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Economic Evaluation of Climate Protection Measures in Germany

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ABSTRACT: The paper builds on a study "Policy Scenarios for Climate Protection VI". In the Current Policy Scenario (CPS) all measures which have been implemented by July 8 2011 are considered. In the Energy Transformation Scenario (ETS) additional measures are included to reach the climate targets of the German government until 2030. Both policy scenarios build on the same socio-economic assumptions and just differ by climate protection measures. Investment in climate protection will reduce energy consumption in the long term and shift it towards low or zero carbon energy carriers. Scenarios are implemented in the model PANTA RHEI. Results of more ambitious climate protection measures are positive: Annual gross domestic product will be 25 to 30 billion Euros higher in the ETS compared to the CPS. Positive employment impacts are in the range of 200 thousand additional jobs. Energy efficiency improvements increasingly contribute via reduced energy imports in the long term.

Keywords: Climate mitigation; energy efficiency; economy-energy-environment model; economic impacts
JEL Classifications: C54; C67; Q43

1. Introduction

Energy efficiency measures and the promotion of renewable energy sources are the two main pillars of the European energy strategy. The German government decided in autumn 2010 on a new energy concept (BMU, BMWi, 2010). “Energy policy is facing enormous challenges: the bulk of our energy is to come from renewable sources by the middle of the century. At the same time, Germany is to remain a competitive business location. This requires the complete restructuring of our energy system” (BMWi, 2012). Key components of this energy concept were 8 to 14 years lifetime expansion for nuclear power plants and measures to foster energy efficiency and renewable energy. On the demand side, i.e. concerning energy efficiency, insulation of buildings is the most important of a number of measures. For the electricity sector, the continued expansion of partly intermittent renewable energy sources, such as wind and photovoltaic generation, calls for new market design. Due to the strong increase in PV capacity between 2010 and 2012 this has become a pressing issue for German energy policy. Feed-in-tariffs for renewable energy sources will remain at least until 2020, but are to be adjusted to improve market integration of renewables and limit electricity price increase.

The central targets of the new energy concept are to reduce greenhouse gas emissions by 40% by 2020 and 80-95% by 2050 (compared with 1990 levels). By 2020, the share of renewables in final energy consumption is to reach 18%, and then gradually increase further to 60% by 2050. The share in electricity production is to reach 80% by 2050. Concerning energy efficiency, the new energy concept aims to reduce primary energy consumption by 20% by 2020 and 50% by 2050 compared to 2008. In the light of the Fukushima Daiichi nuclear disaster in March 2011, the German government decided to phase-out nuclear energy until 2022. On the basis of the energy concept adopted in 2010, the Federal Government laid the ground in the summer of 2011 with a comprehensive package of legislation. The government has established an annual monitoring process (BMWi, BMUB, 2014), which is reviewed by a group of independent experts (Löschel et al., 2014). Recent results indicate that Germany is on track to meet renewables targets in the power sector, but lagging behind concerning efficiency, particularly in the heating sector. Additional measures are currently discussed to fill at least part of the gap.

The results presented in this paper are based on a study on the „Economic evaluation of climate protection measures and instruments for different policy scenarios." Detailed policy scenarios have been developed in the study "Policy Scenarios for Climate Protection VI" (Matthes et al., 2013), published by the German Environmental Agency in March 2013. These scenarios are reported as official national GHG projections to the UNFCCC. They are the basis for the model analysis of economic impacts of climate protection measures. The policy scenarios cluster the description of policy measures in two scenarios: In the Current Policy Scenario (CPS) all measures which have been implemented by July 8 2011 are considered. In the Energy Transformation Scenario (ETS) additional measures are taken into account to reach the climate targets of the German government until 2030. For the economic valuation of measures the two scenarios ETS and CPS are compared.

The main results of the scenarios with regard to energy and emissions developments are described in Matthes et al. (2013): In the CPS compared to the reference year of 1990, a 34 % reduction of the emissions of greenhouse gases is achieved by 2020. By 2030 the emissions are reduced by 44 %. Primary energy consumption in Germany decreases by 9 % by 2020 and by 19 % by 2030 compared to 2008. In the ETS additional measures bring about an emission reduction of approx. 42 % by 2020 and of more than 58 % by 2030 (compared to 1990). Primary energy consumption in Germany decreases in this scenario by approx. 16 % by 2020 and by approx. 32 % by 2030 compared to 2008.

A main challenge of the modeling approach is to consider the overall economy wide effects of improved energy efficiency together with a detailed analysis of the technical change that drives the energy efficiency improvements and the specific investment decisions of economic agents. Traditionally, models are specialized on one of these aspects. Either they consider economy wide effects and relations (top-down models) or they are explicit about the technologies and their dynamics (bottom-up models). As a result of the shortcomings of both approaches, either hybrid models that combine both aspects or soft links of both model types are increasingly used in recent years. Here results of detailed bottom-up models (Matthes et al., 2013) are implemented in a top-down model.

In contrast to former research on renewable energy (Lehr et al., 2008, 2012) the paper presents recent results of economy-wide impacts of adopted and planned climate mitigation measures with a focus on energy efficiency in Germany. It is organized as follows: In section 2 concepts to measure costs and benefits of climate mitigation measures are described. The macro-econometric input-output model PANTA RHEI, which is applied to compare costs and benefits of scenarios ETS and CPS in section 3, is also introduced in section 2. In Section 3 results are presented. Discussion including comparison to other studies follows in section 4. Section 5 closes with some conclusions and policy implications.

2. Methods

2.1. Measuring costs and benefits of climate mitigation

Costs and benefits of greenhouse gas mitigation are both nationally and internationally extensively studied. Bottom-up studies provide detailed insights into the potential in each sector and the spending that is associated with it. Macroeconomic modelling approaches bring together the findings of the various sectors and provide a macroeconomic assessment, which often helps to understand that spending has a cost and an investment aspect, i.e. creates burden and opportunities at the same time. What is perceived in partial analyses as cost can develop macroeconomic stimulus, i.e. a positive impact on growth and employment. In interpreting results, perspectives of private and social costs and benefits should not be mixed. If also the benefits of climate change mitigation are included in the analysis, even more attention has to be paid to the separation of effects: While the incentives for single economic agents are driven by preferences and short-term economic returns, whether through energy conservation, the remuneration of green electricity or avoidance of penalties, total economic benefit lies rather in the long-term prevention of climate damage and long-term growth paths, as well as increased economic activities in short and medium term.

The literature essentially falls into three categories: Scenario studies that project future emission levels and identify the damage of climate change (e.g. IPCC, 2014); scenario studies that develop energy scenarios and macroeconomic effects of a certain energy mix compared to reference or counterfactual scenarios, partly estimating the associated different climate costs (DG Energy, 2012; Prognos, EWI, GWS, 2010) and explicit analyses of the costs and benefits of renewable energy expansion or efficiency measures, focusing on measures or packages of measures as they have been submitted for Germany (Pregger et al., 2013), other countries such as Greece (Markaki et al., 2014), which includes an overview of further country studies, Turkey (Elsland et al., 2014) and the EU in individual studies. Abeelen et al. (2014) look into impacts of energy efficiency improvements in Dutch industry. Tuominen et al. (2013) find positive economic impacts of measures in the building sector in Finland. According to Filippini et al. (2014) there is a high technical and economic potential of further energy efficiency improvement in the EU.

In this paper the predominantly used cost and benefit categories in the literature are briefly reflected, as well as their underlying assumptions and methods. The aim is to isolate those categories, quantities and methods of calculation which make the most sense for a cost and benefit analysis of climate protection scenarios. Further co-benefits of energy efficiency measures with a focus on health are described e.g. in Maidment et al. (2014).

Comparing the results of the various studies is important for policy decisions. For such a comparison a thorough understanding of characteristics which affect the results is important. The methodology should be taken into consideration to the extent that it determines results. A best-practice procedure for the assessment of climate change costs and benefits should fulfill the following general requirements for good practice of cost and benefit assessment of mitigation measures:

Analyses are essentially determined by the *data base* used. One example is the changes in energy prices between 2005 and 2010. Studies which do not take these price changes into consideration are not valid any more. The same holds for technological developments such as the drastic cost reductions in renewable energy, particularly in PV in the last years. The decision to phase out nuclear energy represents a similar milestone.

Transparency means first of all accountability for third parties. A comprehensive documentation facilitates to recognize differences to other calculations and models. The documentation of important assumptions such as energy prices or technology development is central. It must be clear which variables are considered in the analysis as exogenous.

The *model type* used or the methodology generally should match the research question. In macroeconomic considerations with complex feedback processes, top-down approaches are necessary because bottom-up approaches do not consider economic feedback. However, a technically oriented optimization can be used as technological foundation.

The choice of *reference* scenarios is crucial for the evaluation of climate change policies. The more ambitious the technical development proceeds in the reference, the lower the potential benefits or costs will be. This effect is reinforced by the fact that the first measures taken typically are the most cost-effective, i.e. ceteris paribus initially taken mitigation measures are economically more advantageous.

Temporal and spatial definition must both be appropriate to the research question. For example, if measures are considered, in which the individual economic decision calculus spans decades (buildings, infrastructure or dikes), a correspondingly long period of time has to be considered. The analysis of future climate change policies should, therefore, at least run up to the year 2030, better 2050, because the useful life of many efficiency measures ranges so long.

The model analysis below takes these requirements of good practice analysis into account. PANTA RHEI is a top-down model with the scenarios being derived from detailed bottom-up studies with other models. The database includes recent developments. The reference is taken from a recent and official government report. Temporal and spatial solution seems appropriate for the research question.

2.2. Model PANTA RHEI

The economy-energy-environment model PANTA RHEI is at the core of our methodological approach. PANTA RHEI (Lutz et al., 2005; Lehr et al., 2008; Meyer et al., 2012) is an environmentally extended version of the econometric simulation and forecasting model INFORGE (Ahlert et al., 2009; Meyer et al., 2007). A detailed description of the economic part of the model is presented in Maier et al. (2013, 2014). For detail of the complete model see Lutz (2011). Among others it has been used for economic evaluation of different energy scenarios that have been the basis for the German energy concept in 2010 (Lindenberger et al., 2010; Nagl et al., 2011). Recent applications include an evaluation of green ICT (Welfens, Lutz, 2012), and employment impacts of renewable energy promotion (Lehr et al., 2012). A similar model with the same structure for Austria (Stocker et al., 2011) has recently been applied to the case of sustainable energy development in Austria until 2020.

The behavioral equations reflect bounded rationality rather than optimizing behavior of agents. All parameters are estimated econometrically from time series data from 1991 to 2010. Producer prices are the result of mark-up calculations of firms. Output decisions follow observable historic developments, including observed inefficiencies rather than optimal choices. The use of econometrically estimated equations means that agents have only myopic expectations. They follow routines developed in the past. This implies in contrast to optimization models that markets will not necessarily be in an optimum and non-market (energy) policy interventions can have positive economic impacts.

The model is empirically evaluated: The parameters of the structural equations are econometrically estimated. In the model-specification stage various sets of competing theoretical hypotheses are empirically tested. As the resulting structure is characterized by highly nonlinear and interdependent dynamics the economic core of the model has furthermore been tested in dynamic ex-post simulations. The model is solved by an iterative procedure year by year.

Structural equations are modeled on the 59 sector level (according to the European 2 digit NACE classification of economic activities) of the input-output accounting framework of the official system of national accounts (SNA) and the corresponding macro variables are then endogenously calculated by explicit aggregation. In that sense the model has a bottom-up structure. The input-output part is consistently integrated into the SNA accounts, which fully reflect the circular flow of generation, distribution, redistribution and use of income.

The core of PANTA RHEI is the economic module, which calculates final demand (consumption, investment, exports) and intermediate demand (domestic and imported) for goods, capital stocks, and employment, wages, unit costs and producer as well as consumer prices in deep disaggregation of 59 industries. The disaggregated system also calculates taxes on goods and taxes on production. The corresponding equations are integrated into the balance equations of the input-output system.

Another important outcome of the macro SNA system is net savings and governmental debt as its stock. Both are important indicators for the evaluation of policies. The demand side of the labor market is modeled in deep industry disaggregation. Wages per head are explained using Philips curve specifications. The aggregate labor supply is driven by demographic developments.

The energy module describes the interrelations between economic developments, energy consumption and related emissions. The relations are interdependent. Economic activity such as gross production of industries or final consumer demand influence respective energy demand. Vice versa, the expenditures for energy consumption have a direct influence on economic variables.

The energy module contains the full energy balance with primary energy input, transformation and final energy consumption for 20 energy consumption sectors, 27 fossil energy carriers and the satellite balance for renewable energy (AGEB, 2013). All together, the balances divide energy consumption into 30 energy carriers. Prices, also in Euros per energy unit, are modeled for different energy users such as industry, services and private households for all energy carriers. The energy module is fully integrated into the economic part of the model.

Final energy consumption of industries is explained by sector output, the relation of the aggregate energy price – an average of the different carrier prices weighted with their shares in the energy consumption of that sector – and the sector price and time trends, which mirror exogenous technological progress.

For services, the number of employees turned out to be a better proxy for economic activity than gross output. Average temperatures also play a role for the energy consumption of the service sector. For private households, consumption by purpose as heating or by fuels is already calculated in the economic part of the model in monetary terms. Additional information can be taken from stock models for transport and heating from the specific modules, as only new investments in cars, houses or appliances, or expensive insulation measures will gradually change average efficiency parameters over time.

Final demand of each energy carrier for industries can be calculated by definition, multiplying the share of the carrier with overall final energy demand of the sector. For the shares, the influence of relative prices, the price of the energy carrier in relation to the weighted price of all energy inputs of the sector, and of time trends are econometrically tested.

Energy carrier prices depend on exogenous world market prices for coal, oil and gas and specific other price components such as tax rates and margins. For electricity different cost components such as the assignment of the feed-in-tariff for electricity are explicitly modeled. For services, households and transport specific prices are calculated, as for example tax rates partly differ between end users.

For energy-related carbon emissions, fix carbon emission factors from the German reporting (Federal Environmental Agency 2013) to the United Nations Framework Convention on Climate Change (UNFCCC) are applied. Multiplication with final energy demand gives sector and energy carrier specific emissions. All detailed information in the energy balance for 30 energy carriers is consistently aggregated and linked to the corresponding four industries of the IO table.

To examine the economic effects of additional climate protection measures with a focus on energy efficiency in Germany our analysis applies PANTA RHEI to a set of scenarios and compares the resulting economic outcomes. The scenarios are taken from the policy scenarios for the German Federal Environmental Agency (Matthes et al., 2013), which have been reported to the UNFCCC as projections of German emissions.

3. Results

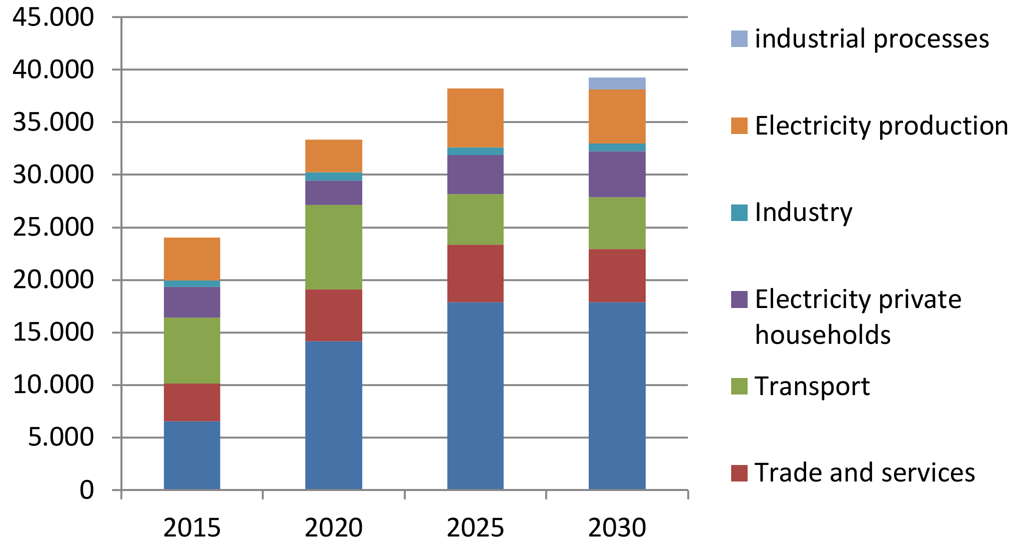
All policy scenarios stem from the study “Policy Scenarios for Climate Protection VI” (Matthes et al., 2013), published by the German Federal Environmental Agency in March 2013. They are the basis for the model analysis of economic impacts of climate protection measures. The policy scenarios cluster the policy measures in two central scenarios: In the Current Policy Scenario (CPS) all measures which have been implemented by July 8 2011 are considered. In the Energy Transformation Scenario (ETS) additional measures are taken into account to reach the climate targets of the German government until 2030. For the economic valuation of measures ETS and CPS are compared. Additionally, for part of the policy areas a so called “No Measures Scenario” (NMS) is defined, which only includes measures implemented until the end of 2004. It is used in a sensitivity analysis to calculate macroeconomic impacts of CPS in relation to NMS to measure effects of early action.

The policy scenarios build basically on the same socio-economic assumptions, e.g. concerning international development as energy prices or GDP growth, and demography. The scenarios just differ by climate protection measures, which are specified extensively in Matthes et al. (2013) applying detailed bottom-up sector models. Investment in climate protection will reduce energy consumption in the long term and shift it towards low or zero carbon energy carriers. Differences in investment (see figure 1) are adopted from that source as well as changes in energy use and emissions. In this way, they are based on the sophisticated bottom-up modelling and detailed observations on the level of policy measures for sectors there.

The additional spending enters the model as investment in equipment and buildings as well as consumption expenditures. Depreciation, annual interest payments and savings reductions to finance the investment are fully included in the model. Due to the cost-efficiency of measures, additional expenditure and investment will not crowd out other investments or consumption. Energy savings and the decrease in energy costs are fully accounted for in the model.

In scenario ETS annual additional annual investment in climate protection, especially in insulation of buildings, will reach 25 to almost 40 billion Euros. Investment is mainly for energy efficiency with a focus on housing insulation. Significant additional investment is also needed in transport, electricity production and for more efficient appliances in electricity consumption of private households.

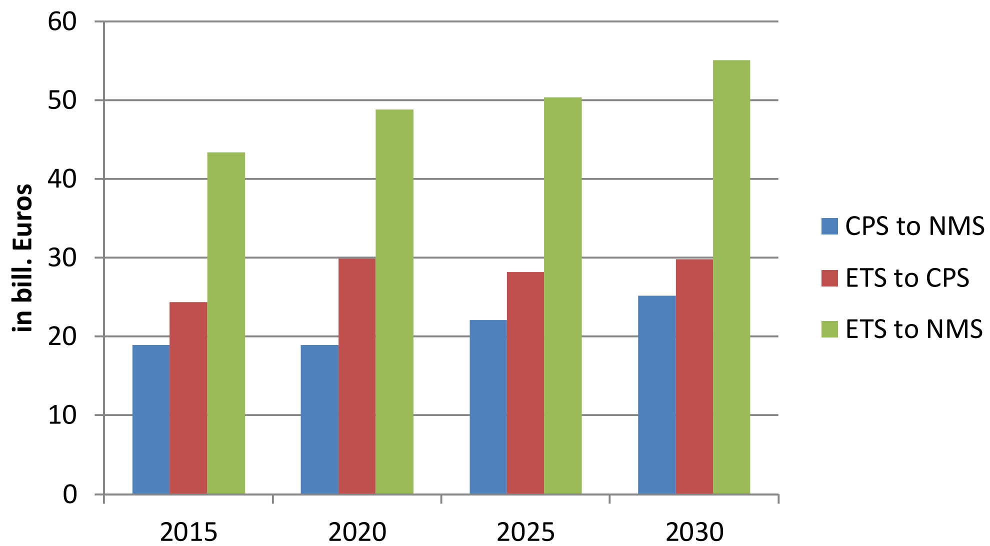
Figure 1. Additional investment in scenario ETS compared to CPS in mill. Euros



Source: Matthes et al. (2013)

The use of a comprehensive macroeconomic model, which depicts the inter-industry structure of the economy, has the advantage of covering the complex interactions of different effects in the categories of official statistics. Due to the applied scenario technique impacts of developments or measures of the respective reference scenario are not taken into account in looking at differences.

Figure 2. Impacts on GDP in constant prices – scenarios ETS and CPS against respective baseline in bill. Euros



Macroeconomic effects of ETS compared to CPS are predominantly positive. GDP will be 25 to 30 billion Euros higher in the ETS compared to the CPS (figure 2). Positive employment impacts are in the range of 200 thousand additional jobs (figure 3). Construction investment contributes to a great extent, with the difference reaching 19 billion Euros in 2025. But also equipment investment plays an important role. Private consumption will also be higher compared to the CPS until 2020. However, cost increases due to financing additional housing insulation, less reduced spending on energy consumption, will partly crowd out other consumption. Energy efficiency improvements increasingly contribute via reduced energy imports in the long term. As very expensive energy imports are reduced, prices for all imports are also lower on average. The higher energy import prices are the higher import reduction in monetary terms will be (see table 1).

Figure 3. Impacts on employment – scenarios ETS and CPS against respective baselines in 1000

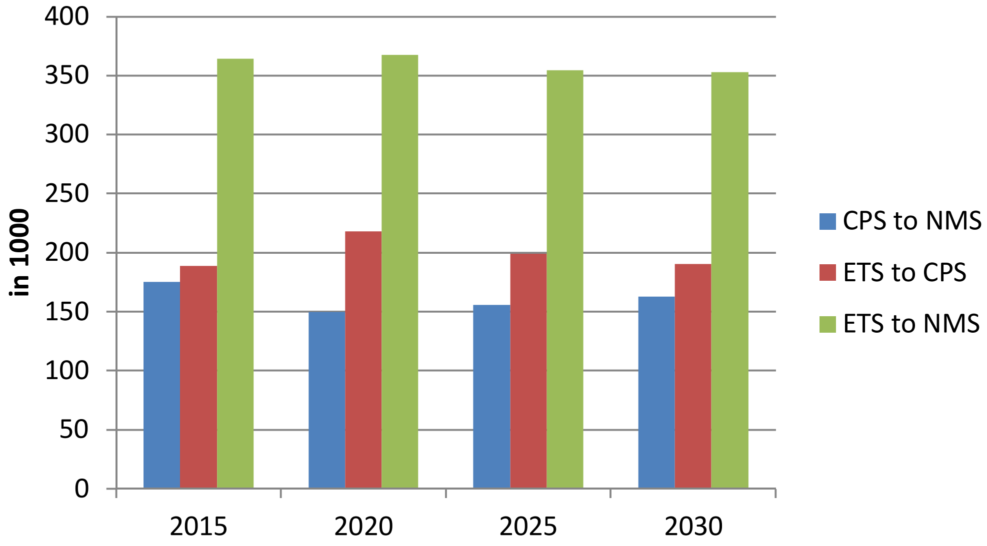


Table 1. Macroeconomic impacts – scenario ETS against CPS

	absolute values					deviations in %				
ETS to CPS	**2013**	**2015**	**2020**	**2025**	**2030**	**2013**	**2015**	**2020**	**2025**	**2030**
GDP and components	deviations in bill. €									
GDP	15.5	24.4	29.9	28.2	29.8	0.6	0.9	1.1	1.0	1.1
Private consumption	9.5	14.7	11.7	4.3	2.7	0.7	1.0	0.8	0.3	0.2
Government consumption	0.6	0.9	0.9	0.7	0.7	0.1	0.2	0.2	0.1	0.1
Equipment investment	6.0	9.5	9.9	8.3	9.3	2.6	4.0	4.1	3.3	3.5
Construction	3.5	5.7	14.5	19.0	18.9	1.6	2.6	6.7	9.0	9.0
Exports	0.5	0.5	-0.3	-0.6	0.4	0.0	0.0	0.0	0.0	0.0
Imports	4.7	7.1	6.9	3.4	1.9	0.4	0.6	0.5	0.2	0.1
Price indices	deviations in percentage points									
Private consumption	-0.10	-0.14	-0.02	0.12	0.10	-0.09	-0.12	-0.01	0.09	0.08
Production	-0.14	-0.16	0.05	0.28	0.34	-0.12	-0.14	0.04	0.22	0.25
Imports	-0.08	-0.18	-0.42	-0.86	-1.35	-0.07	-0.16	-0.35	-0.69	-1.04
Labor market	deviations in 1000									
Employment	123	189	218	199	190	0.3	0.5	0.6	0.5	0.5
Unemployment	-76	-117	-135	-123	-118	-3.3	-5.0	-5.5	-5.5	-8.0

On industry level construction will profit most due to increased housing insulation (table 2). Positive impacts on manufacturing, trade and services are getting significantly smaller after 2020. Trade and services face the lower effects on private consumption.

Macroeconomic impacts will further improve, if climate protection measures of the years 2005 to 2011 are considered as well. They will induce higher investment, more jobs and reduced energy consumption. In scenario CPS annual GDP is about 20 billion Euros higher compared to the NMS scenario with no measures from 2005 onwards in the years 2013 to 2025. Compared to the above comparison between scenarios ETS and CPS private consumption is constantly more important, while the share of investment is reduced and significantly lower than in the comparison of ETS to CPS. Construction investment plays a major role throughout the observation period. Imports start to increase clearly with GDP. With growing reduction of energy imports total imports are a bit lower in CPS than in the NMS in 2030 (figure 2).

Employment effects are highest in 2020. In the following years the positive impact on employment levels off at around 150 to 175 thousand. On industry level construction due to additional insulation as well as trade, services and manufacturing will profit. The impacts for trade and services are lower as private consumption will increase below average due to budget constraints, i.e. money spent for building insulation is not available for other consumption purposes. The positive employment effect is shrinking over time. In (conventional) energy and water industry employment is reduced because of lower energy supply.

The positive macroeconomic effects are the results of different impacts: additional investment yields additional production and therefore additional employment, energy is replaced by capital, imports as crude oil, gas and coal are replaced by domestic value added, construction, trade and services are more labor intensive than the energy industry, energy efficiency improves economic productivity and thus competitiveness, and short term higher demand for (efficient) investment goods and equipment improves private budgets and induces additional incomes.

Table 2. Impacts on sector employment – scenarios ETS and CPS against respective baselines in 1000

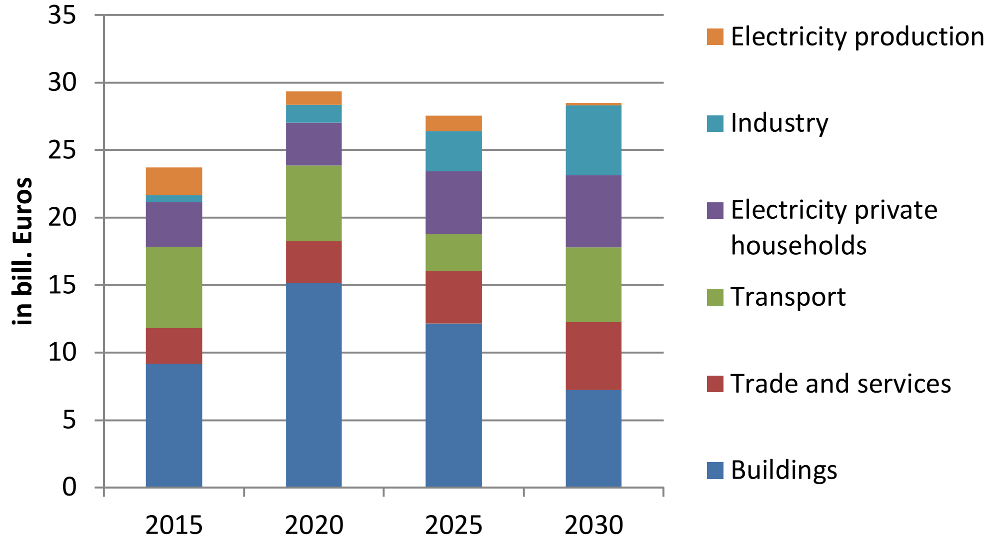
ETS to CPS	2013	2015	2020	2025	2030	2013	2015	2020	2025	2030
Employment	**deviations**					**deviations in %**				
Mining and quarrying	0.1	0.2	0.3	0.3	0.2	0.2	0.3	0.6	0.7	0.7
Manufacturing	21.1	27.3	25.1	21.7	22.3	0.3	0.4	0.4	0.4	0.4
Energy and water supply	-0.2	-0.7	-1.5	-3.0	-4.4	-0.1	-0.3	-0.6	-1.3	-1.9
Construction	16.0	34.8	87.1	109.4	102.1	0.9	2.0	5.2	7.1	7.0
Trade and services	70.0	103.4	81.6	50.0	50.3	0.3	0.4	0.3	0.2	0.2
Total	**107.1**	**164.8**	**192.7**	**178.4**	**170.5**	**0.3**	**0.5**	**0.6**	**0.5**	**0.5**

The reduction of energy-related greenhouse gas emissions in scenario ETS compared to CPS will also reduce external costs of energy supply, which are not accounted for in macroeconomic SNA data. Using the methodological convention on the estimation of external environmental costs of the Federal Environmental Agency (2012), avoided losses due to climate mitigation measures can be calculated on the basis of emission reductions of scenario ETS in relation to CPS. Annual avoided losses as social costs of carbon account for between 11.5 and more than 35 billion Euros in current prices. CO_2 emissions will be 164 million tonnes lower in 2030 in ETS compared to CPS. Assumed social costs of carbon in the methodological convention range between 40 and 215 Euros per tonne of CO_2 for 2030.

4. Discussion

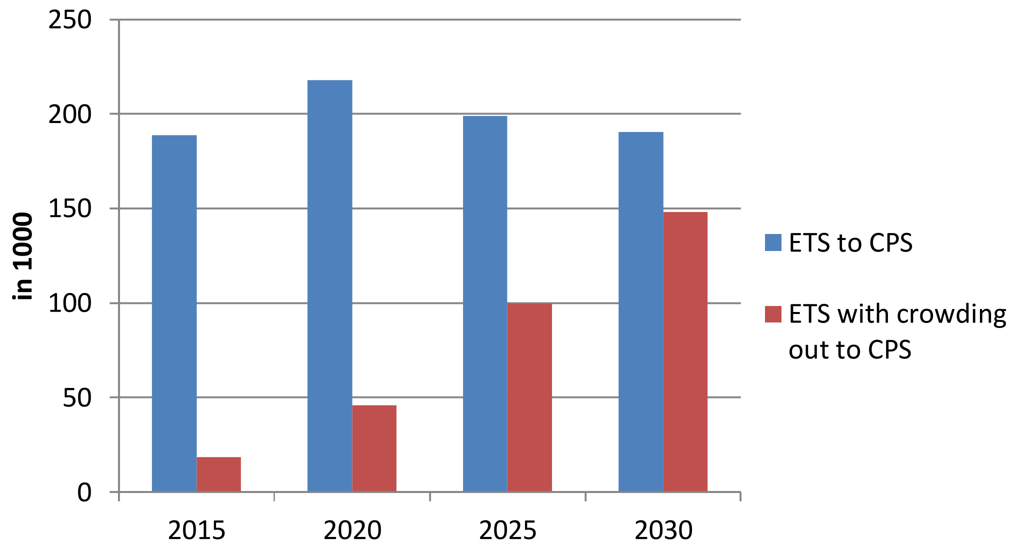
The positive macroeconomic effects of the considered climate mitigation measures are robust with respect to major assumptions. A sensitivity analysis shows that positive economic impacts are mainly driven by energy efficiency measures, particularly in buildings. Trade and services, transport and electricity of private households contribute significantly to positive GDP impacts throughout the whole observation period. The share of industry measures increases over time. Electricity production only plays a minor role, as additional renewable energy production is partly offset by lower production from conventional power plants (figure 4).

Figure 4. Sensitivity analyses for impacts of mitigation measures in different sectors on GDP in constant prices – scenario ETS against CPS in bill. Euros



Assumptions about crowding out of additional investment in climate mitigation are important for magnitude and direction of macroeconomic impacts (figure 5). A second sensitivity analysis looks into the extreme of full crowding out for the scenario ETS, assuming that additional investment in climate protection measures substitutes other investment completely. Even under this extreme assumption, as energy efficiency will at least partly substitute energy with capital, macroeconomic impacts of ETS compared to CPS remain positive. However, assuming full crowding out will reduce the positive impacts especially at the beginning of the observation period clearly. In the short term, positive stimuli of additional investment are missing.

Figure 5. Impacts on Employment – scenarios ETS, and ETS with full crowding out against baseline CPS in 1000



There are different arguments that crowding out only plays a minor role for energy efficiency investment in Germany at the moment: At a time of historically low levels of interest rates interesting investment opportunities are rare. German public investment bank Kreditanstalt für Wiederaufbau offers even lower interest rates for different energy efficiency investment programs. Thus, energy efficiency investment, especially in housing insulation is attractive for private investors. Additionally, the investment ratio, i.e. investment to GDP, at national level is quite low compared to historic development and in relation to other countries. Under these circumstances companies and private households can easily finance additional energy efficiency investments.

Results are in line with the recent energy efficiency outlook of the IEA (2013). An efficient world scenario developed in 2012 leads to a more efficient allocation of resources and comes along with macroeconomic benefits (Chateau et al., 2013). On European level impact assessment for DG Energy (2012) also finds positive macroeconomic impacts of energy efficiency improvement for member states. Similar positive macroeconomic results are reported in country studies for Germany (Kuckshinrich et al., 2010; Kronenberg et al., 2012; Prognos, 2013; Blazejczak et al., 2014) with annual net employment gains of some hundred thousand jobs due to additional energy efficiency measures and other countries such as Greece (Markaki et al., 2014). The study of Blazejczak et al. (2014) shows that assumptions on wage bargaining are crucial for employment impacts, however. Especially in construction large investments are needed for better insulations of buildings. As construction is an industry with high shares of domestic inputs and value added, economic stimuli of additional investment are quite high.

As pointed out in section 2, the choice of reference scenarios is central for the evaluation of climate mitigation policies. As the CPS scenario only includes policies already implemented in summer 2011, impacts include all additional measures that will come in place afterwards. Results confirm direction and order of magnitude of other studies about macroeconomic impacts of climate mitigation measures in Germany, especially for energy efficiency. Keeping difficulties of detailed comparisons in mind, studies give evidence for the macroeconomic benefit of included energy efficiency measures.

Impacts of the strong increase in electricity production from renewable energy sources in recent years have been factored out to large extent due to the scenario design. Major cost increases either took place before summer 2011, and are included in the CPS already, or are not considered. Results are dominated by energy efficiency investment and do not say much on impacts of renewable energy extension and related electricity price increases.

Another disputed aspect of economy-wide energy efficiency improvement is the magnitude of rebound effects, which can partly offset energy savings. Recent results for Germany are far from clear. Galvin (2014) finds high rebound effects, while Schleich et al. (2014) report low rebound effects for the case of lighting. Figge et al. (2014) hint at further possible secondary effects beyond the rebound effect and potential backfire. The recent monitoring report (BMWi, BMUB 2014) shows at least a reduction of energy consumption and an improvement of energy efficiency at the national level. This indicates that rebound effects should closely be monitored, but gives no hint for high rebound effects at place.

5. Conclusions and Policy Implications

Results of more ambitious climate protection measures are positive: Annual gross domestic product will be 25 to 30 billion Euros higher in the Energy Transformation Scenario (ETS) compared to the Current Policy Scenario (CPS). Positive annual employment impacts are in the range of 200 thousand additional jobs. Energy efficiency improvements increasingly contribute via reduced energy imports in the long term. The positive macroeconomic effects of the considered climate mitigation measures are robust with respect to major assumptions.

The results clearly show that additional climate mitigation efforts with a focus on energy efficiency result in a variety of positive impacts on the German economy. These range from reduced greenhouse gas emissions, reduced local air emissions and related negative impacts for human health, other external benefits, reduced energy import bills and more energy security, improved competitiveness of firms and budget savings for consumers to economy wide impacts like additional employment and economic growth. Thus, exploiting the huge potential stemming from cost-effective efficiency measures should have high priority for the design of energy and climate policies.

However, different barriers to realize the efficiency potentials have to be taken into account (see IEA 2012 for an overview). Barriers include visibility, as energy efficiency is not measured, priority of other investment opportunities, uncertainty, split incentives, insufficient finance available, short time horizons, limited know-how, fragmentation and market failures, which may be driven by fuel subsidies.

Although the overall energy efficiency potential is large, it stems from completely different technologies and technology users. Consequently, also the pattern of barriers to invest in energy efficient technologies is manifold and has to be addressed with a broad mix of sector and technology specific policies (e.g. Fleiter et al., 2011 for industry). These will build on the existing mix of regulations, grants and price instruments and take possible undesirable feedback like rebound effects into account.

According to the results German and EU energy and climate policy, which is currently focused on the cost of renewable energy promotion and reforms of the feed-in-tariff plus necessary extensions of the electricity grid and strengthening of the EU-ETS, should concentrate more on energy efficiency and be opened to related issues as reduced external costs of energy consumption, energy security and new export markets for green technologies (BMU, 2012).

In the context of EU climate and energy policy and national targets for energy efficiency improvement, which may not be reached due to the last monitoring report (BMWi, BMUB 2014), Germany should increase its efforts to foster energy efficiency improvements. This may include different kinds of regulations as well as price and tax incentives. The possibility of rebound effects should be accounted for in the policy design. The German government has recently announced an additional national “2020 climate and energy program” for autumn 2014.

The findings also support explicit energy efficiency targets and energy efficiency policies, which are not only in place in Germany and the EU, but also in all other major economies such as US, Japan, China, India, Russia and Brazil (IEA 2012, 276). The need for specific energy efficiency targets is sometimes doubted by climate economists, which see greenhouse gas emission reduction, triggered by a single carbon price, as the central and single policy target. According to this view additional energy efficiency targets are seen as an inefficient sub-target. But results indicate that energy efficient measures may have further positive macroeconomic impacts being a suitable second-best option in an imperfect world.

The arguments for a growing focus on energy efficiency in climate and energy policy will hold even more, if the policy context is taken into account. The additional deployment of renewable energy in electricity beyond already ambitious targets for 2020 is limited, partly for technical reasons as the grid has to be adjusted. At the same time economic impacts of energy efficiency measures are less dependent on global market development than renewable energy policies (Lehr et al., 2012). The construction sector uses a high share of domestic intermediate inputs. It is labor intensive and thus supports generation of value added and employment due to energy efficiency measures. More efficiency or new technologies will also keep German car companies competitive on global markets. Companies specialized on energy efficiency goods and services can profit from cost degression on international markets and focus on growing markets abroad. In short, energy efficiency deployment should step up in (German) energy and climate policy.

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