20% by 2020? Energy efficiency in Germany

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Abstract

The increasing pressure of climate change and the obstacles on the way Post-Kyoto process lead to an increasing interest in energy efficiency measures. The basic idea of the "nega-joule" is that any unit of energy not consumed is a contribution to reaching the 2°-targets. Moreover, energy efficiency is considered a valuable contribution to increased energy security and decreased dependence on energy imports and less vulnerability to price shocks etc.

The objective of the contribution is therefore twofold. It firstly provides a systematic analysis of energy efficiency potentials in different economic sectors (households, industry, and transport). The analysis focuses on so-called no-regret potentials which can be refinanced by the energy saving over the lifetime of the appliances used. Secondly, the analysis takes on a macro-economic view and shows the effects of investments in energy efficiency for various economic sectors and the economy as a whole (labor market, GDP, structural effects, value added).

These objectives are pursued using scenario techniques and the macro-econometric model PANTA RHEI. To be able to model the effects of increased energy efficiency, two scenarios have been developed: A BAU scenario following a business as usual path with no further measures and a policy scenario. The macro-econometric model is then applied to calculate net economic effects on growth, employment, public budgets as well as on the environment in terms of emissions. Costs and benefits are fully accounted for.

The contribution studies these effects for Germany. It turns out that the overall effect of a program to deploy no-regret efficiency potentials leads to positive economic results.

Keywords: Energy efficiency, Input-output analysis, employment, net economic effects.

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1 Introduction

Energy efficiency has been an issue on the political agenda for the last years and will continue to be. The public debate on global change and its impact on the global economy, the scarcity of resources and the growing dependence of some countries on imported oil and gas and on the goodwill of the resource owners have spurred the interest in the decoupling of economic growth and energy consumption. As early as s 1989 Amory Lovins coined the term „Negawatts“ at the *Green Energy Conference* in Montreal [Lovins 1989] as a description of increased energy efficiency, i.e. for energy <u>not</u> used. The idea has been prosecuted by Weizsäcker et al. in the publication „Factor four“ [Weizsäcker et al. 1995]. Europe has committed itself to a 20% reduction of total primary energy supply (TPES) by 2020 compared to a BAU development (COM(2006)545, COM(2005)265, COM(2008) 772). This efficiency target is part of a comprehensive energy concept (COM(2008) 30). In January 2008 the commission passed a note to the EU parliament with the title „20, 20 and 20 by 2020, which includes the commitment for a reduction of GHG to 20% below the 1990 level and a 20% share of renewable energy in total energy consumption by 2020.

Climate protection and efficiency measures not only directly reduce environmental impacts and energy imports but also have various direct and indirect impacts on the economy. Today's investment in energy efficient appliances, machinery and equipment leads to long-term reductions of the energy bill for firms and households. Additionally, new markets for energy efficient products may lead to increasing export chances for the respective industry.

The following contribution summarizes first results of a study for the German Federal Ministry of the Environment (ifeu/ISI/Prognos/GWS 2009) that is part of a larger research project on the impacts of the German efficiency initiative. The goal of the study is the identification of a set of efficiency measures, their additional costs and their impacts on the economy. The analysis starts with a business-as-usual scenario (BAU) that includes all efficiency measures which have already been passed by the political bodies. To simulate the effects of further efficiency increases, an efficiency scenario has been developed that includes a set of 33 additional measures accounting for about 10% of final energy consumption in 2020; i.e. measures not included in the reference. We considered measures in the household sector, the tertiary sector, industry and transport. We did not consider the energy sector, shifts in fuels, urban planning measures or shifts in the modal split. The efficiency scenario could be characterized as “technology oriented”. Both scenarios are implemented in the macro-econometric model PANTA RHEI. The respective differences in economic indicators, such as employment, GDP etc. can then be attributed to the increased efficiency efforts included in the efficiency scenario, since all other factors have been held equal.

This contribution is organized as following. This introduction is followed by an overview of the modeling approach. It summarizes the BAU scenario and explains the efficiency measures considered, their costs and benefits in terms of energy reduction. Section 3 gives a brief introduction to the model PANTA RHEI, section 4 reports the economic effects and section 5 concludes and gives an outlook on ongoing research.

2 The Modeling approach

To examine the economic effects of additional efficiency measures in Germany our analysis consists of two steps: development of scenarios and simulation with PANTA RHEI, which in turn will be explained in the following.

Scenarios provide a structured description of possible future development paths, depending on current and future framework conditions. The BAU scenario is based on Prognos and EWI (2007). This scenario has been coordinated with different government bodies and ministries. Table 1 gives a few key data of this projection.

Table 1: Key data of the BAU scenario

	Unit	2005	2010	2020	2030
Oil price	USD/bbl	55	72	81	128
Population	1000	82,464	82,402	81,425	79,524
Households	1000	39,178	39,631	39,994	39,909
GDP	bill. Euro	2,123	2,312	2,700	3,099
Production	bill. Euro	3,864	4,191	4,957	5,886
Total Primary Energy Supply	PJ	14,690	14,427	13,352	12,890
Oil	%	35	35	35	36
Natural gas	%	23	24	27	29
Hard coal	%	12	13	12	10
Lignite	%	11	10	8	7
Nuclear	%	12	10	4	0
Renewables	%	5	8	12	15
Other	%	1	1	2	4
Final Energy Consumption	PJ	9,141	9,300	9,020	8,954
Households	%	29	29	27	25
Tertiary sector	%	16	16	15	14
Industry	%	27	27	29	30
Transport	%	28	28	29	31
Electricity generation	TJ	2,234	2,341	2,345	2,399
TPES/cap	GJ/cap	178	175	164	162
GDP/TPES	Euro/GJ	145	160	202	240
Production/FEC	Euro/GJ	423	451	549	657
CO_2 emissions	MtCO2	833	824	741	692

Source: Own simulation results.

The projection does not include the 2009 crunch. However, since the efficiency scenario is based on this BAU scenario and the economic effects are considered in terms of differences between two simulation runs, this should not alter the main effects. Chapter 5 gives an outlook on the effects of the credit crunch and the economic crisis on energy consumption and efficiency.

The German population is expected to shrink by almost 3 million people by 2030. However, since the average household size also decreases, the number of households is expected to rise. Total primary energy supply (TPES) is projected to decrease from more than 14,000 PJ to less than 13,000 PJ, a decrease of more than 10% in 20 years. The scenario includes phasing out nuclear energy and a clear shift towards renewable energy in the overall energy mix. Efficiency gains and increases in RES use yield a decrease in CO_2 emissions by 17% between 2005 and 2030. The BAU scenario does contain several efficiency measures and political instruments to support efficiency increases. Thermal insulation of buildings, for instance, has been supported with a program for soft loan conditions and allowances. Car taxes depend on vehicles size and emission category, eco-taxes signal scarcity of energy and labeling is mandatory for certain household appliances. However, energy efficiency does not get as much notice as other environmental issues such as renewable energy or others. Therefore, compared to the national targets with respect to RES share, CO_2 emissions and efficiency, the development projected in the BAU scenario falls short in all three aspects:

- RES share: energy from renewable sources have to contribute 30% to total electricity generation by 2020. The European target of 18% RES in final energy demand also has to be reached by 2020.
- CO_2 emissions: the national goal is set at a 40% reduction by 2020 compared to 1990.
- Efficiency: In the German sustainable development strategy, a doubling of energy productivity, i.e. the ratio between GDP and primary energy, is set for 2020 compared to 1990. This translates into a 3% annual increase in productivity from today until 2020.

It is a well known fact that vast potentials in all economic sectors are left untapped. The barriers to exploit these potentials have been traced back to lack of information, lack of financing instruments, transactions costs and others (cf. IEA (2008a, b). Leaving these barriers and the instruments to overcome them aside, still some measures will be cost efficient (no-regret measures) and others will be only efficient taking additional positive external effects into account (such as costs of climate change). In the following we focus on the first type of potentials, i.e. no-regret measures, which are cost efficient over the lifespan of the equipment.

The efficiency scenario is then constructed bottom up for households, the tertiary sector, industry and transport. Each sector will be described in turn in the following.

Efficiency in households

Energy consumption of private households is dominated by energy for heat. 80% of total household energy consumption are attributed to this purpose, 10% go to electricity and hot water each. Therefore, the efficiency scenario for households includes all feasible measures of insulation of buildings' elements (walls, roofs, ceilings) concerning the building stock and newly built houses plus changes to a more efficient heating system. Fuels switches to renewable energy are not considered, the effects thereof can be found in [Lehr 2008, BMU 2006].

Concerning electricity consumption, the scenario includes the reduction of stand-by and/or operational energy consumption of consumer electronics – entertainment products and household products. Efficient lighting has been analyzed separately. Overall, the fields analyzed cover up to 80% of total household electricity consumption.

All measures together lead to additional energy savings of 254 PJ, with electricity savings of 86 PJ and fuel savings of 168 PJ by 2020. Table 2 gives an overview.

Table 2: ***Energy savings by private households [PJ]***

	Savings compared to BAU by 2020
Sum (% of final energy consumption)	**254 (10.4%)**
Buildings and efficient heat (stock)	154
Highly efficient new buildings	23
Efficient lighting	20
Efficient consumer electronics	25
Reduction of operating electricity of entertainment electronics	15
Reduction of stand-by for consumer electronics	17
Source: ifeu/ISI/Prognos/GWS 2009	

Efficiency in the tertiary sector

The largest share of energy consumption in the tertiary sector comprises of the supply of heat, with the problems and the potential similar to those discussed above. In contrast to the household sector, the tertiary sector not only needs energy to heat buildings, but also for certain processes such as washing, drying or food processing. The next largest application is powering pumps, vents and motors. 6% of total energy consumption goes into office electronics and air conditioning. Also, lighting consumes with 11% a rather large share.

Coverage of the rather general measures suggested for the tertiary sector is not as large as suggested before, since the tertiary sector has more specialized energy consuming processes and needs more detailed measures. However, the measures suggested in Table 3 result in energy savings of 68 PJ.

Table 3: ***Energy savings in the tertiary sector*** **[PJ]**

	Savings compared to BAU by 2020
Sum (% of final energy consumption in the sector)	**68 (5%)**
Buildings and efficient heat (stock and newly built)	10
Optimizing ventilation and AC	10
Efficient cooling	3
Efficient lighting	33
Efficient office electronics	6
Streetlight	5
LED lighting	1
Source: ifeu/ISI/Prognos/GWS 2009	

Efficiency in industry

With 2444 PJ industry contributes more than 30% to final energy consumption in Germany. The main potentials are found across all industries in the fields of process heat, mechanical uses and lighting. These potentials are cost efficient in most cases. Cost efficiency is defined as the positive returns from the investment over the lifetime of the appliance. In other words: the investment plus interest is covered by the gains from energy saving.

Especially electricity consumption can be reduced by large amounts through the use of efficient pumps, vents, pneumatic systems, compressors and lighting. These fields contribute roughly 75% to total energy consumption. 60% of total fuel consumption also go into uses, which are identical across all industries. Process heat, i.e. vapor, drying processes, ovens and the heating of buildings are the major heat applications. For economic efficiency measures the cross-industrial technologies are the ideal targets, because they do not require complex adjustments to individual industries.

Table 4 gives an overview. Total savings come up to 212 PJ in 2020 and 65% of energy consumption is covered by the technologies suggested. Additional potential lies in optimization of processes and the introduction of new technologies in energy intensive sectors such as steel and iron, paper production, concrete and glass production as well as chemicals production.

Table 4: Energy efficiency in industry [PJ]

	Savings compared to BAU by 2020
Sum (% of final energy consumption in the sector)	**212 (8.1%)**
Motors	101
Efficient motors	7
Optimal pneumatic systems	15
Optimal pump systems	17
Optimal vent systems	14
Optimal cooling systems	3
Optimal other systems	45
Efficient lighting	13
Efficient vapor	24
Efficient drying	29
Efficient industrial ovens	40
Efficient caloric value heat (natural gas)	5
Additional potential from specific technologies [1)]	ca. 150

Source: ifeu/ISI/Prognos/GWS 2009

1) Fraunhofer ISI (2001) and Prognos (2007)

Compared to 2007 this amounts almost 9% of final energy consumption. With the majority of the suggested measures the investment is paid back through energy savings over the life-span of the equipment. The last line in Table 4 gives the additional potential of optimized and/ or new processes.

Efficiency in transport

Energy for the transport of people or freight holds a 30% share of final energy consumption in Germany. More than 85% of energy consumption in the transport sector goes into road traffic. Therefore, most measures suggested in the following focus on road traffic.

There is a wide body of literature on efficiency increases in the transport sector. The suggestions reach from behavioral change, e.g. switch from cars to bicycles, or walk for short distances, and technological improvements, such as an increase mileage of cars, to infrastructural improvements (e.g. improvements of public transportation).

The measures suggested here cover mileage improvement, modal shift and efficient driving. Total savings of 300 PJ are attainable by 2020.The largest part with 175 PJ is contributed by efficient cars and trucks. Efficient driving and efficient tires and oils contribute 100 PJ. The costs of the measures can be recovered during the life span of the measures through energy savings.

Table 5*: Efficiency in transport [PJ]*

	Savings compared to BAU by 2020
Sum (% of final energy consumption in the sector))	**302 (11,5%)**
Efficient cars	173
Hybrid busses	0,2
Hybrid light trucks	2,4
Low rolling-resistance tires (cars)	22
Low rolling-resistance tires (trucks)	23
Fuel-efficient oils	18
Efficient driving (cars)	36
Efficient driving/ drivers‘ training (trucks)	3
Inner city modal shift to public transport and bikes	24

Source: ifeu/ISI/Prognos/GWS 2009 and the sources quoted there.

Obviously, the potential for energy saving in the transport sector exceeds the measures suggested here by far. However, the cost effectiveness of measures such as a severe shift in modal split, changes in infrastructure of cities etc. depend on the political instruments used for financing these measures. Here, our goal is not so much a discussion of feasible political instruments but rather the analysis of the effects of cost effective energy efficiency potentials which are attainable with today’s technology. From the bottom-up approach the efficiency scenario for all sectors is constructed carefully to avoid double counts. It comprises of 33 single technological and sometimes behavioral (transport) changes with different impacts on energy efficiency.

Summing up, the efficiency scenario has the following properties:

1. Comprised of measures which predominantly are cost efficient.
2. Technology oriented
3. Coming close to the national targets with respect to energy productivity (80% covered), emission reduction and reduction of electricity consumption. The latter target supports the RES target in electricity generation.

An investment of 136 billion Euro is necessary to tap the outlined potentials. The largest part of this sum will be necessary for insulation and other improvements of buildings as well as other energy savings in the household. Transport takes the second largest share. Again, households contribute to this potential, but a large part of new vehicles is bought as company car or official car.

Table 6*:* ***Additional investment compared to BAU scenario***

	Investment until 2020 in billion Euro
Total	**136**
Private households	81
Tertiary sector	11
Industry	13
Transport	30
Source: BMU 2009	

The efficiency scenario is now compared to the BAU scenario with the help of an economic model. Investments from companies and firms have impacts on the economy influence relative prices, available income, revenues, wages and savings on the expenditure for energy.

3 The economic model

PANTA RHEI is an environmentally extended version (cf. [Lehr et al. 2008, Meyer et al. 2007a, Lutz et al. 2007; 2005]) of the macro-econometric simulation and forecasting model INFORGE of the German economy. It is based on official statistics. INFORGE consistently describes the annual inter-industry flows between the 59 sectors, their contributions to personal consumption, government, equipment investment, construction, inventory investment, exports as well as prices, wages, output, imports, employment, labor compensation, profits, taxes, etc. for each sector as well as for the macro economy (Meyer et al. 2007b, Ahlert et al. 2009).

The economic part of the model also contains a complete SNA system to calculate the aggregated variables and the income redistribution between the government, households, firms and the rest of the world. For these institutional sectors, their disposable income and flow of funds can be estimated and the budget of the government, including fiscal policy and the social security system, is depicted endogenously. In this way the model provides a consistent framework for the analysis of market-based climate change policies, as indirect effects in other industries are captured and additional tax revenues are adequately accounted for.

PANTA RHEI is built fully integrated and bottom up, leading to each sector of the economy being modeled in great detail (Almon 1991). The macroeconomic aggregates are calculated by explicit aggregation. One further strength of the model is its high level of interdependence, for instance between prices and wages or between prices and volumes.

In the behavioral equations decision routines are modelled that are not explicitly based on optimization behavior of agents, but are founded on bounded rationality. The parameters in all equations in PANTA RHEI are estimated econometrically using OLS Producer prices are the result of mark-up calculation of firms. In contrast to models based on optimization no-regret inefficiencies as observed on a micro level can be included in the model.

The energy module captures the relations between economic development, energy input and CO_2 emissions. It contains the full energy balance with primary energy input, transformation and final energy consumption for 20 energy consumption sectors and 30 different energy carriers (AGEB 2009). It is fully integrated into the economic part of the model.

Final demand is determined from the disposable income of private households, the interest rates and profits, the world trade variables and the relative prices for all components and product groups of final demand. For all intermediary inputs, imports and domestic origins are distinguished. Given final and intermediary demand, final production and imports are derived. Employment is determined from the production volume and the real wage rate in each sector, which in return depends on labor productivities and prices. Figure 1 gives an overview.

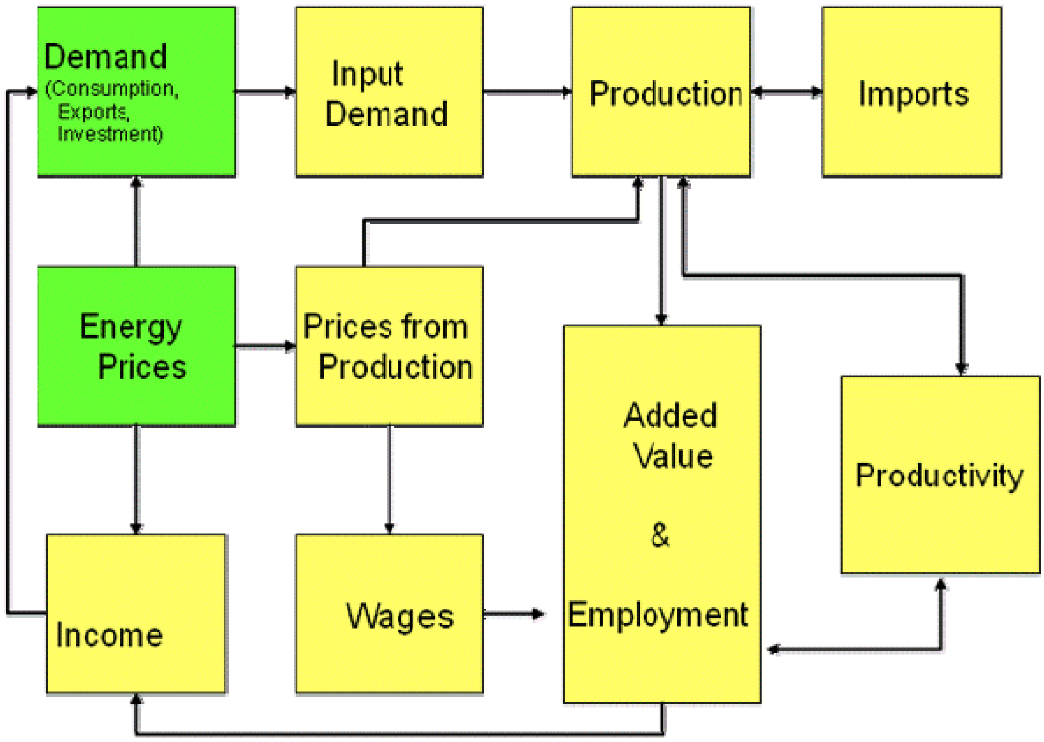

Figure 1: The model PANTA RHEI.

4 Economic impacts of additional efficiency measures

To evaluate the impacts of political instruments or of certain measures, the results of the business–as-usual simulation are compared to the simulation results including additional efficiency measures. Here the additional measures consist of all measures described in the previous chapter. The efficiency scenario has been characterized by investment in improved efficiency and savings on the energy bill. The additional spending enters the model as investment on equipment, structural investment on buildings and consumption expenditure. Depreciation, annual allowances and savings reductions to finance the investment are fully included in the model. Since almost all measures are cost-efficient, additional expenditure and investment does not crowd out other investments or consumption. Energy savings and the decrease in energy costs are fully accounted for in the model.

The sum of the net effects is positive. Gross production, GDP and its components consumption, investment and trade are higher in the efficiency scenario due to the efficiency measures over the whole simulation period (2009 – 2020). Obviously, higher production does not directly translate into higher added value, because it is partly imported and also increases imported inputs according to the German trade structure. A considerable share of the additional GDP stems from private consumption (18.3 bil. Euro). The direct effect comes from consumption of energy efficient goods, but there is a large indirect effect from additional consumption due to energy savings. The reallocation of funds from energy expenditure to consumption leads to more employment in all sectors. Employment also rises in the construction sector and in production, adding to the consumption effect.

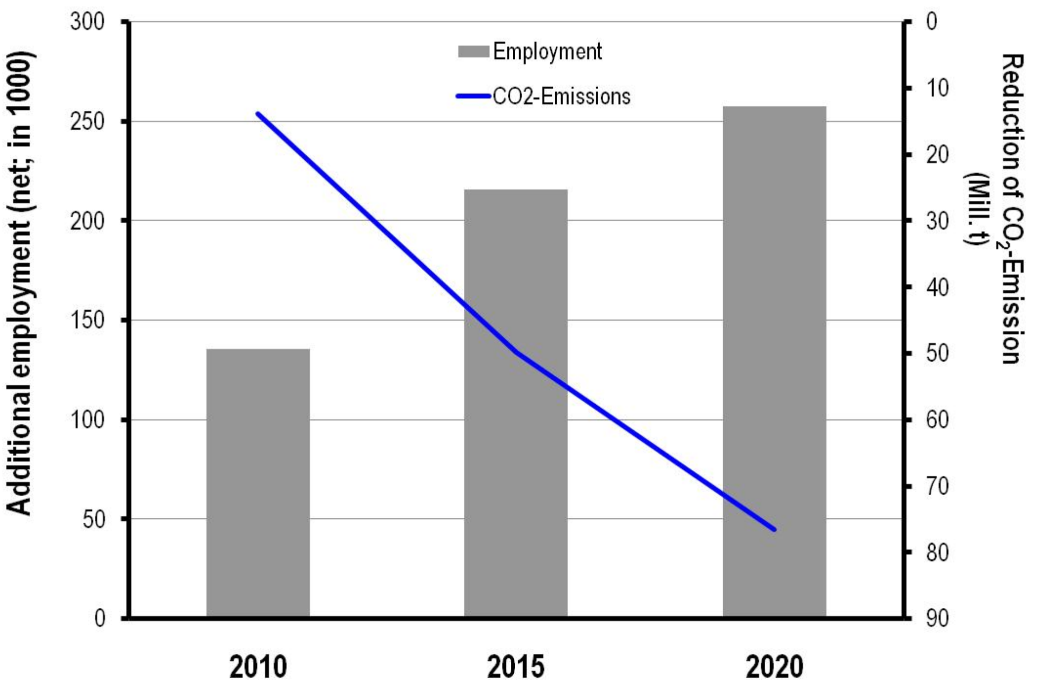

Figure 2*:* ***Employment and CO_2 emissions, difference of efficiency and reference***

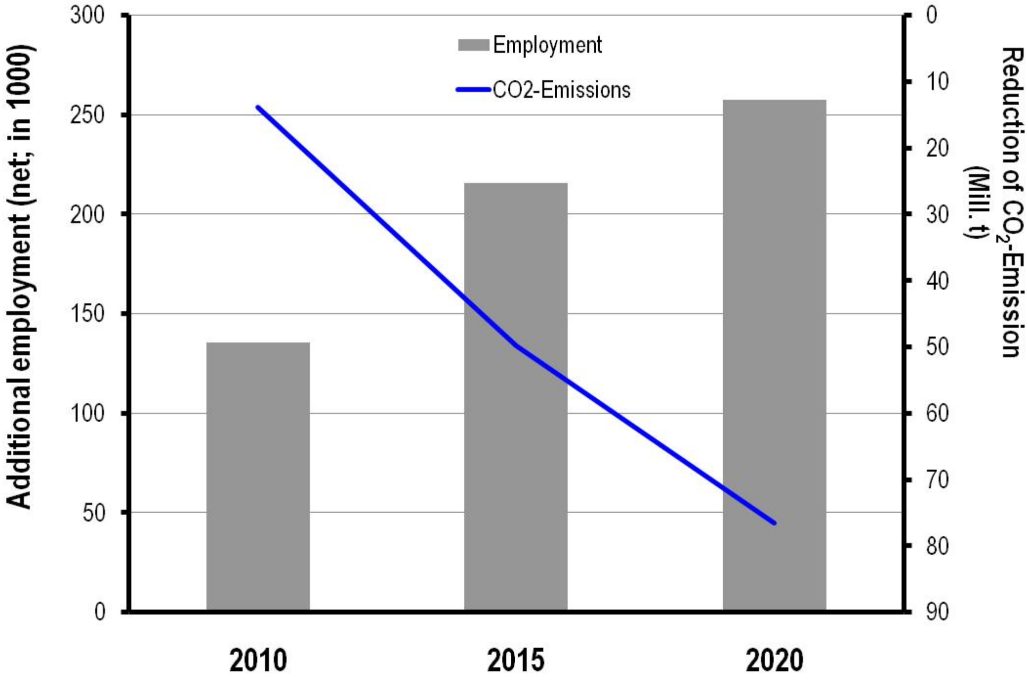

Figure 2 shows the differences between the two simulation runs for two important quantities: CO_2 emissions and employment between 2010 and 2020. The efficiency scenario yields considerable CO_2 reductions and increases in employment. Additional employment reaches 257.000, plus governmental employees and self-employed the number climbs almost up to 290.000. At the same time, wages will increase due to the employment increase (+.27% in 2020). The positive employment effects are the results of different impacts:

- Additional investment yields additional production and therefore additional employment
- Energy is replaced by capital
- Imported value added (e.g. crude oil, gas) is replaced by domestic value added
- Construction and the tertiary sector are more labor intensive than the energy industry
- Energy efficiency improves economic productivity and thus competitiveness.
- Short term higher demand for (efficient) investment goods and equipment improves private budgets and induces additional incomes.

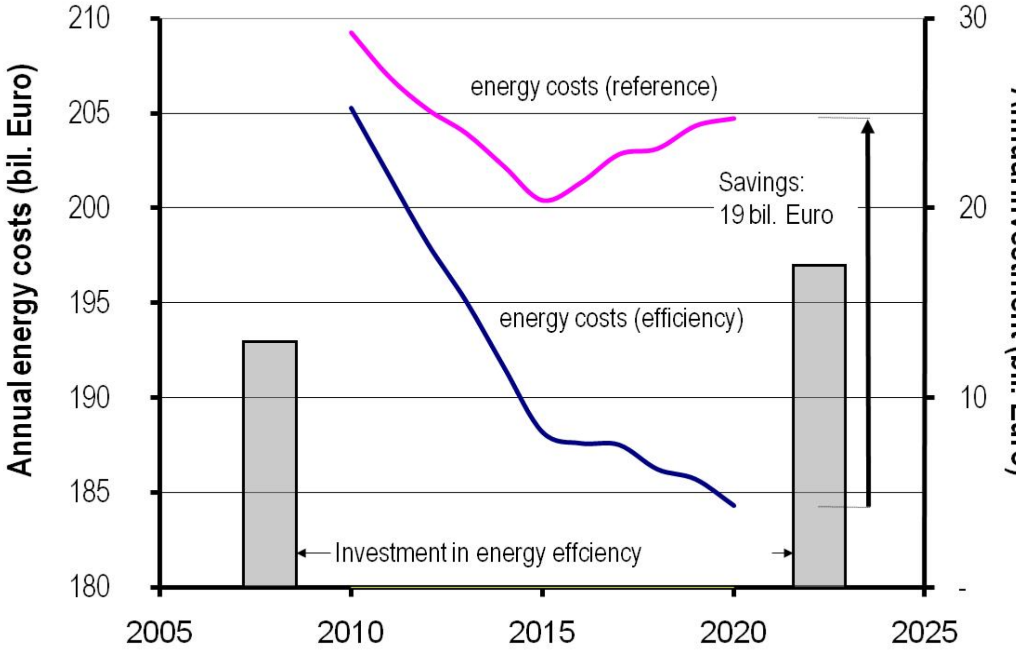

Figure 3: Additional investment (annual) and energy costs for the BAU and the efficiency scenario

The main impact comes from additional investment, especially in the construction sector, where labor intensity is rather high. Given the work necessary for insulation, additional employment will mainly be created in small and medium enterprises. The long term effects go back to energy savings and reductions of the energy bill. Figure 3 shows the long term development of the energy costs for the two scenarios and contrasts investments and savings. Total savings in 2020 will be 19 billion Euro.

Sectoral effects reflect the structure of production in the efficiency scenario. Most sectors show increasing employment. Of course, the highest effects can be seen in construction, this reflects the already mentioned labor intensity and the large investment going into this sector. But employment increases also in other sectors. Efficient appliances and efficient cars involve major inputs from the tertiary sector. The structural distribution of the additional jobs reflects the economic activity of the sectors as well as labor intensity. This shows especially in the large increases in services and the rather small increases in industry. Though for instance the vehicle industry will have turnover gains from the sales of more efficient vehicles, the majority of these gains is seen in the car sales section, since more turnover there translates into more additional employment than in the highly automated vehicle production. The same holds for other production sectors. Additional employment in the retail sectors, in gastronomy and also in real estate, however, result from the shift from energy spending to other consumption goods as a consequence of efficiency gains.

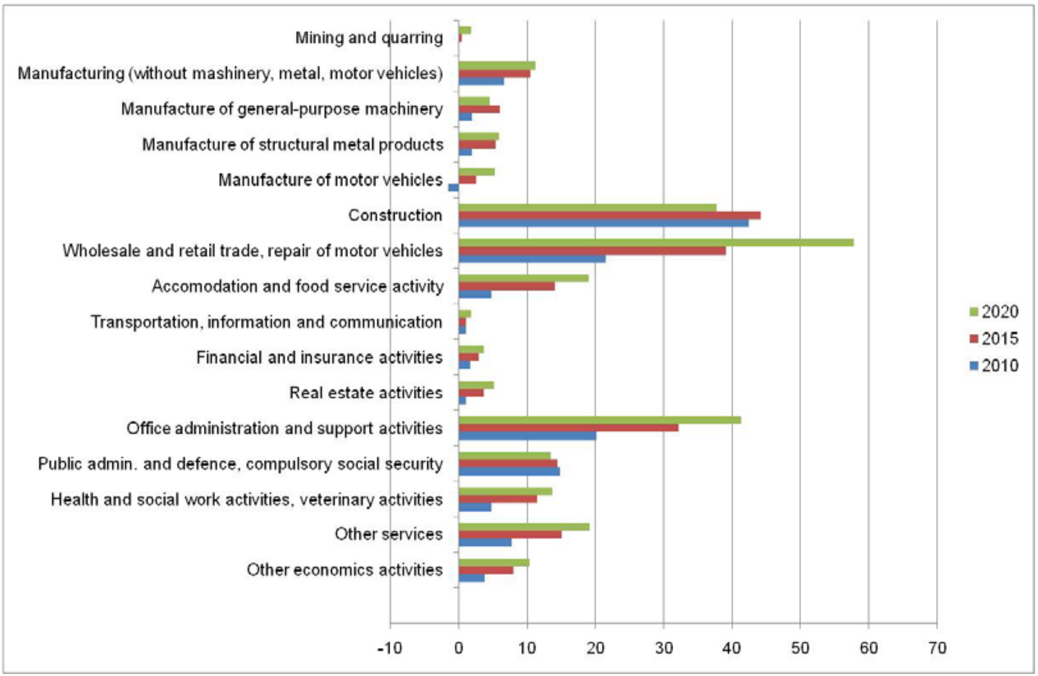

Figure 4*:* ***Sectoral employment in comparison to the BAU scenario (in 1000) (own calculations by GWS)***

The distribution over all sectors (Figure 4) has its merits, because no shortage of skilled labor is to be expected in any sector.

It is important to note, that energy saving and CO_2 reduction are smaller than initially given in the scenario data. This mainly stems from additional energy consumption and therefore additional CO_2 emissions from the increased economic activities. This so-called rebound effect lowers the reduction by some 10%. Also, additional employment yields additional income and additional consumption which is not likely to be without additional consumption. Table 7 shows the important energy quantities and their development over time.

Table 7*:* ***Energy data - Absolute savings compared to the BAU scenario***

		2010	**2015**	**2020**
FEC		**108**	**418**	**693**
Private households	[PJ]	25	115	219
Tertiary sector	[PJ]	8	32	59
Industry	[PJ]	19	123	197
Transport	[PJ]	57	148	219
TPES	**[PJ]**	**162**	**629**	**1.027**
Electricity production	**[PJ]**	**39**	**151**	**245**
CO_2-Emissions	**[Mio. t]**	**13,9**	**49,8**	**76,6**
Oil	[TJ]	67	189	287
Natural gas	[TJ]	26	165	321
Import savings	[Bill. €]	0,8	3,2	6,2

Source: Own Calcuations by GWSmbH

Summary and Conclusions

Model results decisively hinge upon model inputs. International energy price levels, efficiency increases in the rest of the world and long-term economic development play an important role. Overall economic effects of efficiency increase will be more positive with increasing international energy prices [Lutz, Meyer 2009]. The financial crisis on the other hand has affected energy efficiency in two ways: Firstly, energy intensive sectors were among the hardest hit sectors, which increased in 2009 energy efficiency (short term effect). Secondly, investment stagnated and modernizing the equipment got prolonged. This effect will lower energy efficiency in the future if no additional measures are taken. Additionally, energy prices fell and decreased the incentives for investment into energy saving appliances.

However, our scenarios have been simulated with moderate energy prices; therefore the results are still valid. If energy prices doubled until 2020, savings from energy imports would almost double, too. This has been analyzed in a sensitivity analysis.

No effects have been analyzed beyond 2020. Given that an efficiency strategy is a long-term strategy, this puts the results again on the rather conservative side. Some macroeconomic quantities have been left out in the analysis thus far. From studies on the impact of an increase in renewable energy technologies we have learned (Lehr et al. 2008) that exports of these new technologies play a major macroeconomic role. Germany is a very export oriented nation and new markets would lead to high effects for instance in the machinery and electronics sector.

The list of positive economic effects has to be contrasted with the question: why is the "free lunch" not eaten as of yet? Obviously there exist a lot of information costs, and other frictions that have to be overcome with complementing informational and other instruments.

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Tabelle 1

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