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Impacts of German energy policies on the competitiveness of national energy intensive industries

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1. Introduction

The aim of this paper is to assess the impacts of German energy policies on the competitiveness of national energy intensive industries. The idea behind is that energy policies in Germany create a certain electricity market structure resulting in a certain electricity price that plays a major role for the competitiveness of energy intensive industries (e.g. chemicals, paper, aluminum, iron and steel), as energy and electricity in particular make up a large share in manufacturing costs. The electricity price is the outcome of supply and demand decisions of producers and consumers, with a major supply determinant being the electricity generation technology portfolio. Suboptimal allocations within this portfolio are supposed to raise the electricity price and deteriorate the competitiveness of German energy intensive industries. A loss in competitiveness of a sector in a country leads to losses of world trade market shares and may incentivize firms to relocate their manufacturing facilities abroad. As competitiveness is a relative concept and all world regions are connected via trade, especially in manufacturing, competitiveness occurrences in Germany have direct implications for the competitiveness of energy intensive industries in other European countries, China or the U.S. International evidence on the significance of energy costs for the placement of manufacturing facilities, for example, is given by recent shale gas and oil discoveries in the U.S. and subsequent energy price falls, which have attracted U.S. companies to move their international manufacturing operations back to the U.S. (The Economist, 2013).

In Germany, energy intensive and other manufacturing industries have become important contributors to Germany's recent macroeconomic resilience. Consequently, there is a discussion whether energy intensive industries should be exempted from certain energy and climate policy regulations in order not to harm their competitiveness. In this regard, energy intensive industries play a disputed role. On

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the one hand, they are responsible for a major part of Germany's industrial CO_2 emissions and therefore exposed to substantial emission reduction obligations. On the other hand, they manufacture substantial components for energy efficient and renewable energy technologies (e.g. steel for wind turbines) and therefore deserve a certain degree of protection. Innovations in both energy intensive and renewable energy industries are crucial for a cost effective transition towards a low carbon economy, which is a central goal of German and European energy and climate policy.

There are several measures in place that focus on promoting renewable energies and energy efficiency in order to reduce CO_2 emissions in Germany. However, this kind of fiscal guidance involves additional costs, which are differently distributed among energy producers, consumers and tax payers, depending on the design of a specific policy. Who shall bear how much of the burden? Additional costs of promoting renewable energies in electricity generation under the German Renewable Energies Law (EEG), for example, are apportioned to all electricity consumers. In order not to harm the competitiveness of energy intensive industries, the EEG includes a special compensation rule for electricity intensive industries. In 2010 these exemptions amounted to approx. 1.5 bn € (BMU 2012a, p. 7). There has been a lot of discussion to what extent these kinds of benefits are justified, given that the more industrial beneficiaries are compensated the higher is the EEG-apportionment for residential and other consumers (Reuster 2012, BMU 2012b). Besides the EEG, there are also other technology constraints in electricity generation that involve additional electricity costs. For example, there has been recent green political lobbying against new coal power plants, not because of climate protection issues only, but also because of particulate matter issues (Greenpeace 2013). These notions reflect a limited societal acceptance of large coal power plants in Germany, which may influence authorities when considering large power plant investment projects. Thus, there is a not only a push towards renewable energies, but also an obstruction for fossil fuel technologies, especially large 'dirty' coal power plants.

Nevertheless, we are not following the discussion on this kind of issues here. We rather take them as a starting point for the definition of our policy scenarios. Our goal is to find out how this specific energy policy situation in Germany affects the average electricity price and how this consequently impacts on the competitiveness of the energy intensive industries in Germany. Furthermore, we ask who benefits most from the occurring competitiveness shifts and which of the energy intensive sectors is especially affected. With our model we are also able to analyze impacts of distributing excess electricity costs on different agents, such as industry and residential consumers. Therefore, we assess the macroeconomic impacts of assigning all excess costs either onto residential consumers or onto industry in Germany. We do that via calculating mark-ups on electricity consumption, that exhibit the same excess costs as in the case with technological side constraints.

The rest of the paper is organized as follows. Chapter 2 explains the basic functioning of our computable general equilibrium (CGE) model and the indicators we use to measure competitiveness.

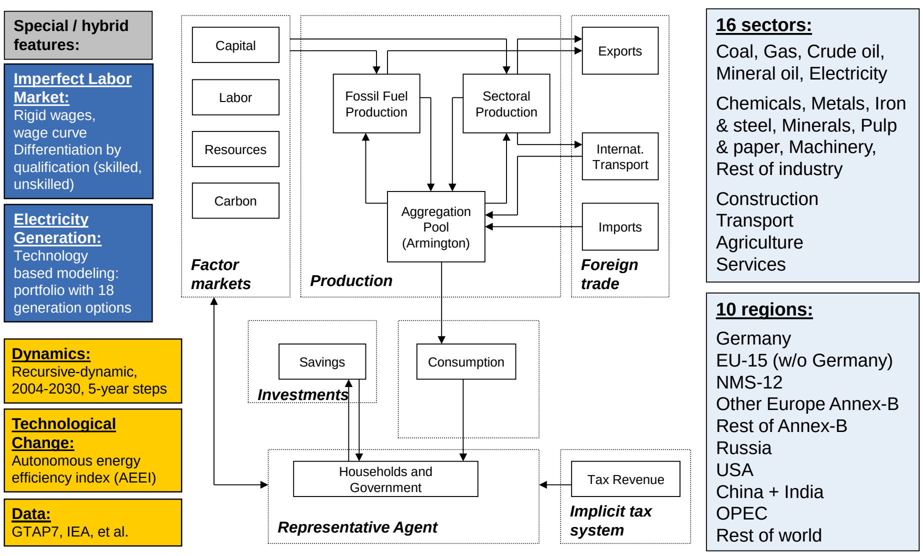
Chapter 3 describes the underlying GTAP database and visually depicts basic relationships of sectors and regions regarding world output and foreign trade. Chapter 4 contains the scenario analyses and describes our modeling results. Chapter 5 summarizes and concludes.

2. Methodology

For our global economic analysis, a worldwide macroeconomic model is needed, which represents a closed circular flow of income. Therefore we use the *NEWAGE* model from IER Stuttgart, which is a global, multi-sector, recursive-dynamic computable general equilibrium (CGE) model with a detailed representation of the energy sector and disaggregated electricity generation technologies (Küster et al. 2007, Küster 2009, Zürn 2010). Due to the total analytical framework of the general equilibrium approach, the interaction of actors on markets of the economy is described in a closed circular flow of income (Figure 1). This allows capturing both direct effects in individual sectors (e.g. electricity) as well as indirect effects (feedback effects) across the economy that are caused by price-induced supply and demand shifts in response to exogenous interventions.

The model basically follows the GTAP-EG model from Rutherford & Paltsev (2000c) and Rutherford (2005a). The equilibrium conditions are formulated as a system of mixed-complementary equations (MCP) based on the work of Arrow-Debreu (1954) and Matthiesen (1985). The basic assumption of the general equilibrium approach is perfect competition on all factor and goods markets. Firms buy production factors and sell goods following cost minimization. Consumers buy these goods using their income from selling the production factors following utility maximization. The government imposes taxes and grants subsidies following guidance and fiscal objectives. All sectors are involved in foreign trade between the model regions. The equilibrium system is solved for the variables prices, production levels and income.

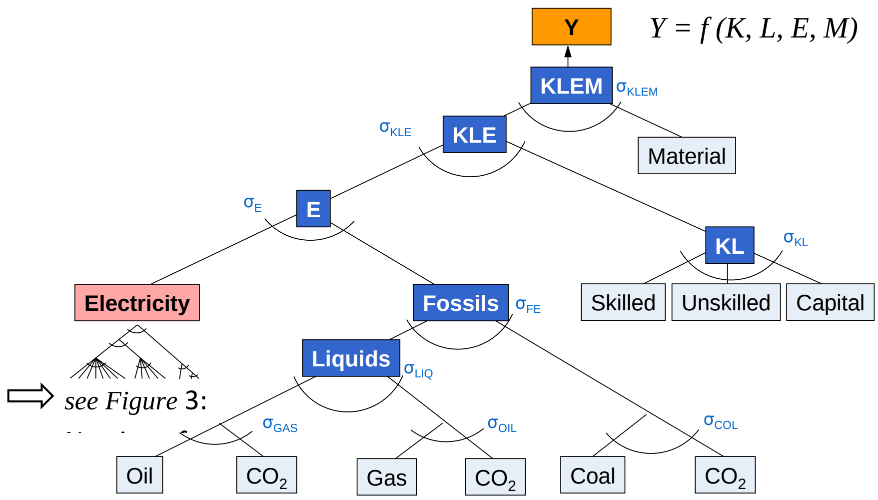
Figure 1: Concept and composition of the NEWAGE model



The demand of the representative agent is made up of household demand and government demand. The disposable income of the representative agent is used to cover the demand for goods and services, thus maximizing the agent's utility or welfare. Investments equal savings. Foreign trade is illustrated by bilateral trade flows. For every good there is an import/export matrix, which shows the flow from countries of origin to countries of destination.

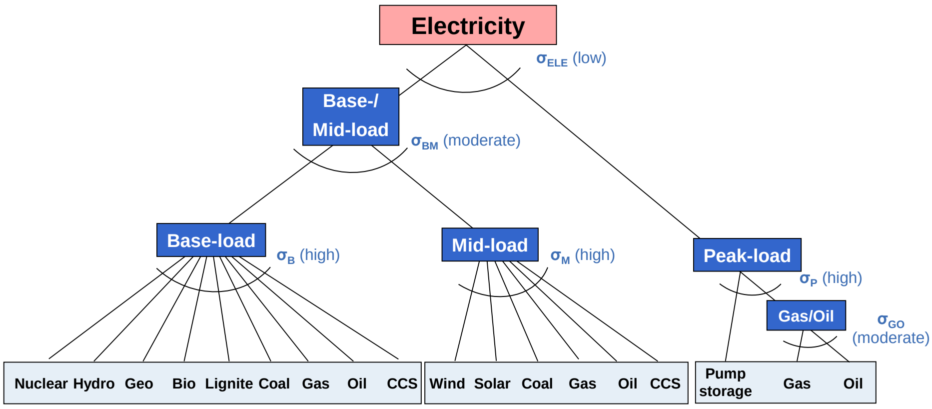
The *NEWAGE* model is based on the GTAP database and maps the global economy into 10 countries/regions and 16 sectors (Narayanan & Walmsley 2008; also see data section below). The production of goods in the 16 sectors is modeled with CES (constant elasticity of substitution) production functions, where output is produced as a combination of the input factors capital, labor, energy and materials (Figure 2). The degree to which inputs can be substituted for each other is determined by the respective elasticities of substitution, which are based on technical assumptions or taken from the literature. CO_2 allowances are an additional input if fossil fuels are used.

Figure 2: Nesting of the CES-production functions



The assumption of perfect competition is waived in the labor market in order to reflect existing imbalances on real labor markets. Therefore, the model considers unemployment, wage rigidities and different grades of labor qualifications (skilled, unskilled). A special focus of the *NEWAGE* model is the technology based representation of the electricity generation sector. The production of electricity is differentiated into 18 electricity generation technologies, distinguished by energy carrier and load range (Figure 3). Each generation technology is modeled as a CES-production function with the inputs capital, labor, energy and materials. Technological improvements are modeled via an autonomous energy efficiency index (AEEI) which reflects sector specific technological changes, i.e. changes in the energy use per unit output of an industry through time. The dynamic approach is recursive-dynamic applying 5-year milestones from 2010 to 2030. The main drivers are the labor force development – which also takes into account human capital and labor productivity aspects – and autonomous energy efficiency changes (AEEI).

Figure 3: Nesting of technology specific electricity generation



On this basis, we are able to assess macroeconomic impacts of policies affecting electricity generation, such as the promotion of renewable energies, the European CO_2 emissions trading system (EU-ETS) or investment constraints. The advantage of our approach is the simultaneous modeling of technological detail and macroeconomic closure, which is known as hybrid modeling. This allows us to analyze technological occurrences together with tax revenues, employment, income and competitiveness.

Competitiveness can be measured by different indicators, such as trade balance or trade volume per sector (I) and country (R), or more complex concepts, such as the *Relative World Trade Share* (RWS) or the *Revealed Comparative Advantage* (RCA) (see Klepper et al. 2008). The RWS relates the share of national exports and world exports of a sector to the share of total national and total world exports:

$$RWS_R^I = \frac{EX_R^I}{\sum_R EX_R^I} / \frac{\sum_I EX_R^I}{\sum_{I,R} EX_R^I}$$

$$Example\!:\;\; RWS_{Germany}^{Machinery} = \frac{Machinery\ exports\ (Germany)}{World\ machinery\ exports} / \frac{Exports\ (Germany)}{World\ exports}$$

The RCA relates the national export/import-ratio of one sector to the total national export/import-ratio.

$$RCA_R^I = \frac{EX_R^I}{IM_R^I} / \frac{\sum_I EX_R^I}{\sum_I IM_R^I}$$

$$Example\!:\;\; RCA_{Germany}^{Maschinery} = \frac{Machinery\ exports\ (Germany)}{Machinery\ imports\ (Germany)} / \frac{Exports\ (Germany)}{Imports\ (Germany)}$$

A value greater than one states that the respective sector has a higher importance for the respective country than average. An overview of the base year values for Germany is presented in chapter 3. The changes in these indicators reflect the production shifts as a result of changes in the input cost structure of the energy intensive industries, i.e. their competitiveness.

The question, whether production shifts occur in a sector, is connected with the competitiveness of the sector. A CGE model represents aggregate data, i.e. they do not capture occurrences on firm level. It cannot be stated how many firms outsource how much of their manufacturing facilities. Rather, the change in competitiveness of a sector can be associated with the displacement of manufacturing facilities, assuming that the input cost structure and therefore the competitiveness is the major incentive for firms to relocate. But there is no movement from one region to the other. It is more losing and gaining market shares. If one sector loses competitiveness, other regions are able to export more. This shifting of world trade shares and comparative advantages may be interpreted as being proportional to displacements of manufacturing facilities.

3. Data

For the *NEWAGE* model we use the global input-output database GTAP (version 7, base year 2004). Additional data come from IEA and expert assumptions on electricity generation technologies. The 113 regions, 57 sectors and 5 production factors are aggregated into 10 regions, 16 production sectors and 4 production factors. The 10 regions include Germany, USA and Russia as single countries. China and India are mapped together. The EU-27 regions are grouped into the 'old' EU-15 (w/o Germany) and the 12 new member states since 2004. Annex-B-countries of the Kyoto-protocol are divided into European and other ANNEX-B-countries and OPEC-countries are grouped together. All other countries belong to the group 'rest of the world'. The production sectors are divided into energy, manufacturing, construction, transport, agriculture and services. Energy production is divided into 3 energy extraction sectors (coal, crude oil and natural gas) and 2 energy processing sectors (petroleum products and electricity). Manufacturing is divided into 5 energy intensive industries (chemicals, metals, minerals and paper), machinery and rest of industry. The latter two maybe interpreted as consumer good production, because households hardly consume energy intensive products, such as steel or cement, directly (see Figure 9 below). Capital also involves the production factor 'land'. CO_2-certificates are an additional factor if fossil fuels are used. Figure 4 summarizes the aggregated data base mapping.

Global trade takes place between all regions. Before starting to look at the model's results it is worth getting an impression of the underlying data. What kind of production and trade relations does this mapping exhibit? The importance of a region in world trade can be measured by its share of world exports (Figure 5). In the base year (2004), most exports (19%) come from the old EU-15 (OEU). Germany (DEU) accounts for 11%, USA for 13% and China and India (CHI) for 10%. The smallest regions regarding world trade are the European NMS-12 (NEU) and Russia (RUS) with 2% and 3%, respectively. Regarding output, it can be stated that USA and Germany have a different structure. The share of world exports is higher than the share of world output, indicating that Germany has a relatively strong export sector. In the USA, domestic consumption seems to be more important, as the share in world exports is lower than the share in world output. In the base year, the world output amounts to 62,028 bn $€_{2000}$, world exports amount to 832 bn $€_{2000}$.

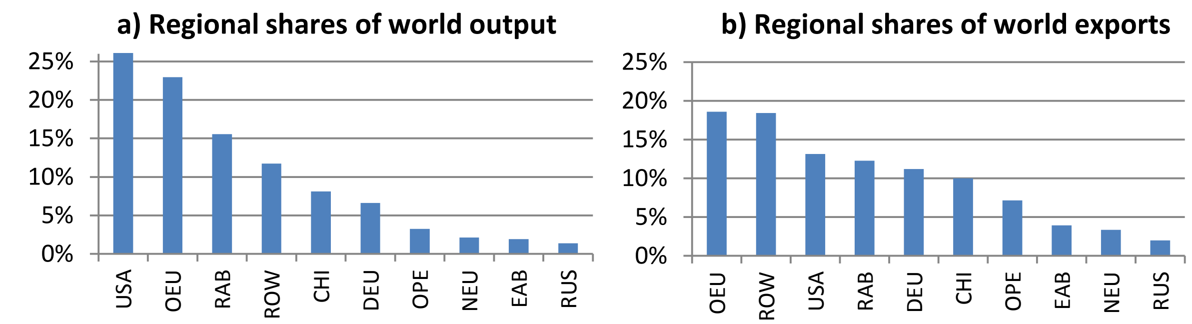
Figure 4: Mapping regions, sectors and production factors in the NEWAGE-model

Sectoral Mapping				
No.	**Abbr.**	**Description**	**Grouping**	
1	COL	Coal	Energy production	
2	CRU	Crude Oil		
3	GAS	Natural Gas		
4	OIL	Petroleum products		
5	ELE	Electricity		
6	CHM	Chemical products	Energy intensive industries	Manu-facturing
7	IRS	Iron & steel		
8	NFM	Non-ferrous metals		
9	NMM	Non-metallic minerals		
10	PPP	Paper, Pulp and Print		
11	MAC	Machinery	Consumer goods	
12	ROI	Rest of industry		
13	BUI	Construction	Rest of economy	
14	TRN	Transport		
15	AGR	Agriculture		
16	SER	Services		
	CGD	*Capital goods*	*Investments*[1]	

Production factors		
No.	**Abbr.**	**Description**
1	SKL	Skilled labor
2	USK	Unskilled labor
3	CAP	Capital
4	RES	Resources

Regional Mapping			
No.	**Abbr.**	**Description**	
1	DEU	Germany	EU
2	OEU	EU-15 (w/o Germany)	
3	NEU	New member states (NMS-12)	
4	EAB	European Annex-B-countries	
5	RAB	Rest of Annex-B-countries	
6	USA	USA	
7	OPE	OPEC-countries	
8	RUS	Russia	
9	CHI	China and India	
10	ROW	Rest of the world	

Figure 5: Regional shares of world output and world exports



The most important sector in world trade is machinery (MAC), which accounts for more than a third (37%) of world exports (Figure 6). It follows other manufacturing (ROI) with 16% and services (SER) with 12%. Given the fact that services are not traded frequently, their relative high share in world exports can be explained by its mere size, which is a 43% of world output, more than 4 times as big as machinery. The U.S. are the major importer in the world. Its foreign trade deficit is more than three times as big as in all other regions (Figure 7). Germany's exports to the world mainly consist of machinery, followed by chemical and other manufacturing products as well as services (Figure 8). The biggest destination region is the EU-15, which is also the biggest net importer (+67 bn €$_{2000}$). All in all, almost two thirds of Germany's exports go to EU-countries. In the base year, Germany's net exports amount to 79 bn €$_{2000}$.

[1] Investments represent gross capital formation from the other sectors as it appears in standard input-output data.

Figure 6: Sectoral shares of world output and world exports

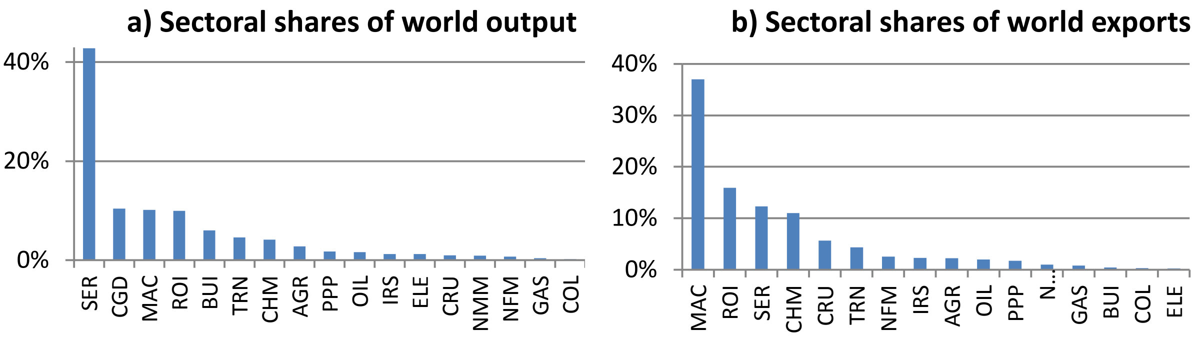


Figure 7: Net exports of Germany and the world

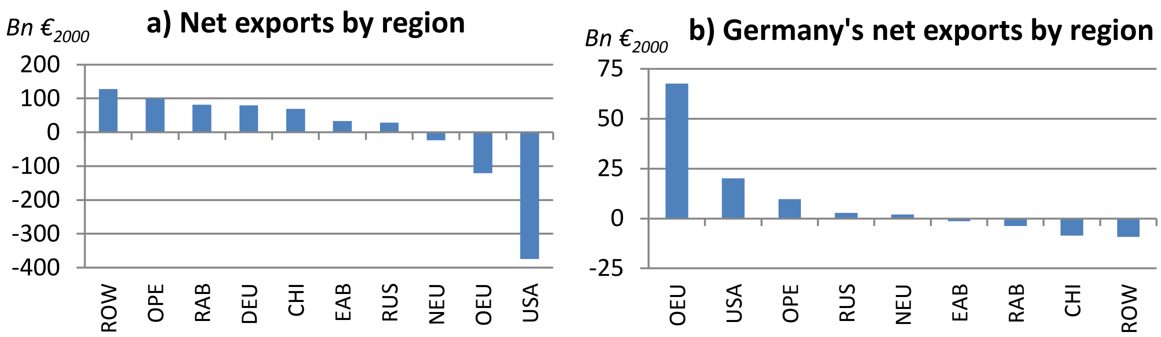
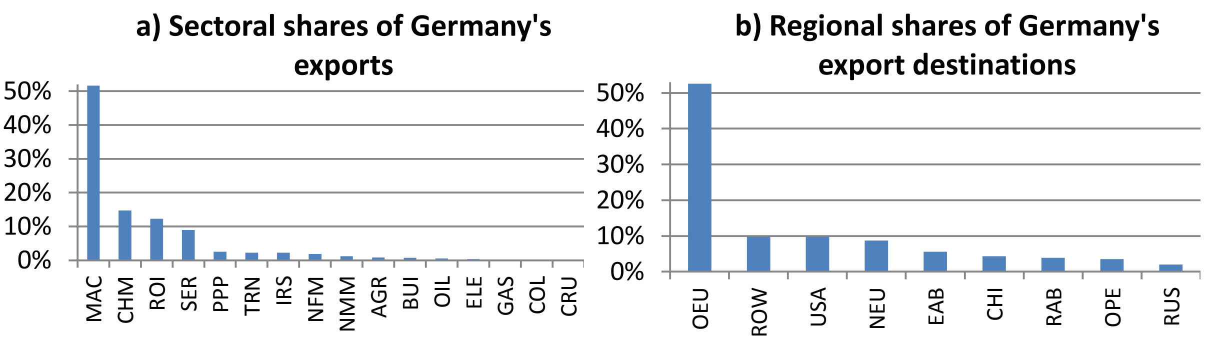


Figure 8: Sectoral and regional shares of Germany's exports



The competiveness of German energy intensive industries is strongly exposed to electricity price changes (Figure 9). Electricity constitutes up to 7 % of total production costs. The energy intensive industries consist of metal, mineral, chemical and paper industries. The non-ferrous metal industries face the highest share of electricity in input costs in Germany's economy (7%). Household expenditures mainly go to services, machinery and other manufacturing products (ROI), whereas electricity represents less than 2%.

As pointed out above, competitiveness can be measured by indicators, such as the RWA and the RCA. The production sectors in Germany reveal the following values for these indicators (Figure 10). Machinery, paper and chemical industries constitute high competitiveness. Iron & steel differs, whereas non-ferrous metals as well as the rest of industry (ROI) are clearly less competitive.

Figure 9: Shares in household expenditures and electricity share of sectoral production costs in Germany

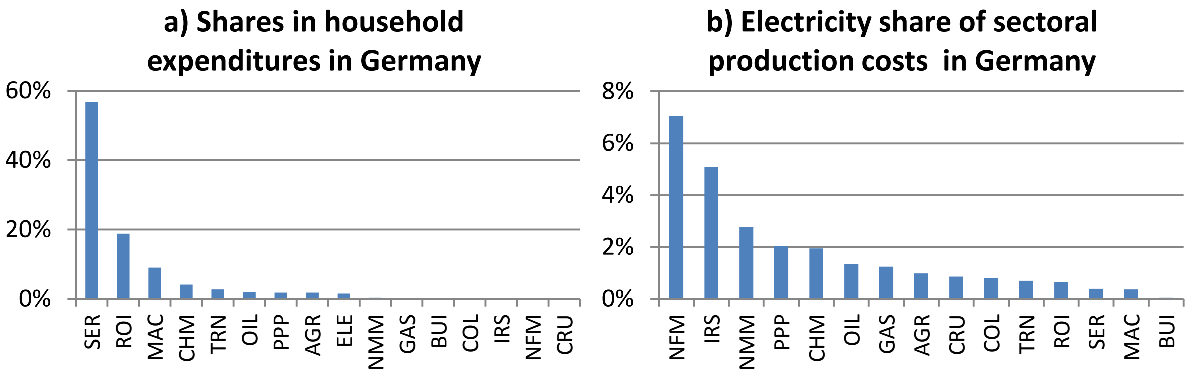
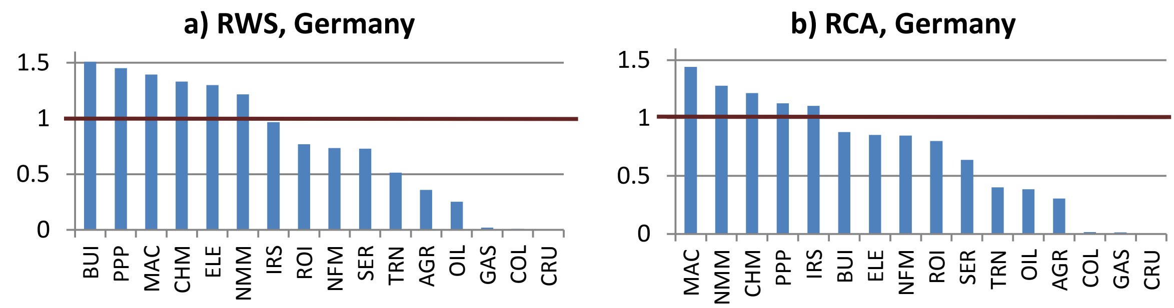


Figure 10: RWS and RCA in Germany



4. Scenario analysis and results

In the following we define three scenarios in order to analyze policy induced technology constraints in electricity generation and assess the impacts on the electricity price in Germany, the competitiveness of national energy intensive industries as well as macroeconomic impacts of different electricity costs distribution concepts:

a. Reference scenario **REF**

b. Scenario **TECH**: Imposing a share for renewable energy technologies in electricity generation in Germany and constraining investment of new coal power plants
   - Impact on the average electricity price (1st round effect)
   - Impact on the competitiveness of energy intensive industries and macroeconomic welfare (2nd round effect)

c. Scenario **DISTR**: Varied distribution of policy induced electricity costs on industry and residential consumers
   - Impact on the competitiveness of energy intensive industries and macroeconomic welfare

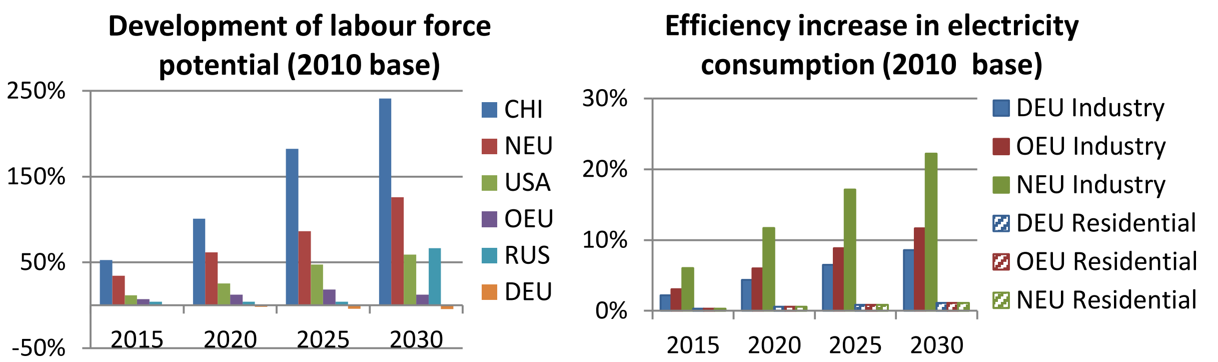
The reference scenario describes a typical business-as-usual development, which serves as anchor point for the other scenarios. Scenario TECH contains a renewable energy share as well as an investment constraint for new coal power plants. Scenario DISTR contains varied distribution concepts of those additional electricity costs induced by scenario TECH.

We calculate impacts for all of the above mentioned competitiveness indicators to assure robustness. The effects are measured in a relative manner, which enables us to control for the arbitrary assumptions of the reference scenario and isolate competitiveness effects. This means that we conduct our analysis producing relative, hardly absolute results regarding physical or monetary units. Within the general equilibrium approach we are able to capture global adjustment processes responding to the impulse of single sectoral or national policy interventions. Our results indicate which countries in the world profit from these energy constraints in Germany, which of the energy intensive sectors as well as which electricity consumer is particularly affected.

a. Reference scenario REF

As mentioned above, the policy scenarios are evaluated against a reference scenario. It entails assumptions on macroeconomic developments and energy policies such as the EU-ETS and nuclear phase out in Germany. Its main dynamic drivers are the development of the labor force (including knowledge and productivity issues) and autonomous energy efficiency increases (Figure 11).

Figure 11: Exogenous labor force and energy efficiency development



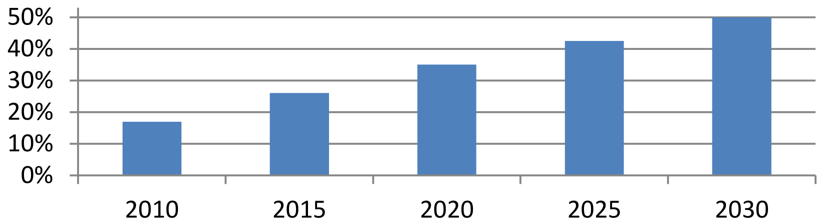
Energy conversion efficiency in power plants is assumed to increase on average by 0.1% p.a. The use of nuclear power in Germany phases out completely until 2025. For the development of international crude oil prices and the CO_2 emission caps, the following rather strong assumptions have been made. Crude oil prices are assumed to rise from 6.1 €$_{2000}$/GJ in 2005 to 10.6 €$_{2000}$/GJ in 2030. The amount of CO_2 certificates in the EU-ETS is reduced by 40% until 2030 (from 2,490 Mt CO_2 in 2005 until 1,500 Mt CO_2 in 2030). This is in line with the EU goal to reach a GHG reduction of between 80-95% by 2050.[2] In the reference scenario moderate coal power plant investments still occur (cf. scenario TECH).

[2] EU Commission (2013), GREEN PAPER - A 2030 framework for climate and energy policies, COM(2013) 169 final, 27.03.2013, Brussels.

b. Scenario TECH

Scenario TECH imposes technological side constraints on the endogenous formation of the electricity generation technology portfolio. It comprises both preventing 'dirty' technologies and promoting 'clean' technologies. The first element is the imposition of a minimum share of renewable energy technologies within the electricity generation technology portfolio to reflect the functioning of the EEG. The share in 2010 amounted to 17%. For the following years we assume a linear path with 35% in 2020 and 50% in 2030. This is in line with the German government's goal to achieve a 80% renewable energies share in 2050 (Figure 12).

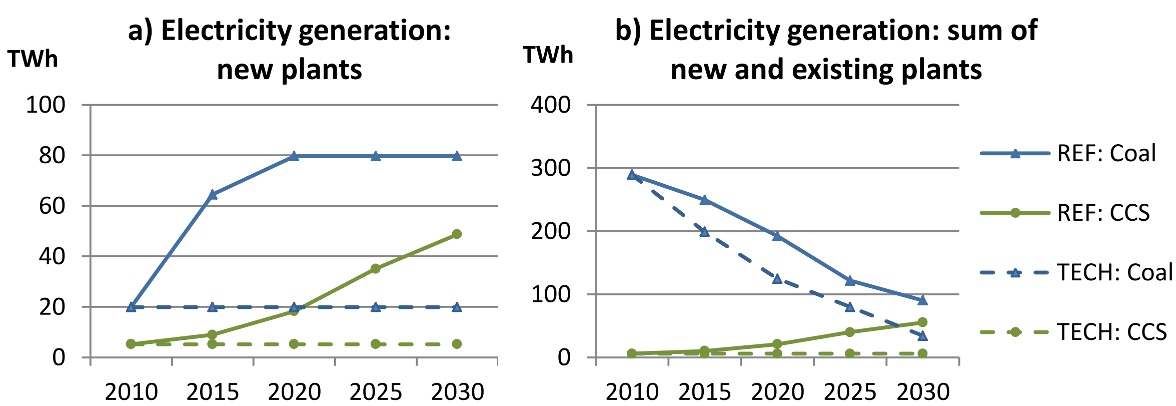
Figure 12: Minimum renewable energies share in German electricity generation



The second element of the TECH scenario is limiting investments in new 'dirty' coal power plants (including CCS). In *NEWAGE* electricity generation takes place in existing and new power plants. Generation from extant plants phases out gradually until 2030 following specific decommissioning curves. Generation from new plants phases in subject to respective technology potentials and restrictions. For limiting investment in new coal fired plants, we set the upper bound of electricity generation from new coal fired plants to the value of 2010.

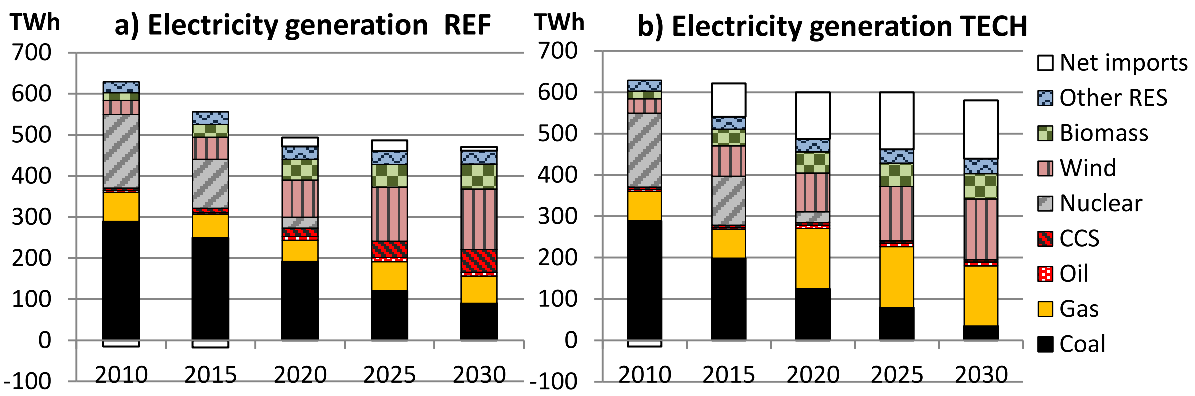
Compared to the reference scenario, where moderate coal power investments occur, electricity generation from coal amounts only 25% (CCS: 10%) of the quantity in the reference scenario in 2030. Summing electricity generation from existing and new coal fired plants reveals an outcome as depicted in Figure 13. The left side shows the constraint, the right side the scenario result.

Figure 13: Electricity generation from new and extant plants in Germany (REF vs. TECH, in TW h)



In response to these two elements of scenario TECH, overall electricity generation in Germany shifts from coal to gas and renewables. At the same time net electricity imports increase strongly due to relative cheaper electricity in the neighboring countries: from -15 TWh in 2010 (net export) to 141 TWh in 2030. The electricity generation mix is depicted in Figure 14.

Figure 14: Electricity generation technology mix in Germany (REF vs. TECH, in TWh)



What is the resulting effect on the electricity price in response to this technology constraint? How does the demand for electricity react and how do overall electricity costs change in Germany and the EU? The electricity price in Germany rises up to 22% in 2030 compared with the reference scenario (Figure 15). Facing higher prices consumers consequently reduce their demand for electricity by up to 11% in 2030. This finally results in additional electricity costs in Germany by around 7% in 2030 (Figure 16). It is striking that there are almost no changes in the rest of the EU, responding to Germany's technology constraints. Anyhow, the direction is opposite: the price falls and demand rises, resulting in slightly decreasing costs in OEU and NEU. The reason for the minor reactivity can be seen in the nature of the electricity sector as a network industry, whose trade is restricted to grid capacities. Although there is increasing electricity trade between Germany and its neighboring countries, accompanied with the political goal of a single European electricity market, the current situation is still quite away from a fully integrated European market. In the model, substitution of German electricity by foreign electricity is not perfectly possible, because of the Armington aggregation between domestic products and imports. This means that the model assumes that goods produced in different regions are qualitatively distinct (cf. Rutherford & Paltsev 2000c, Armington 1969).

Figure 15: Electricity prices and demands in Germany and the EU, 2010-2030, TECH in % to REF

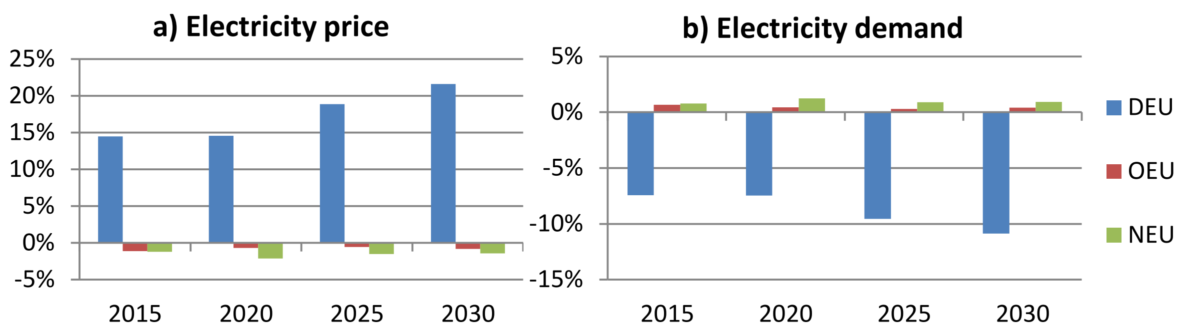
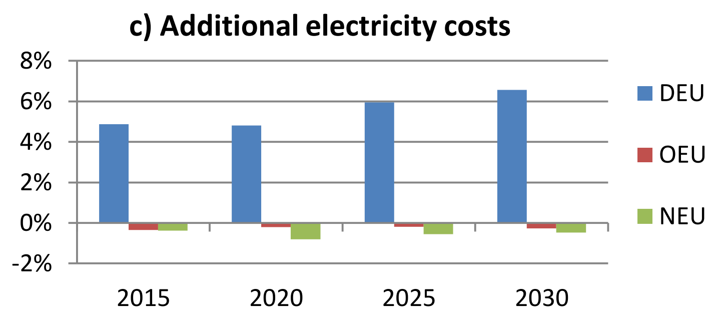


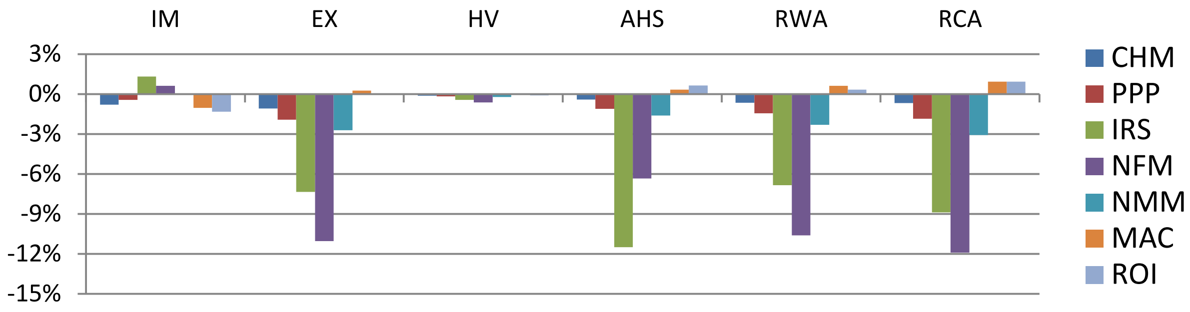
Figure 16: Additional, policy induced electricity costs in Germany and the EU, 2010-2030, TECH in % to REF



Nevertheless, summing the additional electricity costs for every year in 2010 to 2030, gives cumulated costs of 101 bn €$_{2000}$. This represents 0.21 % of the cumulative reference GDP in the same time span. These additional costs are imposed upon electricity consumers, both deteriorating the input cost structure for the production of goods and diminishing available household income for spending. This leads to either avoiding additional costs by substitution or by income loss. Firms face higher unit costs for manufacturing their goods, such that they substitute electricity for other inputs like capital, labor or other intermediates. However, underlying substitution elasticities in the model give room for little substitution only. This leads to income losses by reducing overall production, employment and expenditures.

What is the resulting effect of the increased input cost pressure on foreign trade and competitiveness of Germany's energy intensive industry? Figure 17 shows imports (IM), exports (EX), trade balance (AHS), trade volume (HV) as well as the competitiveness indicators RWS and RCA for the energy intensive industries, machinery and rest of industry. It is obvious that the metal industry (IRS, NFM) is most strongly affected. Exports fall, imports rise and its competitiveness decreases by around 7-12%. The other energy intensive industries (CHM, NMM, PPP) face similar changes, although to a lesser extent. Their competitiveness decreases by around 1-3%. This change can be interpreted as relocation of manufacturing facilities abroad or losing market shares to other countries. In contrast, the machinery industry and the rest of industry are able to slightly gain competitiveness. This results from the relative nature of the indicators.

Figure 17: Trade and competitiveness of Germany's industry in 2030 by indicator, TECH in % to REF



How do these occurrences now change Germany's trade relations? Which regions profit or lose from the changes in Germany? Due to income losses of German consumers, demand for imports goes back in all countries, except for the new EU-member states of Eastern Europe, where a slight increase can be observed (Figure 18). Although, imports of metal products increase, imports from other sectors decrease due to the income losses of consumers. Interestingly, imports decrease stronger than exports, such that Germany faces an increase in net exports to the world, except for trade with the EU: net exports to EAB decrease by up to 15% in 2020. The USA and non-European Annex-B-countries (RAB) observe an increase in net imports from Germany (USA: +24% in 2030).

Figure 18: Germany's (net) exports and imports by origin and destination, 2015-2030, TECH in % to REF

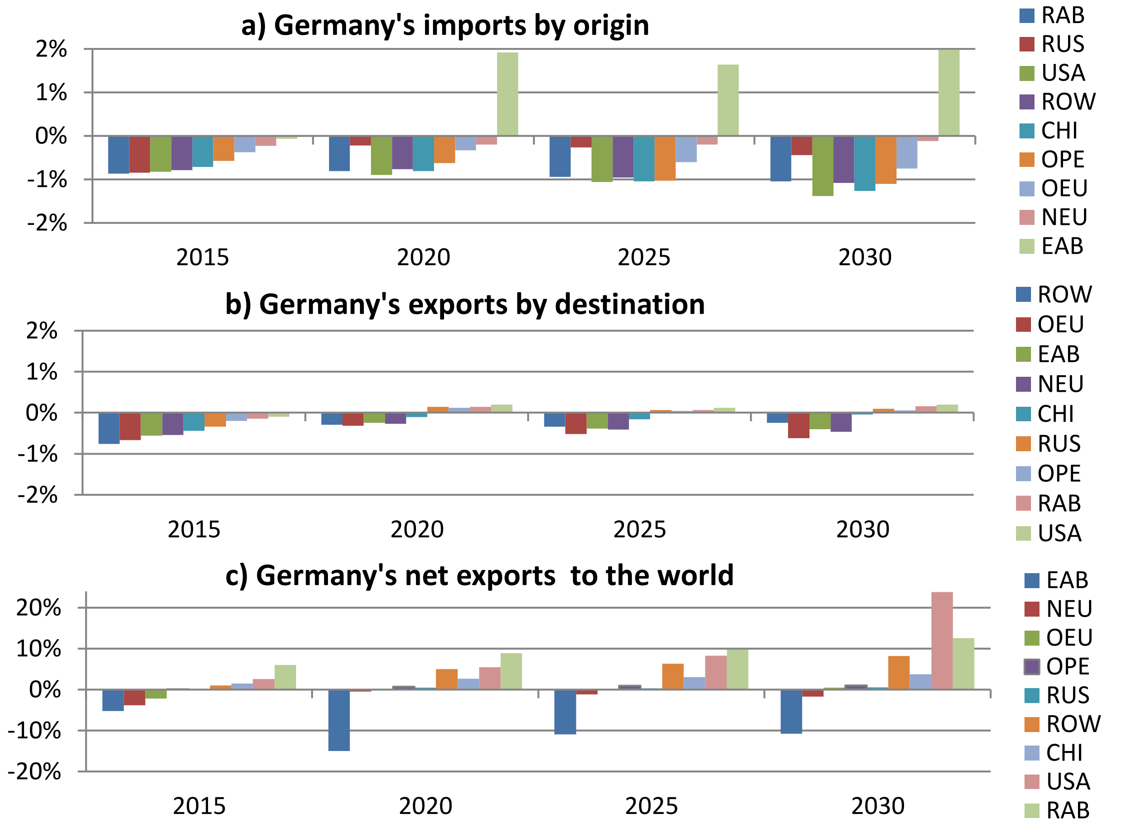
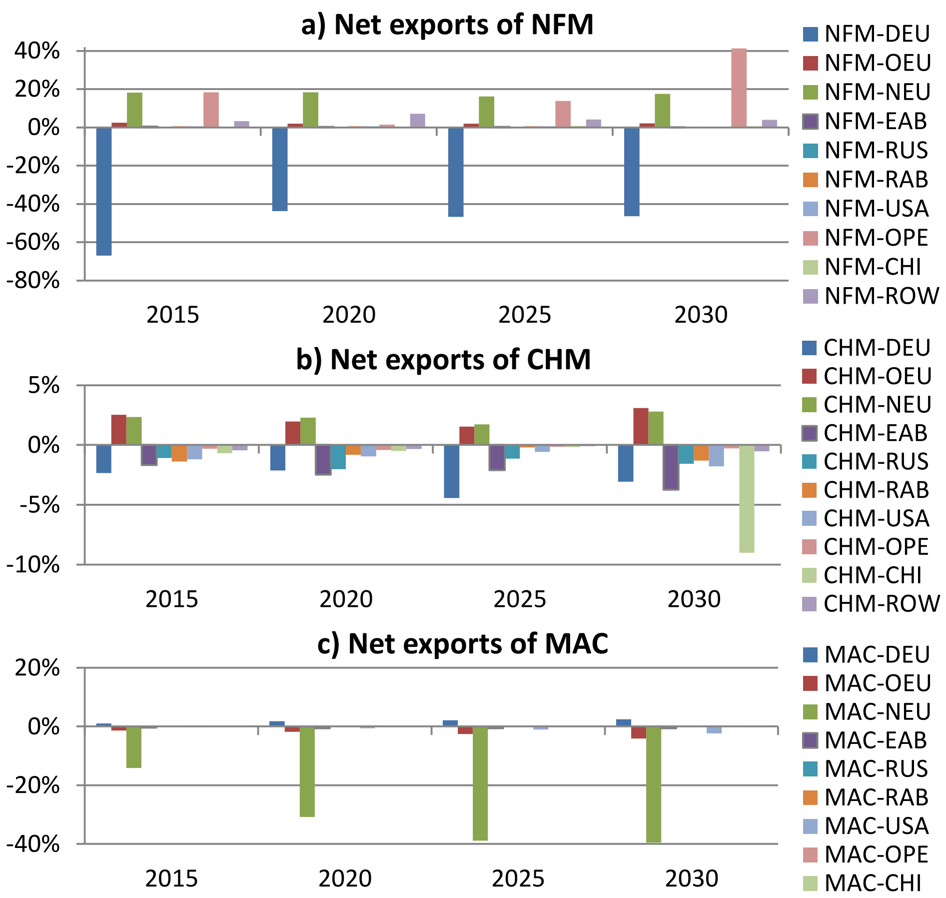


Figure 19 illustrates the changes in net exports of the sectors NFM, CHM and MAC in all model regions. Obviously, net exports of non-ferrous metals (NFM) in Germany diminish by two thirds in 2015 (-67%) and almost half in 2030 (-46%). Major winners in 2030 are the Eastern European countries (NEU: 17%) and OPEC-countries (OPE: +41%). Net exports of the chemical industry do not exhibit such striking positive or negative developments. In Germany, net exports fall by 3% in 2030, in China & India (CHI) even by 9%. Winners are Germany's European neighbor countries (+3% in 2030). In contrast, the machinery industry in Germany experiences a slight increase in net exports (+2% in 2030). This may be explained by the reduced domestic demand for machinery products due to income losses and a corresponding increase in export activity, combined with increased demand in the rest of the world. This dramatically crowds out sensible machinery net exports of NEU (-40%), for which Germany seems to be an important key market.

Figure 19: Net exports of worldwide NFM, CHM and MAC industries, 2015-2030, TECH in % to REF



In addition to the net exports, Figure 20, Figure 21 and Figure 22 show how the competitiveness of single sectors in different countries relates to these trade impacts. For the non-ferrous metal industry in Germany both indicators show a clear cut by 11-12% in 2030. This is mirrored in the other EU countries, who gain competitiveness by (1-3%). The chemical industry faces similar changes, however in weaker intensity: it loses in Germany by only 1-2% and gains in the other EU countries by around 1%. However, Germany is not the only affected market. Also Russia faces a small decline of around 1%. In the machinery sector, Germany is the only country that relatively improves its competitiveness (around 1% in 2030), whereas it mainly deteriorates in the neighboring countries of Europe (OEU, NEU, EAB) and Russia by less than 1%.

Figure 20: Competitiveness of worldwide NFM industries, 2015-2030, TECH in % to REF

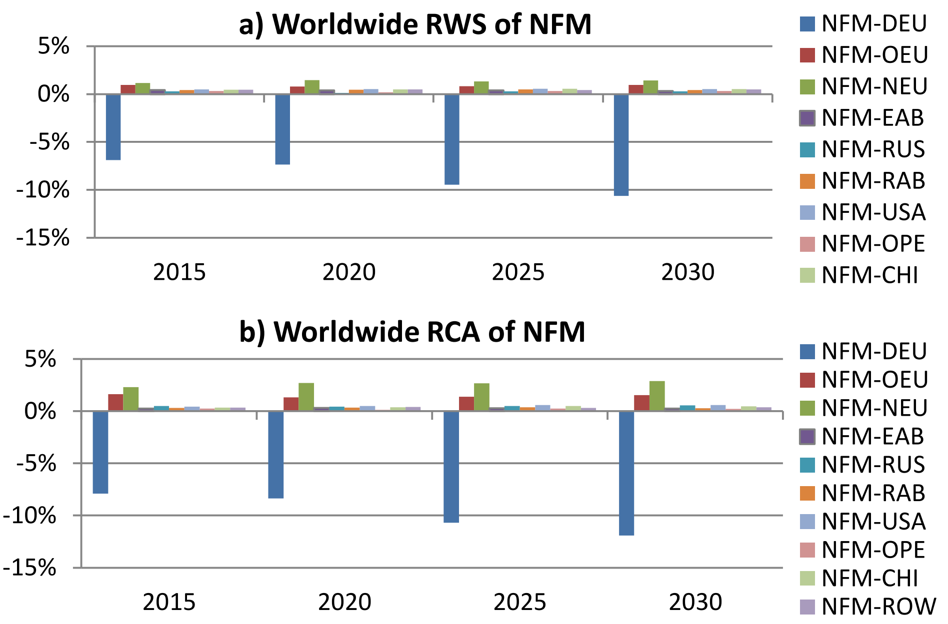


Figure 21: Competitiveness of worldwide CHM industries, 2015-2030, TECH in % to REF

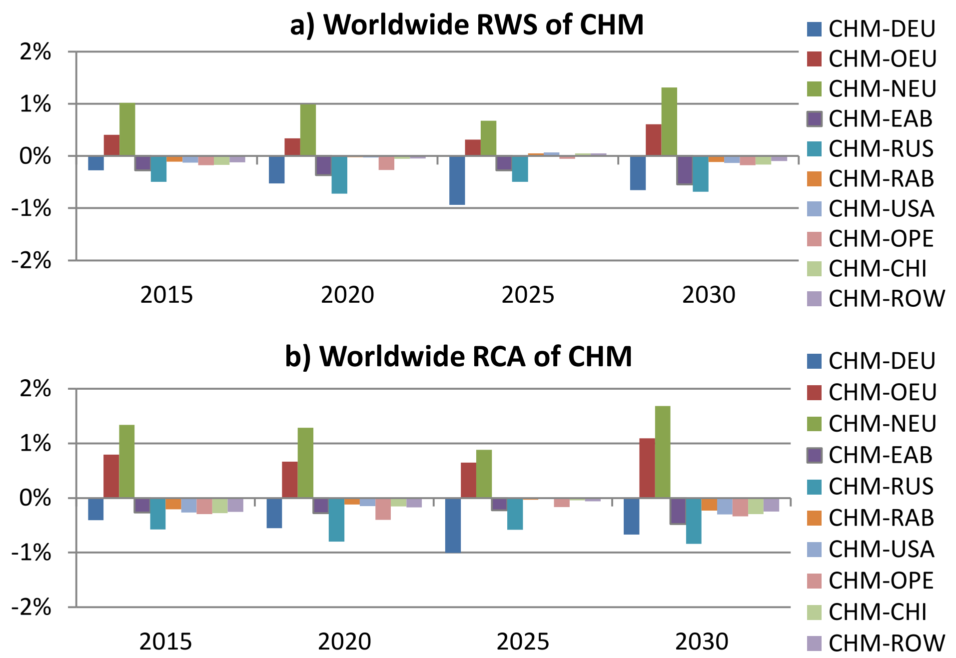
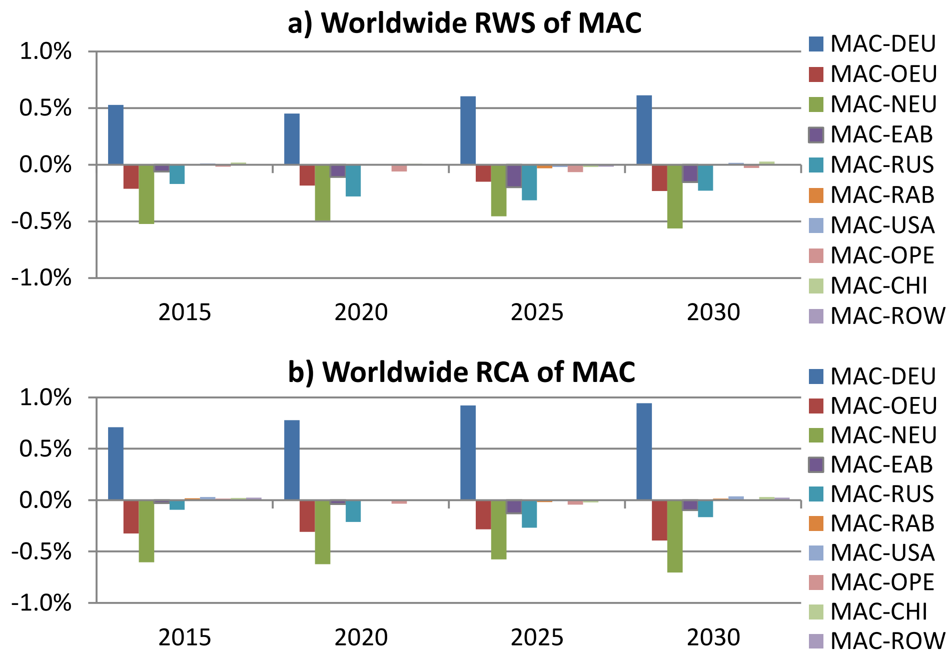
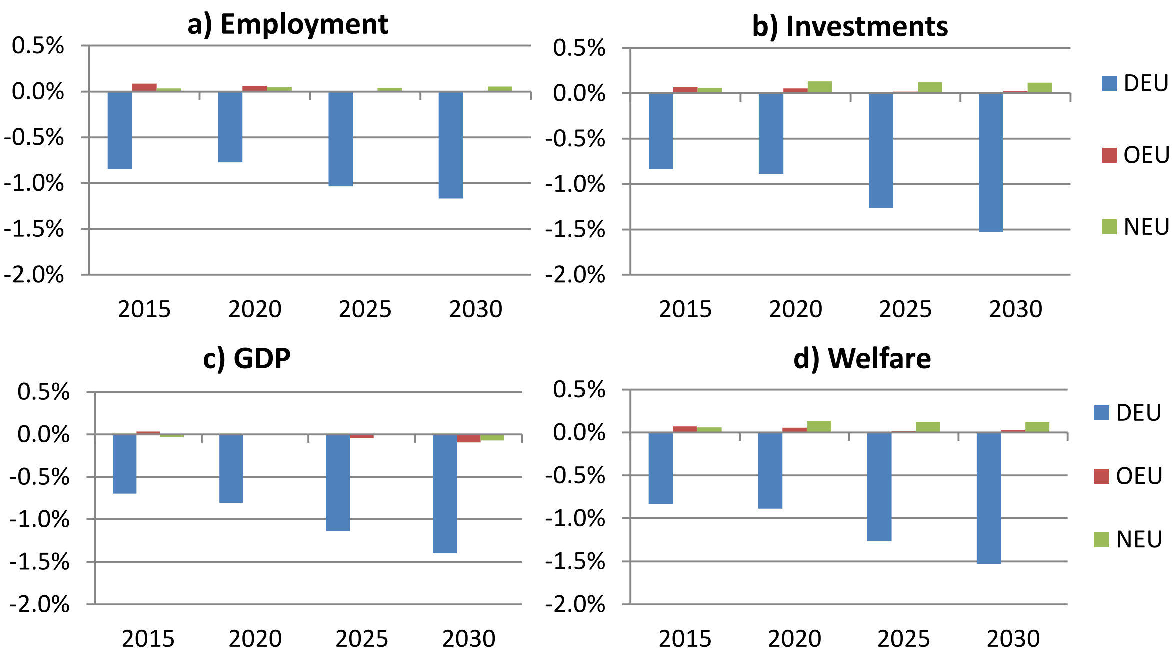


Figure 22: Competitiveness of worldwide MAC industries, 2015-2030, TECH in % to REF



How do these trade and competitiveness shifts affect the macroeconomy? Figure 23 illustrates the development of employment, investments, GDP and welfare in Germany and the EU.[4] Obviously, policy induced technology constraints in German electricity generation have a negative impact on the German macroeconomy. All indicators demonstrate a decline of employment, investments, GDP and welfare by up to 1.5% until 2030. In the rest of the EU, there are diminutive changes, which are positive for employment, investment and welfare and undefined for GDP.

Figure 23: Macroeconomic impacts in Germany and the EU, 2015-2030, TECH in % to REF



[4] Welfare is measured as Hicksian Equivalent variation (HEV).

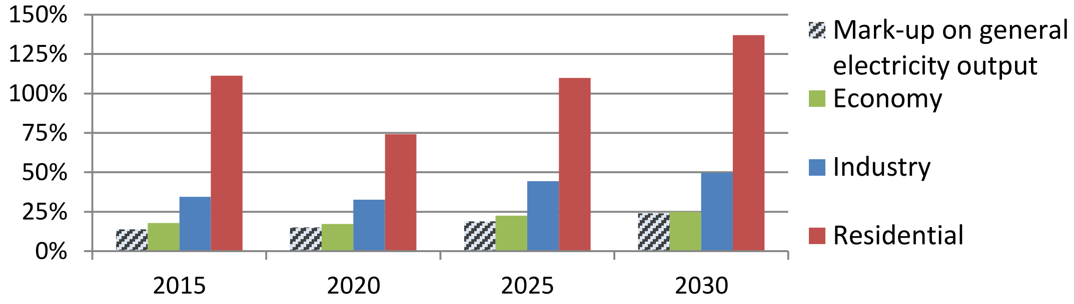
c. Scenario DISTR

Now, after having observed how the technology constraints of imposing renewable energy shares and investment limits for new coal power plants affect the electricity price in Germany, and how this in turn affects trade relations, competitiveness and general macroeconomic welfare, we are going to analyze different distribution concepts of the policy induced additional electricity costs in Germany for different electricity consumers. Therefore, we simulate one general mark-up on electricity output and three mark-ups for electricity input for the consumer groups industry, firms (economy) and residential, which induce the same additional electricity costs as the technology constraints of scenario TECH.[5]

The following results are not evaluated against the reference scenario. Instead, the general mark-up on electricity output is used as reference for the different distribution concepts that induces the same additional electricity costs as in scenario TECH. The general mark-up is modeled as an ad-valorem output tax on electricity. It matches exactly the electricity price increase of TECH in 2015-2025, but for 2030 it is 24% (mark-up) instead of 22% (price increase) (Figure 24). This is because the general mark-up does not affect relative prices within the electricity aggregate and therefore may impact differently on electricity demand, as there is no technology constraint in place. A technology constraint brings about suboptimal allocation of technologies for producing electricity, whereas a general mark-up affects electricity generation independently from technology choice.

The mark-ups for apportioning the policy induced additional electricity costs of TECH to single consumers are modeled as ad-valorem input taxes to the consumption of electricity. Apportioning the additional electricity costs to all production sectors of the economy equally results in a 18-25% input tax, whereas an apportionment to the industry (energy intensive industries, machinery and rest of industry) requires a 34-50% input tax. The highest input taxes emerge in residential electricity consumption, where it amounts to 74-137%, which is up to five times as high as the input taxes to the economy. This is due to the fact that residential electricity consumption in terms of quantities is lower than in the rest of the economy and that electricity exhibits a small share in overall household expenditures (below 2%, cf Figure 9).

Figure 24: Electricity consumption mark-ups for distributing the TECH electricity costs to different consumers



[5] Residential and economy make up 100% of national electricity consumers. Industry is part of the whole economy.

The different distribution concepts affect the competitiveness of Germany's energy intensive industry quite differently (Figure 25), when compared to the general mark-up. Whereas it reduces the competitiveness when distributing costs either to the 16 production sectors as a whole (economy) or solely to the industry, it increases competitiveness when distributing the costs to residential consumers. The smallest changes occur in case of distributing the costs to all production sectors equally. The industry profits most from a residential cost distribution, whereas it deteriorates machinery and the rest of industry, because residential consumers mainly consume manufactured products of these industries instead of directly consuming energy intensive products (cf. Figure 9). Therefore the competitiveness of the energy intensive industries relatively rises. On the contrary, distributing costs to industrial consumers clearly deteriorates their competitiveness. Regarding sectoral effects, again, the metal industry observes the biggest changes. Depending on concept and indicator, competitiveness decreases by 4-17% and increases by 7-14%, in case of residential cost distribution. The other energy intensive industries observe similar, but weaker changes.

Figure 26 finally illustrates the macroeconomic impacts of the distribution concepts in Germany. From a GDP point of view, a residential cost distribution is favorable, when comparing the three distribution concepts to a general mark-up on electricity output. This is due to price effects: industry prices rise, those of services and machinery sink. Because of the bigger importance of the latter, overall GDP decreases up to 1% in 2030. However, economic welfare, investments and employment are quite negative, when distributing costs to residential consumers only (up to 1.2% in 2030). From a welfare point of view, an equal mark-up for the overall economy leads to minimized welfare losses, because it does not severly affect relative prices and therefore does not induce major income losses of consumers.

Figure 25: Competitiveness in Germany at different distribution concepts, 2030, in % of general mark-up

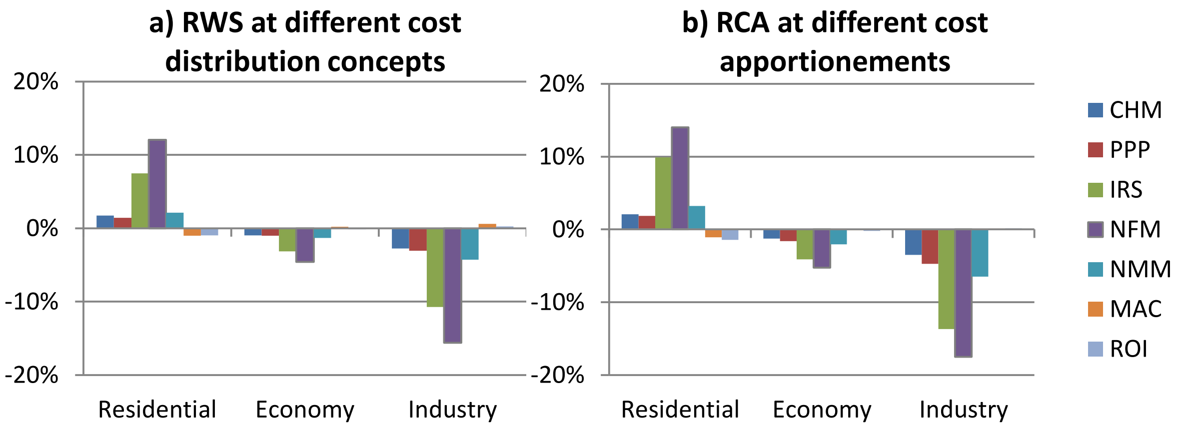
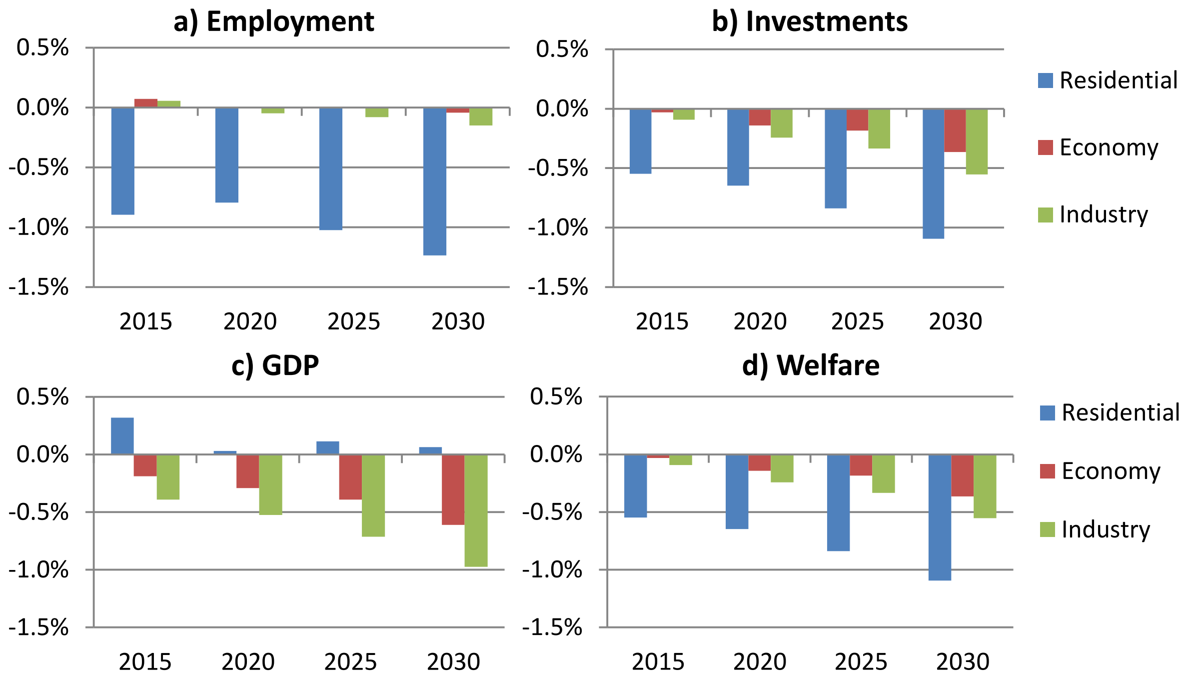


Figure 26: Macroeconomic impacts of the distribution concepts in Germany, 2015-2030, % of general mark-up



5. Summary and conclusions

In this paper we have analyzed the impacts of German energy policies on the competitiveness of national energy intensive industries. Our scenario analysis involved technological constraints for renewable energy technologies and coal (scenario TECH) compared with the reference scenario REF, and a varied distribution of the additional policy induced electricity costs via mark-ups on different electricity consumers in Germany (scenario DISTR) compared with a general mark-up on electricity output.

In the TECH scenario with electricity generation technology constraints, we found out that a minimum renewable energy share together with an investment limit for new coal power plants lead to an electricity price increase by up to 22% in Germany and an electricity costs increase by up to 7% in Germany resulting from an adjusted reduction in electricity demand. The electricity technology mix changes in terms of structure and absolute quantity including imports due to substitution and income effects. The electricity price is the main driver for competitiveness effects, which are measured by the indicators *Relative World Trade Share* (RWS) and *Revealed Comparative Advantage* (RCA). In Germany, the competitiveness of the energy intensive industries clearly deteriorates. Mainly the metal industries (IRS, NFM) are affected, where competitiveness is reduced until 2030 by 7-12%, indicating a proportional displacement of manufacturing facilities abroad to be interpreted as losing market shares to other world regions. Here mainly old and new EU member countries (NEU, OEU) profit by a 1-3% increase in competitiveness until 2030. The changes in the other energy intensive industries (chemicals, minerals, paper) move in the same direction, but exhibit weaker intensity. On the contrary, machinery and the rest of industry mostly react in the opposite direction as the energy intensive industries. This is mainly due to the relative nature of the competitiveness indicators. The machinery industry in Germany slightly gains competitiveness by around 1%, whereas it decreases by up to 0.6% in the rest of Europe and Russia (OEU, NEU, EAB, RUS). Although, Germany's imports of metal products increase, imports from other sectors decrease due to the income losses of consumers that stem from additional electricity costs. Outside the EU, Germany's imports decrease stronger than exports, such that Germany faces an increase in net exports there. Macroeconomic impacts in Germany are negative. Employment, investments, GDP and macroeconomic welfare decrease until 2030 up to 1.5%. Other EU countries observe only minor macroeconomic changes.

The second scenario with varied cost distribution (DISTR) has shown that for distributing the additional policy induced electricity costs of scenario TECH to certain electricity consumers in Germany, a high mark-up of residential and weaker ones for consumers in the economy and industry are necessary. This reflects the fact, that the share of electricity in total household expenditures is less than the share of electricity in the production costs of firms. In the case of a distribution to residential consumers, energy intensive industries' competitiveness increases by up to 12% compared to the case of a general mark-up on electricity output, whereas competitiveness of machinery and rest of industry slightly decreases (up to 1%). From a GDP point of view, a residential distribution leads to lower losses than in the case of a distribution to firms and industry. This is due to stronger changes in relative prices. However, from an employment and welfare point of view, a residential distribution induces clearly negative effects, because household income losses are greater. In this case, employment and welfare decrease until 2030 by around 1%, whereas a distribution to firms and industry only triggers smaller changes.

Based on our results, we draw two major conclusions: First, a single European electricity market would be useful to diversify different national energy systems within a European 'portfolio'. This would help balancing different policy or technology induced price pressures from different national energy systems via more electricity trade. Secondly, it is not justified from a welfare point of view to exempt energy intensive industries from additional electricity costs, because the sum of income and employment losses in other sectors (e.g. machinery) is greater. However, it may be a useful strategy in a world with ambitious climate policies, in order to protect them to a certain point. Here especially the metal industry deserves major attention. The point is that displacement of manufacturing facilities not only shifts jobs, but also knowledge. And that the development of renewable and energy efficient technologies needs deliveries from energy intensive industries. They profit from innovations and cost reductions in energy intensive industries, not only in electricity, also in the buildings and transport sector (e.g. chemicals for batteries, chemicals for insulation, steel for wind turbines, minerals and chemicals for PV, aluminum for lighter vehicles, etc.).

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