for France range between -0.01% and 0.034% of its GDP.

## 4.3 Sensitivity Analyses

In this section we explore how the NBI of new climate policies may change when considering alternative values for the main input variables to our analysis. Section 5.3.1 is dedicated to analyzing the sensitivity of results to the GDP impact of the replacement of high-C products with low-C ones. Section 5.3.2 analyzes the sensitivity of results to the relationship between carbon prices applied in the two climate policy scenarios.

### 4.3.1 Sensitivity of Results to the GDP Impact of the Shift to Low-C Products

The effect that carbon emission reductions required to achieve 2020 objectives will have on the level of output of the economy has been computed in Section 4.2. According to the arguments provided in that section, the resulting decrease in GDP is equal to the costs incurred by industries when abating these carbon emissions. However, estimates of GDP changes that are based on carbon abatement costs neglect efficiency losses that may result from the application of a specific set of climate policies. These policies may produce a suboptimal allocation of emission reductions to economic activities. In other words, economic activities reducing their level of emissions may not be those where the most economical abatement opportunities exist. Besides, abatement costs do not take into account the (at least short-term) loss of competitiveness experienced by the economy due to the increase in the costs of local production resulting from the use of lower-C products.

On the other hand, developing and using cleaner technologies may also create some non-negligible benefits for the economy that we are not considering in our estimate of the GDP impact of the use of these technologies. Potential benefits include an increase in the level of security of supply in the energy system achieved by limiting fossil fuel import dependency. Additionally, using clean technologies reduces environmental harm, which should in the future reduce health care and agricultural costs. The latter benefits will only be realized in the medium- to long-term.

Considering potential economic benefits and costs additional to those reflected in carbon abatement costs could lead to GDP impacts significantly different from those computed in our analysis. This is consistent with the estimates found in the literature on the GDP impact of GHG emission reductions, which show a large dispersion as illustrated in Annex I. Thus, we have estimated how the Net Budget Impact of new climate policies would change if, instead of considering carbon abatement costs when computing the GDP impact of the shift to low-C products, we considered values for the latter impact in the high and low range of those published in the academic lit-

**Table 16**: Sensitivity of results for the medium CAC future to changes in the GDP impact of the shift to low-C products

| | | GDP impact based on CACs [% GDP] | Extreme low GDP impact [% GDP] | Extreme high GDP impact [% GDP] |
|---|---|---|---|---|
| GDP impact | Shift to low-C products | -0.1 | -0.35 | +0.15 |
| | Overall impact | -0.2 | -0.37 | -0.03 |
| GDP impact on State revenues from taxes | | -0.08 | -0.15 | -0.01 |
| NBI | | 0.09 | 0.01 | 0.17 |

erature on the subject, see Annex I. Results have been computed for the central (medium) carbon abatement cost future (and therefore assuming medium carbon price levels).

Based on the literature review we have conducted, which is reported in Annex I, the GDP impact of the shift to low-C products in the Enhanced Policy scenario can be reasonably expected to lie between -0.35% and +0.15% of the EU-27 GDP for 2020. This results in the overall GDP impact of new policies at EU level range from -0.37% of the GDP to -0.03% of the GDP. The GDP impact initially calculated using carbon abatement costs amounted to -0.2% of the GDP. Then, State revenues from taxes would decrease in an amount equal to between 0.15% and 0.01% of the EU GDP (a decrease equaling 0.08% of the GDP had been obtained when considering carbon abatement costs). Lastly, the NBI of new climate policies at EU level would range between +0.01% and +0.17% of the GDP, while the value initially computed corresponded to 0.09% of the GDP. Table 16 provides these same results in a schematic way. Numbers in this table are expressed as a percentage of the GDP.

Hence, assumptions made when estimating the impact that greening the economy will have on GDP have a substantial effect, in relative terms, on the estimate of the NBI of new climate policies. However, the EU average net increase in State revenues from the application of these policies should in any case be positive, assuming medium CAC levels, and limited (probably significantly smaller than other changes in public budgets driven by relevant variations in main macroeconomic variables).

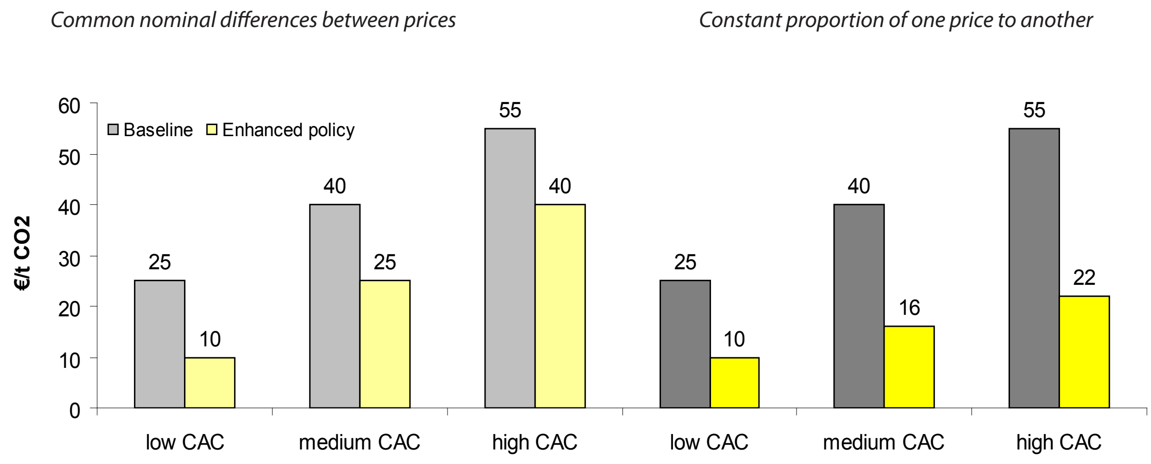
### 4.3.2 Sensitivity of Results to the Relationship between Carbon Prices Applied in the Two Climate Policy Scenarios

Carbon pricing revenues in both scenarios have been computed assuming that differences among carbon abatement costs in the different abatement cost futures envisaged translate into the same nominal differences in carbon prices, which are therefore assumed to be common to the two policy scenarios. This implies that the ratio of the carbon price applied in the Enhanced Policy scenario to that in the Baseline increases with abatement costs. Here we assume instead that the proportion of the carbon price in the Enhanced Policy scenario to that applied in the Baseline scenario is not affected by factors driving abatement costs (i.e. fossil fuel prices and technologies development rates) but remains equal to that in EC (2009)[18] (see Figure 4).

Under the new assumption on the effect of carbon abatement cost levels on the level of carbon prices in both scenarios, additional public revenues from carbon pricing in the EU-27 in the Enhanced Policy scenario are negative for all the three carbon

18 Note that carbon prices in EC (2009) correspond to those we have considered in the low carbon abatement cost future.

**Figure 4**: Assumptions made on carbon prices applied in the two scenarios




Source: Own depiction

**Table 17**: Sensitivity of results for the low, medium and high CAC futures to the relationship between carbon prices applied in both policy scenarios

| | | **Additional Carbon Pricing Revenues in the Enhanced Policy scenario** [%GDP] | **NBI** [%GDP] |
|---|---|---|---|
| **Common nominal differences between C-prices in both scenarios** | Low CAC | -0.05 | -0.10 |
| | Medium CAC | 0.23 | 0.09 |
| | High CAC | 0.52 | 0.27 |
| **Constant proportion of C-price in Enhanced Policy scenario to that in Baseline** | Low CAC | -0.05 | -0.10 |
| | Medium CAC | -0.08 | -0.13 |
| | High CAC | -0.11 | -0.16 |

abatement cost futures considered. They amount to -€7.3bn, -€11.6bn and -€16bn for low, medium and high abatement costs, respectively. Hence, additional revenues in the Enhanced Policy scenario obtained from carbon taxes applied in non-ETS sectors cannot outweigh foregone ETS auction revenues associated with both GHG emission levels and carbon prices being lower than those in the Baseline scenario.

It should, however, be highlighted that nominal carbon pricing revenues in both scenarios and in any of the futures considered are expected to increase significantly with respect to current, i.e. 2010, levels. For the EU-27 as whole, they range between €50bn and €109bn for the Enhanced Policy scenario and between €57bn and €125bn for the Baseline.

Differences in carbon pricing revenues among Member States are driven by the same factors as those identified in Section 3.1. Only those countries where the share of non-ETS emissions is clearly above the EU average (i.e. Austria, France, Hungary, Ireland, Latvia, Luxembourg and Sweden) show positive extra revenues in the Enhanced Policy scenario.

Since revenues from carbon pricing are one major component of the overall impact of climate policies on State budgets, changes in the carbon prices assumed to be applied in the two scenarios also affect the net budget impact of new climate policies. Thus, for the set of carbon prices considered in this section, the NBI of these policies for the EU-27 as a whole is -€14bn (representing -0.1% of GDP) in the low CAC future, -€18bn (-0.13% of the GDP) for medium CACs and -€23bn (-0.16% of the GDP) for high CACs. Hence, considering new carbon prices, the net increase in public revenues resulting from the adoption of a more ambitious climate policy is always negative. However, the difference between public revenues under both policy regimes is always small compared to nominal revenue values. Table 17 provides the impact of new climate policies both on carbon pricing and overall net public revenues for both of the assumptions considered in our analysis on the relationship between carbon prices applied in the Baseline and Enhanced Policy scenarios. Numbers in this table are expressed as a percentage of the GDP.

## 5. Conclusions

The decarbonization of the EU energy system will impact the fiscal equilibrium of Member States affecting both sides of a country's budget. Understanding the effects of climate policies on public finances is of high interest in the current situation, where most EU economies are facing substantial public deficits. To our knowledge, no study has so far attempted to quantify those impacts. The presented analysis, therefore, provides a first, largely tentative, estimate of the medium-term, stand-alone, impact of climate policy measures implemented from 2009 onward on the public budgets of EU Member States in 2020. Existing effects include both new revenue and expense streams as well as changes to existing public revenues and expenses resulting from the impact of these new policy instruments on economic agents' decisions on the use of resources.

The Net Budget Impact (NBI) of new policy instruments is non-negligible but small compared to the impact of possible changes in main macroeconomic variables such as GDP growth. For the EU-27 as a whole, additional net revenues of about €12.5bn (0.09% of the EU-27 GDP) can be expected if future carbon abatement costs, reflecting fossil fuel prices and the rate of development of new technologies, are at a medium level. Assumptions made on the level of carbon abatement costs greatly affect the NBI, with values of the latter ranging between -€13.6bn and €38.7bn for low and high carbon abatement costs, respectively. Net public revenues increase with the level of carbon abatement costs in the presented modeling exercise.

The overall budget impact is clearly dominated by the additional revenues that Member States are expected to obtain from carbon pricing. Other relevant factors are the decrease in revenues associated with climate policy driven changes to the GDP and the decrease in revenues from excise taxes on fossil fuels. Differences among countries result mainly from differences in the carbon intensity of the economy, the share of emissions produced in non-ETS sectors and the extra reduction in GHG emissions achieved when new policies are applied: The larger the carbon intensity of the economy, the larger the absolute value of the NBI tends to be; the larger the share of non-ETS GHG emissions and the lower the reduction in GHG emissions resulting from new policies, the more positive the impact will be.

The impact of new climate policies on State budgets varies widely across countries. Countries most significantly affected, both positively and negatively, are among the ten "new" Member States with the two countries most negatively affected by the application of new policies being Bulgaria and Estonia. These are the only two countries that, according to the assumptions made, could experience a decrease in net public revenues larger than 0.5% of their GDP in some of the scenarios considered. In fact, this decrease could be as high as 1% in terms of their GDP for low abatement costs. Both are countries with a small, highly carbon-intensive (traditional), economy and a low GDP per capita, especially in the case of Bulgaria. Thus, implementing the required changes in the economy of these countries may require external support.

Countries whose public accounts may be most positively affected by the implementation of new climate policy measures in any scenario are Hungary, Latvia, Lithuania and Romania. These could experience an increase in their net public revenues at or above 1% of their GDP for high carbon abatement costs. The economies of these countries are also carbon-intensive and their GDP per capita is low. Thus, extra public revenues in these countries should be employed to fuel their economic growth instead of supporting "losers" in the decarbonization process.

However, the impact of new climate policy instruments on large EU economies is expected to be small, generally positive, and in line with average EU values. Therefore, authorities may consider the option of sharing among all EU countries, taking into account their economic strength, the economic burden that the transition to a low-C economy may represent for those most negatively affected.

The absolute level of the budget impact of new climate policies in the Enhanced Policy scenario is quite sensitive to assumptions made within this analysis concerning the value of main input variables. NBI values computed at the EU-27 level for medium carbon abatement costs range from +0.01% to +0.17% in terms of GDP depending on the underlying assumption concerning the impact of moving to a lower-C economy on GDP. Besides, changing the assumptions made regarding the effect that the application of new policies will have on carbon prices may lead to the estimate of the NBI for the EU-27 changing its sign. However, our analysis has allowed us to determine the order of magnitude of the main effects of new climate policies on public budgets. Besides, relative differences among countries in the impact of new policies on their net public revenues seem to be far more robust than the nominal level of this impact in each country.

New climate policies have to be financed in a context in which substantial budget adjustments will be necessary to correct large short-term deficits and avoid an explosion of debt in the long-term. Public finance variables like the fragility of State budgets, the level of fiscal pressure and the expected growth of economies may affect the implementation of climate policies. The higher the financial fragility of a country, the more difficult the implementation of expensive climate policies may be, while strong expected growth rates could provide more room for the latter. However, closely assessing the effect of general public finances on climate policies is out of the scope of our analysis and must be left for future work.

Though we are well aware that the methodology that we have applied has obvious limitations, we have been able to provide a first quantitative idea of the impact that the climate and energy policy package introduced by the EU in 2009 will have on Member States' public budgets in 2020. Figures put forward may provide useful indications to national governments as to the repercussion of the policy package for their own public accounts and their management. They may also assist the European Commission in the fine tuning of climate and energy policies. The obvious developments of the analysis provided herein would consist of conducting a full set of simulations using a complex computable general equilibrium model where all the direct and indirect effects of climate policies could take place and their ultimate impact on public budgets could be traced through the inter-sectoral interdependencies within economies.

## References

Abel, A.B., B.S. Bernanke, and D. Croushore (2008): Macroeconomics, 6th Edition, Pearson Education Inc., Boston.

Acemoglu, D., P. Aghion, L. Bursztyn, and D. Hemous (2010): The environment and directed technical change. Working Paper, Harvard University. Available at http:// www.economics.harvard.edu/faculty/aghion/files/Environment%20and%20Directed.pdf

Allen, M., D. Frame, C. Huntingford, C.D. Jones, J.A. Lowe, M. Meinshausen, and N. Meinshausen (2009): Greenhouse-gas emission targets for limiting global warming to 2°C. *Nature*, Vol. 458, pp. 1163-1166.

Andersen, M.S. (2009): Carbon-energy taxation, revenue recycling, and competitiveness. In: Andersen, M.S. and P. Ekins (2009): Carbon Energy Taxation: Lessons from Europe. Oxford University Press.

Andersen, M.S. and P. Ekins (2009): Carbon Energy Taxation: Lessons from Europe. Oxford University Press.

Barker, T., M. Saeed Qureshi, and J. Köhler (2006): The costs of greenhouse gas mitigation with induced technological change: A meta-analysis of estimates in the literature. Tyndall Centre for Climate Change Research, Working Paper 89.

Bassi S. et al. (2007): Reforming environmentally harmful subsidies. Institute for European Environmental Policy. Available at: http://www.ieep.eu/assets/308/report_on_ehs_23_03_07.pdf

Berndes, G. and J. Hansson (2007): Bioenergy expansion in the EU: Cost-effective climate change mitigation, employment creation and reduced dependency on imported fuels. *Energy Policy*, Vol. 35, pp. 5965-79.

Böhringer, C., A. Löschel, U. Moslener, and T.F. Rutherford (2009): EU climate policy up to 2020: An economic impact assessment. *Energy Economics*, Vol. 31, pp. S295-S305.

Broek, M.v.d., P. Veenendaal, P. Koutstaal, W. Turkenburg, and A. Faaij (2011): Impact of international climate policies on $CO_2$ capture and storage deployment – Illustrated in the Dutch energy system. *Energy Policy*, Vol. 39, No. 4, pp. 2000-19.

Busch, C. (2009): Climate policy and economic growth in California – A comparative analysis of different economic impact projections. Center for Resource Solutions.

Cambridge Economics (2008): Projections of UK $CO_2$ emissions and assessment of the economic impacts of carbon budgets. Report for the Committee on Climate Change, Ref. RMP/4973.

Cambridge Economics (2010): The revision of the trans-European energy network policy (TEN-E). Final Report by Cambridge Econometrics, Cowi, Kema and Imperial College London under the Multiple Framework Services Contract for Impact Assessments and Evaluations TREN/A2/143-2007 Lot 1. Available at: http://ec.europa.eu/energy/infrastructure/ studies/doc/2010_11_ten_e_revision.pdf

Cansino, J.M., M.d.P. Pablo-Romero, R. Román, and R. Yniguez (2010): Tax incentives to promote green electricity: An overview of EU-27 countries. *Energy Policy*, Vol. 38, pp. 6000-8.

CEER (2011): CEER report on renewable energy support in Europe. Available at: http://www.energy-regulators.eu/portal/page/portal/EER_HOME/

EER_PUBLICATIONS/ CEER_ERGEG_PAPERS/ Electricity

Centre for Economic Studies (CES, KULeuven): The GEM-E3 model; http://www.gem-e3.net/

Cleto, J., S. Simões, P. Fortes, and J. Seixas (2007): Marginal $CO_2$ abatement costs for the Portuguese energy system: scenarios analysis for 2030. Presentation at the 9th Conference on Energy for a Clean Environment. Available at: http://air.dcea.fct.unl.pt/projects/e2pol/docs/ JCleto%20et%20al2007_MACCO2costs-forPortugalfor2030.pdf.

Comillas (2011): Development of regional and Pan-European guidelines for more efficient integration of renewable energy into future infrastructure. Report within the EC FP7 project SUSPLAN, Available at: http://www.susplan.eu/fileadmin/susplan/documents/downloads/ regional_reports / D2.6_Report_Regional_Case_Study_South-Western_Europe.pdf

Committee on Climate Change (2008): Building a low-carbon economy – The UK's contribution to tackling climate change. Available at: http://www.theccc.org.uk/reports/building-a-low-carbon-economy

Contaldi, M., F. Gracceva, and G. Tosato (2007): Evaluation of green certificates policies using the MARKAL-MACRO-Italy model. *Energy Policy*, Vol. 35, pp. 797-808.

Dalton, G.J. and T. Lewis (2011): Metrics for measuring job creation by renewable energy technologies, using Ireland as a case study. *Renewable and Sustainable Energy Reviews*, Vol. 15, pp. 2123-33.

EC (2003): Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community.

EC (2005): New and updated budgetary sensitivities for the EU budgetary surveillance. European Commission, Directorate General for Economic and Financial Affairs. Available at: http://europa.eu/epc/pdf/budgetary_en.pdf.

EC (2006a): Action Plan for Energy Efficiency: Realizing the Potential. COM(2006)545.

EC (2006b): Directive 2006/32/EC on energy end-use efficiency and energy services.

EC (2007): A European Strategic Energy Technology Plan (SET-Plan). Technology Map. European Commission Staff Working Document SEC(2007) 1510 accompanying the Communication from the Commission to the Council, the European Parliament, the European Social and Economic Committee and the Committee of the Regions on the SET Plan.

EC (2007b): European Energy and Transport Trends to 2030. Update 2007. Available at: http://ec.europa.eu/dgs/energy_transport/figures/trends_2030_update_2007/energy_transport_trends_2030_update_2007_en.pdf

EC (2008a): Impact Assessment. Document accompanying the package of implementation measures for the EU's objectives on climate change and renewable energy for 2020. SEC(2008) 85/3.

EC (2008b): 2nd Strategic Energy Review. COM(2008)781.

EC (2009): EU energy trends to 2030. Update 2009. European Commission, DG ENERGY. Available at: http://ec.europa.eu/energy/observatory/trends_2030/index_en.htm.

EC (2009a): Directive 2009/29/EC amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading scheme of the Community.

EC (2009b): Directive 2009/28/EC on the promotion of the use of energy from renewable sources.

EC (2009c): Decision 406/2009/EC of the European Parliament and the Council on the effort of Member States to reduce their greenhouse gas emissions.

EC (2009d): Accompanying document to the SET-Plan – Impact Assessment. SEC(2009) 1297. Available at: http://ec.europa.eu/energy/technology/set_plan/doc/ 2009_comm_investing_development_low_carbon_technologies_impact_assessement.pdf

EC (2010): Excise duty tables – Tax Tax receipts for energy products and electricity. Available at: http://ec.europa.eu/taxation_customs/index_en.htm#

EC (2011): Communication from the Commission to the European Parliament and the Council on Renewable Energy – Progressing towards the 2020 target. COM(2011)31.

EC (2011b): Proposal for a Council Directive amending Directive 2003/96/EC restructuring the Community framework for the taxation of energy products and electricity. COM(2011)169/3.

Energy Information Administration (EIA, 1992): Federal energy subsidies: Direct and indirect interventions in energy markets.

European Climate Foundation (2010): Roadmap 2050. Available at: http://www.european climate.org/index.php?option=com_content&task=view&id=72&Itemid=79

European Environment Agency (EEA, 2004): Energy Subsidies in the European Union: A Brief Overview.

Eurostat (2010): Science, technology and innovation in Europe. Eurostat Statistical Books. Available at: http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-EM-10-001/EN/KS-EM-10-001-EN.PDF

Fischer, C. and L. Preonas (2010): Combining Policies for Renewable Energy. Is the Whole Less than the Sum of Its Parts? Discussion Paper. Resources for the Future. Available at: http://ssrn.com/abstract=1569634

Foxon, T.J. (2003): Inducing Innovation for a Low-Carbon Future: Drivers, Barriers and Policies. Report for The Carbon Trust.

Glachant, J.-M., R. Grant, M. Hafner, and J.d. Jong (2010): Toward a smart EU energy policy: Rationale and 22 recommendations. EUI Working Paper, RSCAS 2010/52.

Global Trade Analysis Project (GTAP) Database 7.1 (2004), Purdue University, http://www.gtap.agecon.purdue.edu/

Gorina, N. (2009): Carbon prices: pre and post 2012. Presentation at the Expert Meeting on Trade and Climate Change – Trade and investment opportunities and challenges under the CDM.

Goulder, L.H. (1995): Environmental taxation and the 'Double Dividend': A reader's guide. *International Tax and Public Finance*, Vol. 2, pp. 157-84.

Gracceva, F. and U. Ciorba (2008): Abatement cost curves by group of technologies by Italy. ETSAP Semi-annual Workshop. IEA – Paris. 3-4/07/2008. Available at: http://www.etsap.org/ Workshop/Paris_07_2008/7Gracceva-IEW2008.pdf

Hall, B.H. and J. Lerner (2009): The Financing of R&D and Innovation. NBER Working Paper 15325.

HM Government (2009): The UK low carbon transition plan: analytical annex. Department of Energy and Climate Change. Available at: http://www.decc.gov.uk/publications/basket.aspx? FilePath=White+Papers%5cUK+Low+Carbon+Transition+Plan+WP09%5c1_20090727143501_e_%40%40_uklctpanalysis.PDF&filetype=4

International Energy Agency (IEA, 2006): Carrots and Sticks: Taxing and Subsidising Energy. Note on Energy Subsidies and Taxes, Economic Analysis Division.

International Energy Agency (IEA, 2010): World Energy Outlook 2010. IEA/OECD, Paris.

International Energy Agency (IEA, 2010b): Coal Information 2010. IEA statistics/OECD, Paris.

Institute for European Environmental Policy (IEEP, 2007): Reforming Environmentally Harmful Subsidies, Report of the European Commission's DG Environment.

Jones, C. and J.-M. Glachant (2010): Toward a zero carbon energy policy in Europe: Defining a feasible and viable solution. EUI Working Papers, RSCAS 2010/17.

Kempfert, C. and T. Truong (2007): Impact assessment of emissions stabilization scenarios with and without induced technological change. *Energy Policy*, Vol. 35, pp. 5337-45.

Kitous, A. and P. Criqui (2009): POLES model: An integrated energy model (Some key insights from recent studies). Workshop on estimating GHG mitigation potentials and cost for annex I countries. IIASA, May 2009. Available at: http://www.iiasa.ac.at/rains/meetings/Annex1/ presentations/kitous.pdf

Kosonen, K. and G. Nicodème (2009): The role of fiscal instruments in environmental policy. CESIFO Working Paper N°. 2719.

Lehr, U., J. Nitsch, M. Kratzat, C. Lutz, and D. Edler (2008): Renewable energy and employment in Germany. *Energy Policy*, Vol. 36, pp. 108-17.

Loisel, R. (2009): Environmental climate instruments in Romania: A comparative approach using dynamic CGE modeling. *Energy Policy*, Vol. 37, pp. 2190-204.

Lu, Chuanyi, Qing Tong and Xuemei Liu (2010): The impacts of carbon tax and complementary policies on Chinese economy. *Energy Policy*, Vol. 38, pp. 7278-85.

Lutz, C. and B. Meyer (2010): Environmental tax reform in the European Union: Impact on $CO_2$ emissions and the economy. *Zeitschrift für Energiewirtschaft*, Vol. 34, pp. 1-10.

Martin, S. and J.T. Scott (2000): The Nature of Innovation Market Failure and the Design of Public Support for Private Innovation. *Research Policy*, Vol. 29, No. 4-5, pp. 437-447.

Mathiesen, B.V., H. Lund, and K. Karlsson (2011): 100% renewable energy systems, climate mitigation and economic growth. *Applied Energy*, Vol. 88, pp. 488-501.

Mckinsey (2009): Pathways to a Low-Carbon Economy. Version 2 of the Global Greenhouse Gas Abatement Cost Curve. Available at: http://www.mckinsey.com/clientservice/ sustainability/pathways_low_carbon_economy.asp

Mckinsey UK (2009): CBI climate change report 2007. Available at: http://www.mckinsey.com/ clientservice/sustainability/pdf/CBI_Climate_Change_Report_2007_McKinsey_appendix.pdf

Mckinsey Sweden (2008): Greenhouse gas abatement opportunities in Sweden. Available at: http://www.mckinsey.com/clientservice/sustainability/costcurves.asp

Mckinsey Germany (2007): Costs and Potentials of GHG abatement in Germany. Available at: http://www.mckinsey.com/clientservice/sustainability/costcurves.asp

Mckinsey Poland (2008): Assessment of GHG emissions abatement potential in Poland by 2030. Available at: http://www.mckinsey.com/clientservice/sustainability/costcurves.asp

Mckinsey CZ (2008): Costs and potentials for greenhouse gas abatement in the Czech Republic. Available at: http://www.mckinsey.com/clientservice/sustainability/costcurves.asp

Morris, J., S. Paltsev and J. Reilly (2008): Marginal abatements costs and marginal welfare costs for GHG emissions reductions: results from the EPPA model. MIT Joint Program on the Science and Policy of Global change. Available at: http://globalchange.mit.edu/files/ document/MITJPSPGC_Rpt164.pdf

Neuhoff, K., F.C. Matthes, et al. (2008): The role of auctions for emission trading. Report prepared by Climate Strategies. Available at: http://www.climatestrategies.org/reportfiles/role_of_auctions_09_oct_08final.pdf

Newbery, D.M., L. Olmos, S. Ruester, S.J. Liong, and J.M. Glachant (2011): Public Support for the Financing of RD&D Activities in New Clean Energy Technologies. A report for the European Commission, Directorate General Energy within the EC FP 7 project THINK.

Newbery, D.M. (2011): Financing research, development, demonstration and deployment of low-carbon energy. Working paper. University of Cambridge.

National Technical University of Athens (NTUA), E3MLab, The PRIMES model, European Consortium for modeling of Air Pollution and Climate Strategies.

Pazienza, M.G., G. Iannuzzi, and M. Massaro (2011): The impact of current climate and energy policies on the public budget of EU Member States. Working Paper. University of Florence. Available at: http://www.studistato.unifi.it/mdswitch.html

Parry, I.W.H., D. Evans, and W.E. Oates (2010): Do energy efficiency standards increase social welfare? Working Paper.

Pissarides, C. (2008): Assessment of macro economic transmission mechanisms of carbon constraints through the UK economy. Report for the Committee on Climate Change. Available at: http://www.theccc.org.uk/reports/building-a-low-carbon-economy/supporting-research

Porter, M.E. and C.v.d. Linde (1995): Toward a new conception of the environment-competitiveness relationship. *Journal of Economic Perspectives*, Vol. 9, pp. 97-118.

Rogge, K.S. and V.H. Hoffmann (2010): The impact of the EU ETS on the sectoral innovation system for power generation technologies – Findings for Germany. *Energy Policy*, Vol. 38, pp. 7639-52.

Sandmo, A. (2000): The Public Economics of the Environment.

Stankeviciutea, L., A. Kitousb, and P. Criqui (2008): The fundamentals of the future international emissions trading system. *Energy Policy*, Vol. 36, pp. 4272-86.

Stern, N. (2006): Stern Review: The Economics of Climate Change. PART III: The Economics of Stabilisation. Chapter 9: Identifying the Costs of Mitigation. Available at: http://webarchive.nationalarchives.gov.uk/+/http://www.hm-treasury.gov.uk/d/Chapter_9_Identifying_the_Costs_of_Mitigation.pdf

Strachan, N. and R. Kannan (2008): Hybrid modeling of long-term carbon reduction scenarios for the UK. *Energy Economics*, Vol. 30, pp. 2947-63.

Wei, M., S. Patadia, and D.M. Kammen (2010): Putting renewables and energy efficiency to work: How many jobs can the clean energy industry generate in the US? *Energy Policy*, Vol. 38, pp. 919-31.

Weitzman, M.L. (1977): Is the Price System or Rationing More Efficient in Getting a Commodity to Those Who Need it Most? *Bell Journal of Economics*, Vol. 8, pp. 517-24.

World Trade Organization (WTO, 1995): Agreement on Subsidies and Countervailing Measures", Art.1.

# Annexes

## Annex I: Studies Estimating the Closed Loop Impact of Climate Policies on GDP

Mitigating climate change, i.e. reaching a stabilization of GHG at a level of 500 to 550ppm, is expected to be feasible at a cost level of about 1% of global GDP in 2050 (with average estimates typically lower for 2020). Therefore, GDP impacts are not negligible, but "they are also not high enough seriously to compromise the world's future standard of living" (Stern, 2006, p. 240).[19]

Estimates vary strongly by analysis and scenario depending on the underlying assumptions made and the modeling approaches used (see Barker et al., 2006 for an in-depth meta-analysis). It can be expected that the impact on the global – or regional/ national – GDP will be lower for i) high technology development rates resulting from technology innovations and learning-by-doing; ii) high future fossil fuel prices; iii) high flexibility in abatement between sectors, technologies and GHGs; and last but not least iv) high productivity increases from revenue recycling. See Table 18 for a summary of selected studies.

## Annex II: Computation of Off-Budget Components

### Support to clean technology deployment

For an in-depth overview of clean technology deployment support instruments by EU Member States and technology see CEER (2011). The level of subsidies provided to immature technologies could be roughly estimated as the extra cost of their deployment compared to the use of alternative, cost-competitive technologies. Following this reasoning, we estimate the extra amount of deployment subsidies in the more ambitious Enhanced Policy scenario as the increase in system costs resulting from the use of new clean technologies.

In EC (2007) the extra amount of emissions abated with respect to a business-as-usual case reported in EC (2007b) is discussed and the extra system cost per unit of emissions abated that would result from the use of new clean energy technologies up to their economic potential. Using this information, we have computed the extra cost for the EU-27 resulting from the use of each technology in 2020 as the extra cost per unit of $CO_2$ abated using each technology times the annual amount of emissions avoided at that horizon.

To compute the amount of subsidies to be provided to each technology, we have subtracted from the extra system cost associated with the use of this technology the cost in the market of the extra carbon emissions that for higher-C technologies replaced by the former would otherwise have to be paid. The price of the corresponding emission allowances would have to be paid by technologies replaced, which are assumed to be of the same type as the ones at the margin. Hence, higher-C technologies enter the market at the sum of both production cost and the carbon price. The gap between this sum and the cost of new clean technologies would need to be covered through support payments.

The increase in the use of clean technologies up to their economic potential, which is the level of use considered in EC (2007), is much larger than that taking place in the Enhanced Policy scenario with respect to our Baseline. Thus, we have scaled down the estimate of extra system costs associated with the use of each

19 Various other studies conclude similarly that climate change mitigation is affordable (e.g. CCC, 2008; Busch, 2009; Strachan and Kannan, 2008; Lu et al., 2010). Barker et al. (2006) – providing a meta-analysis of the costs of mitigating climate change – similarly conclude that "the overall conclusion from the modeling literature is that even stringent stabilization targets can be met without materially affecting world GDP growth, at low carbon tax rates or permit prices, at least by 2030."

**Table 18**: Studies investigating the impact of climate policies on GDP

| Study | Climate policy restrictions | Estimates on GDP impact | Sensitivities and comments |
|---|---|---|---|
| Stern (2006)<br>Global scale | 550ppm stabilization | 2050: - 1% of GDP with a range of +1 to -3.5%<br>**2025: -0.7%** (-0.2 to -1.1%) | Costs lower with<br>* Optimistic technology case<br>* High future oil/gas prices |
| Stern (2006)<br>[literature review] | 500-550ppm stabilization | Expected impact of -1% of GDP by 2050 with a range of +/-3% | Models differ in:<br>* Assumed BAU level<br>* Technological change<br>* Flexibility between sectors/ technologies/ GHG gases and about where to abate<br>* When abatement takes place |
| ECF (2010)<br>EU-27 | <u>Decarbonization</u> (80% GHG reduction in EU-27 compared to 1990 by **2050**) compared to BAU with different RES scenarios (40, 60, 80%)<br>Baseline:<br>* Overall GDP: assumed to grow from €10 to 22 trillion<br>* GHG emissions: decreased by about 10% during last decade, assumed to stay relatively flat until 2050<br>* Climate policies: <u>status quo</u> remains (enhanced ETS, 20-20-20 policy package, incl. significant energy efficiency improvements; transportation efficiency targets; some CCS pilot projects | 1// **Direct GDP effect**: **negligible** (Difference in annual growth rates between the two scenarios less than 0.05% points p.a. → given uncertainties in 40-year projection this is not significant)<br>2020: zero<br>2050: +0.5 to +1%<br>2// **Technology developments** may have sustainable positive impact of **+0.5 to +1%** | * No material difference in macroeconomic impact across different RES scenarios (40%, 60%, 80%)<br>* Doubling of fossil fuel prices will cause a growth of GDP impact of between 0.3 and 0.5% by 2050<br>* Exports of clean technologies add ~€250 bn to GDP in 2010-2020 period |
| Strachan and Kannan (2008)<br>UK | 60% reduction by 2050 | Three energy price scenarios (central, low, high) → impact of -0.3 to -1.5% of GDP in 2050<br>Prior to 2030: slight GDP gains ($CO_2$ constraint only imposed in 2030) | This cost range comparable to zero to 2.5% of global GDP for 550ppm target |
| CCC (2008)<br>UK | Reduction GHG emissions by 80% below 1990 levels by 2050 | Resource cost modeling: impact of -0.28% of GDP in 2020<br>Macroeconomic model: GDP impact of -0.82% in 2020<br>CGE: impact of -0.25% of GDP in 2020 | Model 2 does not include any automatic mechanism for the economy to return to full resource use and therefore might include transitional effects<br>High fossil fuel price scenario reduces GDP impact |
| Contaldi et al. (2007)<br>Italy | BAU scenario with respect to RES vs. green certificate scenario, where there is an increase of RES obligation for producers up to 2020 to reach share of 7% in 2020 | Moderate impact on GDP of -0.05% p.a. | |
| Busch (2009)<br>US | Reduction scenarios:<br>i) 80% below 1990 level by 2050 (= cumulative emission allowance to 2050 of 167 Gt)<br>ii) Emissions capped at 2008 level (287 Gt) | Results from four modeling exercises for 2020:<br>Average impact 167Gt scenario: -2% from BAU GDP<br>Average impact 287Gt scenario: -0.19% | Models focus on costs (savings due to improved efficiency; only benefit component) |
| Busch (2009)<br>California | Return to 1990 levels by 2020 (legally binding) | 2020: Impact on GDP for three different CGE models between +0.15% and -1.4% | All three models reach target, difference in how is unclear from this meta-analysis |
| Lu et al. (2010)<br>China | Impact of carbon tax (different levels, different recycling mechanisms)<br>2050 perspective | 1// Different levels of carbon tax: GDP impact between -0.19% (~€5/t) and -1.1% (€33/t)<br>2// Case of ~€22/t<br>BAU: -0.74%<br>Recycling to industry: -0.71%<br>Recycling to HH: -0.67% | Revenue recycling decreases the negative effect on GDP |
| Barker et al. (2006)<br>**Meta-analysis**<br>Typically global models | Stabilizing $CO_2$ concentrations at 450, 500 and 550ppm levels | Global impact to 2100:<br>450: average -3.1% GDP change from baseline (range: -27.6 to +4%)<br>500: av. -0.9% (-15.8 to +4%)<br>550: av. -0.5% (-7.5 to 2.1%) | Reasons for differences in outcomes lie in assumptions and modeling approaches |
| | | **Results from meta-analysis:**<br>- Adoption of static CGE models: GDP becomes 0.8% larger with respect to average analysis<br>- Use of Kyoto mechanism (modeling of international trade in emission permits): GDP becomes 0.9% larger w.r.t. average analysis<br>- Introduction of backstop technology (unlimited substitution at high enough carbon prices): 0.5% larger than average analysis<br>- Allowing for climate change benefits (these are monetized and discounted): 0.5% larger than average analysis<br>- Allowing for non-climate benefits: 1% larger than average analysis<br>- Introduction of ITC: 2% larger than average analysis<br>- Recycling of additional revenues: 3.3% larger than average analysis | |

**Table 19**: Calculation of additional subsidies to the deployment of low-C technologies

| | Basis for calculation of extra system cost (based on EC, 2007) | | | | Baseline scenario in 2020 | | Difference Enhanced Policy scenario Baseline in 2020 | |
|---|---|---|---|---|---|---|---|---|
| | Extra cost of abatement | Extra amount of emissions avoided | Change in capacity assumed | Subsidies required | Use of technology | Subsidies required | Capacity difference | Extra subsidies required |
| | [€/t $CO_2$] | [Mt $CO_2$] | | [M€] | [GW installed] | [M€] | | [M€] |
| Wind | -5 | 0 to 100 | 120 GW → 120-180 | - | 172.3 | - | 172.3 GW →222.1 | - |
| PV | 240 | 30 to 60 | 9 GW → 65-125 | 9,900 | 38.9 | 4,376 | 38.9 GW → 48.64 (total solar) | 1,121 |
| CSP | 15 to 55 | 5 to 35 | 0 GW → 1.8 | 300 | 1.8 | 200 | 1.8 GW → 1.8 | - |
| Solar heat/cooling | 270 to 330 | 4 to 30 | 52 GWth → 90-320 | 4,760 | 69.2 | 2,115 | No reference | **539** |
| Large hydro | 25 | 3.5 to 15 | 100 GW → 101-108 | 45 | 113.4 | - | 113.4 GW → 114.2 (both large and small) | **5.8** |
| Small hydro | 5 to 10 | 0.5 to 7.5 | 14.5 GW → 14.5-18 | - | - | - | Increase of 0.224 GW | 0 |
| Geothermal | 0 to 100 | 15 to 35 | 1 GWe → 1-6 | 750 | 0.82 | 205 | 0.82 GW → 1.4 | 174 |
| Ocean wave | 70 to 150 | 10 to 15 | 0.9 GWe → 5-10 | 1125 | 1.64 | 264 | 1.64 GW → 3.62 | 338 |
| CHP | 15 to 30 | 50 to 85 | 160 GWe → 165-185 | 169 | 132.5 | - | 71.98 Mtoe (heat),17.6% electricity from CHP → 72.88 Mtoe & 18.4% | **67.8** |
| Zero emission fossil fuel power plants | 30 | 20 to 120 | 0 GWe → 5-30 | 700 | 10.5 | 2101 | No change | - |
| Nuclear fission | -5 | 55 to 160 | 114 GWe → 127-150 | - | 123.6 | - | 123.6 GW → 123.3 | - |
| Nuclear fusion | N.A. | N.A. | N.A. | - | - | - | - | - |
| Electricity networks | N.A. | 20 to 30 | 1% less losses | N.A. | N.A. | - | 459 TWh → 443 (losses) | N.A. |
| Bio-fuels | 150 to 160 | 15 to 40 | 24 Mtoe →32-45 | 3,713 | 22 | 5,438 | 22 Mtoe → 29.6 | 1,953 |
| H2/FC (only passenger cars) | 475 | 5 | 0 → 1.5% | 2,275 | - | - | - | - |
| Total subsidies | - | - | - | 23,736 | - | 12,809 | - | 4,198 |

clean technology in EC (2007) to match the increase in the use of clean technologies necessary to meet 2020 objectives under the Enhanced Policy scenario.

Table 19 illustrates the process we have followed to determine the extra amount of required support payments to clean technologies. For each new clean technology it provides the extra system cost per unit of carbon abated, the amount of carbon emissions avoided, and the overall amount of support payments to be provided if the respective technology would be used up to its economic potential. We provide the nominal level of support payments estimated to be provided in 2020 in the Baseline scenario as well as the additional support payments needed in the Enhanced Policy scenario based on changes in the installed capacity.[20] The overall amount of extra support payments expected to be necessary is about €4.2bn.

The overall amount of extra subsidies has been allocated to Member States proportionally to the increase in their use of the different technologies expected to take place in the Enhanced Policy scenario in 2020 (see Table 20).

20 Only supply side technologies and networks have been considered because major clean demand-side technologies (energy efficiency) are either already cost competitive by 2020 or are not mature enough to be deployed according to projections in the Enhanced Policy scenario.

**Table 20**: Additional deployment subsidies in the Enhanced Policy scenario compared to the Baseline

| [M€] | PV | | Solar heating/ cooling | | Hydro | | Geothermal | | Ocean | | CHP | | Biofuels | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Baseline | Increase | Base | Incr. | Base | Incr. | Base | Incr. | Base | Incr. | Base | Incr. | Base | Incr. | Base | Incr. | % GDP |
| EU-27 | 4,376 | 1,121 | 2,115 | 539 | - | 5.76 | 205 | 174 | 264 | 338 | 200 | 68 | 5,438 | 1,953 | 12,809 | 4,198 | 0.030 |
| Austria | 28.28 | 1.21 | 296.07 | 16.26 | - | 0.567 | 0.22 | 0.25 | - | - | 1.29 | 134.15 | 126.23 | 24.64 | 452.10 | 177.08 | 0.057 |
| Belgium | 18.35 | 2.69 | 20.51 | 3.86 | - | - | - | - | - | - | 0.84 | -48.25 | 140.31 | 78.54 | 180.00 | 36.83 | 0.009 |
| Bulgaria | 5.54 | 1.68 | 2.26 | 0.88 | - | - | 0.18 | 1.03 | - | - | 0.25 | 97.19 | 14.08 | 18.48 | 22.32 | 119.27 | 0.344 |
| Cyprus | 9.27 | 2.69 | 60.01 | 22.35 | - | - | - | - | - | - | 0.42 | 0.34 | 4.45 | 3.08 | 74.15 | 28.47 | 0.127 |
| Czech R. | 21.79 | 0.00 | 11.67 | 0.00 | - | - | - | - | - | - | 1.00 | 20.19 | 114.62 | 34.14 | 149.07 | 54.33 | 0.035 |
| Denmark | 5.45 | 3.03 | 33.97 | 24.22 | - | 0.005 | - | - | - | - | 0.25 | -62.63 | 77.81 | 17.71 | 117.48 | -17.66 | -0.007 |
| Estonia | 0.19 | 0.13 | 0.14 | 0.13 | - | 0.005 | - | - | - | - | 0.01 | -7.53 | 8.40 | 3.08 | 8.74 | -4.18 | -0.027 |
| Finland | 7.17 | 0.40 | 2.71 | 0.20 | - | 0.518 | - | - | - | - | 0.33 | 206.02 | 54.59 | 25.92 | 64.80 | 233.06 | 0.116 |
| France | 471.45 | 60.78 | 139.38 | 23.04 | - | - | 15.36 | 18.29 | 62.71 | 32.71 | 21.55 | 109.51 | 744.55 | 220.47 | 1454.99 | 464.79 | 0.022 |
| Germany | 1,741.90 | 261.89 | 826.88 | 159.42 | - | - | 14.34 | 14.78 | - | - | - | -317.92 | 1137.82 | 251.27 | 3748.31 | 369.43 | 0.014 |
| Greece | 171.51 | 60.44 | 289.03 | 130.61 | - | 0.295 | 1.51 | 3.71 | - | - | 7.84 | -11.29 | 81.52 | 53.64 | 551.41 | 237.41 | 0.082 |
| Hungary | 7.36 | 0.00 | 4.14 | 0.00 | - | - | 2.47 | 1.36 | - | - | 0.34 | 30.46 | 76.58 | 19.51 | 90.88 | 51.32 | 0.045 |
| Ireland | 2.29 | 0.34 | 5.68 | 1.07 | - | - | 3.88 | 5.73 | 16.08 | 26.41 | 0.10 | 5.82 | 60.28 | 44.91 | 88.30 | 84.27 | 0.038 |
| Italy | 578.85 | 57.75 | 110.15 | 14.09 | - | - | 115.27 | 21.98 | - | - | 26.45 | -255.64 | 635.11 | 256.65 | 1484.71 | 94.84 | 0.006 |
| Latvia | 0.76 | 0.13 | 0.51 | 0.12 | - | - | - | - | - | - | 0.03 | 18.14 | 16.55 | 3.85 | 17.86 | 22.24 | 0.128 |
| Lithuania | 1.43 | 1.62 | 0.31 | 0.45 | - | - | - | - | - | - | 0.07 | 8.21 | 20.01 | 6.67 | 21.82 | 16.95 | 0.056 |
| Luxembourg | 6.88 | 0.47 | 1.61 | 0.14 | - | - | - | - | - | - | 0.31 | -10.61 | 40.27 | 17.71 | 49.07 | 7.71 | 0.016 |
| Malta | 4.97 | 0.34 | 2.54 | 0.22 | - | - | - | - | - | - | 0.23 | - | 0.74 | 1.03 | 8.48 | 1.58 | 0.023 |
| Netherlands | 11.85 | 1.68 | 52.56 | 9.57 | - | - | 2.11 | 1.55 | 0.32 | 3.24 | 0.54 | -110.54 | 149.45 | 61.60 | 242.20 | -32.90 | -0.005 |
| Poland | 0.96 | 0.54 | 26.60 | 19.22 | - | - | - | 2.62 | - | - | 0.04 | 811.75 | 232.95 | 117.03 | 286.74 | 951.17 | 0.234 |
| Portugal | 149.25 | 146.12 | 26.45 | 33.20 | - | 0.356 | 8.55 | 5.96 | 18.01 | 26.41 | 6.82 | -44.49 | 83.00 | 25.15 | 292.08 | 192.71 | 0.107 |
| Romania | 11.08 | 2.62 | 5.56 | 1.69 | - | - | 0.52 | 0.52 | - | - | 0.51 | -137.23 | 41.75 | 20.28 | 59.42 | -112.13 | -0.083 |
| Slovak R. | 2.87 | 0.00 | 8.01 | 0.00 | - | - | - | 1.15 | - | - | 0.13 | 25.67 | 31.62 | 22.59 | 42.63 | 49.40 | 0.067 |
| Slovenia | 4.59 | 0.00 | 9.16 | 0.00 | - | 0.204 | - | 0.59 | - | - | 0.21 | -29.09 | 42.74 | 23.36 | 56.70 | -4.94 | -0.011 |
| Spain | 1,087.47 | 513.22 | 122.60 | 74.19 | - | 0.722 | 0.02 | 40.59 | - | 0.17 | 129.30 | -79.05 | 748.25 | 228.17 | 2102.00 | 778.01 | 0.061 |
| Sweden | 7.26 | 0.40 | 28.45 | 2.03 | - | 2.770 | - | - | - | - | 0.33 | -381.58 | 125.98 | 35.42 | 162.03 | -340.96 | -0.090 |
| UK | 17.49 | 1.08 | 27.67 | 2.18 | - | 0.322 | 40.58 | 53.92 | 166.9 | 248.57 | 0.80 | 96.16 | 628.20 | 338.27 | 980.24 | 740.51 | 0.031 |

## Energy infrastructure investments

Changes to required infrastructure investments may represent a non-negligible part of the impact on of the implementation of climate policies on the economy. Large upgrades of electricity transmission grids are deemed to be necessary to cope with very high penetration levels of RES. The impact on distribution costs is deemed to be mixed, since infrastructure investments required to make the grid smarter are substantial but the installation of large shares of distributed generation (DG) and the activation of demand could contribute to locally balancing demand and generation and thus avoid investments in lines and transformers. Distribution infrastructure requirements are in any case deemed to depend much on the specific features of the area considered and the regulation in place affecting the development of the grid. Finally, investments in gas infrastructures are expected to decrease as a consequence of the expected reduction in the demand for natural gas.

According to most analyses and in line with current practices in most systems, energy infrastructure in-

**Table 21**: Additional infrastructure cost in 2020 [Enhanced Policy - Baseline scenario]

| [M€ p.a.] | Electricity transmission | | | | Electricity distribution | Gas infrastructure |
|---|---|---|---|---|---|---|
| | Off-shore | Interconnection | Back-up generation | Total | | |
| EU-27 | 786.1 | 1,087.3 | 1,683.7 | 3,557.1 | 376.15 | -522.04 |
| Austria | - | 28.2 | - | 28.2 | 4.95 | -20.82 |
| Belgium | 22 | 23.5 | 107.5 | 153 | 7.33 | -20.58 |
| Bulgaria | 14.6 | - | - | 14.6 | 2.92 | -3.21 |
| Cyprus | 9.8 | - | - | 9.8 | 0.24 | 0.00 |
| Czech R. | - | 4.7 | 35.8 | 40.5 | 1.01 | -6.83 |
| Denmark | 19.5 | 32.9 | 71.6 | 124.1 | 5.75 | -4.43 |
| Estonia | 12.2 | 14.1 | - | 26.3 | 1.77 | -0.54 |
| Finland | 17.1 | 89.4 | 35.8 | 142.3 | 11.02 | -5.77 |
| France | 100.1 | 136.5 | 143.3 | 379.9 | 34.99 | -88.09 |
| Germany | 105 | 108.3 | 322.4 | 535.6 | 75.14 | -81.23 |
| Greece | 14.6 | 18.8 | - | 33.5 | 11.28 | -10.85 |
| Hungary | - | 18.8 | 71.6 | 90.5 | 1.89 | -10.01 |
| Ireland | 12.2 | 9.4 | - | 21.6 | 8.56 | -11.97 |
| Italy | 26.9 | 70.6 | - | 97.5 | 57.00 | -72.91 |
| Latvia | - | - | - | - | 0.63 | -4.80 |
| Lithuania | - | 28.2 | - | 28.2 | 0.77 | -4.04 |
| Luxembourg | - | 4.7 | - | 4.7 | 0.30 | -1.05 |
| Malta | 7.3 | - | - | 7.3 | -0.02 | -0.01 |
| Netherlands | 39.1 | 108.3 | 71.6 | 219 | 5.59 | -15.24 |
| Poland | 17.1 | 9.4 | 35.8 | 62.3 | 6.58 | -10.78 |
| Portugal | 12.2 | 18.8 | - | 31 | 9.07 | -12.39 |
| Romania | 17.1 | - | - | 17.1 | 2.18 | -7.66 |
| Slovak R. | - | 9.4 | 35.8 | 45.2 | 1.64 | -4.10 |
| Slovenia | - | 14.1 | - | 14.1 | 1.52 | -1.69 |
| Spain | 39.1 | 75.3 | - | 114.4 | 41.14 | -57.41 |
| Sweden | 14.6 | 113 | 107.5 | 235.1 | 17.10 | -5.37 |
| UK | 285.6 | 150.6 | 644.8 | 1,081.1 | 65.82 | -60.23 |

vestments should probably be financed mainly by energy consumers through electricity and gas tariffs. Besides, there are already plans for the EU to fund a fraction of strategic infrastructures contributing to the integration of different regions in Europe and that of large amounts of RES generation. Hence, the fraction of total new infrastructure requirements expected to be afforded using national public funds is deemed to be quite low. As a consequence, we have decided not to consider infrastructure costs in the computation of the impact of climate policy on State budgets.

In this section we provide an estimate of the additional energy infrastructure requirements in the Enhanced Policy scenario with respect to the Baseline. This represents the largest expense that the State would have to face in the unlikely case that it became a major funding contributor to the development of energy networks.

Table 21 provides an estimate of the extra main energy network infrastructure costs deemed to be incurred in the Enhanced Policy scenario. Increases in electricity transmission costs are much larger than those in electricity distribution or decreases in gas transmission. Overall, the former amounts to about €3.5bn annually at the EU level, while the latter two are expected to almost cancel out, each being smaller than €500M. The most important infrastructure needs in electricity transmission are in the UK (almost one third of the total for Europe) and, at some distance, Germany and France (€535M and €380M, respectively). This has to do with the installation of large amounts of RES in these countries, which will be associated with large infrastructure investments, as in the case of the UK, where a large part of the RES generation installed will be off-shore wind that needs to be connected to the main grid on-shore.

Estimates of unit electricity transmission infrastructure needs per unit of RES installed and gas transmission infrastructure per unit of gas demand have been computed from information published in CE (2010), while those of unit electricity distribution infrastructure costs per unit of DG installed have been obtained from Comillas (2010). Increases in RES generation and gas demand in the Enhanced Policy scenario with respect to the Baseline, which have been employed to scale up unit costs previously computed, have been obtained from EC (2009).

## Annex III: Graphical Representation of the Individual Impacts

This Annex includes a graphical representation of results obtained for all individual impacts of new climate policies on public budgets distinguishing between the low, medium and high abatement cost futures whenever the three of them have been considered.

**Figure 5**: Revenues from carbon pricing

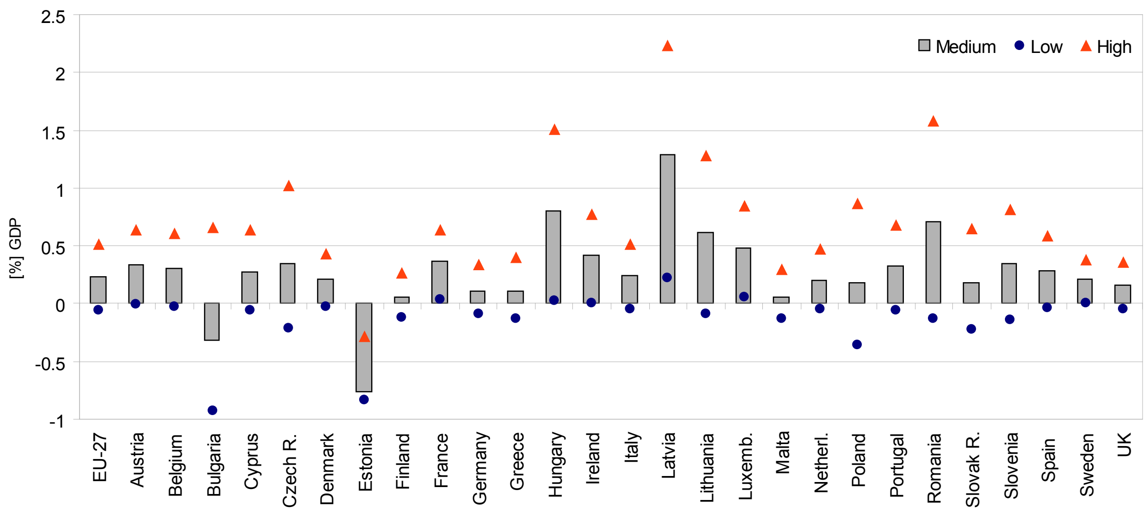



**Figure 6**: Impact on GDP

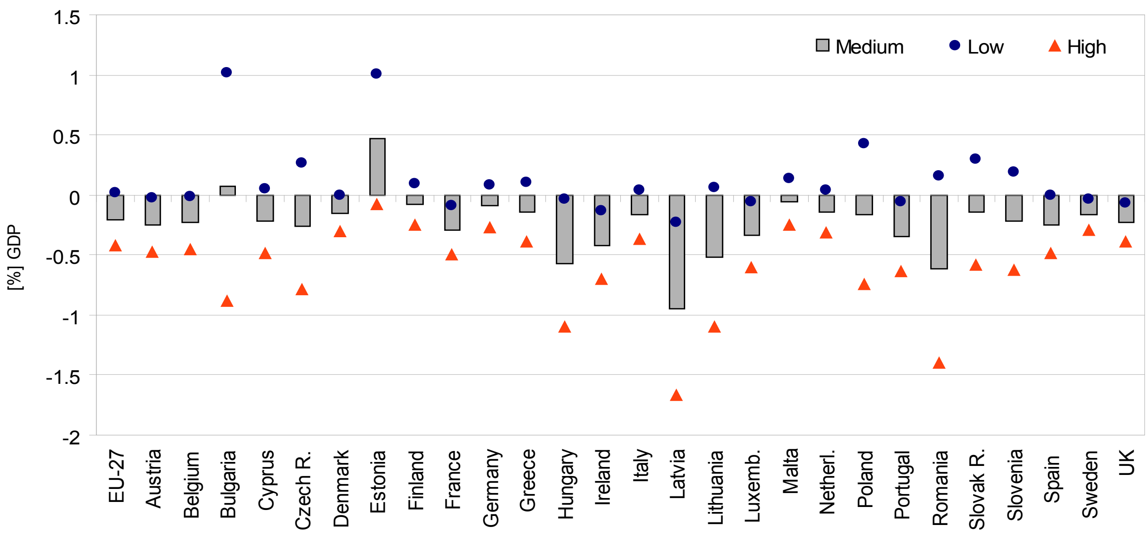


**Figure 7**: Change in general tax revenues from climate policy driven changes to the GDP

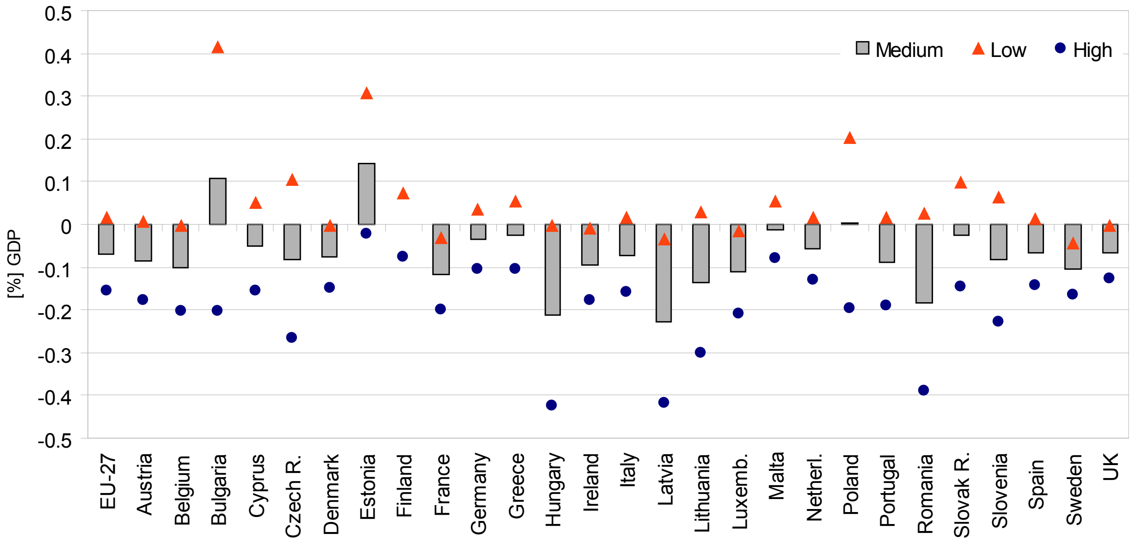



**Figure 8**: Change in general State expenses from climate policy driven by changes to the GDP

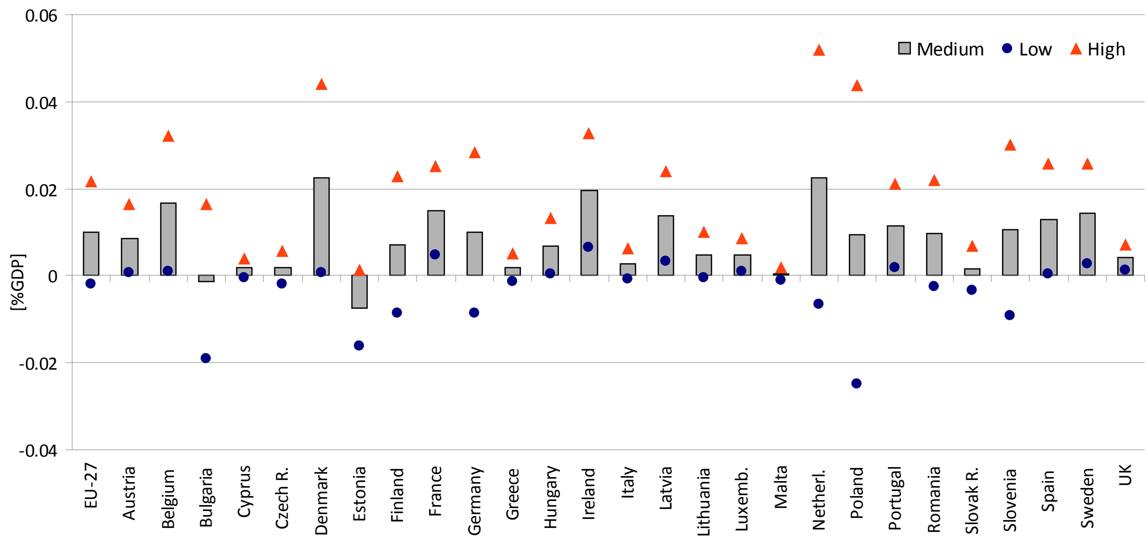


**Figure 9**: Changes in subsidies for fossil fuels

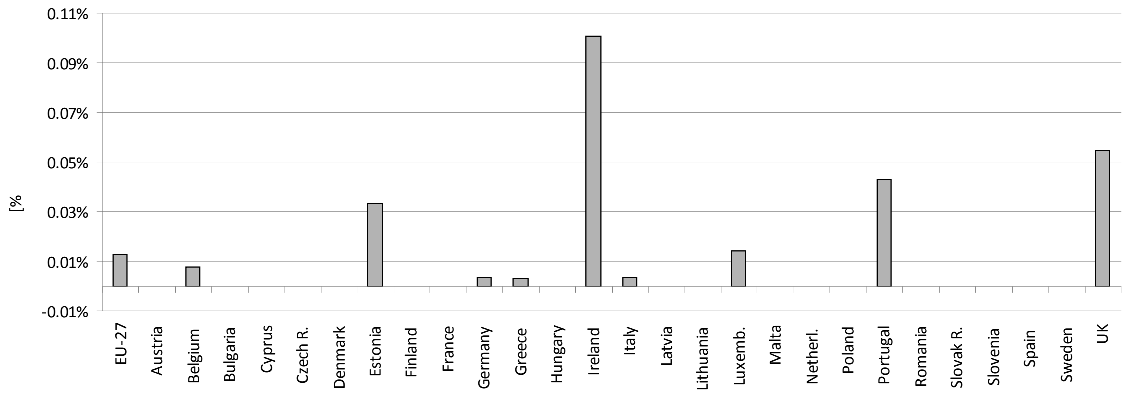
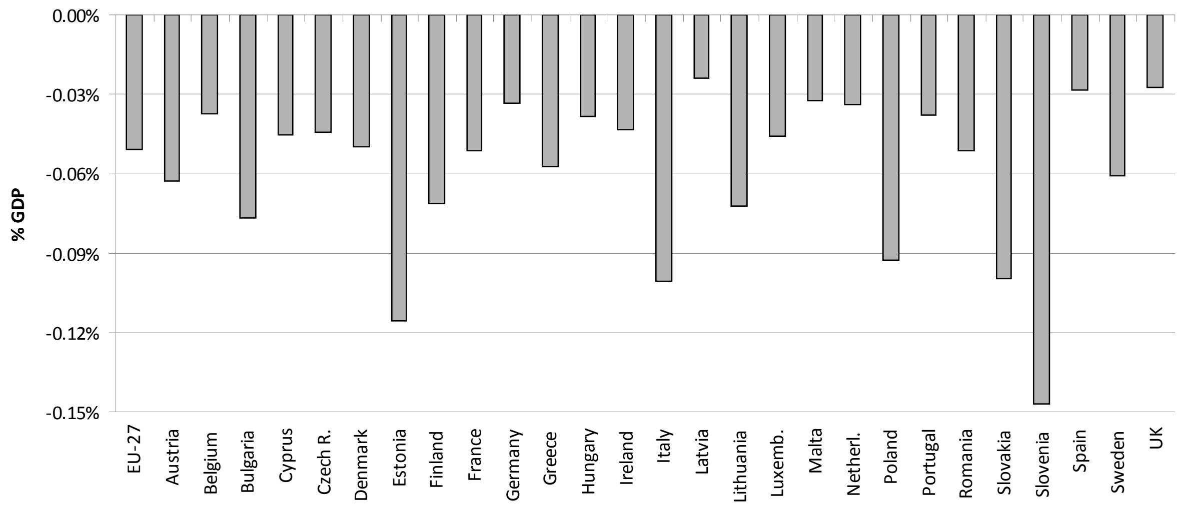



**Figure 10**: Changes in fossil fuel excise tax revenues




## 6.

## 7.

## Annex IV: Data Sources and Main Assumptions

This Annex presents a detailed list of the sources of data we have used to carry out our analysis. A description of main assumptions made is also provided.

**Table 22**: Data sources used within the impact assessment

| Component | Data sources | Main assumptions |
|---|---|---|
| Carbon pricing | GHG emissions in ETS and non-ETS sectors: EC (2009)<br>Carbon price levels in the Baseline and Enhanced Policy scenarios of the low-price storyline: EC (2009)<br>Carbon price levels for medium- and high-abatement cost storylines: Own calculation based on literature review and assumptions<br>National VAT rates: Excise duties table EC<br>GDP in 2020: EC (2009) | In 2020, auctioning of 100% of allowances for the electricity sector and 70% for other ETS sectors.<br>Carbon pricing only in ETS for Baseline vs. unique carbon price (i.e. allowance price ETS = carbon tax applied in non-ETS sectors) for Enhanced Policy scenario.<br>Standard VAT rate applies to auctioning revenues as well as on top of carbon tax.<br>Differences among carbon prices in the different futures are the same as those among carbon abatement costs. |
| Subsidies clean technology deployment | Extra system cost per unit of emissions abated using low-C technologies up to their economic potential: EC (2007)<br>Change in technology use between Baseline and Enhanced Policy scenario: EC (2009)<br>GDP in 2020: EC (2009) | Estimate of extra system cost has been scaled down according to expected additional employment of the different technologies in Enhanced Policy scenario as compared to Baseline.<br>Allocation of overall EU-wide extra amount of subsidies to MSs proportional to local increase in the use of the respective technologies. |
| Subsidies clean technology RD&D | Innovation financing needs over the next decade to realize SET-Plan goals: EC (2009d)<br>GDP in 2020: EC (2009) | Private share in RD&D investments likely to decrease.<br>Any policy scenario aimed at achieving 2020 objectives should also pave path for 2050.<br>Public sector contributions to RD&D proportional to their GDP. |
| Change in GDP | Average unit carbon abatement costs for extra amounts of carbon abated in the Enhanced Policy scenario with respect to Baseline: Various sources from literature<br>GHG emissions in ETS and non-ETS sectors: EC (2009)<br>National carbon intensities in 2020 Enhanced Policy scenario: EC (2009)<br>GDP in 2020: EC (2009) | Isolated effect of climate policies on the budget; no revenue recycling considered.<br>Three major components: i) substitution of high-C products with low-C ones; ii) funds drawn from or injected into the economy through climate policy; iii) public expenses on clean innovation.<br>Clustering of carbon abatement cost levels in countries into 3 groups according to economies' carbon intensity. |
| Change in State revenues and expenses resulting from changes to GDP | National levels of fiscal pressure: EC (2010b), Taxation Trends in EC (2005)<br>GDP in 2020: EC (2009)<br>State revenue and expense elasticities taken from EC (2006) | Fiscal pressure equal for both scenario and not differing from current levels.<br>Elasticities of tax revenues and State expenses with respect to GDP assumed to be those applicable to the GDP gap. |
| Subsidies paid for production of fossil fuels (on-budget) | Overall amount of subsidies to the production of fossil fuels in the EU in the year 2001: EEA (2004)<br>Fossil fuel production: EC (2009), PRIMES model; IEA (2010)<br>Subsidies for the coal sector: GTAP7.1 database, EEA (2004)<br>GDP in 2020: EC (2009) | Overall fossil fuel production subsidies in 2001 (most recent data) have been distributed proportionally to level of coal subsidies reported in GTAP database.<br>Changes in state expenses proportional to changes in the fossil fuel production. |
| Subsidies for consumption of fossil fuels (off-budget through reduced VAT) | Fossil fuel consumption: EC (2009), PRIMES model<br>Subsidies for fossil fuel consumption: EEA (2004), IEEP (2007)<br>GDP in 2020: EC (2009) | Overall consumption subsidies proportional to those corresponding to the application of reduced VAT to household consumption.<br>Changes in state expenses proportional to changes in fossil fuel consumption. |
| Excise tax revenues from fossil fuels | Fossil fuel consumption levels in each scenario: EC (2009), PRIMES model<br>State revenues from taxes on fossil fuel consumption: EC (2010)<br>GDP in 2020: EC (2009) | Implicit tax rates in 2020 kept constant (equal to the values of 2008). |

## Annex V: Analytical Setting

In this annex, we outline the reasoning and assumptions behind this analysis, its structure and the sources of data employed. Our analysis aims to estimate the impact on public budgets in the year 2020 of those climate policy instruments whose implementation was decided from the year 2009 on. We do this by comparing public revenues and expenses in a Baseline scenario with those in a more ambitious Enhanced Policy scenario where 2020 policy objectives are met.

The remainder of the annex is structured as follows. First, we describe in detail the two climate policy scenarios (as reported in EC, 2009) and the set of possible future situations that we are considering. Second, we describe the different effects of climate policy on State budgets. Finally, we explain the main features of the process followed to compute numerical results.

### A) Description of policy scenarios and carbon abatement cost futures

The Baseline scenario takes into account the strengthened ETS and legislation related to energy efficiency in place in April 2009. In the Enhanced Policy scenario both targets for GHG and RES in 2020 are met through the implementation of additional measures, namely carbon pricing in non-ETS sectors and further efficiency regulations.

State revenues and expenses in both scenarios are influenced by factors not closely related to climate policies and whose future evolution is highly uncertain. Among the main conditioning factors are fossil fuel prices and the rate of development of clean technologies. Therefore, instead of computing a single value for State revenues and expenses in each of the two policy scenarios considered, we have computed a range of values aimed to be representative of different combinations of non-climate-policy related conditioning factors. Three different futures have been considered.

**"Baseline" policy scenario**

The Baseline scenario takes into account those climate policies whose implementation was decided before April 2009. These include:

– The revised and strengthened ETS (Directive 2009/29/EC) allowing for a total CDM amount of 1,600 Mt.

– The full implementation of the 2nd Internal Market Package by 2010 and of the 3rd Package by 2015 concerning the creation of a fully liberalized market regime for electricity and gas.

– Legislation on energy efficiency including different eco-design implementation measures (being gradually applied up to their full implementation in 2030), the Labeling Directive 2003/66/EC, Directive 2006/32/EC on end-use energy efficiency and services and the Buildings Directive 2002/91/EC.

– Different pieces of legislation addressing aspects of energy markets and power generation (e.g. Directive 2001/80/EC on large combustion plants), energy taxation, or the transportation sector (e.g. Regulation 2009/443/EC on $CO_2$ emissions from cars; or the Biofuels Directive 2003/30/EC – with targets typically to be achieved gradually).

Other measures included relate to the support for the deployment of clean technologies, mainly national measures addressing RES such as feed-in tariffs, quota systems, green certificates, subsidies or cost incentives in other forms. National decisions on nuclear phase out are taken into account.[21] Direct public

21 Nuclear investments are possible in Bulgaria, the Czech Republic, France, Finland, Hungary, Lithuania, Romania,

financial support of CCS demonstration facilities[22], off-shore wind and clean R&D in low-C technologies have been considered as well. Infrastructure projects under TEN-E[23] are supposed to be undertaken. The ETS has been modeled such that emissions in these sectors – benefiting from the maximum allowed amount of CDM credits – meet the cumulative emission cap over the period 2008-2030.

**"Enhanced Policy" scenario**

The Enhanced Policy scenario includes additional instruments which have been adopted from 2009 on and shall result in the achievement of 2020 legally binding targets on overall GHG emission reductions and RES deployment. These include:

– Additional energy efficiency legislation, namely four eco-design regulations, a recast of the Energy Performance and Buildings Directive 2010/31/EU and regulations on labeling;

– Directive 2009/28/EC mandating the achievement of the 20% RES share in gross final energy consumption target including the sub-target of a 10% RES share in transport fuels. Some flexibility among Member States in achieving RES targets is allowed;

– Decision 2009/406/EC on the sharing of efforts in GHG reduction is included. Hence, the 20% GHG reductions target is met via the full implementation of ETS provisions (as in the baseline) as well as by reaching national non-ETS targets.

We have considered carbon pricing measures applied in both scenarios as being additional to existing taxes on fossil fuels.

**Carbon abatement cost futures**

The future evolution of several factors conditioning the impact of climate policies on public budgets is uncertain. These include fossil fuel prices and the rate of clean technology development. We assumed that the level of these factors is reflected in the cost of abating carbon. Three possible futures for carbon abatement costs, namely "low-", "high-", and "medium carbon abatement cost" futures, have been defined.

The level of carbon abatement costs is related to the amount of funds to be transferred between low- and high-C technologies. Carbon prices together with other support policies aim to close the gap between the net market profits of high-C and low-C products and services. The net market profit of a product is the difference between its market value and the cost of producing it. Carbon prices and other support policies compensate market agents for the costs incurred when abating carbon, thus, encouraging them to use clean technologies.

We have assumed that changes in carbon abatement costs among the different future situations considered affect carbon prices but not the level of public support payments. The application of carbon prices improves the competitive position of clean technologies regardless of their maturity and proportionality to their level of emissions. Thus, they are suitable to

Slovakia, Slovenia and Spain. The following plans on new nuclear capacities have been considered: Bulgaria (1 GW by 2020 and 2025 each), Finland (1.6 GW 2015), France (1.6 GW by 2015 and 2020 each), Lithuania (800 MW by 2020 and 2025 each), Romania (706 MW by 2010, 2020 and 2025), Slovakia (880 MW 2015).

22 The following CCS facilities have been taken into consideration: Germany 950 MW (450MW coal post-combustion, 200MW lignite post-combustion and 300MW lignite oxy-fuel), Italy 660 MW (coal post-combustion), Netherlands 1460 MW (800MW coal post-combustion, 660MW coal integrated gasification pre-combustion), Spain 500 MW (coal oxy-fuel), UK 3400 MW (1600MW coal post-combustion, 1800MW coal integrated gasification pre-combustion), Poland 896 MW (306MW coal post-combustion, 590MW lignite post-combustion).

23 See http://ec.europa.eu/energy/infrastructure/tent_e/ten_e_en.htm for more information on Trans-European energy networks (TEN-E).

close the cost gap between the most economic clean technologies and the high-C cost-competitive alternatives. This gap depends on the rate of development of clean technologies, which we have deemed to be common to all of them, and the price of fossil fuels, which conditions the cost of high-C technologies. Therefore, underlying factors affecting the evolution of carbon prices are the same as those driving differences in carbon abatement costs.

Support payments to clean technologies are aimed at encouraging the use of less mature clean technologies by closing the cost gap between these and more mature clean alternatives. If we assume a common rate of development for all clean technologies, the cost gap between clean technologies within the same activity should generally not be significantly affected by main factors characterizing the futures considered (fossil fuel prices, technology evolution rate). There may be some degree of substitutability between clean technologies used in different activities, but we cannot take it into account within our analysis.

Furthermore, we assume that nominal changes in carbon prices among the different abatement cost futures are the same for both scenarios. This is coherent with assuming a common rate of development for the most efficient clean technologies employed in both policy scenarios and another rate common to all high-C technologies in both scenarios as well. It also implies that changes in fossil fuel prices must affect equally the cost of all high-C technologies per unit of carbon emissions produced.

Based on these assumptions, we have jointly estimated the values of carbon abatement costs and carbon prices in the two scenarios for each of the three considered carbon abatement cost futures. Therefore, not only carbon abatement costs, but also carbon prices have been considered as input for our analysis. Strong simplifying assumptions about the relationship between changes in carbon abatement costs and those in carbon prices have been made since it was out of the scope of this study to simulate the functioning of the economy for the two scenarios in the different futures. A description of the three carbon abatement cost futures considered and the corresponding carbon abatement costs and carbon prices follows:

1. *Low carbon abatement cost future*: High fossil fuel prices and rates of development of clean technologies lead to a small difference between the net market benefits produced by high- and low-C products. Values assumed for carbon abatement costs and prices are as follows:
   - Carbon abatement costs: In the range of €0-45/ $tCO_2$ with different values applying to the different EU countries.
   - Carbon prices: In the Enhanced Policy scenario, the global carbon price considered is €10/$tCO_2$. In the Baseline scenario, the price in ETS sectors is €25/$tCO_2$. No carbon tax or similar instrument is considered within non-ETS sectors.

2. *Medium carbon abatement cost future*: Medium fossil fuel prices and rates of development of clean technologies lead to a competitiveness gap which is larger than that of the previous scenario but still moderate. Hence, we have considered:
   - Carbon abatement costs: In the range of €15-60/$tCO_2$ with different values applying to the different EU countries.
   - Carbon prices: In the Enhanced Policy scenario, the global carbon price considered is €25/ $tCO_2$. In the Baseline scenario, the price in ETS sectors is €40/$tCO_2$. No carbon price is applied in non-ETS sectors.

3. *High carbon abatement cost future*: Low fossil fuels and rate of development of clean technologies lead

to a large gap between the cost of high- and low-C products. Levels of carbon abatement costs and carbon prices considered are:

- Carbon abatement costs: In the range of €30-75/t$CO_2$ with different values applying to the different EU countries.
- Carbon prices: In the Enhanced Policy scenario, the global carbon price considered is €40/t$CO_2$. In the Baseline scenario, the price in ETS sectors is €55/t$CO_2$. No carbon price applied in non-ETS sectors.

### B) Types of effects considered

Climate policies impact the public budget in two different ways. First, they **directly impact** the budget by creating new public revenue and expense streams (in the sense that they follow directly from "new" policies). Second, they **indirectly impact** the public budget by affecting decisions by economic agents on the use of resources, which has an impact on the base and average rates of main State taxes and expenses.

Direct impacts of climate policy instruments on the public budget analyzed include revenues from carbon pricing and expenses associated with the development of new clean technologies. Indirect impacts we consider are of two main types. First, we have changes to State revenues and expenses from excise taxes and on-/off-budget subsidies that are associated with the change in the level of fossil fuel production and consumption triggered by climate policy. Second, the application of climate policies affects the level of the GDP, which impacts the tax base, tax rates and different public social expenses such as unemployment subsidies.

Subsidies directly or indirectly affected by climate policy may be of two main types: on and off-budget. Off-budget subsidies (or support payments) can, in turn, be classified into two main types. i) the so called "hidden subsidies", which are not directly affecting public accounts because they are afforded by consumers through an increase in the tariffs they pay (and which from a legal perspective are not subsidies); and ii) those that are directly affecting State revenues and expenses but are not reflected in the public budget because they correspond to foregone State revenues, e.g. in the form of reduced tax levels.

We have not considered the first type in our analysis, since they are not directly affecting State revenues and expenses and their indirect effect on State revenues through a change in consumers' decisions is difficult to estimate. On the other hand, we did take into account those off-budget subsidies corresponding to reduced tax rates applied by States on some products or services directly related to the application of climate policy. Subsidies of this type have a clear impact on State revenues that can be quantified more easily than that of hidden subsidies. See Box 3 for a more detailed description of the different types of subsidies.

### C) Data input and central assumptions

**Main modeling assumptions**

Strictly speaking, an accurate computation of the impact of climate policy on revenues and expenses of EU Member States requires determining – for each scenario and carbon abatement cost future – the functioning of the economy in general and of the energy sector in particular using complex simulation models. This is beyond the scope of this project. Thus, results on main State revenue and expense streams computed are based on advanced back-of-the-envelope computations making use of publicly available data. This implies that the choice of the policy scenarios considered has been constrained by data availability. It also implies that we have only been able to assess the impact of climate policies on the output of the economy using estimates from external analyses

**Box 3: Different types of subsidies**

There is not a common and shared definition of "subsidy". Some possible ones follow:

- "any government action that concerns primarily the energy sector that lowers the cost of energy production, raises the price received by energy producers or lowers the price paid by energy consumers" (IEA, 2006).
- "any government action designed to influence energy market outcomes, whether through financial incentives, regulation, research and development or public enterprises" (EIA, 1992).
- "a 'subsidy' exists when there is a 'financial contribution' by a government or a public body that confers a 'benefit'. A 'financial contribution' arises where: (i) a government practice involves a direct transfer of funds (e.g. grants, loans, and equity infusion), potential direct transfers of funds or liabilities (e.g. loan guarantees); (ii) government revenue that is otherwise due is foregone or not collected (e.g. fiscal incentives such as tax credits); (iii) a government provides goods or services other than general infrastructure, or purchases goods; or (iv) government entrusts or directs a private body to carry out one or more of the above functions. A 'benefit' is conferred when the 'financial contribution' is provided to the recipient on terms that are more favorable than those that the recipient could have obtained from the market" (see "WTO Agreement on Subsidies and Countervailing Measures", Art.1).

All these definitions include not only direct financial transfers from the government to producers or consumers, but also those services directly undertaken by the public sector and all those measures which support a certain sector or activity without explicitly incurring a public outlay. Furthermore, some studies have stated that, for the energy sector in particular, other types of implicit support should be taken into account including the limitation of civil liability for nuclear accidents, provided by the Paris (1960) and Vienna (1963) Conventions and by the Joint Protocol (1988), and, in general, the lack of measures imposing external costs on the energy sector operators that could be deemed responsible for them (see e.g. EEA, 2004).

Government subsidies in the energy sector can be classified into on- and off-budget subsidies. **On-budget subsidies** include those interventions that appear as outlays in the general government balance-sheet. **Off-budget subsidies** represent cash transfers to industry and households that are either not identified as a subsidy in the Government's accounts or not reflected in these accounts at all, even when they may have some economic impact on the public budget. This category includes tax exemptions and tax arrears, support payments financed through consumer tariffs or benefits provided through market regulation (e.g. reduced VAT rates for fuel products). Off-budget subsidies may be financed by consumers within certain sectors through an uplift in the level of regulated tariffs or correspond to foregone State revenues mainly in the form of reduced tax rates.

of the unit social cost of the decarbonization of each system (carbon abatement costs).

The work in EC (2009) is the only publicly available one we have found simulating the functioning of the energy sectors of EU Member States under different climate policy packages. However, EC (2009) only considers carbon prices in the low range of those projected in other works. Therefore, we took values of carbon prices in EC (2009) as those corresponding to our low carbon abatement cost future. Based on these prices and information in the literature, we have estimated the level of carbon abatement costs in this future as well as abatement cost and carbon price levels in the two other futures considered. Specifically, differences in carbon prices (both in ETS and non-ETS sectors) among futures, both in the Baseline and Enhanced Policy scenarios, have been assumed to be of the same nominal value as those in abatement costs.

Due to the fact that data on fossil fuel production and use in each system and policy scenario are also published only for the low-C abatement cost future, we have assumed the same level and distribution of the use and production of fossil fuels in our three futures.

Our analysis does not consider the recycling of revenues and the sourcing of expenses resulting from the implementation of climate policy. However, we must make an assumption on which of the costs associated with climate policies will be financed from general tax revenues (thus directly affecting the public budget) and which are to be financed through surcharges in consumer tariffs (and therefore are not directly affecting the public budget). We have assumed that climate policy expenditures will be financed from the same sources in 2020 as they are today in most systems (the most common option today is assumed to be adopted by all systems in 2020).

Once those climate policies financed through the public budget have been identified, we focus on the effect of the stand-alone application of these policies on State budgets. Considering revenue recycling would imply that a number of further State policies not related to climate or energy would have to be considered together with new climate and energy policy measures. Then, the overall impact on public budgets of all these policies would be revenue neutral, i.e. public revenues from climate would be reinvested somewhere else in the economy, while expenses would have to be financed through an increase in revenues or debt, or a decrease in other public expenses.[24]

Given that we are not discussing the sourcing of public funds and recycling of public revenues, we cannot assess either the impact that the application of climate policies will have on the distribution of income within the society. The welfare of households and firms is critically conditioned by the allocation of costs and revenues of policies.

Finally, information in EC (2009) on the expected functioning of the energy system in the EU countries in the year 2020 does not include the set of taxes on fossil fuels expected to be applied. Hence, we have regarded carbon pricing measures considered in our analysis as additional to taxes on fossil fuels, which are deemed to have the same level as those currently applied. In reality, taxes of different types levied on high-C products will probably be merged into a single one, which may include two components, one related to the energy content, and another to GHG emissions.

24 Recycling of additional revenues can mitigate the negative impact of higher production cost due to e.g. carbon pricing (see e.g. Pissarides, 2008; Cambridge Economics, 2008); the literature here also talks about the so called "double dividend of environmental taxation" (see e.g. Sandmo, 2000). The net effect depends on whether the welfare gain from recycling (through e.g. a reduction in existing distortionary taxes) exceeds the welfare loss from higher energy prices.

## Data used as an input to our analysis

Values for main macroeconomic variables and parameters characterizing the energy sector in the Baseline and Enhanced Policy scenarios for the low carbon abatement cost future have been obtained from the prospective analysis regularly published by the European Commission on the likely evolution of the energy sector under several climate policy regimes (EC, 2009). In this EC analysis, the partial equilibrium model PRIMES and the general equilibrium model GEM-E3 are employed to compute the equilibrium of the energy system and the whole economy, respectively.

However, information published does not include data needed to estimate some of the main components of State revenues and expenses. Missing information that has been obtained from additional sources include: i) carbon abatement costs, ii) the level of investments required in RD&D of low-C technologies, iii) the productivity, or capital-output ratio, of activities being drained of funds and those being subsidized through new climate policies applied; iv) elasticities of State revenues and expenses with respect to changes in GDP; v) implicit excise tax rates applied to fossil fuels, and vi) on- and off-budget subsidies applied.

Main input variables considered in our analysis and the sources of data we have employed are provided in Annex IV. Carbon abatement costs and prices considered for the medium- and high abatement cost futures have been provided at the beginning of this annex. Box 4 summarizes the analysis presented in EC (2009), which is our main source of information. It also includes a discussion of its main results that have had input in our study.

**Box 4: External modeling of the economy under the two scenarios that our analysis is based upon**

The analysis in EC (2009) has been carried out by a consortium led by the National Technical University of Athens (E3MLab). It is based on the use of model PRIMES to simulate the functioning of the energy sector, which has been developed by the E3MLab. Input data used by PRIMES have been produced with the help of external models, like GEM-E3 (computation of projections of the value added per branch of activity) and PROMETHEUS (computation of projections of world energy prices). Results produced in EC (2009) include the evolution of main variables of the energy sector for the EU as a whole and each of its 27 Member States both in the Baseline and the Enhanced Policy scenarios for the low carbon abatement cost future that we consider up to 2030.

**Description of the PRIMES and GEM-E3 models**

**PRIMES** is a modeling system that simulates a market equilibrium solution for energy supply and demand in the EU-27 and its individual Member States. The model determines the equilibrium by finding the prices of each energy form such that supply matches demand. The market equilibrium is computed for different time periods. The simulation of the functioning of the energy system is dynamic over time. The model is based on assumptions about the rational behavior of agents in the system. However, it also represents in an explicit and detailed way available energy demand and supply technologies and pollution abatement technologies. The modeling approach followed includes considerations about market economics, industry structure, energy/environmental policies and regulation, which may all influence the market behavior of energy system agents. PRIMES is structured in modules representing the distribution of decision making among agents that act individually regarding their supply, demand, combined supply and demand, and prices. The market module of PRIMES subsequently simulates market clearing.

Macroeconomic data corresponding to the whole economy has been computed with **GEM-E3**, an applied general equilibrium model aiming at covering the interactions between economy, energy system and environment. GEM-E3 simultaneously computes the competitive market equilibrium under Walras' law (prices are computed as a result of supply and demand interactions in the markets) and determines the balance for energy demand/supply and emissions/abatement. The model explicitly formulates the supply and demand behavior of economic agents regarding production, consumption, investment, employment and allocation of their financial assets.

**Discussion of external modeling results**

Analyses conducted in EC (2009) for both scenarios rely on the same macroeconomic, demographic and fossil fuel price assumptions. Projections of the evolution of the economy, population and fossil fuel prices are exogenous to the different scenarios, taking into account the recent economic crisis. Economic growth for the past decade is set at 1.2% p.a., while the projected rate for the period 2010 to 2020 is deemed to be 2.2% p.a. (i.e. the EU-27 GDP increases from €10,100 bn to €14,164 bn). Economic growth projections differ by Member State. Whereas countries in northern and central Europe are more affected by the recession and economic recovery is deemed to take relatively long, "new" Member States are expected to recover faster. For southern economies long-term prospects on GDP growth are slightly lower than the average. The European population is forecasted to reach 513.8M people in 2020 with a growth rate of 0.3% p.a. over the next decade. GDP per capita is expected to increase in the long-term at an average rate below 2% p.a. (in real terms). World fuel prices are projected to increase over the period 2010-2020 with oil prices reaching a level of $88/bbl in 2020 ($106/bbl in 2030). Gas prices are assumed to develop in line with oil prices and reach $62/boe in 2020 ($77/boe in 2030), and coal is expected to be traded at $26/boe in 2020 ($29/boe in 2030) on international markets (all in 2008 values).

Results computed for the **Baseline** show that EU-27 GHG emissions would decrease by 14% with the largest part of the reduction in energy-related $CO_2$ emissions occurring in the ETS sectors. ETS carbon prices drive CCS investments; power generation capacity equipped with carbon capture facilities increases up to 5.4 GW in 2020. Electricity prices increase which in turn result in lower consumption supporting emission reduction. The share of RES in gross final energy demand is projected to increase to 14.8% in 2020, with a RES share in transport of 7.4%.

The emission allowance price in the **Enhanced Policy scenario** is lower than that in the Baseline, resulting from the implementation of RES support policies and additional legislation supporting the deployment of highly efficient technologies. The calculated shadow value for carbon emissions originating from the non-ETS sector is lower than the ETS allowance price since abatement opportunities in non-ETS sectors include a large number of energy efficiency measures that are deemed to be already cost competitive by 2020. EU-27 GHG emissions in the Enhanced Policy scenario decrease by 20.3% with respect to 1990 levels. The emission reduction target is met internally without any use of CDM. Emissions decrease faster than in the Baseline scenario up to 2020 since both emission reduction and RES targets have to be met. Afterwards, this decrease becomes less steep resulting in a convergence of the carbon intensity of the economy in both scenarios by 2030. However, it is the stock (and not the flow) of GHG what matters for climate protection and hence, the Enhanced Policy scenario is environmentally superior. With respect to CCS, only already advanced demonstration plants are realized until 2020 because carbon prices in this modeling exercise do not to provide strong enough investment incentives. Electricity prices do not change substantially compared to the Baseline scenario because lower allowance auctioning expenditures as well as lower fuel and variable costs compensate for higher capital costs related to the larger amount of energy produced from RES. The share of RES in primary energy consumption amounts exactly to 20% in 2020 with 10% for the transport sector.

## Annex VI: Industrial Council Meeting – Summary discussion on robustness of preliminary project results

Responsible: **Serge Galant**, Technofi
Submission date: March 2011

### The question

What is the impact of the EU climate and energy policies on the public budget of each Member State?

### The tentative answer

The Council agreed on climate and energy targets to be met by 2020 in 2007 (the so called "20-20-20 targets"). Implementing actions to reach such targets will require national policies, which may affect Member State revenues and expenses. It is proposed to use "back-of-the-envelope" calculations in order to obtain orders of magnitudes for the resulting changes in revenues and expenses, using a combination of the PRIMES and GEM-E3 modelling results implemented by the EC in a recent publication.[25]

### Clarity improvements

The following improvements are proposed in the new version of the report.

- A new section is needed detailing the underlying assumptions onto which the baseline and reference scenarios are built and compared. More convincing strength to the report can be brought by comparing the assumptions in both scenarios, and by recalling the working assumptions of PRIMES and GEM-E3, which would in turn help avoiding sterile debates on the sense of the figures presented in the report. "Back-of-the-envelope" should lead trends in revenue and expenss changes when implementing the action plans required to meet EU policy objectives at national level.
- A table recalling the main answers brought by the "back-of-the-envelope" calculations for each Member State and giving a "back-of-the-envelope" explanation for each Member State would help understanding the sense of the results (including the specific position of the new Member States).
- The models allow to link fuel prices with GDP. It seems that no such links have been made between carbon pricing and GDP. Is there any chance to

25 Communication from the Commission to the European Parliament and the Council on Renewable Energy-Progressing towards the 2020 target (COM (2011)31)

isolate a section where the role of assumptions on carbon prices is examined?

- A section on the feedback of the proposed answers to the initial EU policies is relevant: it would show why and how initial EU policies and implementation plans should be modified in order to make the decarbonisation targets more realistic because of the changes in revenues and expenses within the Member States.

**Completeness improvements**

- One of the main issues raised by the intensive use of feed-in tariffs is the following: (i) actual feed in tariffs lead to extra costs of renewable electricity which are charged to all the consumers of electricity (almost every household in EU-27), (ii) another path would be to use tax payer money to pay for such extra costs. Both have pros and cons: they impact the state budget (revenues and expenses) differently. A section is needed to address this issue (also called 'hidden subsidies').
- Further study should look into the impact of taxation on GDP, provided that "back-of-the-envelope" calculations allow extracting such influences.
- The 2020 targets are still about 10 years away from where this report stands. There is evidence of fuel prices influence on long term fuel consumption. Can this effect be taken into account (long term decrease of fuel consumption due to sharp rises in fuel prices), which would impact the whole set of criteria for which people choose or not to go for less carbon intensive energy resources?
- Assuming that the basic assumptions of the "back-of- the-envelope" calculations have been underlined, is it possible to give trends induced by changes in assumptions onto the conclusions of the report? (Are the present results insensitive (or robust) to changes in assumptions made to perform the "back-of-the-envelope" calculations?)

**Coherence improvements**

- The role and impacts of R&D investments (and not "expenditures"!) might appear incoherent with the conclusions of the THINK report published early 2011 on "Funding innovation about low carbon energy systems".
- Assuming that the results appear robust enough, what are the climate and energy policy implementation consequences when looking both at Member State and EU-27 level?
- Carbon taxing has distributional effects: they should be addressed in the new version of the report.

## Annex VII: Comments by Project Advisors – Based on a preliminary version of the report

Project Advisor I: **Pantelis Capros**,
Professor at NTUA – E3MLab/ICCS
Submission date: April 2011

The lengthy report is a very good effort to make a synthesis and quantify effects from published scenarios by the EU. Remarks for improvement:

EU ETS auction payments apply from 2013 onwards (not for 2020 as stated). The use of 50% of revenues for climate policies support is at the discretion of MS, according to my understanding. There is a strange situation with this provision: as most EU economies face high public deficits, the ministry of finance has interest to get maximum revenues from ETS and so not to incite energy market players to undertake extensive decarbonisation (mainly in power generation); but the energy consumers (electricity buyers) have interest from seeing extensive decarbonisation, which will increase costs incurred by power producers but will decrease auction payments; hence the optimal degree of decarbonisation (in power sector) is not the same from the perspective of public finance and from the perspective of electricity consumers. Concrete example: failure of RES deployment until 2020 is of interesting for public finance but not interesting for consumers paying electricity prices (with passing through auction payments). **I recommend mentioning this paradox in the report.**

Regarding carbon taxes (on non ETS), raising such taxes on top of other taxation (excise taxes on fuels) is rather rare and unlikely to take place in the future. The current policies mainly envisage reform of taxation structure with new rates partly or totally reflecting carbon pricing. Examples are excise taxation on fuels, car ownership taxes, accessibility charges, etc. The impact on public finance is questionable as the reform may be revenue neutral. **I propose to simplify the corresponding section in the report, based on the above.**

The EU is preparing a new draft taxation directive with the spirit of reflecting carbon pricing in the reform. **The report should mention it.**

The section on public support to technologies is lengthy and a bit confusing. In my knowledge, the majority of cases of public support to technologies (mainly for RES) are neutral for public finance, because the mechanisms include cost recover from consumers or from suppliers. There are few cases with subsidies financed by public budget. **I propose to simplify and change the emphasis (showing the importance of self cost-recovering mechanisms). An exemption to be maintained is for R&D (public support must continue).**

The section on indirect impact on public budgets is written in an academic style but in a very vague way without visible practical outcomes. For me it is confusing and should be rewritten in a simpler and pragmatic way. I also think I missed there some of the main issues:

The main economy-wide effects of decarbonisation policies in Europe come from the substitution of (mainly) imported energy commodities (fossil fuels) by non-energy goods and services, which at a large extend are domestically produced. Saving energy means paying more for insulation and other similar investments and for purchasing more advanced appliances and equipment (which are more expensive in capital terms than ordinary technology) and saving on the fuel bill. Decarbonizing in power generation means again paying more for capital (RES, grids, CCS, nuclear and so on) and less for fuels. Saving on the imported energy bill and spending more on domestic goods and services is, *ceteris paribus*, beneficial for public revenues (more revenues from VAT and other indirect taxes on non-energy goods and services). However, substituting fossil fuels, especially substituting oil in transport (electrification, biofuels, etc.) is detrimental to public revenues; the same applies on all savings of fossil fuels. This is the main effect on public budget, which dominates over the additional revenues from VAT and taxes on non-energy products, and so the net balance is negative for public budget. An interesting issue is what part of the missing revenues will be covered by the new sources of revenue, such as the EU ETS and possible additional carbon taxes. Another very important issue is that until now the price elasticity of gasoline/diesel and other energy products was low allowing public finance policies to raise high excise tax levels on these products and get public revenues with sufficient assurance. But when de facto replacing these revenue sources with carbon oriented taxes and EU ETS, revenues are no longer assured because by definition decarbonisation will decrease carbon intensity hence will decrease public revenues. **The above paragraph summarizes the major policy issue with decarbonisation and its interference with public budget policies. I am not sure that the report mentions this major and central issue.**

The decarbonisation policy may have depressive effects on economic activity (and GDP). This is a controversial issue. Negative effects may arise as the net cost of getting energy services increases (net means after taking into account more capital spending and less fuel spending), if compared to the average cost of energy services based on the previous model of importing fossil fuels. The higher cost for energy has a crowding out effect on the economy, exerts pressures on capital and labor markets (because the decarbonisation is more capital and labor intensive) and may propagate inflationary effects which undermines competitiveness in foreign trade. However, with additional considerations the negative effect on economic activity may turn into a positive one: if the EU economy departs from a situation with labor markets having unused resources (unemployment) and capital markets having possibilities to expand (because of currently insufficient investment), the decarbonisation would have a positive Keynesian effect on the economy and employment; if the sectoral productivities and the technology level of equipments and services improves as a consequence of decarbonisation then the economy would benefit from competitive advantages in the world market for such equipments and services (this may be non linear if the sufficiently wide EU market achieves high productivity gains and economies of scale in producing the new goods that will enable decarbonisation, like PVs, wind mills, electric cars, efficient appliances, etc.); saving on the imported energy bill has an additional benefit as insurance against future volatility of imported energy prices. **It is advisable to mention the above in the session on indirect impacts on public budget stemming from possible depressive effects of decarbonisation on GDP.**

The most significant economic gain from decarbonisation is the avoidance of future climate change. This will have detrimental effects on public budget, firstly because of the highly depressive effects on GDP and activities (see Stern report) and because of the costly adaptation measures, which mostly will be financed by the public budget (new public works, protection measures, payments to indemnify for extreme weather consequences, etc.). Of course these public budget losses will take place later in time, than possible losses for decarbonisation and climate change mitigation. **This issue is not mentioned in the report.**

On section 4.2.2 and the sub section on subsidies to technology deployment: I do not agree with the approach and the implicit assumption that the "subsidies" are charged on public budget. Beside few exceptions, there is no cost for public budget because of self cost-recovery mechanisms (through electricity prices). The so-called subsidies are then additional costs to consumers, the term subsidies not being appropriate.

Direct subsidies paid from public budget may exist in some countries, such as tax exemptions, direct capital subsidies (few cases), state guarantees and the recent CCS fund. These should be accounted for explicitly. The difference in generation costs cannot be interpreted as a subsidy, because both the feed-in tariff systems and the RES obligation or RES certificate systems have self cost-recovering mechanisms. **I recommend changing this section**

I have big problems with section 4.3 (except 4.3.3) both regarding the methodology (MAC curves) and the outcome. Recommending an alternative approach is out of scope of this short note. I also do not understand why unemployment would decrease!

**Final remark:** The whole quantitative analysis was based on the Baseline and Reference scenarios as published in the EU Energy Trends to 2030 – update 2009. The second scenario corresponds to the EU Climate Action and Energy Policy package, but the first one (the baseline) is not a good basis for comparisons, because it includes the full EU ETS mechanism and at a lesser degree other policies. It is not a scenario without climate and energy policy actions. The baseline scenario, not including other measures of the Reference one such as the renewables and additional energy efficiency measures, show high ETS carbon prices as the EU ETS is binding and the other measures do not contribute for lowering emissions.

Project Advisor II: **Christian von Hirschhausen**,
Professor at TU Berlin & DIW Berlin
Submission date: April 2011

As one of the scientific advisors to THINK on the report „The Impact of Climate and Energy Policies on the Public Budget of EU Member States" I have participated both in the experts meeting with the Industrial Council as well as in the Scientific Committee. In the following, I summarize the issues raised live at these meetings.

The objective of the report is to analyse the fiscal impacts of climate policies in the European context, and to identify areas with particularly strong effects. There is an interesting methodology developed, that looks at the climate intensity of nations and sectors; however, the calculations upon which the results are then based are somewhat biased by the methodology. Thus, abatement costs negatively affect GDP, and the support to low-carbon technologies also has a negative short-term effect in the perspective of 2020. Both assumptions are not necessarily plausible. The report in its second version now contains an explanation why the approach was chosen! However, here, too, a stronger and profound argumentation would be useful, including the theoretical background.

It is not totally clear on what the "Baseline" is based, which may be linked to the fact of the underlying model used (PRIMES modeling exercises and assumption behind them). In particular, in the first versions of the report there was a very straight relation between carbon pricing, GDP, and the fiscal impact. This has been relaxed slightly in the V1-version, where it was recognized that the relation between GDP and carbon is subject to a host of theories on macro-economic relations, and that the link between abatement and GDP is all but linear. I also appreciate the broader discussion of causality that entered the V1 version, in particular the discussion on GDP increases when going from "dirty" to "clean" economy (Acemoglu and Aghion – "green growth theory"). The authors are now more aware that they should consider a medium- (not short-) term perspective, and arguments in that direction have been strengthened.

Distributional issues are addressed, though not fully with respect to pricing. It might have been useful to include a "Ramsey argument" (i.e. you should tax the most inelastic demand); thus, taxing through a carbon price could be efficient even though not fair; the trade-off between efficiency and fairness needs to be taken into account in policy, too.

The results are presented in a detailed manner, and at three digits specific. This overshoots the way results can be interpreted, since after all we are dealing with a "back-of-the-envelope" approach.

What can be conclusions for European policy? There will be winners/loosers; actually, distributional issues are one main reason why we have the EU. Carbon pricing is the dominant effect on state budgets, other – and especially indirect – effects are negligible. There are significant differences between the countries, in particular in the "new" Member States (e.g. Bulgaria and Estonia), that need to be taken into account. Overall, the finding that climate policy can be financed "on average" is plausible, but there is a need for distributive policies to maintain the political consensus, e.g. a type of burden sharing agreement.

Overall, climate policies can be financed relatively easily, but the distributional effects need to be taken into account; there is a broad consensus on this result, both in the stakeholder community and in the academic council, and thus the report provides an important input to the further discussion at the EU and at the member level.

## THINK

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EC project officers: Sven Dammann and Norela Constantinescu (DG ENER; Energy Technologies & Research Coordination Unit; Head of Unit Christof Schoser)
Project coordination: Jean-Michel Glachant and Leonardo Meeus
Steering board: Ronnie Belmans, William D'haeseleer, Jean-Michel Glachant, Ignacio Pérez-Arriaga
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## Contact

**THINK**
Advising the EC (DG ENERGY) on Energy Policy
http://think.eui.eu

FSR coordinator: Annika.Zorn@eui.eu
Florence School of Regulation

RSCAS – European University Institute
Villa Malafrasca
Via Boccaccio 151
50133 Firenze
Italy

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