

EFFECTS OF THE CHANGING ENERGY POLICY ON THE GERMAN ECONOMY

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Abstract

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1 Introduction

The German government is keen to provide international leadership in climate protection and the establishment of a bio-based economy. In September 2010 the German government approved an energy strategy, the *Energy Concept*, which is going to require a fundamental restructuring of the German energy supply system during the period until 2050: the main objectives are a comprehensive replacement of fossil by renewable fuels, the development of the grid and increased efficiency in energy use. At the same time affordable energy prices, a high level of economic competitiveness and economic development must be maintained. The *Energy Concept* envisaged extending the operating lifetime of German nuclear power plants by 12 years on average (BMW_i 2014, BMU 2012).

Beyond that, in December 2007 the EU Council of Ministers introduced a stepwise reduction of hard coal subsidies until 2018 starting on 1st January 2011. Consequently, German hard coal production is expected to end due to a lack competitiveness compared to the international coal production (SteinkohleFinG 2007).

After the nuclear accident in Fukushima in March 2011, the federal government changed again its energy strategy on June 6, 2011, with a commitment to phase out nuclear power by the year 2022, starting with the immediate closure of the eight oldest plants. This decision, combined with the political target to further progress towards a low-carbon energy sector, had a major impact on the German energy policy. This second Energy Package, commonly known as *Energiewende (Energy Shift)*, contains seven legislative measures to support renewable energy and grid expansion, promote energy efficiency, fund the reforms and reverse the previous decisions to extend the lifetime of the nuclear plants (BMW_i 2012).

The reduction of hard coal subsidies and the nuclear phaseout require major changes in the structure of German energy supply: In 2011 nuclear power and hard coal provided 17.6 % and 18.3 % respectively of German energy sources. These 35.9 % of old-established energy sources have to be replaced by, predominantly, renewable energy sources by 2022 (AGEB 2014).

This paper analyses the economic effects of the nuclear phase out, the abolition of the hard coal subsidies and the simultaneously increase of renewable energy on the economy in Germany.

The analysis is conducted using a single country Computable General Equilibrium (CGE) model, a derivative of the STAGE model (McDonald 2007) that includes a detailed specification of the supply/production and demand for energy products in Germany. In this paper particular emphasis is placed on the modelling of the electricity sector: the model allows multiple production technologies for electricity that encompass both existing technologies, like nuclear, coal or gas and new technologies that use new energy sources and/or existing energy sources with different cost structures than 'conventional' technology of electricity production. This formulation requires addressing the problems presented by a homogenous product – electricity – being produced by different technologies with different cost structures. The time sequencing for the model is either a comparative static or a recursive dynamic variant, which allows an evaluation of implications of different time paths for the introduction of the new energy policies in Germany.

The analysis requires the development of a new database for Germany including a disaggregated database for energy sectors in Germany. The database is presented as a Social Accounting Matrix (SAM) with satellite accounts that record data on electricity use in quantity terms associated with different production systems. The source datasets are Supply and Use Tables (SUT) from National Accounts in Germany together with additional data on energy production and use collected by the German Federal Statistical Office, the Arbeitsgemeinschaft Energiebilanzen (AGEB) and additional data on commodity taxes, e.g., input (activity level) subsidies e.g., hard coal subsidies.

2 Energy policy in Germany

The current German energy policy captures several goals. Behind the big declared topics, the granting of the economic efficiency, the security of energy supply and climate protection, a multitude of objectives are in the focus of German government. Economic efficiency covers market structures and competition in the energy markets, but also the securing of growth and competitiveness of the German industrial sector in total, as well as appropriate consumer prices for energy.

For Germany, a country poor in natural resources and dependent on energy imports, the security of energy supply has priority. Security shall be reached by a diversification of energy sources and reduction of energy demand by the increase of energy savings and energy efficiency.

Increasing energy savings and energy efficiency are all requests in the context of climate protection. Next to this the importance of renewable energy sources are supposed to be increased and in doing so, green house gas emissions reduced. (BMW i 2014).

The implementation of these complex objectives is laid out in two comprehensive programs: The Energy Concept of 2010 and the Energy Package of 2011, described in the following chapter.

2.1 The Energy Concept 2010

With the *Energy Concept*, determined on 28th September 2010, the Federal Government established guidelines for the implementation of ambitious economic, energy and climate political objectives. The aim is to implement a long-term, integrated strategy until 2050. The transformation sets out to increase energy efficiency, to expand renewable energy sources and to reduce GHGs and includes the extension of the run-time of nuclear power plants by an average of 12 years.

The objective to reduce greenhouse gas (GHG) emissions is determined by 40 % in 2020 and by at least 80 % in 2050. Renewable energy sources should be developed to become a cornerstone of energy supply. The aim is to increase the renewables share in gross energy consumption from around 10 % in 2010 to 60 % in 2050. The energy strategy considers a sustainable energy supply of electricity, heat and mobility, which shall be ensured by renewable energy sources. This includes wind, biomass hydropower, solar power, geothermal and ocean energy, which will serve as an alternative to fossil (oil, coal, natural gas) and nuclear energy. The share of renewable energy in electricity generation shall be increased from 35 % in 2020 up to 80 % in 2050.

Simultaneously, the aim is to reduce energy consumption in the long term. By 2020, primary energy consumption is intended to decline by 20 % and in 2050 by 50 % compared to 2008. It requires annual increases in energy productivity by an average of 2.1 % based on total energy consumption.

It is envisaged that electricity consumption will be reduced by 25 % by 2050 compared with 2008. Final energy consumption in the transport sector is expected to decline in 2050 by about 40 % compared to 2005. Furthermore, the rate of renovation of buildings from the current approximately doubled each year to be 2 % of the total building stock.

On top of this, an immediate action program has been declared consisting of ten s-called urgent measures. The immediate action program focuses in particular on the expansion of offshore wind power and the expansion/upgrading of power grids (BMW i 2012).

Table 1: Objectives of the energy concept

	2012	2020	2030	2040	2050
Reduction in GHGs (base: 1990)	-27%	-40%	-55%	-70%	-80%
Share of renewable energies in total final energy consumption	10%	18%	30%	45%	60%
Share of renewable energies in electricity consumption	20%	35%	50%	65%	80%
Reduction of primary energy consumption (year: 2008)	-5%	-20%			-50%
Reduction of electricity consumption (base: 2008)	-1%	-10%			-25%
Reduction of final energy consumption in transport sector (base: 2008)		-10%			-40%

Source: BMU (2012)

2.2 The Energy Package 2011

Following the Fukushima Daiichi nuclear accident in March 2011, the federal government reconsidered the long-term role of nuclear power, with the result to phase-out the use of nuclear power for commercial electricity generation at the earliest possible time. On 30 June 2011, the *Bundestag* passed the Thirteenth Act amending the Atomic Energy Act (*Dreizehntes Gesetz zur Änderung des Atomgesetzes*). This act entered into force on 6 August 2011. In order to phase-out nuclear power more quickly, the process of reorganizing German energy supply at a fundamental level needed to be substantially accelerated. This process is known as the *Energiewende* (Energy Shift). So the Federal Cabinet, the *Bundestag* and the *Bundesrat* adopted a comprehensive so-called *Energy Package*, in June and July 2011. This *Energy Package* consists of seven acts and one ordinance, e.g. on expanding renewables, expanding the grid, energy efficiency and on the funding of the reforms. The Energy Package marked a second significant step by the federal government towards the restructuring of the energy supply. An important aim of the legislative package was to ensure that the nuclear phase-out could proceed as fast as possible, with the eight oldest nuclear power plants not being reconnected to the grid. Shortly afterwards, the Federal Council followed the *Bundestag*'s vote and approved the energy legislation. The key elements of the *Energy Package* 2011 adopted in July 2011, based on the *Energy Concept* of 2010 are:

- Act to Accelerate the Expansion of Electricity Networks (NABEG): acceleration of spatial planning;
- Energy Industry Act (EnWG): transposition of Third Internal Market Directive;
- Renewable Energies Act (EEG): cost-efficient expansion of renewables;
- Nuclear Energy Act: phase-out of German nuclear power plants until 2022;
- Energy and Climate Fund Act;

- Act to Strengthen Climate-compatible Development in Cities and Municipalities;
- Act on Tax Incentives for Energy-Related Modernisation of Residential Buildings;
- Ordinance on the Award of Public Contracts (BMW 2012).

2.3 The Hard Coal Financing Act

The extraction of hard coal in Germany is not competitive in the international context; therefore hard coal extraction has been subsidized since 1974.

In February 2007 a coal policy agreement was reached between the government, the hard coal industry and the coal-mining Länder. The agreement “Terminating subsidised hard coal production in Germany in a socially acceptable manner” contents the details of the phase-out process until the year 2018. The corresponding Act “The Act to Finance the Termination of Subsidised Hard Coal Production by the Year 2018” (Hard Coal Financing Act, *Steinkohlefinanzierungsgesetz*), entered into force on 28 December 2007. Subsidies will be reduced annually. Appropriate to the agreement, the government and the coal-mining Länder grant the financial support for sales, mine closures and liabilities needed in the period 2009-19. The industry has to contribute to the costs from 2012 onwards.

Beyond the German act, operational aid of hard coal extraction from 2018 onwards is permitted by a European Council Regulation, which came in force in January 2011 (BMW 2007, IAE 2013).

3 Energy and Electricity Taxation in Germany

The tax revenues from energy comprised 39.3 bn € and for electricity tax 6.9 bn € in the year 2012. This come up to 7.7 % of the country’s total tax revenues in this year (Statistical Office 2013).

The Petroleum Tax Act and the Electricity tax Act have been introduced in Germany on 1 April 1999 within the framework of ecological tax reform. These acts organized the energy and electricity taxation on petroleum (products) in Germany.

Due to the requirement of the EU Energy Tax Directive from 2003 (European Commission 2003) a harmonisation of minimum taxation on electricity and energy products from other energy sources than petroleum was necessary. On 1 August 2006 the Energy Tax Act replaced the previously Petroleum Tax Act. The Electricity Tax Act has been adopted.

The Energy Tax Act

The Energy Tax Act (EnergieStG 2006) regulates the taxation on energy products used as transport and heating fuels in Germany. These includes fuels of fossil origin and renewable energy products. The energy tax is a federally implemented excise tax containing a number of different tax rates on energy sources. The reason for these different tax rates is due to the fact that energy products are taxed depending on their use and because of their contribution on climate protection.

There also exist a number of exceptions. Depending on their use, energy products can be tax free or tax relieved. Tax exemptions are granted for example for air and water transport, as well as for the production of energy products. Tax reliefs are possible for energy-intensive enterprises in the agricultural and forestry sector and the base as well as energy-intensive manufacturing industries. In addition, manufacturing companies can receive repayments from paid electricity and energy taxes in the so-called tax cap. These regulations were introduced by the government in 2000 in the context of a Climate Agreement with the industry to ensure the international competitiveness of these industries. The European Commission has recognized the tax benefits until the end of 2012. Since the 6 August 2013 the receipt of the tax cap is linked to the establishment of an energy management system according to ISO 50001 or an environmental management system according to EMAS established. The intention of introducing these management systems are a systematically capture of energy consumption by the companies, the identification of potential savings and a specified reduction of energy use by 1.3 % until 2015 and 1.35 % from 2018 onwards.

The Electricity Tax Act

The Electricity Tax Act (StromStG 1999) regulates the taxation of consumption of electricity. It is an indirect excise tax, accrued by the electricity supplier, if electricity is used by the last consumer. The energy tax is passed to the consumer by electricity prices. The amount of electricity tax is 2.05 ct/KWh since 2003.

There exist different tax exemptions and tax abatements, for example reduced tax rates for the manufacturing industries or the abolition of electricity taxes on electricity produced from renewable resources.

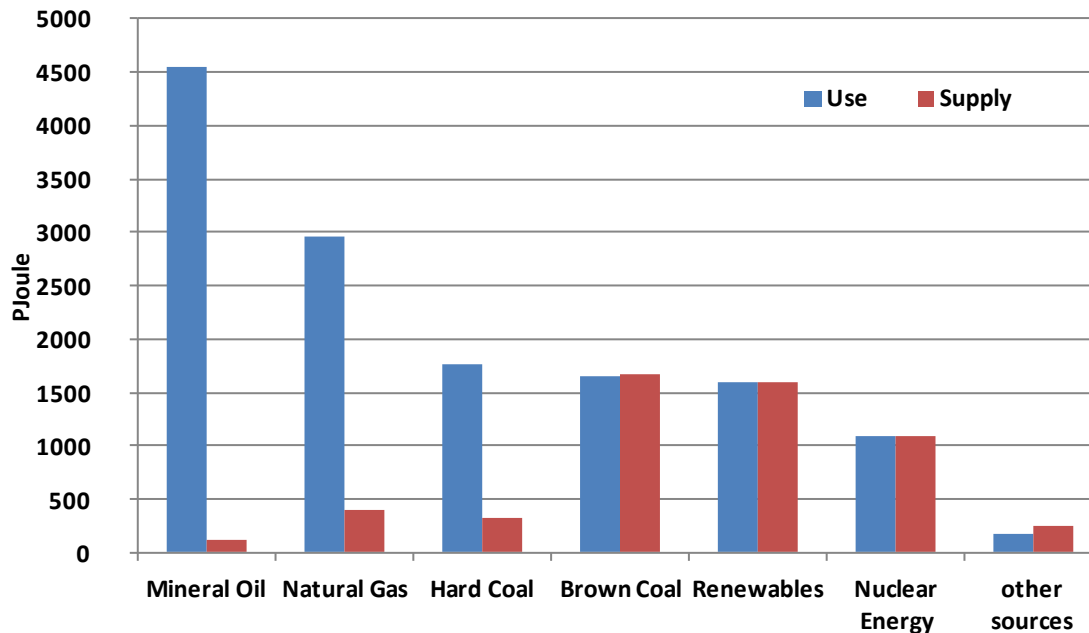
Further information and detailed tax rates can be found at the homepage of the Federal Ministry for Economic Affairs and Energy (www.bmwi.de) and the Ministry of Finance (www.zoll.de).

4 The Energy sector in Germany – An overview

Within the European Union (EU) Germany is the biggest user of energy with a primary energy consumption of 13,757 PJoule in 2012 (AGEB 2014). The main reasons for this high energy demand is due to the fact that Germany is one of largest countries in the EU in terms of population and energy intensive industries. 50 % of Energy is used for heat, 30 % for Transport and 20 % for electricity generation (BMU 2013).

For getting an impression of the German energy supply and use structure, Figure 1 shows the shares of energy sources in 2012. The blue bars show the use of the energy source for heat, transport and electricity in Germany. The red bars show the supply of energy based on domestic resources.

Figure 1: Shares of energy sources on primary energy consumption (2012)



Source: AGEB 2014

Germany represents a resource-poor country. Only the amount of energy of 4348.5 PJoule, what represents 32 % of energy use, is produced by domestic resources. Therefore almost 70 % of energy sources are imports. 98 % of mineral oil and 87 % of natural gas are imported energy sources, but also 82 % of hard coal. Energy from brown coal and renewable is based on domestic resources. Nuclear power has been produced continuously over years from nuclear fuel rods and can be seen as a medium-term domestic resource (AGEB 2014).

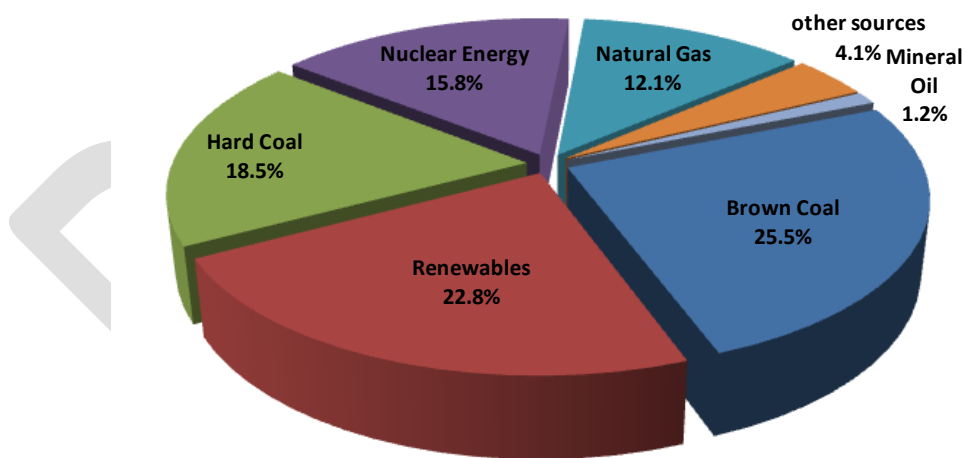
The use of energy is dominated by mineral oil, with a share of 33.5 %. Until today, oil based products cover almost the total requirements in the transport sector. Other important energy sources in Germany are hard and brown coal with shares of 12.6 % and 12.1 % as well as natural gas, with 21.5 %. While brown and hard coal are predominantly used for electricity generation, gas is mostly used for heat generation. The share of nuclear power on primary energy consumption adds up to 8 % in 2012. Beyond that, renewable energy sources became increasingly important. Water and wind power in addition with the use of biomass produced together 11.3 % of the primary energy consumption in 2012 (AGEB 2014).

The main objective of this paper is to discuss and to analyze the phase-out of nuclear power and the increasing use of renewable energy source accompanied with the phase-out of hard coal production. With this focus the next section will be on electricity generation and use in Germany.

4.1 Electricity generation in Germany

In 2012 629.9 bn kWh of electricity have been produced in Germany. Figure 2 presents the shares of energy resources on gross electricity generation in Germany for the year 2012.

Figure 2: Shares of gross electricity generation by energy source



Source: AGEB 2014

Brown and hard coal are the most important sources for electricity production with shares of 25.5 % and 18.5 %, respectively. Since the political decision to phase-out from hard coal production, the extractions have been reduced slightly. Nevertheless the share of hard coal on gross electricity production is relatively stable around 18-19 %.

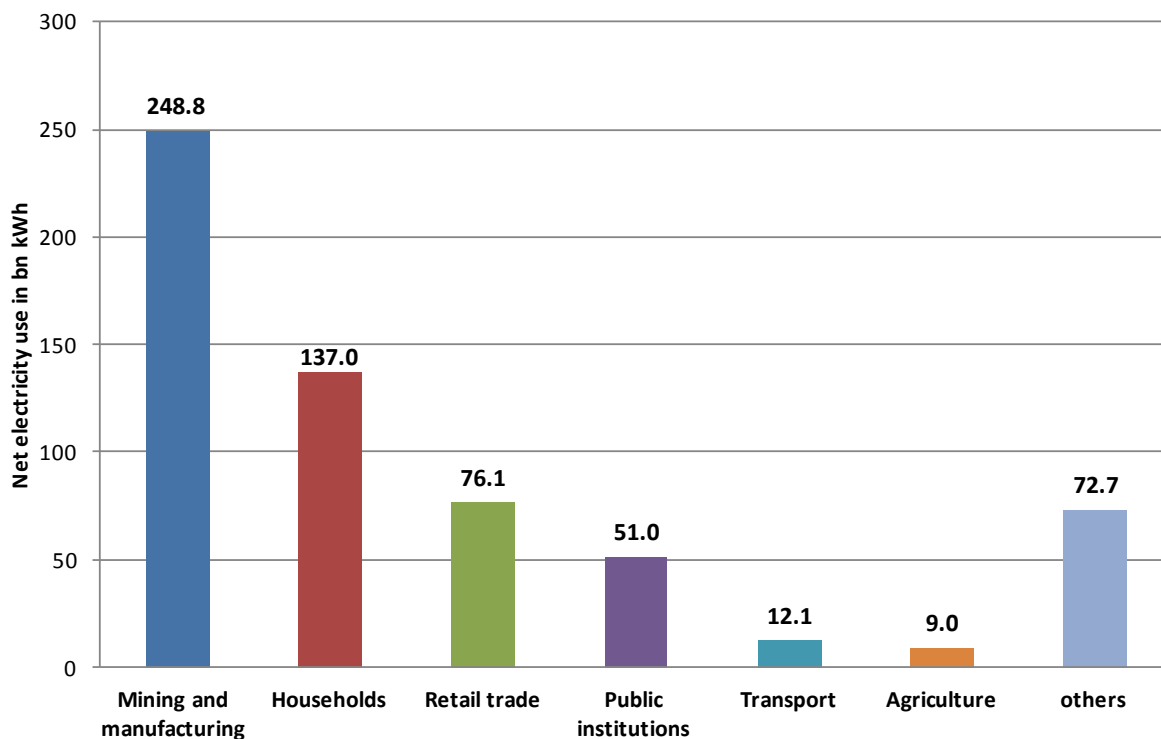
Brown coal does not depend on subsidies and is available in sufficient quantities. Germany is the biggest extractor of brown coal worldwide. In 2012 two new power plants with a capacity of 2,875 MW have put into operation (AGEB 2014)

Other important energy sources are nuclear power with a share of 15.8 % and natural gas with 12.1 %. Due to the energy change policy and the nuclear phase out, nuclear power lost 7 % compared to 2010. On the other side, the use of renewable energy source experienced a significant upturn, because of the energy change policy. All together renewable energies have a share on electricity generation by 22.8 %, started with a share of 5.2 % in 1999. The most important developments could be observed in the use of wind power, solar energy and biogas.

4.2 Electricity use in Germany

The use of electricity in 2012 comprehended 606.7 bn kWh. The biggest user of electricity are the mining and manufacturing sectors (see Figure 3) with 248.8 bn kWh, which correspond to 41 %. 23 % of electricity is used by households. Retail trade, public institutions, transport and the agricultural sector belong to the biggest users of electricity.

Figure 3: Electricity use in Germany in the year 2012



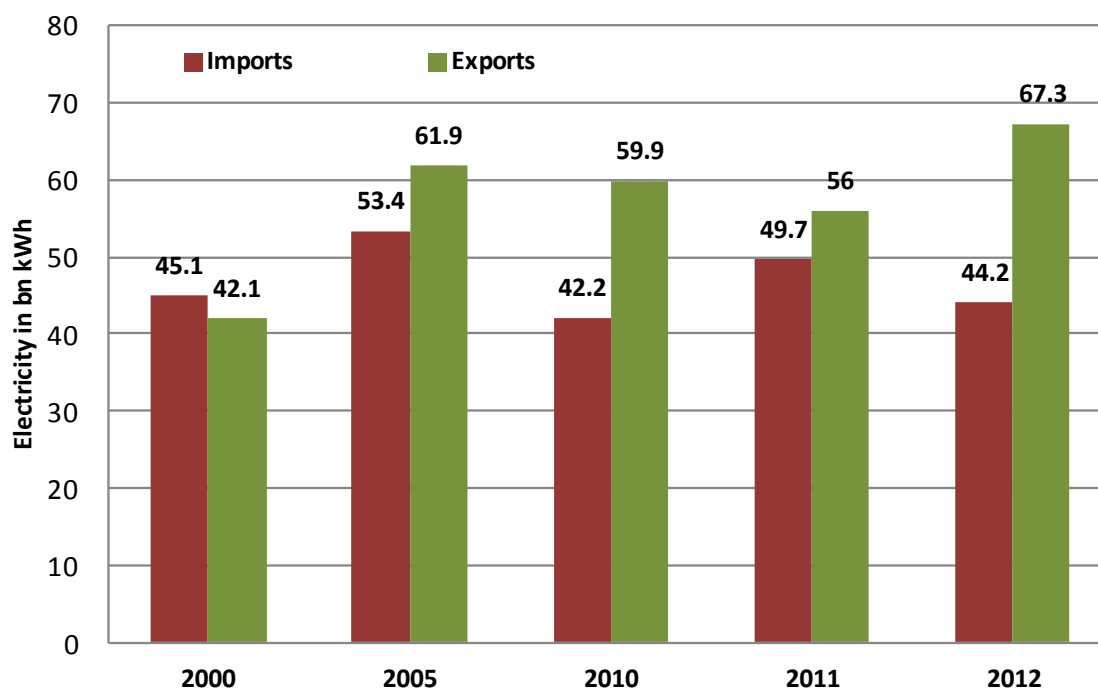
Source: AGEB 2014a

Germany is a net exporter of electricity. The most important consumer of German electricity exports is the Netherlands, who transferring German electricity also to Belgium and to the UK.

Figure 4 illustrates the imports and export in selected years. All together 67.3 bn kWh have been exported in the year 2012. 44.2 bn kWh have been imported, mostly from France, the Czech Republic and Austria. It has to be stated, that transboundary electricity flows are not always bounded by contracts. Rather they are so called transit amounts or loop-flows.

In addition, the figures shows that the immediate shut down of the nuclear power plants, did not affect great changes in electricity trade. Germany persist a net exporter of electricity in 2011 and 2012.

Figure 4: Electricity trade



Source: AGEB 2014a

5 Database

The database used in this paper, is compiled as a Social Accounting Matrix (SAM). A SAM represents social and economic data for an economy in the form of a square matrix, for usually one year. It represents the income generation by activities during production and the distribution and redistribution of income between all social and institutional protagonists of an economy. In a SAM receipts are captured in the row accounts and expenditures in the column accounts, which have to be equal in their

sum. Further information on the basic structure and characteristics of a SAM can be found in Pyatt (1991) and Round (2003).

Due to the lack of an actual existing SAM for Germany a completely new SAM has been compiled. The SAM is based on Supply- and Use Tables and other data sources from the German Statistical Office. The base SAM involves 71 commodities and 59 activities, 2 capital accounts, 1 labour account, 1 private household and 1 government account, 2 accounts for enterprises, 3 tax accounts, 1 investment and 1 stock changes account, 1 account for the rest of the world. Because of the high aggregation level of the base SAM, an energy SAM was developed, which reflects the complex structure of different sources of electricity generation, different commodities and activities have to be disaggregated. The development of the energy SAM for Germany is described in the following chapter.

5.1 The German Energy SAM 2007

The approach taken for this analysis of this paper is guided by the principle that the model and the database, i.e. the SAM, must be configured in such a way that both reflect the policy environment which is supposed to be analysed. As such the alternative of adapting the SAM to the CGE model is rejected and instead the choice is made to adapt the model to the 'reality' that should be reflected in the structure and reported transactions in the SAM. In order to follow the logic of this principle it is first necessary to determine the range of agents/accounts and policy instruments that need to be included within the SAM. However even a cursory review of the available databases indicates that the published degree of detail with respect to the energy sector and policy has limitations.

This requires additional disaggregation of inputs - intermediate use and final demand, outputs – joint- and by-production within the energy sector and its use for further processing, and of energy policy instruments.

The main challenge therefore is the further disaggregation of the electricity sector in the base SAM for Germany. Moreover, the energy policy environment in Germany is such that policy instruments impact upon decision making with respect to different commodities and different types of activities.

In order to reflect the influence of different policy instruments on the decisions made by different protagonists of the electricity sector the SAM for this study is based on the Supply and Use tables i.e., the commodity and activity accounts are potentially different. This distinction allows for the inclusion of policy instruments that impact on commodities, e.g., electricity taxes etc., and those that impact upon different activities, e.g., hard coal subsidies. In the published SUT electricity is recorded in different

commodities and activities. Often different energy sources are aggregated into a single account. Thus electricity is less disaggregated than required for the analysis here. The disaggregation draws heavily on the data collated by the Federal Statistical Office and the Federal and the Arbeitsgemeinschaft Energiebilanzen (AGEB). Therefore the compilation of an extended SAM faces a number of methodological and data-handling challenges. Table 2 shows the disaggregation of the original data from the SUT to the SAM database used in STAGE.

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Table 2: Disaggregation of the energy sector in the SAM

Original Aggregation in Statistic	Code	Disaggregation SAM	Code STAGE
Commodities			
Coal and lignite; peat	ccoal	Dark coal Brown coal	cdark cbrown
Crude petroleum and natural gas; services incidental to oil and gas extraction	coil	Crude petroleum	ccrudeoil
Coke, refined petroleum products and nuclear fuels	ccoke	Coke Refined petroleum Nuclear fuels	ccok cpetro cnucl
Electricity, district heat, Services	celec	Electricity District heat	celectricity cdist
Gas, Services of gas supply	cgas	Gas, Services of gas supply	cgas
Activities			
Mining of coal and lignite; extraction of peat	acoal	Mining of dark coal Mining of brown coal	adark abrown
Manufacture of coke, refined petroleum products, nuclear fuels	acoke	Manufacture of coke Manufacture of refined petroleum products Manufacture of nuclear fuels	acokeman apetro anucl
Electricity, gas, steam and hot water supply	agaswa	Gas supply Steam and hot water supply Electricity supply from dark coal Electricity supply from brown coal Electricity supply from oil Electricity supply from gas Electricity supply from nuclear fuels Electricity supply from other sources	agas awater aelblack aelbrown aeloil aelgas aelnucl aeloth
Taxes			
Taxes less subsidies on products	gtax	Taxes on products Energy tax Electricity tax Subsidies on products	SALTAX ENTAX ELTAX SUBS

6 The Model – STAGE

6.1 The basic STAGE model

The STAGE model suite falls into the class of models that follow the approach described by (Dervis, de Melo, & Robinson, 1982) and the models developed by (Robinson, Kilkenny, & Hanson, 1990) and (Kilkenny, 1991). At the core of the suite is the basic STAGE model, but the basic STAGE model is not often used in practical work rather it is customised to the setting/economic environment being explored. The guiding principle is that the basic STAGE model provides a template that can support multiple variants; indeed the expectation is that for most studies it will be necessary/desirable to make changes and/or additions to the basic STAGE model.

The basic STAGE model is characterised by several distinctive features. First, the model allows for a generalised treatment of trade relationships by incorporating provisions for non-traded exports and imports. Second, the model allows the relaxation of the small country assumption for exported commodities that do not face perfectly elastic demand on the world market. Third, the model allows for (simple) modelling of multiple product activities through an assumption of fixed proportions of commodity outputs by activities with commodities differentiated by the activities that produce them. Hence the numbers of commodity and activity accounts are not necessarily the same; this captures the empirical fact that real activities/industries typically produce multiple commodities/products and while for many manufacturing and services activities secondary products are relatively unimportant this is far from the case for agriculture.¹ Fourth, (value added) production technologies are specified as nested Constant Elasticity of Substitution (CES). And fifth, household consumption expenditure is modeled using Stone-Geary utility functions; these yield linear expenditure systems that allow for minimum levels of consumption of commodities, which is valuable when modelling consumption choices by households with very low incomes.

The model is designed for calibration using a reduced form of a Social Accounting Matrix (SAM) that broadly conforms to the UN System of National Accounts (SNA). This approach has been influenced by (Pyatt, 1987).

¹ An additional advantage is that the requisite databases can be compiled from the directly observed transactions data in Supply and Use tables rather than the transformed data in Input-Output tables. Thus output composition choices are modelled explicitly rather than being subsumed into data transformation processes.

7 Scenarios

8 Simulation Results

9 Discussion

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