Economic evaluation of climate protection measures in Germany

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Abstract for the 22nd International Input-Output Conference, 15th – 18th July, 2014, Lisbon, Portugal

The paper builds on a study on the „Economic evaluation of climate protection measures and instruments for different policy scenarios“ for the German Environmental Agency. “Policy Scenarios for Climate Protection VI” are the basis for the model analysis of economic impacts of climate protection measures: 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.

The two 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. In ETS annual additional investment in climate protection, especially in insulation of buildings, will reach 25 to almost 40 billion Euro.

Scenarios are implemented in the model PANTA RHEI. PANTA RHEI is an environmentally extended version of the econometric simulation and forecasting model INFORGE, which includes a time series of Input-Output tables for Germany. In PANTA RHEI IO data, energy accounts and SNA data are consistently linked for prices and volumes.

Results of more ambitious climate protection measures are positive: GDP 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. The positive macroeconomic effects of the considered climate mitigation measures are robust with respect to major assumptions.

Keywords

Climate mitigation, energy efficiency, economy-energy-environment model, economic impacts

JEL classification

C54 - Quantitative Policy Modeling, C67 - Input-Output Models, Q43 - Energy and the Macroeconomy

1. Introduction and background

Energy efficiency measures and the promotion of renewable energy sources are two of the main pillars of the German and EU energy concept. The German government decided in autumn 2010 on its new energy concept (BMU, BMWi 2010). Key components have been 8 to 14 years lifetime expansion for nuclear power plants and the need for further measures to foster renewable energy and energy efficiency. On the demand side, insulation of buildings is the most important of a number of measures. For the electricity sector, the continued expansion of partly fluctuating renewable energy sources, such as wind and photovoltaic generation, calls for new market design. Feed-in-tariffs for renewable energy sources will remain at least until 2020, but are to be adjusted to enforce the market entry of renewables.

The central targets of the new energy concept are to reduce greenhouse gas emissions by 40% by 2020, 55% by 2030, 70% by 2040 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 30% by 2030 and 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. The building renovation rate is to be doubled from currently 1% to 2%. It is planned to cut energy consumption in the transport sector by around 10% by 2020 and around 40% by 2050 (BMU, BMWi 2010). While the power sector and large industrial energy consumers take part in the EU-ETS, about have of German energy consumption stems from other sources. Energy efficiency plays a major role to reduce these emissions (Taylor et al. 2010).

In the light of the nuclear disaster in Japan in March 2011, the German government defined higher security standards for nuclear power plants. As eight older reactors could not be retrofitted to meet these higher standards, they have been shut down in the spring of 2011. The remaining nine reactors will be closed step by step until 2022. Additional measures for renewable generation and energy efficiency will have to fill the gap. But the changes made in 2011 are marginal in the long-term and overall economic perspective of the new German energy concept. The major decisions have been made in 2010. On the basis of the Energy Concept adopted in 2010, the Federal Government put the necessary foundations for this in place in the summer of 2011 with a comprehensive package of legislation (BMWi, 2011).

This paper results from a study on the „Economic evaluation of climate protection measures and instruments for different policy scenarios. “Policy Scenarios for Climate Protection VI” (Öko-Institut et al. 2013), published by the Umweltbundesamt in March 2013, 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 ETS and CPS are compared.

In contrast to former papers on renewable energy (Lehr et al. 2008, 2012) the paper presents recent results of economy-wide impacts of adopted and planed 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 4, is introduced in section 3. In Section 5 results are discussed and some conclusions drawn.

2. Measuring costs and benefits of climate mitigation

Costs and benefits of mitigation are both nationally and internationally extensively studied. Bottom-up studies provide detailed insights into the potential in each sector and the costs that are 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, 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 economic returns, whether through energy conservation, the remuneration of green electricity or avoidance of penalties, the total economic benefit lies rather in the long-term prevention of climate damage and long-term growth paths, as well as in short and medium term increased economic activities.

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 Greek (Markaki et al. 2014), which includes an overview of further country studies, 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 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 makes the most sense for a cost - benefit analysis of climate protection scenarios. Further co-benefits of energy efficiency measures are described e.g. in Maidment et al. (2014) with a focus on health.

Assessment of the costs and benefits of mitigation

Cost-benefit analysis (CBA) is an established instrument of economic theory to assess welfare changes due to government action to provide public goods or to internalize external effects. In particular, environmental economics knows many examples of external effects (damages and benefits) that are not reflected in market prices. To internalize these external effects, monetary values have to be estimated to provide comparable units for costs and benefits, as the costs incur in monetary units.

Latest since the second Assessment Report of the IPCC (1995) CBA has been used to evaluate climate change mitigation measures. Climate change as a global problem calls for the global dimension in an appropriate cost-benefit analysis. However, this same global dimension in addition leads to uncertainties and bandwidths of the effects of climate change. The time horizon of climate change effects leads to considerable uncertainties in both the results of the evaluation and the methods to be used. Global models include assumptions on the individual effects of climate change on human health, agriculture, marine, infrastructure, etc. to calculate the social costs of climate change. Other sub-models are limited to individual effects, such as the costs of climate change in fisheries.

Typically, three building blocks of a complete cost-benefit analysis of mitigation measures exist: (1) The analysis of future developments in (target-oriented) scenarios, (2) the translation of physical emission reductions, energy savings etc. into monetary units, and (3) the calculation of macroeconomic effects in economic models.

In addition to the macroeconomic point of view, which ultimately assumes a benevolent omniscient regulator, however, renewable energy, energy efficiency and other mitigation measures are analysed from the decision maker perspective of an investor. For existing programs such as the German feed-in-tariff, the potential revenues are compared with investment costs. In macroeconomic terms, this is a distribution effect, because the burden is distributed to all electricity consumers. Comparing results from studies one should pay attention not to mix these two approaches.

Good practice for the evaluation of climate change policies and instruments

The comparison of study results 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 needs not go into all the items listed, but may be limited to matters relevant to the question part. Nevertheless, the following general requirements for good practice of cost and benefit assessment of mitigation measures have been deduced from the literature:

Data base: analyses are essentially determined by the data used. One example are 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 dramatic cost reductions in renewable energy, particularly in PV in the last three years. The decision to phase out nuclear energy represents a similar milestone.

Transparency: Transparency means first of all accountability for third parties. A comprehensive documentation facilitates to recognize differences with 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.

Model: 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 technical foundation.

Reference: 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: Both must 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, because the useful life of many efficiency measures ranges so long.

3. 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. (2012, 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 (1991 – 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 time consuming 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 sectoral disaggregation. Wages per head are explained using Philips curve specifications. The aggregate labor supply is driven by demographic developments.

An integral element of input-output modeling is the determination of intermediate demand between industries. Input coefficients represent the relation of intermediate demand to total production. In the economic part technological change is identified by applying variable input coefficients. They are endogenously determined with relative prices and time trend. The Leontief-inverse $(I-A)^{-1}$ – with A as input coefficient matrix and I as identity matrix – multiplied with final demand fd gives gross production y by 59 industries. In the following equations the notations are as follows: lower case letters are vectors, upper case letters are either time series or matrices. The dimension of vectors and matrices are indicated with subscripts. The subscript t indicates time dependency.

$$y_t = (I - A_t)^{-1} \cdot fd_t \qquad [1]$$

Private consumption patterns by 41 purposes of use c as a function of real disposable income Y/P and relative prices p/P are estimated. For some consumption purposes, trends t as proxy for long-term change in consumption behavior or the number of private households HH is used as explanatory variable.

$$c_{l,t} = c_{i,t}\left(\frac{Y_t}{P_t}, \frac{p_{l,t}}{P_t}, t, HH_t\right) \qquad [2] \qquad l \in [1,...,41]$$

Gross fixed capital formation is separately modeled for equipment and construction investment. Equipment investments by 59 industries are determined by estimating capital stock k which again is a function of production y of the previous year, costs of production factor labor l, autonomic technological change t and real interest rates IR. Depreciation is taken into account.

$$k_{i,t} = k_{i,t}\left(y_{i,t-1}, l_{i,t}, t, IR_t\right) \qquad [3] \qquad i \in [1,...,59]$$

Export demand is kept constant in current prices, as similar energy and climate policy developments are assumed for the main competitors. Exporters just react to price changes.

Prices are estimated econometrically. Basic prices p, which are decisive for entrepreneurs, are the result of unit costs uc and mark-up pricing. The extent to which mark-up pricing can be realized depends on the market form prevailing in specific industrial sectors. In industries with monopolistic structures, mark-up pricing is easier to realize than in competitive industrial structures. Industries will also consider import prices pim, if they are exposed to foreign competitors as well.

$$p_{i,t} = p_{i,t}\left(uc_{i,t}, pim_{i,t}\right) \qquad [4] \qquad i \in [1,...,59]$$

The labor demand functions depend on the number of hours employees work (volume of work). This approach builds on two important observations: first, a volume-based approach to labor demand considers the growing importance of part-time employees; second, labor policy instruments such as short-time work, for example, can be explicitly addressed. Working hours h are determined by sector-specific production y. In some industries real wages ae/p are also influential.

$$h_{i,t} = h_{i,t}\left(\frac{ae_{i,t}}{p_{i,t}}, y_{i,t}\right) \qquad [5] \qquad i \in [1,...,59]$$

Average earnings are determined by using a Phillips curve approach (a graphic description of the inverse relationship between wages and unemployment levels). Accordingly, average earnings by industry ae depend on the one hand on tariff wages AE (e.g. in machinery) and on the other hand on sector-specific productivity y/h.

$$ae_{i,t} = ae_{i,t}\left(AE_t, \frac{y_{i,t}}{h_t}\right) \qquad [6] \qquad i \in [1,...,59]$$

The number of employees e is derived by definition, dividing the number of working hours h by working time per year and head hy. The latter is preset exogenously.

$$e_{i,t} = \frac{h_{i,t}}{hy_{i,t}} \cdot 1000 \qquad [7] \qquad i \in [1,...,59]$$

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

$$fe_{i,t} = fe_{i,t}\left(y_{i,t}, \frac{pe_{i,t}}{p_{i,t}}, t\right) \qquad [8] \qquad i \in [1,...,59]$$

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

$$sfe_{k,t} = sfe_{k,t}\left(\frac{pe_{k,t}}{p_{k,t}}, t\right) \qquad [9] \qquad i \in [1,...,59]$$

$$fed_{k,t} = sfe_{k,t} \cdot fe_{k,t} \qquad [10] \qquad k \in [1,...,30]$$

Energy carrier prices pe depend on exogenous world market prices, European import prices for gas, pw for coal, oil and gas and specific other price components such as tax rates tr and margins mr. For electricity different cost components such as the assignment of the feed-in-tariff for electricity are explicitly modeled.

$$pe_{k,t} = pe_{k,t}\left(pw_t, tr_{k,t,}, mr_{k,t}\right) \qquad [11] \qquad k \in [1,...,30]$$

For services, households and transport specific prices are calculated, as for example tax rates partly differ between end users.

For energy-related carbon emissions ce, fix carbon emission factors cef 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 fe gives sector and energy carrier specific emissions.

$$ce_{i,k,t} = cef_{i,k,t} \cdot fe_{i,k,t} \qquad [12] \qquad i \in [1,...,59]; \; k \in [1,...,30]$$

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 efficiency measures and increasing shares of renewable energy 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 (Oeko-Institut et al. 2013), which have been reported to the UNFCCC as projections of German emissions.

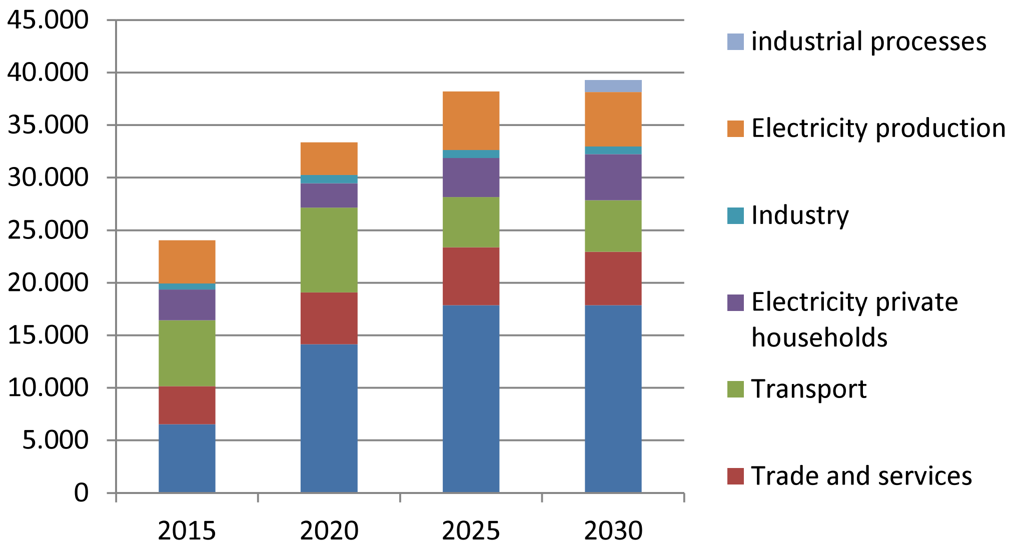
4. Climate mitigation scenarios

All policy scenarios stem from the study “Policy Scenarios for Climate Protection VI” (Oeko-Institut et al. 2013), published by the Umweltbundesamt in March 2013. 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 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 the CPS in relation to NMS.

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 Oeko-Institut 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.

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. Euro**



Source: Oeko-Institut et al. (2013)

The use of a comprehensive macroeconomic model, which depicts the interindustry 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.

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 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 will be (see table 1).

Table 1: Macroeconomic impacts – scenario ETS against CPS

ETS to CPS	absolute values					deviations in %				
	2013	2015	2020	2025	2030	2013	2015	2020	2025	2030
GDP and components	deviations in bill. Euros									
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

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

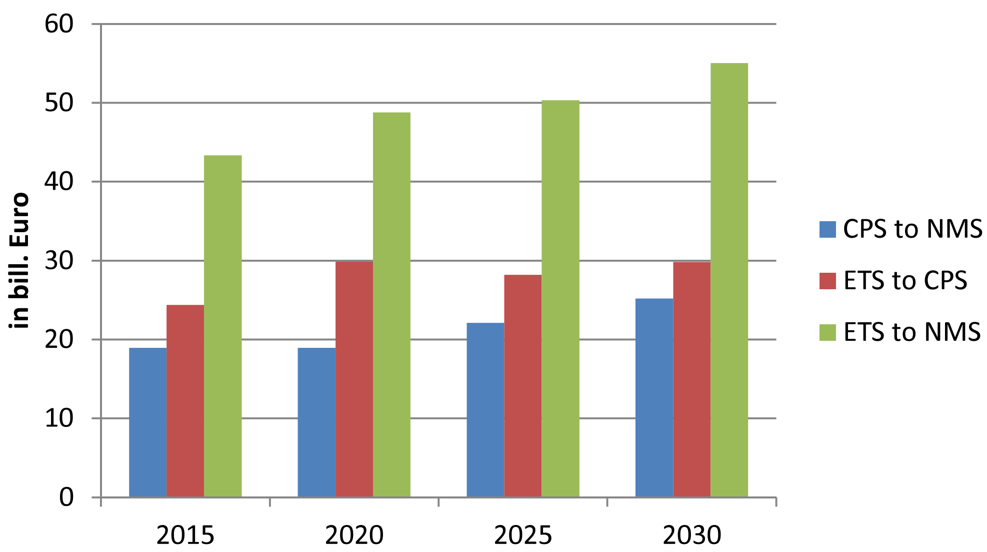
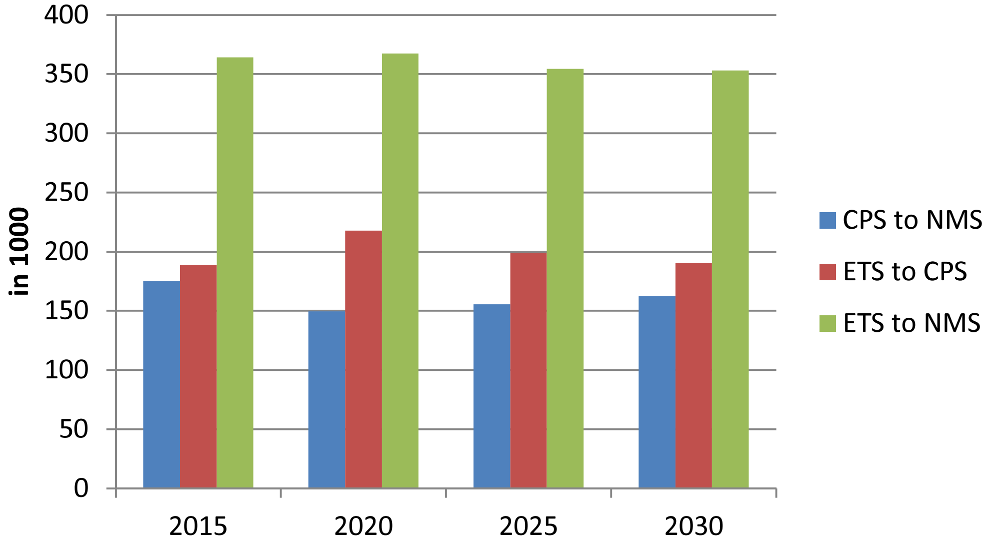


Figure 3: **Impacts on employment – scenarios ETS and CPS against respective baselines in 1000**



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 taken into account. They will induce higher investment, more jobs and reduced energy consumption. In scenario CPS annual GDP is about 20 billion Euros higher compared to NMS 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 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 than in the NMS in 2030 (figure 2).

Table 2: **Impacts on sector employment, subject to social security contributions – scenarios ETS and CPS against respective baselines in 1000**

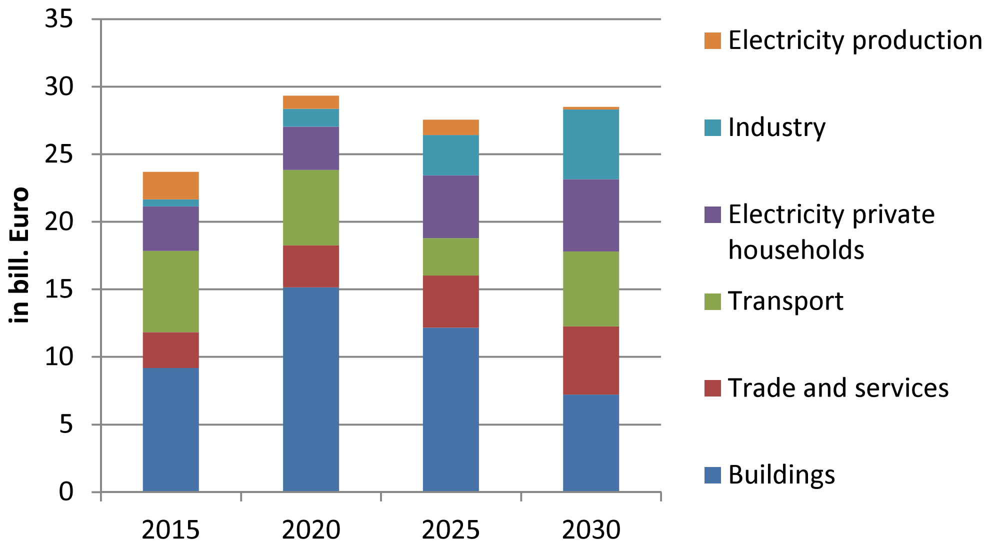
ETS to CPS	2013	2015	2020	2025	2030	2013	2015	2020	2025	2030
Employment	**deviations**					**deviations in %**				
Mining and quarrying	0.1	0.2	0.3	0.3	0.2	0.2	0.3	0.6	0.7	0.7
Manufacturing	21.1	27.3	25.1	21.7	22.3	0.3	0.4	0.4	0.4	0.4
Energy and water supply	-0.2	-0.7	-1.5	-3.0	-4.4	-0.1	-0.3	-0.6	-1.3	-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**

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 positive employment effect is shrinking over time. In (conventional) energy and water industry employment is reduced because of lower energy supply.

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 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.

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. 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).

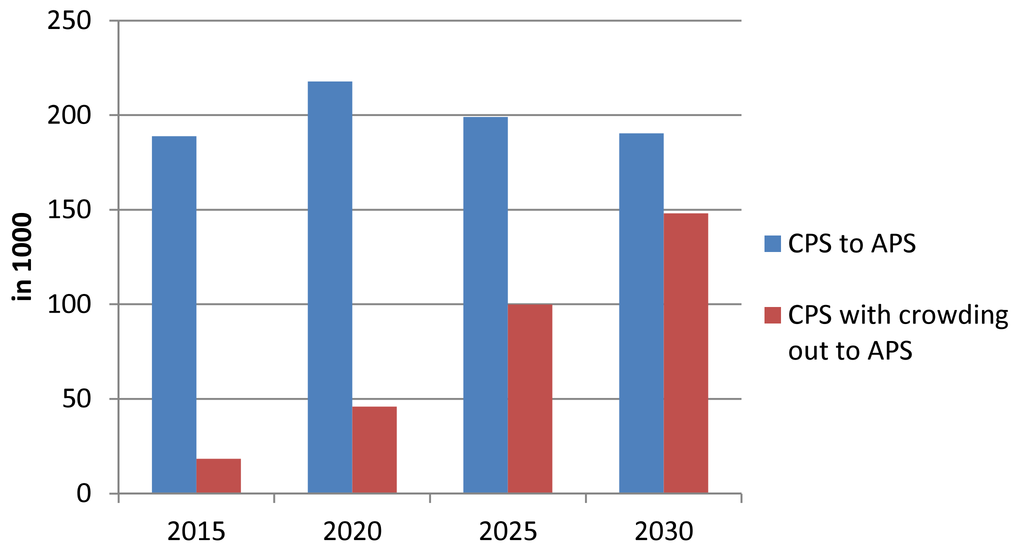
Figure 4*:* **Sensitivity analyses for impacts of mitigation measures in different sectors on GDP in constant prices – scenario ETS against CPS in bill. Euro**



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 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.

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 advantage of studied measures.

Figure 5*:* Impacts on Employment – scenarios ETS, and ETS with full crowding out against baseline CPS in 1000 full time equivalents



5. Conclusions and outlook

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 and the environment. These range from reduced greenhouse gas emissions, reduced energy import bills, 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.

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, DG Energy 2012). Similar positive macroeconomic results are reported in country studies for Germany (Kuckshinrich et al. 2010, 2014, Kronenberg et al. 2012, Prognos 2013, Blazejczak et al. 2014) and other countries (Markaki et al. 2014).

However, different barriers to realize the efficiency potentials have to be taken into account (see IEA 2012 for an overview). 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).

The current discussion about German energy policy, which is focused on the cost of renewable energy promotion 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, the "green" technology race and new export markets.

Economic impacts of energy efficiency measures are less dependent on global market development compared to renewable energy policies (Lehr et al. 2012). The construction sector needs 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 also profit from cost degression on international markets and focus on growing markets abroad. The German energy concept should focus more on energy efficiency deployment.

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