Energy Efficiency trends and policies in Germany

Report prepared by

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CONTENT OF THE REPORT

This report is dedicated to the development of energy efficiency indicators in Germany between 2000 and 2013. It analyses the main trends in energy consumption and energy efficiency since 2000 based on data and indicators from the ODYSSEE database.

The report also gives an overview of the main national energy efficiency policies in Germany by sector. The main focus is on the policies which were reported by the Member States in the 3rd National Energy Efficiency Action Plans (NEEAP) under the Energy Efficiency Directive (EED) and on the new energy efficiency polices which were decided by the German Government in the National Energy Efficiency Action Plan (NAPE) from December 2014. The analysis is based on the MURE database on energy efficiency policies.

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1. ECONOMIC AND ENERGY EFFICIENCY CONTEXT

1.1. THE ODYSSEE AND MURE DATABASES

The analytical background for this study form two databases: the ODYSSEE database on energy efficiency indicators (see Box 1) and the MURE database on energy efficiency policies (see Box 2). Both databases are regularly updated by a network of national correspondents from all EU Member States, generally from the energy efficiency agencies. They are managed by a technical coordination, namely Enerdata for ODYSSEE and Fraunhofer-ISI and ISIS for MURE. The two databases can be accessed at http://www.odyssee-mure.eu/.

Box 1: The ODYSSEE database

The ODYSSEE database contains detailed energy efficiency and CO_2-indicators, about 180 indicators with data on energy consumption by sector and end-uses, their activity drivers and their related CO_2-emissions, about 600 data series. The ODYSSEE database provides a comprehensive monitoring of energy efficiency trends in all the sectors and priority areas to address EU policies.

The database contributes to the development of a monitoring methodology based on top-down assessment of energy savings, through different types of indicators:

- Energy and CO_2 intensities, that relate the energy used (or CO_2 emissions) by sector to macro-economic variables (GDP, value added, etc.)
- Specific energy consumption (or CO_2 emissions) (e.g. consumption per ton of steel, per car or per dwelling, gCO_2/km)
- Adjusted intensities to allow the comparison of intensities (adjustments for differences in climate, general price level, fuel mix, industry and economic structure, etc.)
- Indicators of diffusion that monitor the diffusion of energy efficient technologies and practices Benchmark indicators compare specific energy consumption among countries and with reference values

An energy efficiency index (ODEX) for assessing energy efficiency progress and energy savings by main sector (industry, transport, households, tertiary) and for the whole economy (all final consumers).

Box 2: The MURE database

The MURE database provides an overview of the most important energy efficiency policy measures in the EU Member States, Norway, Croatia and the EU itself. The database is structured by final energy consumption sectors (household, tertiary, industry, transport) and also includes a general cross-cutting section. At the level of sectors, the focus is on single policy measures in order to allow a specific analysis of each measure. More general programs comprising several measures are mainly described in the cross-cutting section of MURE.

The homogeneity of the measure descriptions in the MURE over sectors and countries is ensured by detailed guidelines. All measures are classified according to specific keywords, thus allowing queries based on criteria as e.g.:

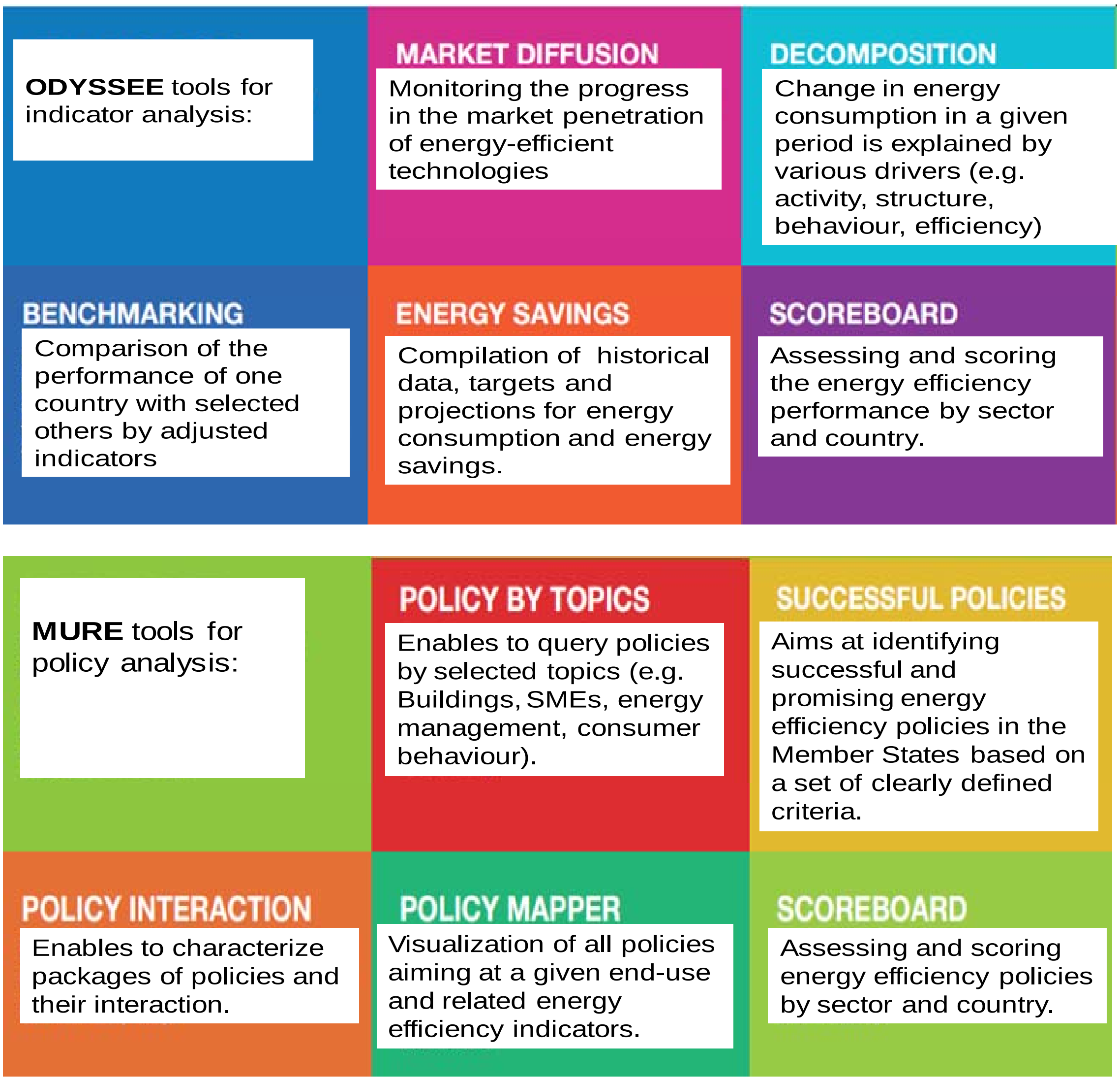
- their status (completed, on-going or proposed);
- their year of introduction and completion;
- their type: legislative/normative (e.g. standards for new dwellings), legislative/informative (e.g. obligatory energy labels for appliances), financial (e.g. subsidies), fiscal (e.g. tax deductions), information/education (e.g. advise programs), cooperative (e.g. voluntary agreements) and New market-based instruments(on energy or CO_2-emissions);
- the targeted end-uses and the main actors involved by the policy measures;
- their semi-quantitative impact: low, medium or high impact, based on quantitative evaluations or expert estimates;
- the end-uses involved and the quantitative impact of the policy measure related to a specific end-use (if this information is available).

In order to allow a separate analysis of policy measures from specific sources, two additional categories have been added to the MURE database:

- If a measure is included in the National Energy Efficiency Action Plan under the former EU Energy Efficiency and Service Directive ESD (2006/32/EC) and the current Energy Efficiency Directive (2012/27/EU, EED) respectively, it is classified as “NEEAP measure” in the MURE database. Distinction is also made between the 1st, 2nd and 3rd NEEAPs and the reporting on energy efficiency obligation schemes and alternative measures under Article 7 of the EED. This allows an easy identification of policy measures reported in the NEEAPs and under Article 7 EED and a specific analysis of these policies.
- In order to separate of EU-wide measures which are common to all countries (mainly EU Directives) from pure national measures, a set of “EU measures” was defined in the MURE database.

In order to make the use of these databases easier and to enable the user to make its own analysis of indicators and policies, several support tools have been developed (see Figure 1). Apart from the two databases themselves, these tools will be the main analytical basis for this brochure.

Figure 1: The new ODYSSEE and MURE support tools for indicator and policy analysis

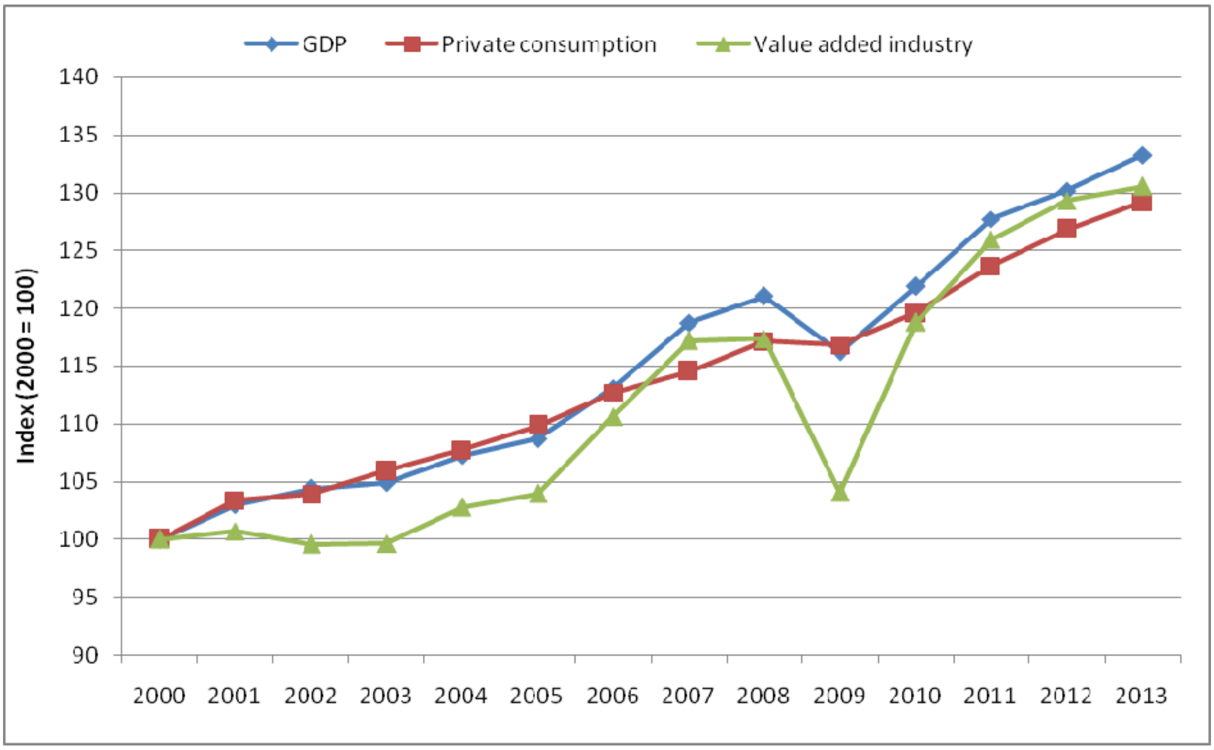


Source: http://www.odyssee-mure.eu/

1.2. ECONOMIC CONTEXT

In 2013, total real GDP in Germany amounted to 2820 billion € (or 2693 billion $€_{10}$). After stagnating between 2001 and 2003, GDP increased again between 2004 and 2008, followed by a strong decline in 2009 due to the financial and economic crisis. Since 2010, however, an above-average growth could be observed again in Germany as shown in the Figure 2. The private consumption increased continuously during the last decade. The growth was stagnant for 2008-2009 financial years. However the growth rebounds thereafter. Value added of industry also showed a fairly stagnant development since 2000, which then changed for positive increase from 2004, however affected by the financial crisis in 2009. In the course of the financial crisis in 2008, industrial value added strongly declined by 16 %. The increasing trend returned from 2010 when the economy rebounds after the peak of financial crisis.

Figure 2: Macro-economic development in Germany, 2000 - 2013



Source: Odyssee Database

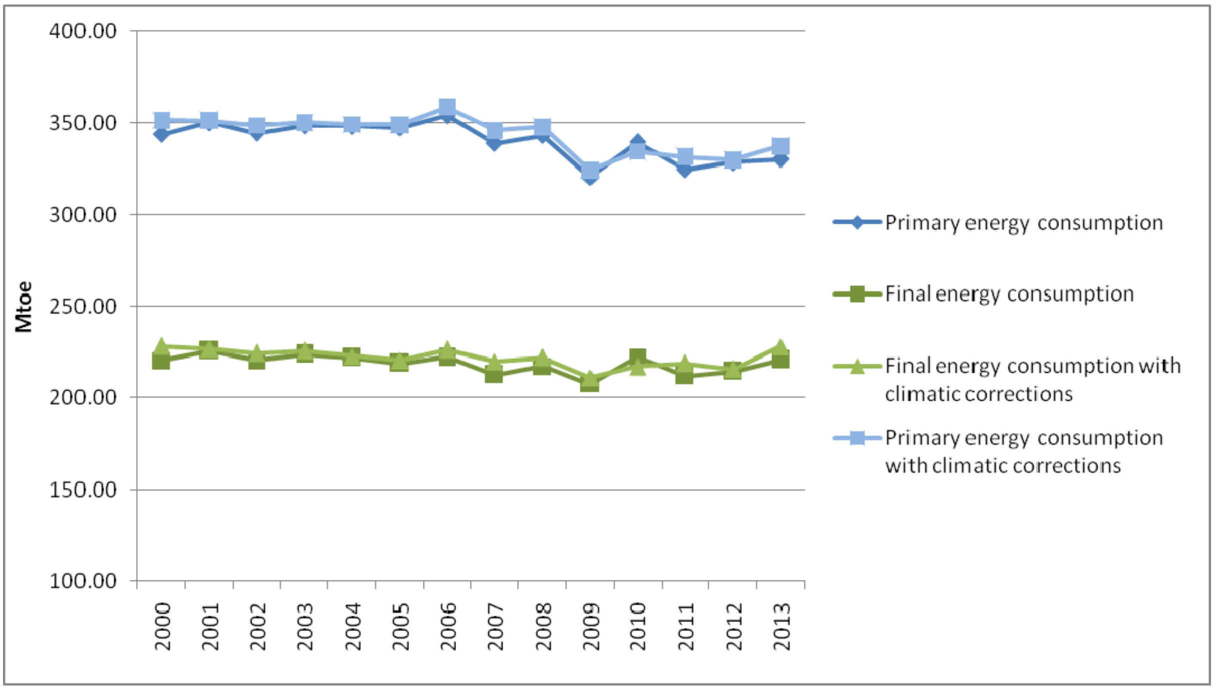
1.3. TOTAL ENERGY CONSUMPTION AND INTENSITIES

Between 2000 and 2013, primary energy consumption (not climate-corrected) fell from about 344 Mtoe to 330 Mtoe, i.e. by 4.1%. Between 2007 and 2013, the decrease amounted to 2.7% (Figure 3). There has been a marginal increase in final energy consumption (not climate-corrected) between 2000-2013. Between 2007 and 2013, the increase was about 3.7% (Figure 3).

The impact of weather fluctuations on energy consumption is shown by the different development of the actual and the temperature-corrected consumption. The climate - corrected final energy consumption is higher than the actual consumption except in the cold year 2010. Although the difference is relatively small in most of the years, the climate - corrected consumption shows the more meaningful trend. Over the whole period 2000 - 2013, the consumption decrease based on temperature-corrected data was more pronounced: between 2000 and 2013, primary energy consumption fell by 4.1% and final energy consumption by 0.2% (Figure 3).

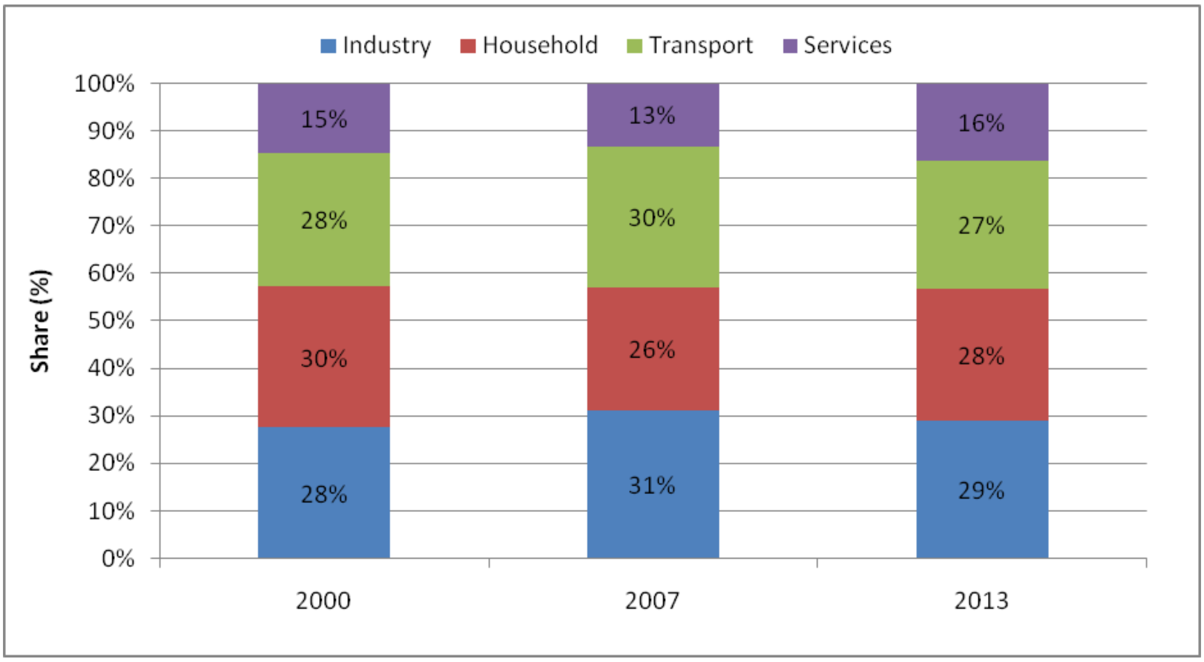
With regard to the composition of final energy consumption by sector, the main sectors, i.e. households, transport and industry, contribute relatively equally with a share of 30% or below of total final energy consumption in Germany (Figure 4). There have been no fundamental changes since 2000. The share of industry only slightly increased, by 1 or 2 percentage points, during the last decade which was mainly due to the relatively high industrial growth since 2005 (except the recession year 2009).

Figure 3: Development of primary and final energy consumption in Germany, 2000 – 2013



Source: Odyssee Database

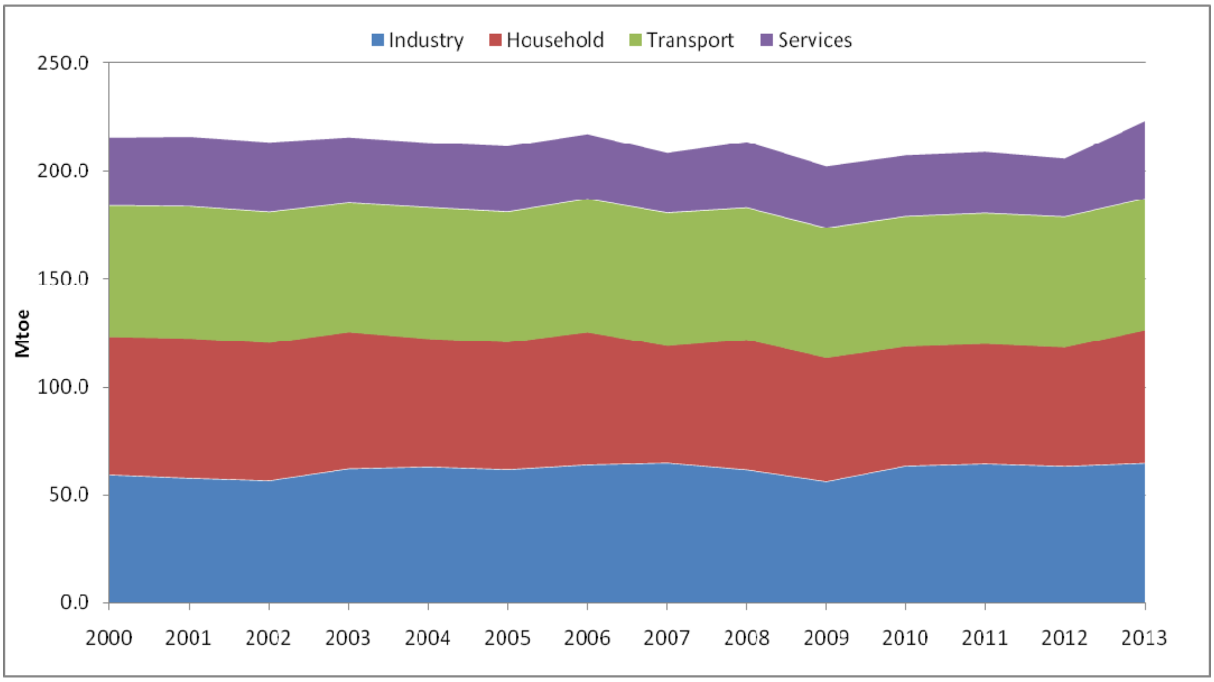
Figure 4: Sectoral shares in final energy consumption



Source: Odyssee Database

With regard to the composition of final energy consumption by sector, the most important change between 2000 and 2013 in Germany was the rising share of the transport sector (Figure 5). The share of the industrial sector dropped until the early 2000s, but due to the relative high industrial growth since, the share of industry in total final energy consumption in 2013 was almost the same as in 2000.

Figure 5: Final energy consumption by sectors in Germany, 2000 – 2013



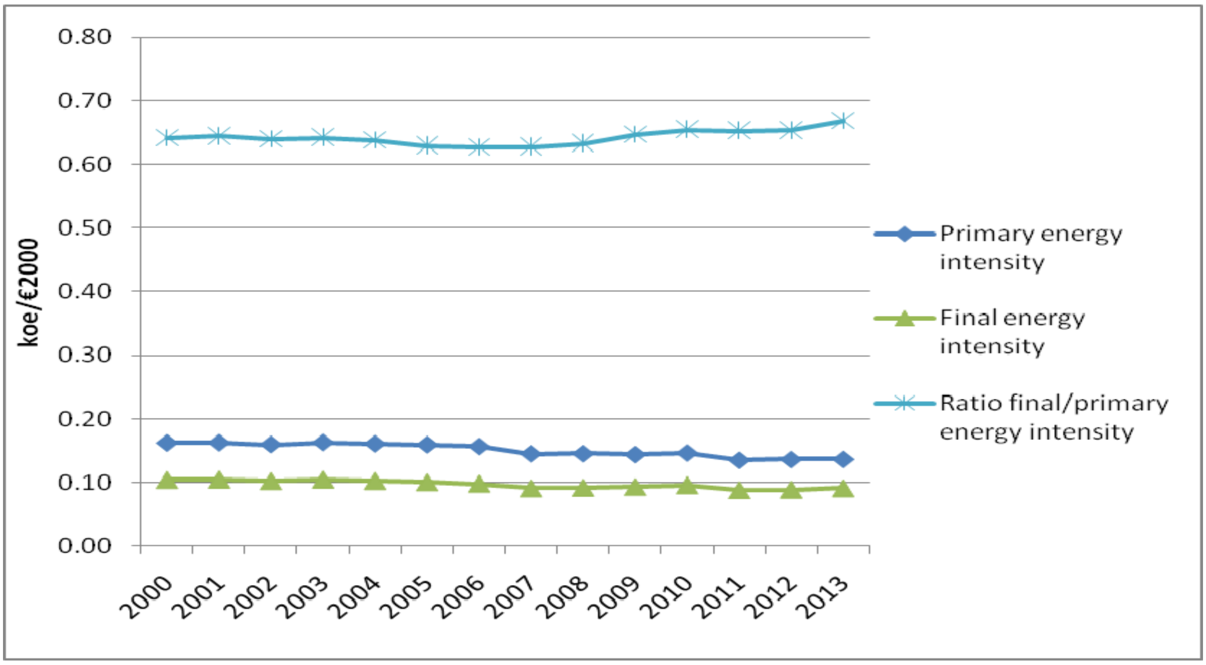
Source: Odyssee Database

Energy intensity

There are two general indicators which are often used to characterise the overall energy efficiency of a country from an economic viewpoint: the primary energy intensity and the final energy intensity, i. e. the ratio between primary or final energy consumption and gross domestic product (GDP). The reverse of this ratio is called "energy productivity". The effects of economic growth, as measured by GDP, are removed from this indicator as are weather fluctuations; the temperature-corrected intensities are the more meaningful ratios.

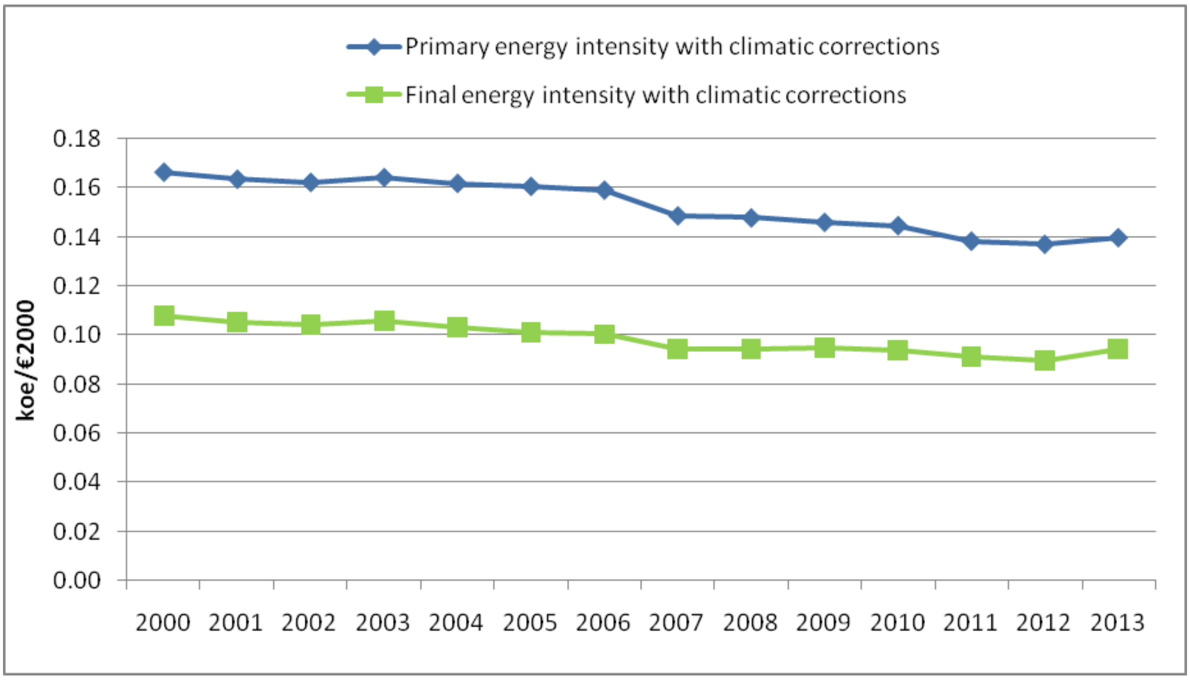
Since 2000, actual primary energy intensity in Germany fell by 1.3% per year on average (by 1.3% with temperature correction as well) (Figure 6 and Figure 7). The decrease in final energy intensity was less pronounced in this period with an annual improvement amounting to 1.0% or 1.04% based on temperature-corrected data (Figure 6 and Figure 7). Looking at the development from 2007, there had been in actual no change in final energy intensity for the period 2007 – 2013. Primary energy intensity however showed a favourable development during these years; the decrease from 2007 was even stronger than over the whole period 2007 – 2013, i.e. about 6%. This was mainly due to changes in the power sector, especially the rising share of renewable energies.

Figure 6: Development of primary and final energy intensity in Germany between 2000 and 2013



Source: Odyssee Database

Figure 7: Primary and final energy intensities with climatic corrections, 2000 - 2013



Source: Odyssee Database

ODEX indicator

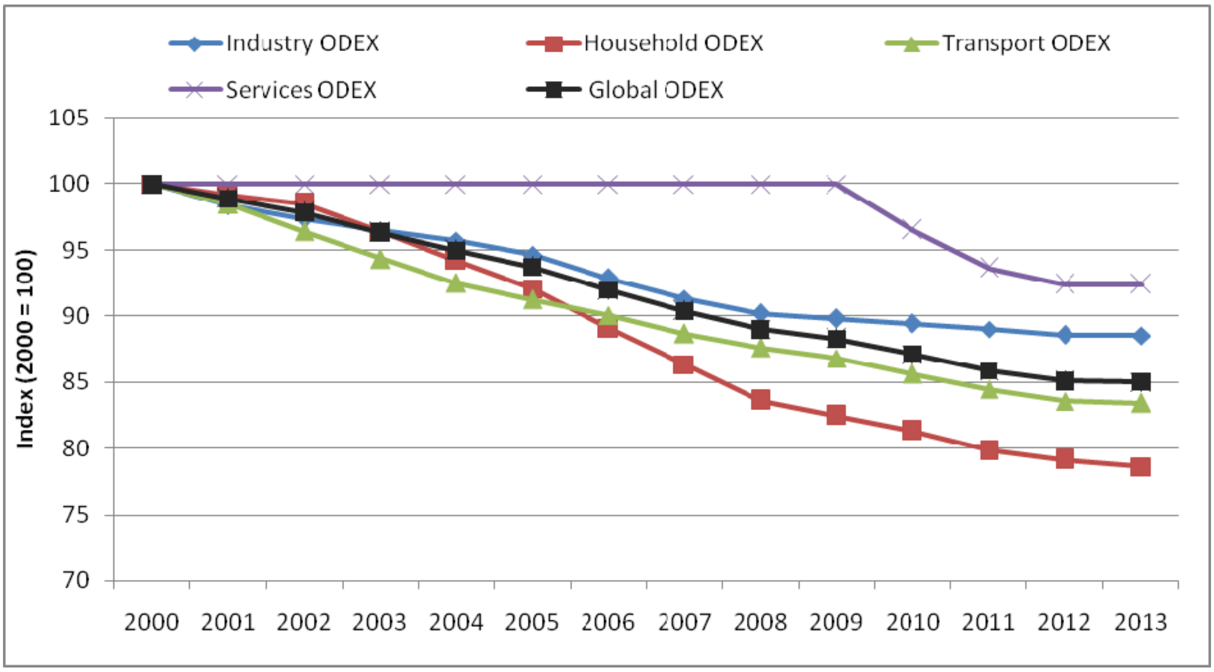
Although the overall energy intensities described above already take into account the impact of short-term weather fluctuations and changes in activities, the meaningfulness of aggregate energy intensities in capturing energy efficiency is limited by many structural effects within or across the different energy consumption sectors (e.g. sector or product structure in the industrial and tertiary sectors) and several comfort effects (e.g. larger living area per household, higher room temperature, larger appliances). In addition, energy intensities which are based on monetary activities at a highly aggregated level (i.e. total GDP or added value of a sector) only give a limited understanding of the pure energy efficiency developments. In order to improve the meaningfulness of such ratios, the use of activities measured in physical units (e.g. production in tons in manufacturing or per kilometre driven in transport) is widely recommended (see e.g. Farla et al., 1998; Farla and Blok, 2000; Neelis et al., 2007).

In order to take into account these limitations of aggregate energy intensities, ODYSSEE provides a re-aggregated energy efficiency indicator (the so-called ODEX) at the level of final energy consumption, which takes into account both short-term fluctuations as well as some structural effects (especially changes in the shares of sectors or industrial branches in total economic output) and behavioural changes (such as higher room temperature or user habits).. Since the ODEX is originally calculated at the sectoral level and largely based on ratios using physical instead of monetary activities, it is a more suitable indicator to evaluate pure energy efficiency trends than energy intensities.

The development of the ODEX indicator in Germany in the period 2000-2013 is shown in Figure 8. In the year 2013, the global ODEX in Germany amounted to85 which represent a 15% improvement of the overall energy efficiency since the base year 2000, or 1.25% per year on average. In the period 2007 to 2013, the energy efficiency improvement at the level of the whole economy was cut by half to an average of around 0.7% per year. During these years the industrial ODEX only showed a slight improvement, whereas the transport and household ODEX further improved, though at a variable rate. The stagnation of the industry ODEX during the period 2008-2010 is due to the fact that during an industrial recession the energy consumed per unit of production tends to increase. This reflects the fact that process energy does not decrease in proportion to activity (as the efficiency of equipment drops when not used at full capacity) and other energy uses (e.g. heating and lighting of the premises) remain roughly constant. The ODEX for the service sector stagnated for several years and only started to decrease since 2010.

A more detailed analysis of the development of the ODEX at the level of final energy consumption sectors will be given in the following sections.

Figure 8: Development of the energy efficiency index ODEX in Germany for the overall economy and by sector for the period 2000-2013

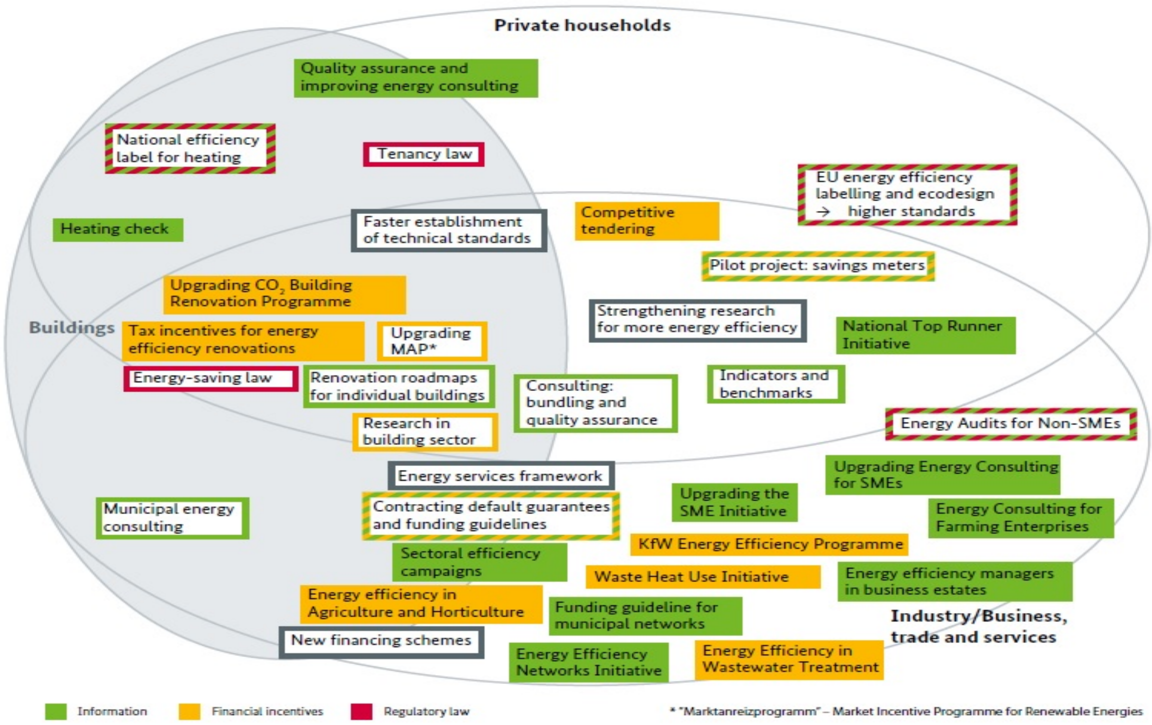


Source: Odyssee Database

1.4. ENERGY EFFICIENCY POLICY BACKGROUND

With its Energy Concept from September 2010 and the decisions from summer 2011, Germany initiated a far-reaching transformation of its energy system, the so-called “Energiewende” (BMU, 2011). Alongside intensifying the use of renewable energies, reducing energy consumption by increasing energy efficiency is a key pillar of the Energiewende. The Energy Concept also includes ambitious energy efficiency targets for Germany (see section **Fehler! Verweisquelle konnte nicht gefunden werden.**). The overall energy efficiency target demands a reduction of primary energy consumption by 20% until 2020 (and by 50% until 2050). However, a remaining shortfall to meeting the primary energy target in 2020 was estimated to be around 10 to 13% based on current forecasts and an extrapolation of the statistical development of primary energy consumption observed up to 2013. This is equivalent to a decrease in primary energy consumption of between 1440 and 1870 PJ (or 34.4 to 44.7 Mtoe) which is necessary to reach the 2020 target. In order to fill this gap, the German Federal Ministry for Economic Affairs and Energy (BMWi) presented the “National Action Plan on Energy Efficiency” (NAPE) in early December 2014 (BMWi 2014). The NAPE includes new and further developed policy measures to increase energy efficiency in buildings, industry and the tertiary sector (Figure 9). The highest contributions to energy and CO_2 savings are expected from a newly introduced competitive tendering scheme for energy efficiency and the establishment of up to 500 energy efficiency networks in industry (Table 1).

Figure 9: Short-term measures and long-term work processes of National Energy Efficiency Action Plan (NAPE)



Source : BMWi, 2014

At the same time, the German Federal Ministry for the Environment, Nature Conservation, Buildings and Nuclear Safety (BMUB) presented a “Climate Action Programme 2020” which includes – among others - some further policy measures for the transport sector (BMUB, 2014). The NAPE measures, together with the transport measures, are expected to lower primary energy consumption by 500 to 620 PJ (or 11.9 to 14.8

Mtoe) by 2020. This means that this package of measures, most of which are planned to start in the course of 2015, cannot completely close the gap to the primary energy target, but they do make a substantial contribution to doing so. However, additional, substantial contributions have to come from the energy sector, which is also considered in the Climate Action Programme 2020.

Table 1 :Key energy efficiency policies of the NAPE and the Climate Action Programme 2020 and their impact on energy consumption and CO_2 emissions

Sector	Key policy measures of the NAPE and the Climate Action Programme 2020	Impact		
		Final energy [PJ]	Primary energy [PJ]	CO_2 emissions [Mt CO_{2eq}.]
Cross-sectoral	Introduction of a competitive tendering scheme for energy efficiency	10.7-21.5	25.7-51.6	1.5-3.1
	Support of Energy Performance Contracting	3.2	5.4	0.3
Industry & Tertiary	Energy Efficiency Networks Initiative	50.0	75.0	5.0
	Upgrading the KfW efficiency programme	10.9	29.4	2.0
	Obligation to perform energy audits for non-SMEs (implementation of Art. 8 EED)	33.3	50.5	3.4
Buildings	Upgrading and increased funding of the CO_2 Building Renovation Programme	9.6	12.4	0.7
	Energy saving legislation	11.6	13.5	0.7
Appliances & Products	National Top Runner Initiative	15.8	37.9	2.3
	National Energy-efficiency Label for Old Heating Installations	8.4	10.0	0.7
Transport	Extension of HGV toll to all vehicles >7.5 t	4.2-9.8	4.6-10.8	0.3-0.7
	Differentiation of HGV tolls based on vehicles energy consumption	21.0-32.2	23.1-35.4	1.5-2.3
	Strengthening of public transport	9.8-14.0	10.8-15.4	0.7-1.0

Sources: BMWi, 2014; BMUB, 2014

Table 2 gives an overview of the overall and sectoral targets of the Energiewende in Germany and the actual status of target achievement.

Table 2 :National energy and climate targets for 2020 in Germany and status of target achievement in 2014

Greenhouse gas emissions	**2014**	**2020**
Greenhouse gas emissions (comp. to 1990)	-27.0%	at least -40%
Renewable energy sources	**2014**	**2020**
Share in gross electricity consumption	27.4%	at least 35%
Share in gross final consumption	13.5%	18%
Energy efficiency	**2014**	**2020**
Primary energy consumption (comp. to 2008)		-20%
not temperature-corrected	-8.7%	
temperature-corrected	-7.0%	
Gross electricity consumption (comp. to 2008)	-4.6%	-10%
Share of (net) electricity production from CHP	17.3%	25%
Energy productivity		2.1%/a
Final energy productivity (not temp.-corr.)	1.6%/a	
Primary energy productivity (not temp.-corr.)	2.2%/a	
Primary energy productivity (temp.-corr.)	1.8%/a	
Buildings	**2014**	**2020**
Heat demand (comp. to 2008)	-12.4%	-20%
Transport	**2014**	**2020**
Final energy consumption (comp. to 2005)	+1.7%	-10%
Number of electric cars	28,264	1 Million

Sources: AGEB, 2015; BMWi, 2015; own calculations

2. ENERGY EFFICIENCY IN BUILDINGS

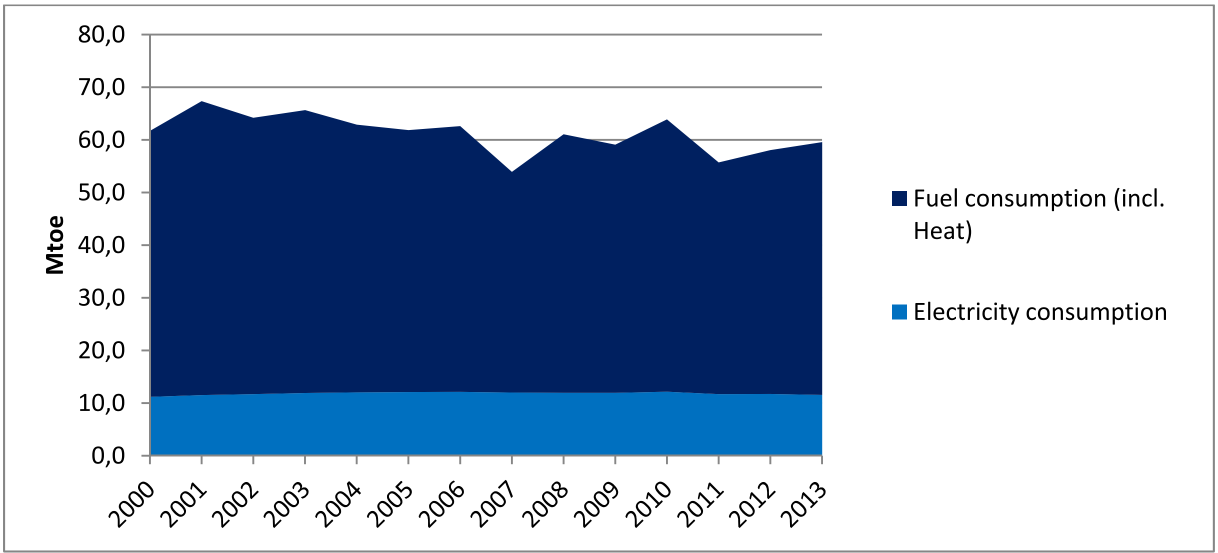
2.1. ENERGY EFFICIENCY TRENDS

2.1.1. HOUSEHOLD SECTOR

Between 2000 and 2013, energy consumption in the household sector (not climate-corrected) fell from 62 to 60 Mtoe, i.e. by around 5 % (Figure 10). This can be explained with the fact that fuel consumption in residential buildings generally decreased in the last decade. In a few years however, it was interrupted by consumption increases. This was partly due to weather fluctuations, which are an important influencing factor for this part of energy consumption. Especially in the mid 2000s[1] some jumps can be observed, however until 2011 a stable and slow increase is shown in the graph. The overall decreasing trend is in line with the target for the building stock, which also predicts a reduction in heating requirements up to 2020. Electricity consumption however remained stable at around 12 Mtoe. In 2013, the share of electricity in total household energy consumption amounted to 19.5%.

[1] A sharp decline, in particular in the consumption of mineral oil and to some extent also in the consumption of gas, has been noted in the national energy balances (AGEB, 2013) for the year 2007. This is partly explained by variations in stocks. But a recording error may be suspected, too, since survey data do not confirm this sharp decrease.

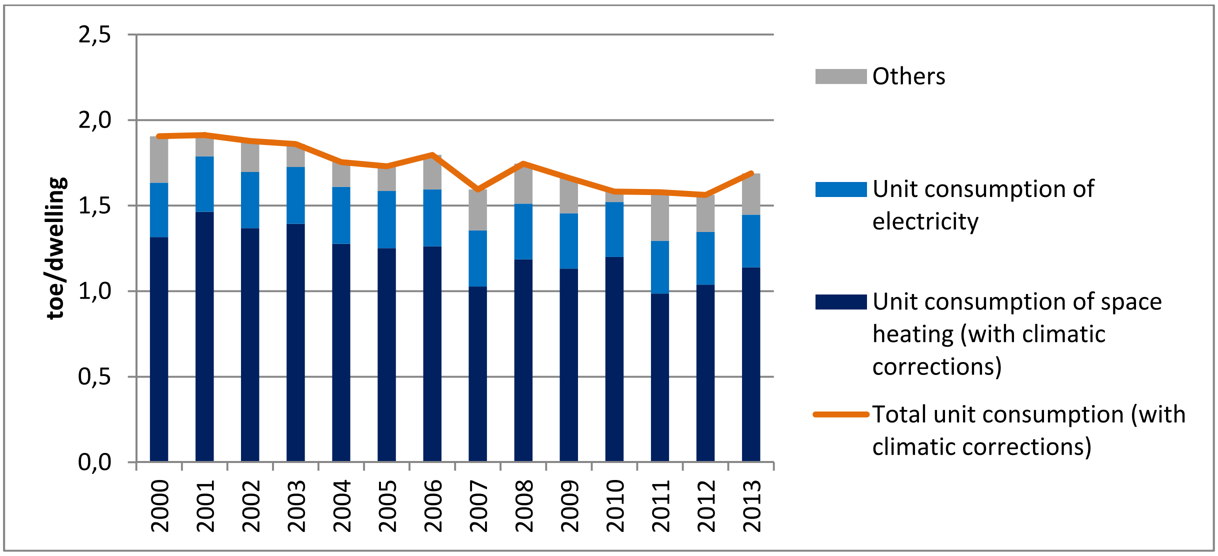
Figure 10: Fuel and electricity consumption in households (not climate-corrected), 2000-2013



Source: ODYSSEE database

We calculate unit consumption both for total energy and electricity consumption of private households and for space heating alone. Energy consumption is related to physical factors (number of dwellings or square metre) and the total energy consumption and space heating figures are temperature-corrected, to remove the effect of weather fluctuations. Total unit consumption generally follows the development of unit consumption of space heating, which represents about 70% of total household energy consumption in Germany (see Figure 11). Although total unit consumption and unit consumption for space heating declined over the period, electricity consumption per dwelling remained quite static. After an increase to the mid 2000s, this ratio decreased by around 1% per year from 2005. Although the impact of the activity drivers (i.e. number of dwellings or square metre) and weather fluctuations are removed from the unit consumption indicator of private households in ODYSSEE, it is still influenced by several factors, which partly compensate for each other: fuel substitution, higher energy efficiencies due to thermal regulations, changes in dwelling size or heating system (trend to central heating), changes in the share of single and multi-family dwellings and last but not least behavioural factors (e. g. a trend to higher indoor temperature or a more intensive use of electrical appliances and lamps).

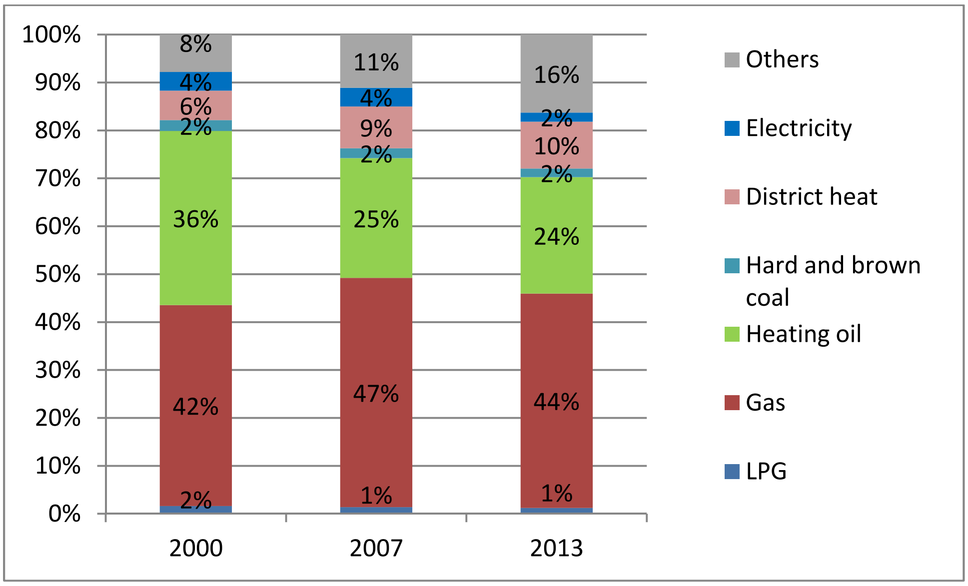
Figure 11: Unit consumption of private households in toe/dwelling (total and space heating climate corrected), 2000-2013



Source: ODYSSEE database

Heating oil for space heating have been partially replaced by gas and to lesser extent by district heat (-12 points for oil between 2000 and 2013; +2 points for gas, +4 points for district heat). The LPG market share remained roughly stable (1% in 2013) (Figure 12). The effect of these different substitutions on the specific energy consumption per m^2 was marginal as switches to more efficient fuels at end-use level (i.e. gas or electricity) was balanced by an increasing share of biomass (summarized in others) which reduce CO_2 emissions but decrease efficiency. Germany has a slightly increased consumption per m^2 (around 0.1%/year), as biomass and other low-carbon technologies substituted the use of heating oil.

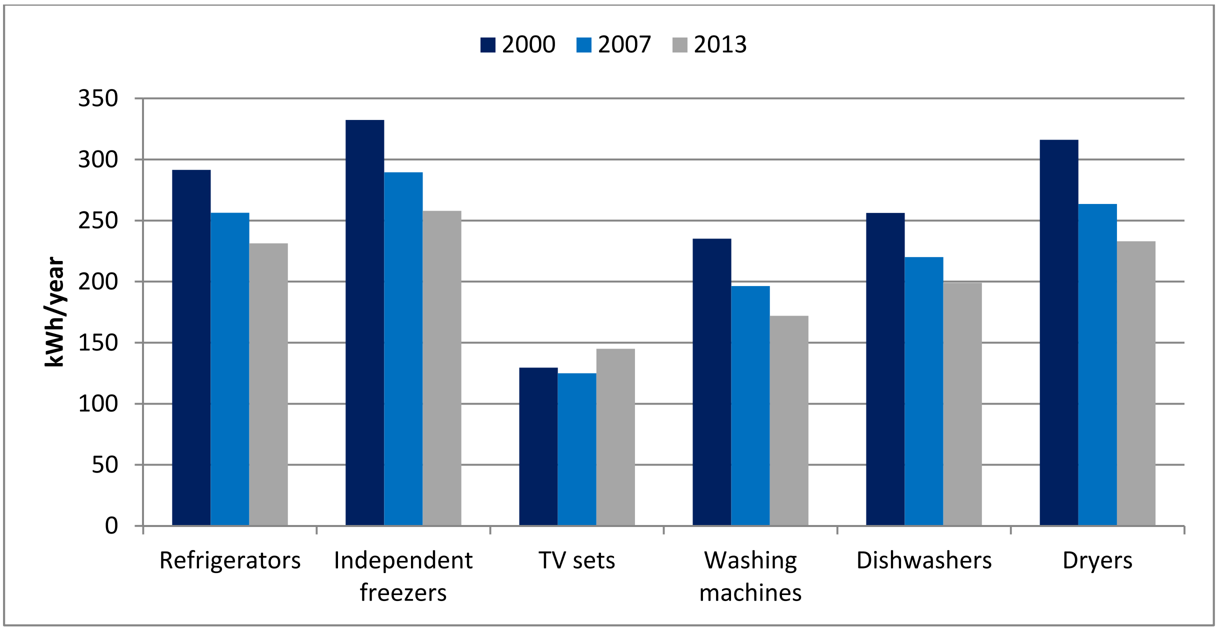
Figure 12: Household energy consumption for space heating by energy in 2000, 2007 and 2013



Source: ODYSSEE database

The specific electricity consumption of most of the major household appliances in Germany decreased considerably between 2000 and 2013, thus improving the energy efficiency considerably (Figure 13). Only for TV sets, an increasing trend was observed since 2006, which was mainly due to the increasing size of TV screens. It must, however, be noted that these data are not available from yearly statistics or surveys, but had to be taken from modelling calculations (see Annex 1) and therefore may not fully reflect the yearly status of the appliance stock.

Figure 13: Specific consumption of electrical household appliances in 2000, 2007 and 2013



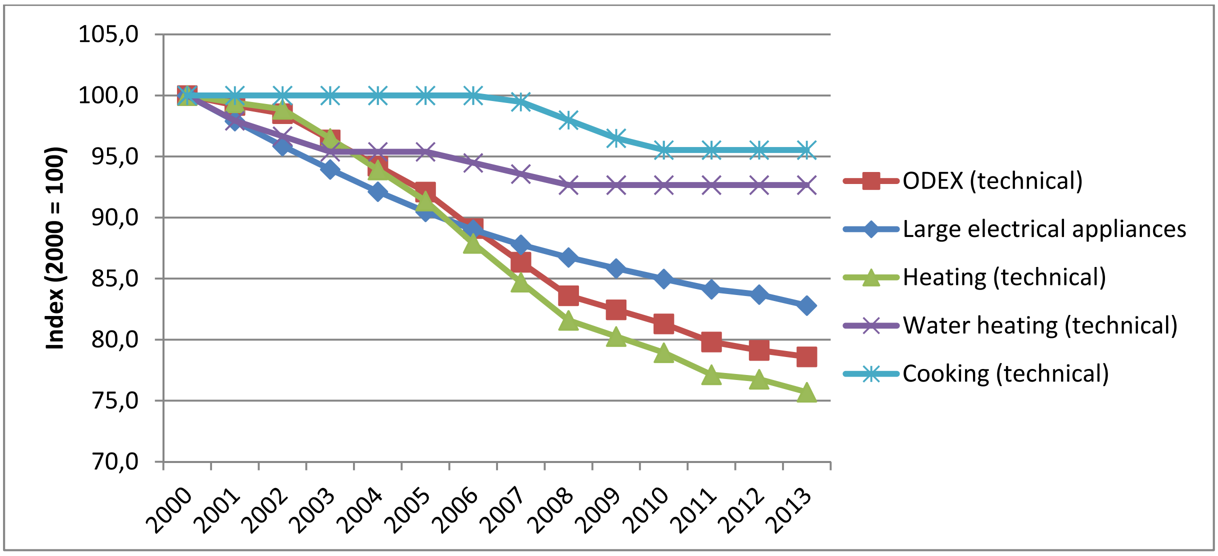
Source: ODYSSEE database

ODEX indicator

For the residential sector, the bottom-up energy efficiency index (ODEX) is calculated at the level of eight end-uses or appliances: heating, water heating, cooking and five large appliances (refrigerators, freezers, washing machines, dishwashers, TV). The main methodological problem of the household ODEX is to clean the indicator from behavioural factors, which play an important role in the household sector and often compensate energy efficiency gains (as e. g. a higher indoor temperature, increasing use and number of lamps, increasing use of TV, increasing use of hot water). In order to solve this problem, the calculation of the household ODEX was revised in 2006 and a so-called "technical ODEX" was calculated, which separates technical and behavioural trends by assuming that technical energy efficiency cannot be reverse. Between 2000 and 2013, the technical ODEX in the household sector as a whole decreased by about 21.4%, which represents an average energy efficiency improvement of 1.6%/year (Figure 14). The development of the household ODEX is strongly influenced by the heating sector, similar to the unit consumption. Here, the improvement accelerated between 2002 and 2008, which was also reflected in the total household ODEX. Since 2009, however, a flattening of the incline can be observed.

The efficiency improvements of the five large appliances also contributed considerably to the total energy efficiency gains in the household sector, whereas the improvement for water heating and cooking was less pronounced.

Figure 14: Energy efficiency trends in the household sector measured by the ODEX, 2000-2013



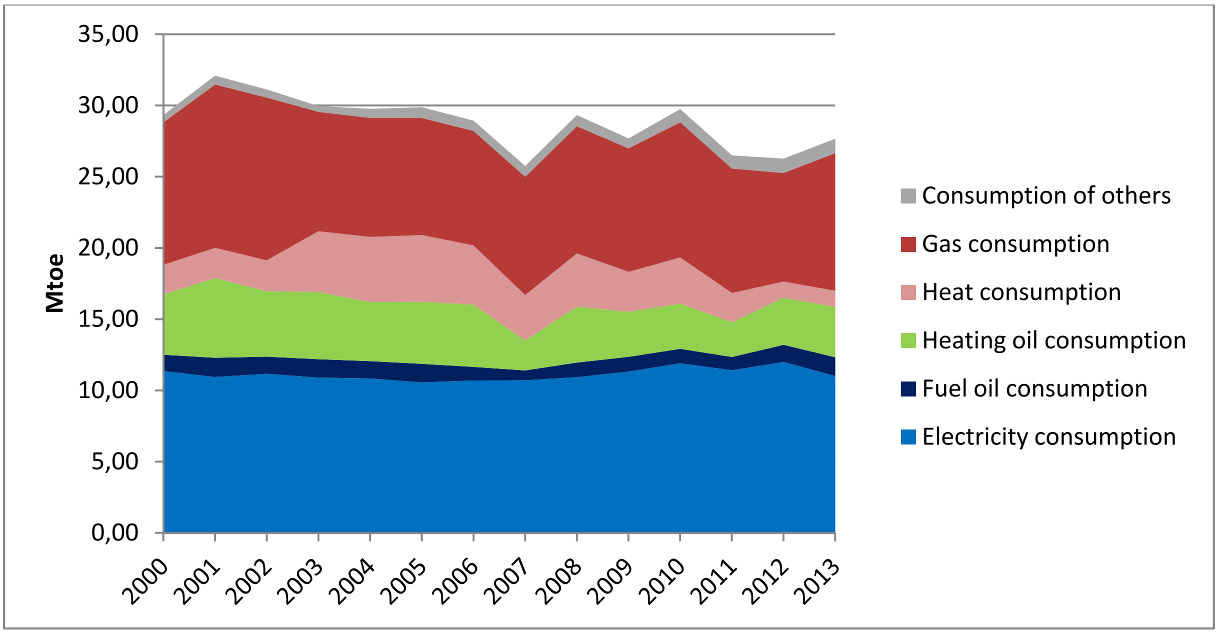
Source: ODYSSEE database

2.1.2. TERTIARY SECTOR

The German energy balance only shows energy consumption of the total tertiary sector, broadly defined as private and public services, agriculture, construction industries and military. In 2013, energy consumption of this aggregate amounted to 28 Mtoe. This is around 13 % of total final energy consumption in Germany and a decrease by 8% compared to 1990. The main focus of the ODYSSEE database is on energy consumption of the service sector only, including private and public services. For Germany, energy consumption data for this aggregate are available from a regular survey, which distinguishes several branches. In 2013, energy consumption of the service sector amounted around 80% of total consumption of the tertiary sector as defined in the German energy balance.

Between 2000 and 2013, energy consumption in the service sector fell by almost 6 % from 29 to 27 Mtoe (Figure 15). There can be observed several increases in the consumption over the years, but consumption of fuel oil remained constant. Whereas heating oil and heat consumption declined over the years. In 2013, around 40% of final energy consumption in the tertiary sector can be ascribed to electricity which is rising since 2007.

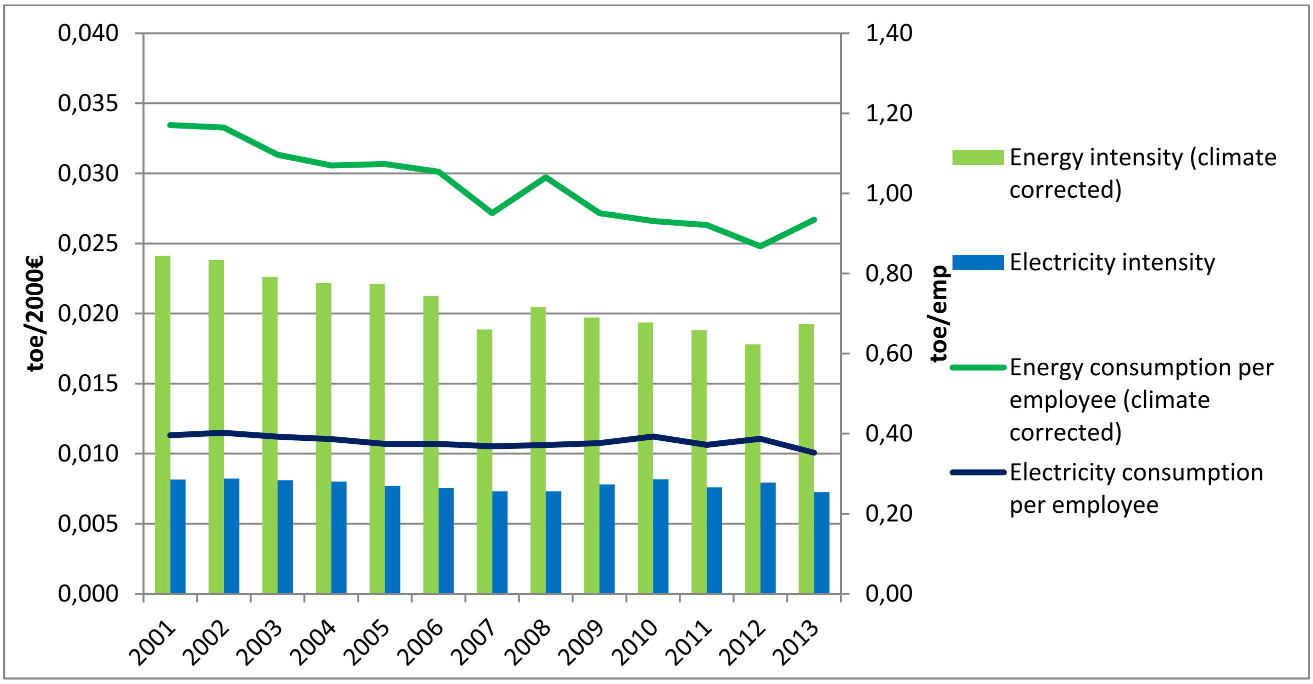
Figure 15: Energy consumption by fuel in the tertiary sector in Germany (not climate-corrected), 2000-2013



Source: ODYSSEE database

The intensity curve and the consumption per employee (both temperature-corrected for energy) for the corresponding category show an almost parallel behavior. Over the whole period, both energy indicators show a decreasing trend, with a few periods of stagnation especially during 2002 and 2005. Especially between 2006 and 2008, both curves showed a fluctuating behavior, which went back to the overall trend, in 2009 (Figure 16). The data corresponding to electricity shows a constant development and even increased between 2008 and 2010, i.e. in the years of the recession and the following revival of the economy. Electricity intensity amounts to 38% of energy intensity in 2013.

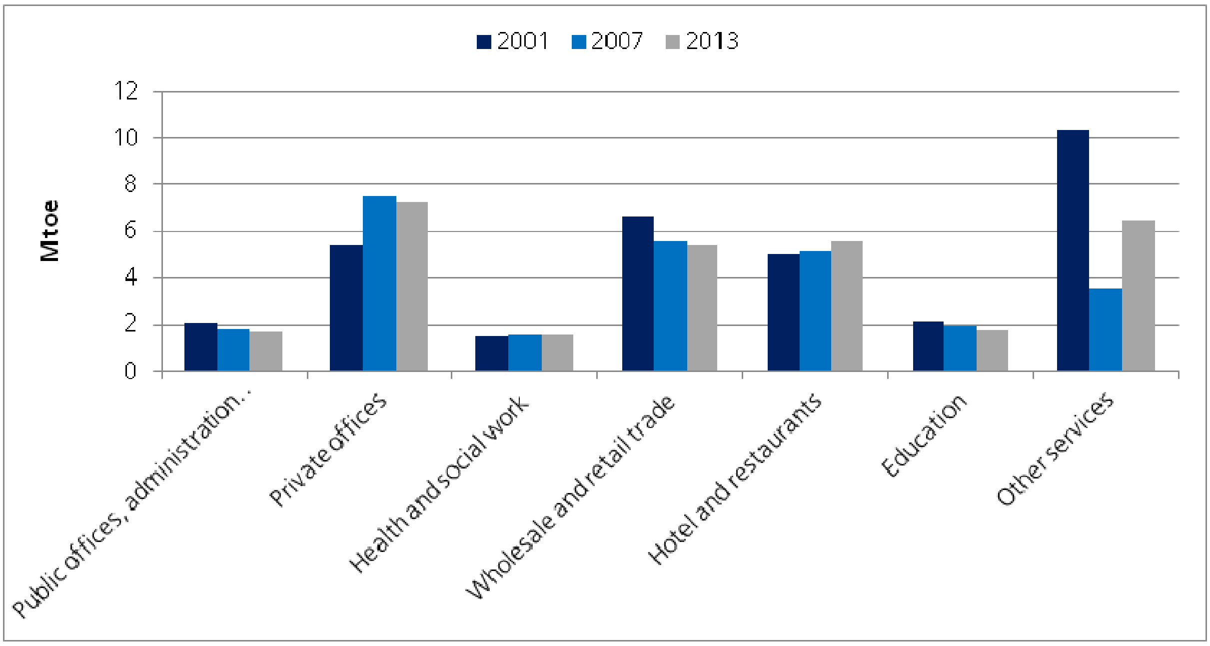
Figure 16: Energy intensity and energy consumption by employee in the tertiary sector (private and public services), 2001-2013



Source: ODYSSEE database

Figure 17 shows the trend of energy consumption in several branches of the tertiary sector between 2000 and 2013. A decline of energy consumption, between 2001 and 2013, can be observed in public offices, educational buildings and trade (Figure 17). The health and social work sector show a constant consumption during this period.

Figure 17: Energy consumption in the tertiary sector in Germany by branches (in Mtoe) in 2001, 2007 and 2013



Source: ODYSSEE database

2.2. ENERGY EFFICIENCY POLICIES

Many recent policy measures in the household and tertiary sector are already included in the 3rd National Energy Efficiency Action Plan (NEEAP) of Germany which was submitted in June 2014 (BMWi 2014b). Some additional policy measures have been decided in the "National Action Plan Energy Efficiency " (NAPE) which was launched in December 2014 (BMWi 2014a; also see section 1.4). In the following, some of the key energy efficiency policy measures from the 3rd NEEAP and the NAPE are be described. More information on these polices including their quantitative impact can be gathered directly from the MURE database[2].

2.2.1. HOUSEHOLD SECTOR

Measures from the 3rd NEEAP

The **KfW Energy-efficient Construction Programme** is preceding the KfW(reconstruction bank) CO_2 Building Rehabilitation programme since 2009. Support is provided for new buildings in the area of energy-efficient construction that surpass the applicable building standard. Energy-efficient homes require innovative heating technology based on renewable energies and very good thermal insulation. Since the 3rd NEEAP only houses which meet the conditions to be a KfW Energy Efficient House 70, 55 or 40 or to be a Passive House, receive funding. A KfW Energy Efficient House 70 has an annual consume of only 70% of the primary energy of a similar normal house. In 2016 the funding for the Energy-Efficient House 70 will end. The funding is provided through long-term soft loans and is arranged in a staggered manner.

[2] http://www.measures-odyssee-mure.eu/

Since 2009, Caritas offers free **energy efficiency checks** for low-income households. In the first appointment a power saving check, including the measurement of electricity consumption of refrigerator and lighting, is made. For the second visit, the energy-saving assistants will install the needed utilities. The energy-saving assistants performing the energy efficiency check can be a trained long-term unemployed.

To achieve the ambitious climate targets, a programme named '**Energy-Related Urban Renewal – Grants for Integrated District concepts and Renovation Managers**' was initiated in 2011. Supported by the BMVBS (Federal Ministry of Transport and Digital Infrastructure) and enforced by the KfW, the programme aims to improve the energy efficiency of whole districts. Therefore a renovation manager will prepare a renovation concept including measures for buildings and infrastructure with involvement of the owners. The renovation manager will supervise the implementation for maximum three years.

Measures from the NAPE

National efficiency label for old heating systems has been launched to motivate the building owner to replacing the old inefficient heating systems and to increase the rate of change. One of the requirements in accordance with the EU ordinance of 811/2013 is to assign all the boilers which are in operation for over 15 years an energy label. Integrated circulators are to be replaced with the new ones. The related fuel as well as the electricity consumption will then subsequently be saved. With the Energy Label, the boiler will be assigned a certain energy efficiency class and the building owner will receive information about the energy costs savings and the description of possible further energy consultancy offers such as Heat Check or On-site counselling. The label will be given for a period of 7 years starting from 2016. The aim of the measure is assigning the label to boilers that are older than 15 years up to 400 kW are in the residential houses and buildings installed.

Further development of EU Ecodesign and Labelling 2015 involves within the framework of EU negotiations for the revision of the EU-labelling directive, that the labelling for the consumers are meaningfully structured, the speeding up the decision-making processes and the strengthening of EU-top-runner strategy. Hereby, Germany is expected to meet following requirements;

- For the product groups in which the best energy efficiency classes are already occupied, a rescaling of efficiency classes will be carried out. For the revaluation, an energy label should be chosen that is well understood by consumers (for e.g. A-G). When introducing or changing a label it should be ensured that the highest efficiency classes are not yet assigned to allow for the sufficient room for a dynamic development.
- The labelling directive should provide precise guidelines for conducting preliminary studies for the product groups so as to enhance their semantic content and for faster adequate adaptation of implementing measures. The efficiency requirements will be set on the basis of costing concept. In the upcoming preliminary study could the first experience about the sophisticated cost concept (for e.g. relation to "Break even point" in addition to the lowest life cycle cost) be gathered.
- EU-online Database: The manufacturers must publicize the data (the information about the labels, the product datasheets as well as other data in accordance with the ecodesign directive) in an online database. The online database will generally be made available and could be disseminated to third-party through user-friendly processed information. Through this database, an overview of the updated market-available models with EU can be achieved.

Heating Check (Heizungscheck) is to initiate additional heating modernization by a novel method for heat inspections. Funding by the governmental authorities for about 50 € per heat check has been estimated as well as a processing amount of 10 €. The heat check has been conceptualized as a voluntary non-binding integrated service. It thus requires a corresponding contract on behalf of the owner of the heating system. It is estimated that a total of 100,000 heat checks will be carried out from 2016 to 2018. The impact of these checks is estimated to be experienced from in 2017. The cost of heat checks between 2016 and 2018 are estimated to be 6 Million euros.

Quality assurance and the optimization of existing energy consultation deals with various measures of information and energy consulting in Germany that have been established. The Energy Consulting provides the investors and other related parties (such as tenants) an important contribution to increasing the willingness to invest and acceptance of refurbishment measures. The energy consulting is closely linked with the CO_2 Building Rehabilitation Programme. The program already funds the initial consultation by Consumer Centre (Verbraucherzentrale), the further indepth consulation throught On-site consulting by BAFA (Vor-Ort-Beratung) as well as supports the refurbishment measures through the "Construction Supervision" program by KfW. The existing energy consulting programs (including that of Consumer Centre and the On-site consultation by BAFA) in accordance with requirements will be further developed as goal-oriented for example by linking together the measures and increase the consistency, transparency and a avoiding the overlapping of other energy consulting programs. Costs for scaling up the existing energy consultancy measures stand at about 50% in addition to energy consultation to the municipalities (about 20,000 Euro per consulation with 200-300 consultations/year).

2.2.2. TERTIARY SECTOR

Measures from the 3rd NEEAP

To improve the infrastructure most likely energy-efficient urban lighting will be needed. The **KfW – IKK – Programme for Energy Efficient Urban Lighting** provides funding up to 100% of the investment costs per project. Repayment can be in 10 years with up to 2 years of grace period. The measures financed are various for example improving the energy efficiency of lighting of pedestrian crossings, parking lots, traffic signals or public open spaces.

Measures to increase energy efficiency in municipalities are urgently needed and also supported with related programs called '**IKK – Energy-Related Urban Renewal – Energy-Efficient Renovation**' and '**IKU – Energy-Related Urban Renewal – Energy-Efficient Renovation**'. Here funding is provided for renovation work to obtain KfW Efficient House Standard 100, 85, 70 and 55 and for energy-efficient individual measures. KfW offers loans or sub-loans for this purpose.

The public sector has to fulfill an exemplary role in using renewable energy sources for heat and cold. Therefore another measure to improve the energy efficiency of public buildings was initiated. The **investment pact** between federal and state governments and municipalities aims to modernise the social infrastructure. Nearly half of the 150 000 buildings accommodating schools, kindergartens and nurseries urgently need energy renovation. The grant is for the cities and municipalities which are in difficult budgetary situation and are not able to reduce the accumulated backlog of investments in recent years on their own. The Pact was supplemented by efforts of the federal and state governments to improve energy efficiency in their own buildings. Helping communities by reducing the investment backlog is only the short term goal. The long-term effects are cost savings on energy, which will be a relief for the local budget of these communities.

A program which affects all sectors (also the industry sector) is called **Market Incentive Programme for Renewable Energies in Heat Market**. It first went into effect 1999 and supports the use of renewable energy sources for heat in existing buildings. This includes the installation of solar collector systems, biogas systems, geothermal systems and others. The program aims to strengthen the sales of renewable energy technologies and thereby improving the profitability of the implementation. The support can be received in two different ways: as partial repayment grant by the KfW or as partial investment allowance by the Federal Government (BAFA – Federal Office of Economics and Export Control). The annual budget has been enlarged several times from 213 million € (2007) to 500 million € in 2009(EEWärmeG). The budget is used almost exclusively to fund the housing stock since 2010.

Measures from the NAPE

Upgrading the CO_2 Building Renovation Programme aims to exploit the potential savings In the area of promoting energy-related building renovation. In particular, the non-residential buildings sector has until now only partly addressed through the promotion policies. This contrasts with a high potential for energy savings in this sector, because more than 30% of the building area in Germany comprises of non-residential buildings. The measure includes increased funding for programs under KfW building renovation up to 200 million euros a year with a total so far available amount of about 2.0 billion euros per annum.

2.3. SEMI-QUANTITATIVE IMPACT OF ENERGY EFFICIENCY POLICIES IN THE BUILDING SECTOR

In the measure descriptions in the MURE database, a high importance is attached to the impact evaluation of a measure. If a quantitative evaluation is available for a measure, the methods used for the evaluation and related results are provided, as well as real/estimated energy savings (fuels and electricity) and carbon dioxide emissions reductions achieved over a given time-frame. If no quantitative evaluation is available, or in addition to the quantitative evaluation, a qualitative expert judgment is reported, too, namely an assessment of the measure's impact (high/medium/low) in terms of energy and CO_2 savings.

The categories (low, medium, high) are linked to the aggregate electricity or final energy consumption of the respective sector (households, transport, industry or tertiary). The following limits are defined for the three impact levels: low impact: <0.1 %; medium impact: 0.1 - <0.5 %; high impact: ≥0.5 %. If a quantitative evaluation is available, the qualitative impact can easily be calculated by applying this definition to the quantitative figures. For measures with no quantitative evaluation, the qualitative evaluation is a relatively rough expert judgement.

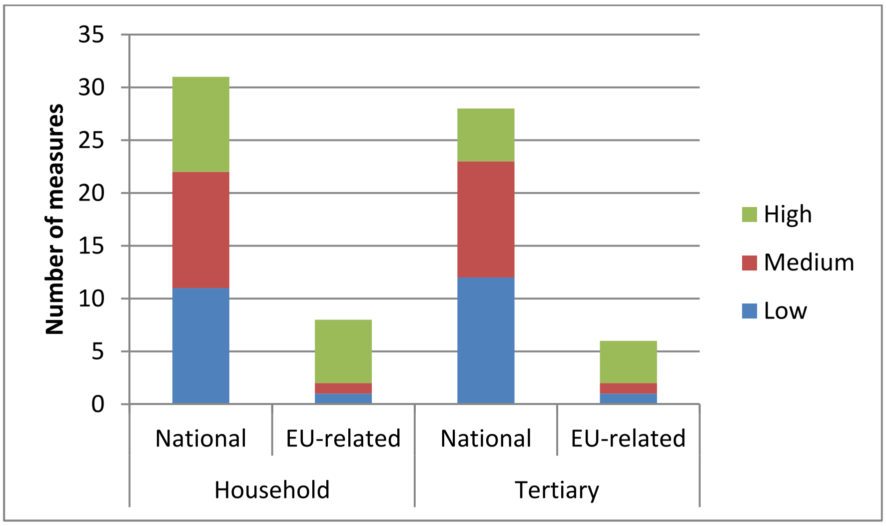
In Figure 18 the number of measures in each qualitative impact evaluation category is summarized.

The building sector has 73[3] ongoing measures in total. The household sector has the most with 31, closely followed by the tertiary sector with 28 measures. There are 14 EU-related measures in Germany of which 10 have a high impact. Among them are the Energy Performance of Buildings EPBD Recast (legislative/normative) and the Energy Labelling of Household Appliances (legislative/informative).

In the household sector mostly legislative/normative measures (building regulations) are assigned to the high impact category. Only two financial measures are assumed to have high impact: the main KfW programme for the energy-efficient modernisation of existing buildings and tax incentives for energy efficient renovation. Beyond it, the impact of the Ecological Tax Reform (cross cutting with sector-specific character) and of the proposed top runner strategy (information/education) are assessed as high-impact measures. The impact of most of the financial measures, which are dominant in the household sector, is assumed to be in the medium category, whereas some financial programmes and informative measures are seen as low-impact measures.

[3] As of September 17, 2015

Figure 18: Impact of national and EU-related measures in Germany



Source: MURE database

In the tertiary sector, some measures from different types are in the high-impact category: the Ecological Tax Reform (cross cutting with sector-specific character), the Top Runner Strategy as a legislative/informative measure and the special fund for energy efficiency in SMEs as a financial measure. Most measures in the tertiary sector are categorised to have a low impact; among them the measures of the KfW investment programme (financial) which were released in the 3rd NEEAP. The other measures in this category are mostly of the type Information/Education/Training like Mission E.

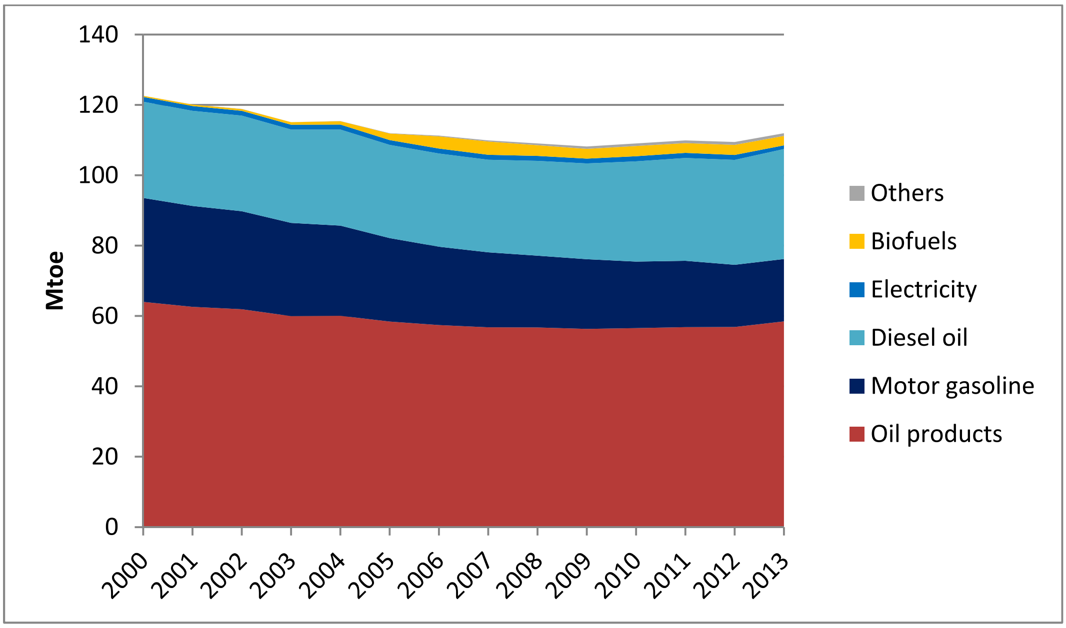
3. ENERGY EFFIENCY IN TRANSPORT

3.1. ENERGY EFFICIENCY TRENDS

Between 2000 and 2013, total energy consumption in the transport sector fell by about 5% from 65.7 to 62.4 Mtoe (Figure 19). Compared to 2005, however, the base year for the German energy consumption reduction target for the transport sector, consumption in 2013 was around 1% higher. This means that there is still a considerable gap to close to meet the 2020 reduction target of 10% compared to 2005.

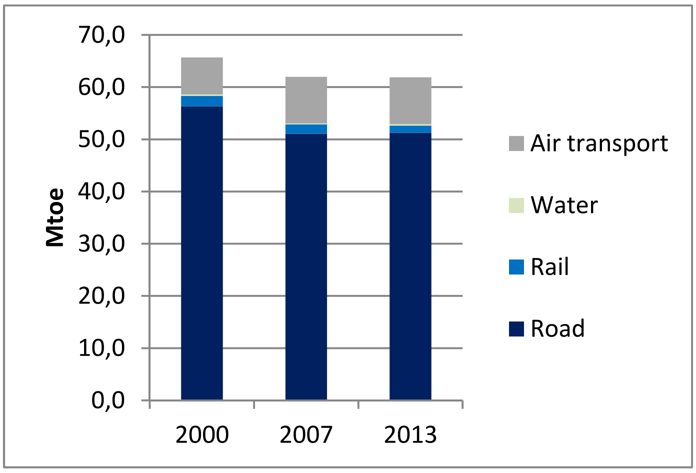
Energy consumption in the transport sector is dominated by road transport, with a share of more than 80% (Figure 20). Therefore, in the following special emphasis is put on this transport mode. Due to the considerably above-average growth of air transport (inter-national and domestic), its share in total consumption increased from 10% in 2000 to 14.4 % in 2013. With a share of about 2 %, the role of rail transport for transport energy consumption is rather small and further lost importance during the last 15 years. The share of inland navigation is insignificant.

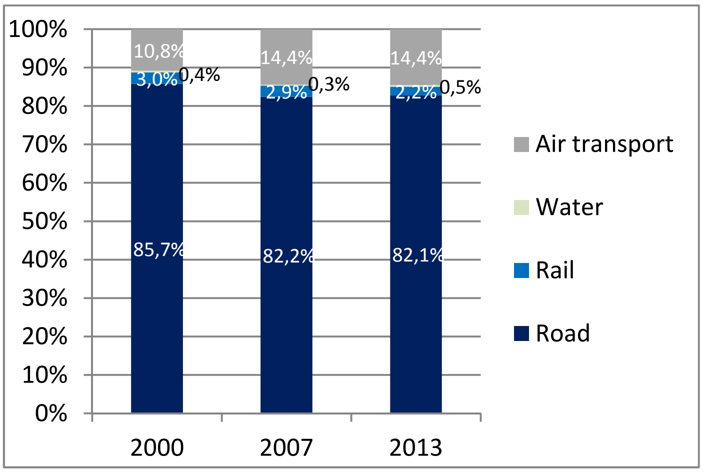
Figure 19 : Energy consumption by fuel in the transport sector, 2000-2013



Source: ODYSSEE database

Figure 20: Development of transport energy consumption by mode in 2000, 2007 and 2013



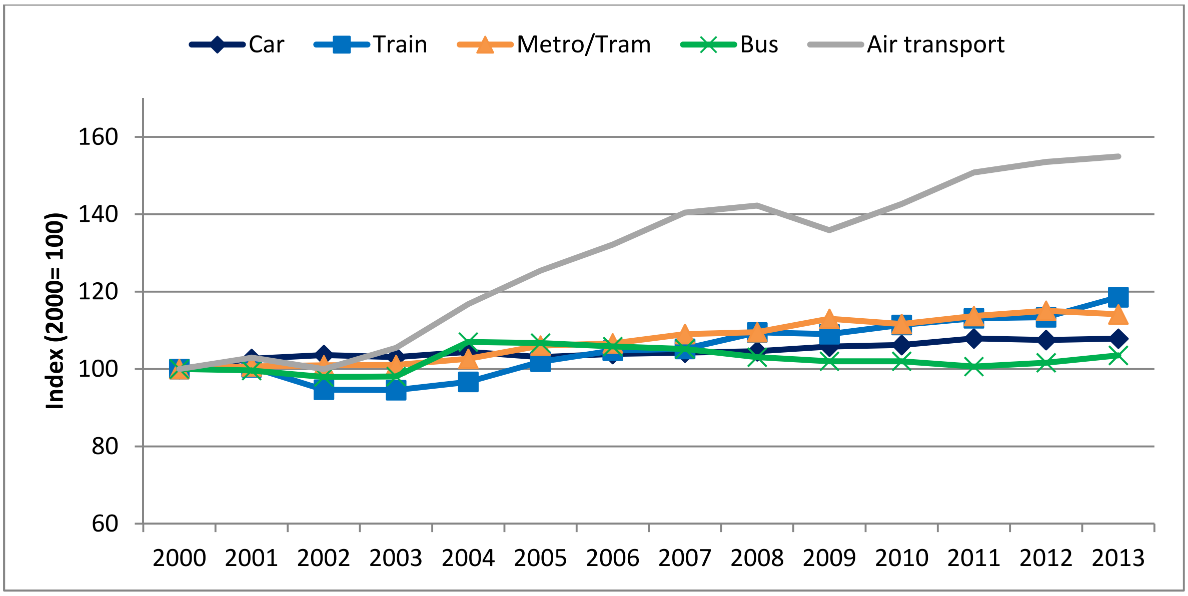


Source: ODYSSEE database

With regard to passenger traffic by means of transportation, the number of passenger kilometres for cars is slightly increasing since 2000 (Figure 20). The transport by train also showed an increasing trend, whereas traffic by buses lost shares in passenger transport since 2004, after a sudden increase. This trend should be reversed in the future, as the market for long-distance buses is growing rapidly since 2013. This is due to the fact, that long-distance buses which were banned by the Passenger Transportation Act, are allowed in Germany since January 2013.

In contrast to road and rail transport, energy consumption for air transport (international and domestic) strongly increased especially between 2004 and 2008 (Figure 21). This can particularly be explained by the relatively strong growth of GDP by 2.2% per year during that period and also by the increasing market entry of low-cost carriers. In the following years, a consumption decrease could be observed during the economic recession, but consumption started to grow again in 2010.

Figure 21: Passenger traffic by means of transportation, 2000-2013



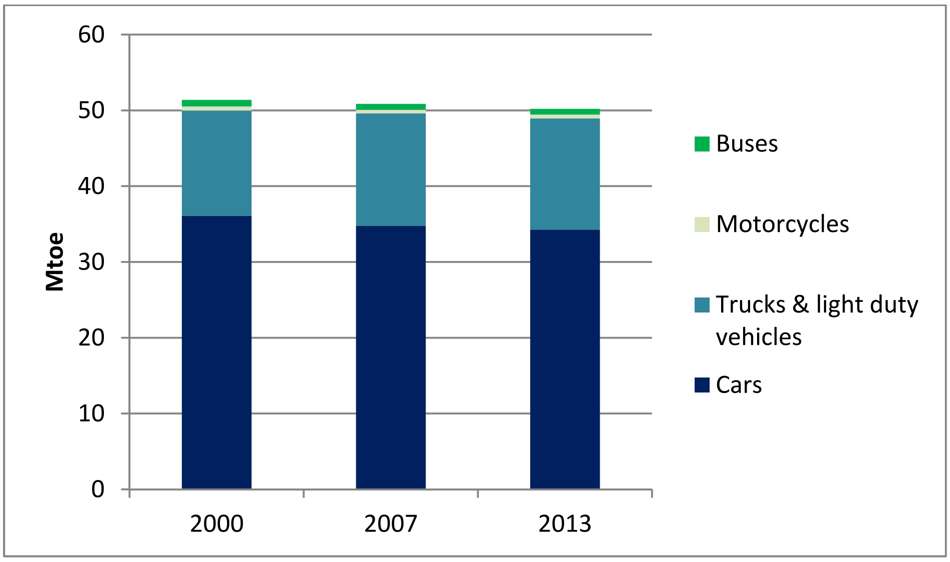
Source: ODYSSEE database

Road transport

In road transport, 68% of energy consumption is caused by cars and further 29% by trucks and light vehicles. Compared to 2000, the importance of trucks increased. Other vehicle types (motor cycles, buses) are not important (Figure 22). Road energy consumption widely follows the total trend, it only lies slightly below. The development of total energy consumption of road transport in the period 2000-2013 was influenced by two opposite trends: the rising number of passenger-kilometres for cars and ton-kilometres for trucks, and the decreasing unit consumption of these vehicle types.

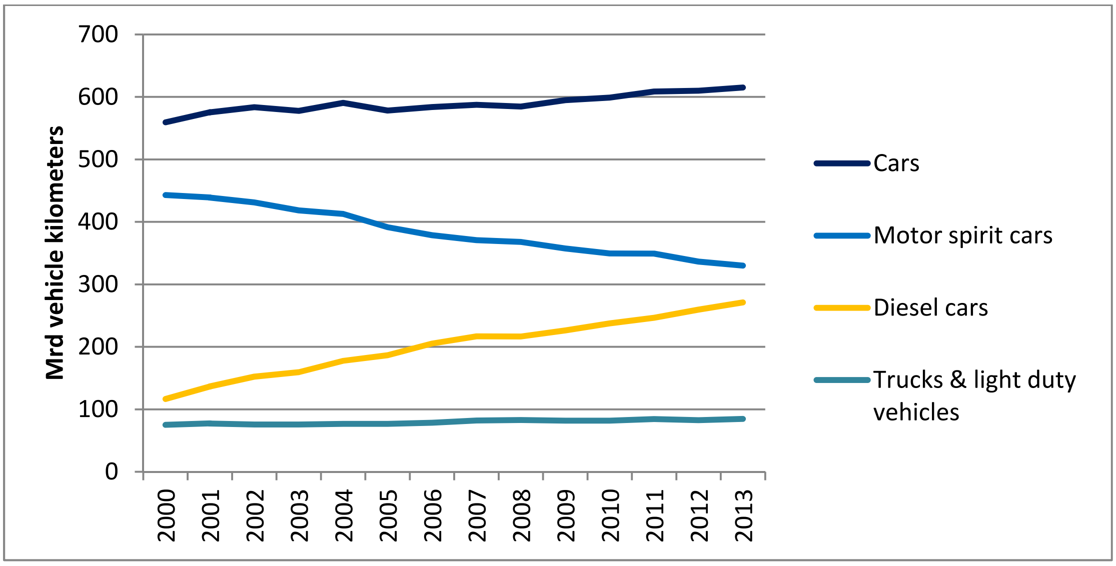
The slightly decreasing trend of energy consumption in road transport since 2000 is mainly driven by petrol-driven cars whose number of vehicle kilometres has decreased since 2000, whereas diesel-driven cars show a continuous increase since then (Figure 23). This means that the trend to diesel-driven cars, which was rather moderate during the 1990s, considerably strengthened since the beginning of the new century. Between 2000 and 2010, the share of diesel cars in the total car stock more than doubled and correspondingly its share in road transport grew from 17 to almost 33%. This trend is continuing until today. Domestic truck transport has almost remained constant since 2000, whereas the number of foreign trucks crossing Germany has increased considerably.

Figure 22: Energy consumption by vehicle type in 2000, 2007 and 2013



Source: ODYSSEE database

Figure 23: Development of vehicle kilometres in road transport by type of vehicles, 2000-2013



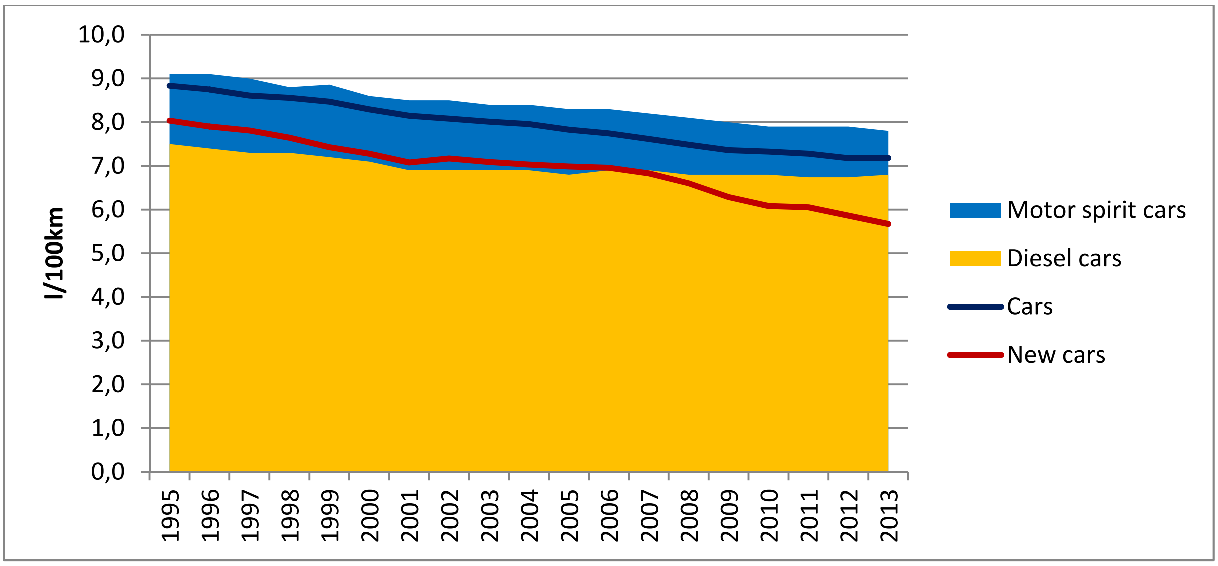
Source: ODYSSEE database

The decrease of total average fuel consumption for cars was also driven by the increasing share of diesel cars in Germany, showing considerably lower average fuel consumption than gasoline-driven cars. Another influencing factor which contributed to the decreasing energy consumption in road transport was the decreasing fuel consumption per vehicle (in l/100 km). For cars, the decrease was fairly strong. The average consumption for diesel-driven cars was almost constant during that period (Figure 24). It only decreased by 9.3% since 1995. In comparison: Motor spirit-driven cars reduced their specific consumption by 14.3%.

The decrease of total average fuel consumption for cars was also driven by the increasing share of diesel cars in Germany, showing considerably lower average fuel consumption than gasoline-driven cars. Since the beginning of the 2000s, however, the difference became smaller for new cars.

The slowing-down in fuel efficiency especially of diesel cars suggests that the purchasing trend towards large cars did out-weigh the efficiency benefits of engine improvements. The average power of new cars in Germany is still above the EU-average and there is also an increasing share of new cars with 4-wheel-drive. Since 2006, however, this trend seems to turn back and the improvement in the specific consumption of cars sped up again. Before 2000 the difference between the consumption of new cars and the car stock was constantly around 1 l/100km; recently the gap widened up to 1.5 l/100km in 2013.

Figure 24: Specific fuel consumption of cars, 1995-2013

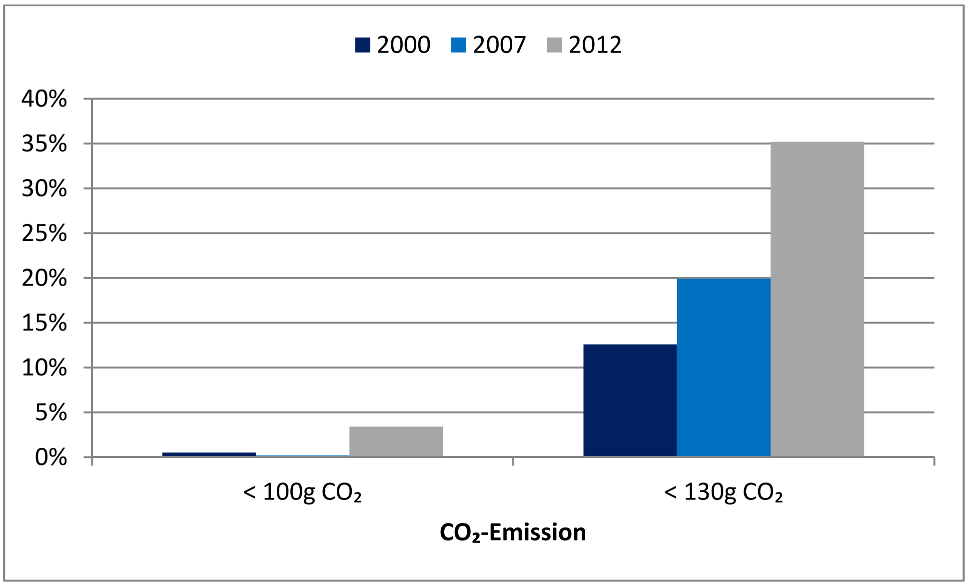


Source: ODYSSEE database

A decrease in fuel consumption leads also to a decrease in CO_2-Emissions. Additionally the technologies reducing the CO_2-Emissions have been improved for new cars. Awareness of consumes seem to have risen, so that the share of low emissions cars (i.e. below 100 gCO_2/km) increased from 0.5% in 2010 of newly registered cars to 3.4% in 2012. And 35% of new cars had emissions below 130 gCO_2/km in 2012 (Figure 29).

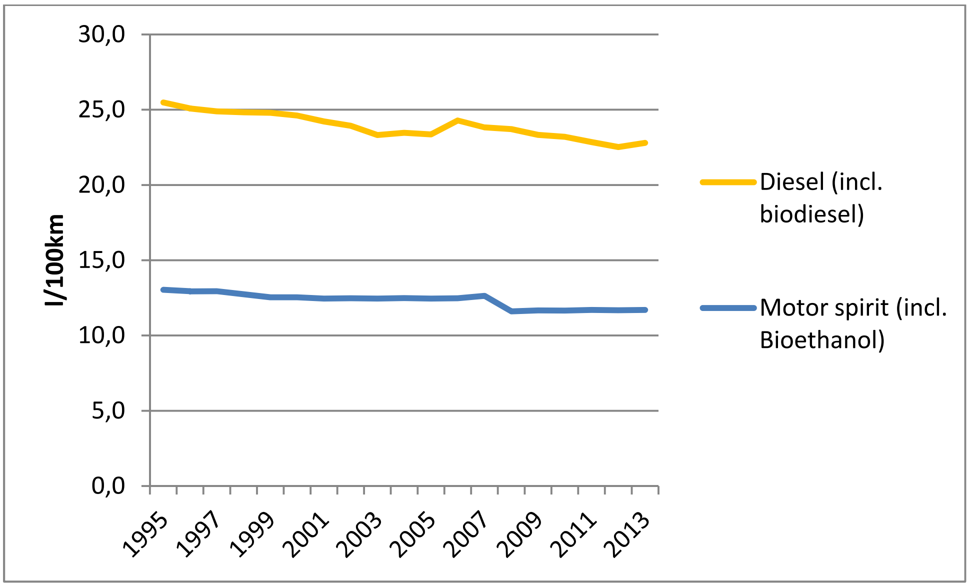
With regard to trucks (for Germany incl. light vehicles), the average diesel consumption has decreased from 25.5 to 22.8 l/100 km, i.e. by 11 % (Figure 26). As in the case of cars, this development stagnated between 2002 and 2005 and in 2006 even an increase could be observed. But since then, the decreasing trend seems to continue again. Average consumption of gasoline trucks has remained constant over the whole period, apart from a break in 2007. Since only 3% of all trucks are gasoline-driven, this is only of minor importance for the development of energy consumption in road transport.

Figure 25: Share of new low emission cars in 2000, 2007 and 2012



Source: ODYSSEE database

Figure 26: Specific fuel consumption of trucks and light duty vehicles, 1995-2013



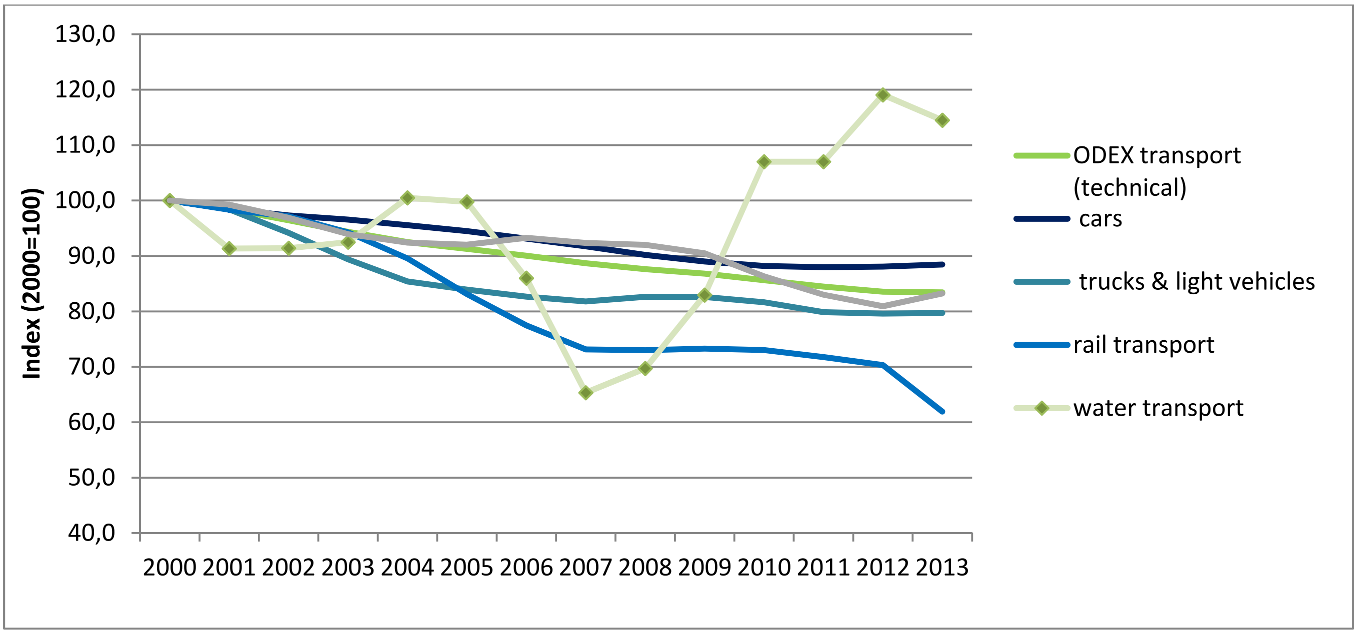
Source: ODYSSEE database

ODEX indicator

The energy efficiency progress in the transport sector is measured by an aggregated energy efficiency index (ODEX), which is calculated at the level of seven transport modes or vehicle types: cars, trucks/light duty vehicles, motorcycles, buses, rail, water and domestic air transport (Figure 27). The calculation is based on the unit consumption indices for these modes. To ensure clarity and because of their small influence, buses and motor cycles are not included in the following figure.

In 2013, the energy efficiency index of transport improved by 16.6% compared to 2000. Efficiency improvements in the car stock as a consequence of the penetration of new, more efficient cars (measured by a specific consumption in l/km) and a continuous trend to diesel cars, contributed steadily to this development. Since 2009, however, the energy efficiency improvement for cars has slowed down considerably. The energy efficiency index for trucks and light duty vehicles also contributed to energy efficiency gains in transport, especially over 2001-2006. Between 2007 and 2009, the ODEX for trucks increased, which represents a worsening of energy efficiency during the economic crisis. Since 2011 the index for trucks and light duty vehicles remained constant. The contribution of the other transport modes (air, train, water) is less important due to their small shares in consumption. Therefore, the development of the total transport ODEX strongly follows the car and truck ODEX. Modal shift had a comparatively small impact on transport energy consumption.

Figure 27: Energy efficiency progress in transport sector measured by the ODEX, 2000-2013



Source: ODYSSEE database

3.2. ENERGY EFFICIENCY POLICIES

The 3rd Energy Efficiency Action Plan (NEEAP) published in 2014 (BMWi 2014b) contains most of the recent measures in Germany. The following text will summarise the most recently initiated, measures. Some additional policy measures for the transport sector are included in the Climate Action Programme 2020 (see Section 1.4; BMUB 2014).

Measures from the 3rd NEEAP

First, with its **Ecological Tax Reform**, initiated in 1999, the German Government aimed to encourage energy saving and promote renewable energies, as well to create jobs. The eco-tax consists of an Electricity tax and a premium on the energy tax. Enterprises can apply for tax reductions, if they use more than a specified base amount per year. In 2003 the Act of Further Development of the Ecological Tax Reform modified parts of the original tax reform. The dismantling of tax reductions and the adaption of the taxes on gas and heavy heating oil were the main targets of these changes. Since 2015 a company can apply for a "Peak-load Balancing" if they have either a certified energy management system or an environmental management system (lower requirements for SMEs), or can prove the reduction of energy intensity of 1.3% a year (reference period 2007-2012).

Second, a **levy on air traffic** has become valid from 1 January 2011 for all flights from German airports. The levy has to be paid by the airline and depends on the distance of the flight. It ranges between 8 EUR for short-haul flight, 25 EUR for medium-haul flights, and 45 EUR for long-haul flights. Since 2011 the air-traffic levy has been increased. This increase is usually included in flight tickets for the passengers who visit any of the Germany's airports. The increase in the levy considers the destination of the flight and the flight distance/travel time. The levy has been classified in three classes since January 2013.

Measures from the Climate Action Programme 2020

In Germany, most of the measures introduced during the last years, represent a continuation of well-established measures and policies from the previous decades. In the transport sector, several new measures have been introduced under the "Climate Action Programme 2020".

A package of measures has been put forward to *make freight transport more efficient and climate – friendly*. It includes the efficient reorganisation of road freight transport, expansion of rail freight transport and strengthening the role of waterways as a mode of transport complement and influence each other. Improved linking up of the different modes of transport also helps to make freight transport environmentally sound.

A raft of measures is also to be put in place to *make passenger transport more environment- and climate-friendly*. These measures will focus on strengthening local public transport and long-distance passenger transport and on strengthening cycle and pedestrian transport. Mobility management systems will also be promoted. In the area of public transport, the federal government provides financial support to the federal states and local authorities in the form of regionalisation funds through legislation on unbundling (Entflechtungsgesetz) and under the provisions of legislation regulating federal government support for local transport funding (Gemeindeverkehrsfinanzierungsgesetz) and in this way contributes to more environmentally sound mobility.

Promotion of alternative drives systems in local public transport will continue in line with on-going financial programmes, including those that are funded by the National Climate Initiative (NKI).

Increasing electrification of vehicle drives in passenger and freight transport is of prime importance in reducing CO_2 emissions in the transport sector in the medium and long term. Since the reduction effect depends on the market penetration of electric vehicles, the German government will create conditions that are advantageous to their rapid market launch and to meeting its target of one million electric vehicles by 2020 (see Table 2). One of the key options under consideration is a special depreciation allowance for commercial electric vehicles, which would be jointly financed by the federal government and the federal states.

In total, the measures for the transport sector as explained in the "Climate Action Programme 2020" are estimated to save 110 – 162 PJ of primary energy and thereby avoiding 7 – 10 $MtCO_2$ equivalent GHG emissions.

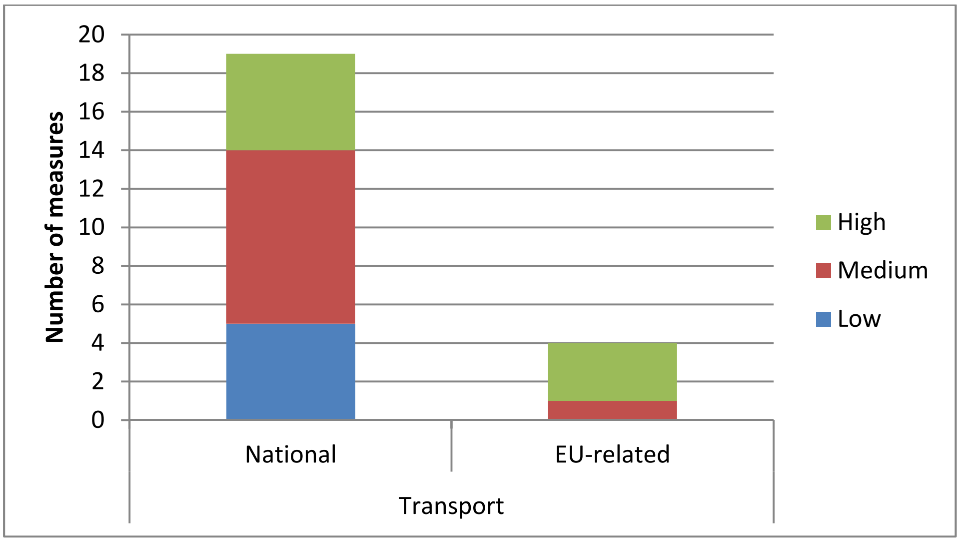
3.3. SEMI-QUANTITATIVE IMPACT OF MEASURES IN THE TRANSPORT SECTOR

In the MURE database, with a number of 19 measures the transport sector has the lowest amount of measures for Germany (Figure 28). Nevertheless the EU-related measures mostly have a high impact. One example is the

Community Framework for the Ecological Tax Reform (fiscal) of which the measures are deemed to be high in both in the household and the transport sector. The other two high impact measures belong to the type legislative/normative.

On national basis there are some measures from different types in the high impact category. Apart from one cross-cutting measure with sector-specific characteristics, the Ecological Tax Reform, there are two fiscal (levy on air traffic, motor vehicle duty) and two financial measures evaluated to have a high impact. Most of the measures in the transport sector are perceived to have a medium impact like the voluntary agreement by German automobile industry or the effort of improving the infrastructure for cyclists.

Figure 28: Semi-quantitative impact evaluation of measures in the transport sector



Source: MURE database

4. ENERGY EFFICIENCY IN INDUSTRY

4.1. ENERGY EFFICIENCY TRENDS

The industrial sector contributes to the overall targets in total final energy consumption with a current share of around 29% (Figure 4). In 2013, final energy consumption of industry (incl. construction and mining industries) in Germany amounted to 64.54 Mtoe, which is higher than the consumption of 59.3 Mtoe in 2000. Energy consumption of manufacturing amounted to 61.02 Mtoe in 2013 (Figure 29).

The following analysis will mainly focus on manufacturing industry, which contributes about 97 % of total energy consumption of industry[4] in Germany (Figure 29).

Energy consumption by manufacturing branches did not change significantly in Germany during the last 10 years (Figure 30). The most important energy consumer is the primary metals industry followed by the

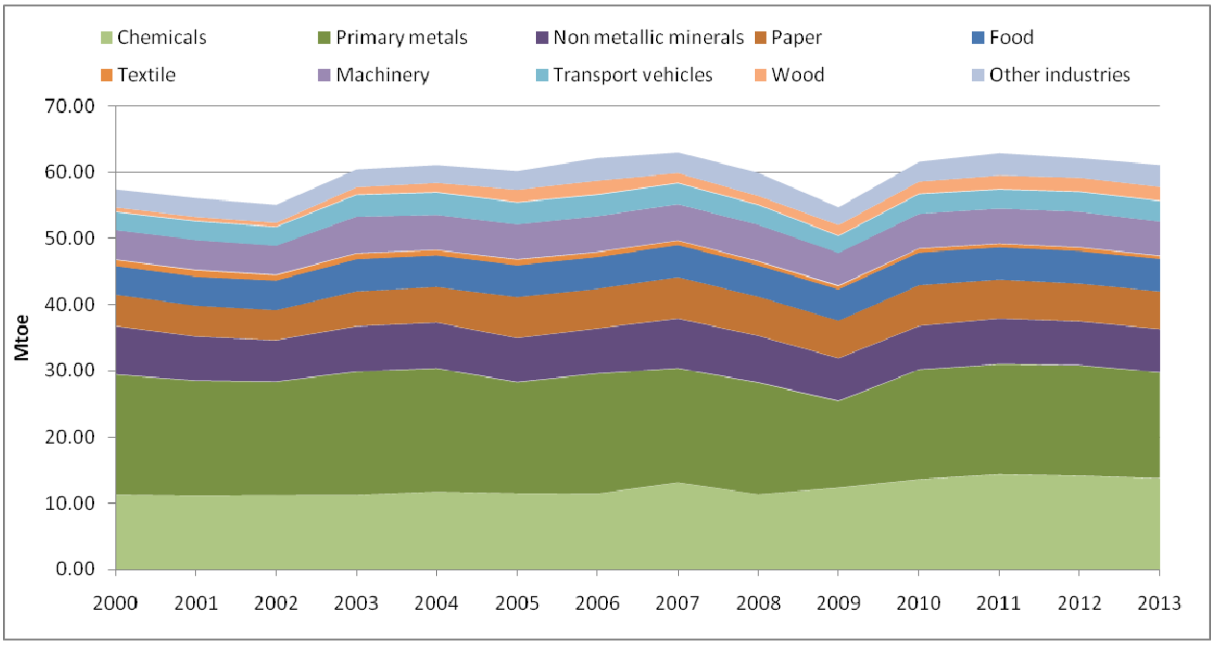
4 Industry is defined in ODYSSEE as manufacturing industry, mining, water processing and construction. The branches are defined in accordance with the statistical classification of economic activities in the European Community (NACE, Rev. 2, 2008) http://ec.europa.eu/eurostat/ramon/index.cfm?TargetUrl=DSP_PUB_WELC

chemicals industry. The share of the other very energy-intensive branches (non-ferrous metals, non-metallic minerals, chemicals, pulp and paper) in total energy consumption of manufacturing amounted to about 60 % in 2013.

Figure 29: Final energy consumption in industry in Germany, 2000 - 2013

Source: Odyssee Database

Figure 30: Final energy consumption in the manufacturing sector by branches since 2000



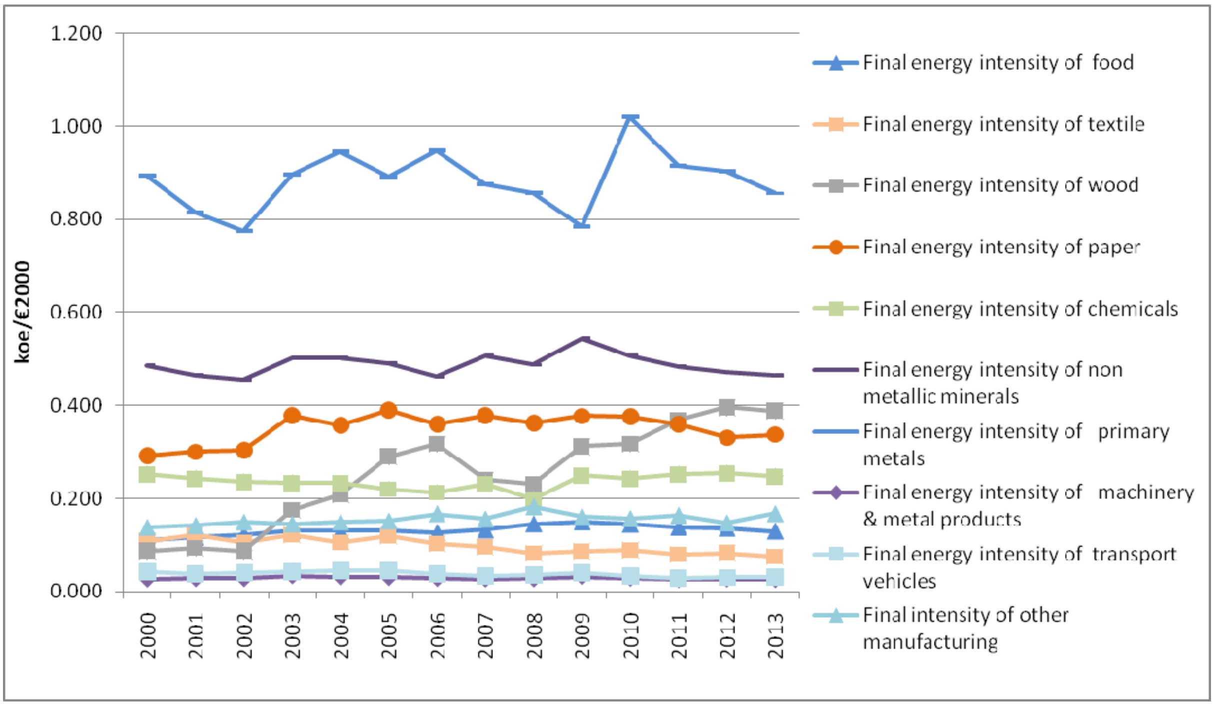
Source: Odyssee Database

Energy intensity and unit consumption

Energy intensity is an aggregate indicator which is often used to describe the development of energy efficiency in industry (Figure 31). Between 2000 and 2013, the actual energy intensity of manufacturing decreased by 1.0% per year on average (

Figure 32). However, the development of energy intensity in the different branches of manufacturing was rather heterogenous (Figure 31).

Figure 31: Development of energy intensity in manufacturing branches, 2000 - 2013



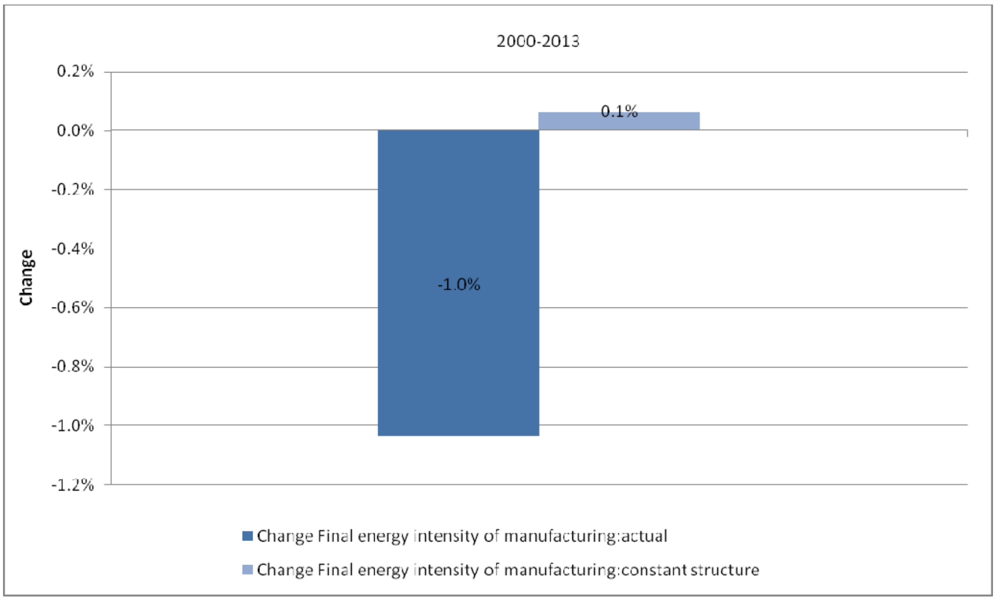
Source: Odyssee Database

As already stated above, the development of energy intensity does not only reflect energy efficiency improvements; structural changes within manufacturing (i.e. changing shares of the more or less energy-intensive branches in total industrial output), may also have an important influence. This is shown by the energy intensity calculated within a constant structure of manufacturing. The intensity at constant structure better reflects the predominantly technically induced efficiency changes in manufacturing since the impact of structural changes are removed. In the period 2000-2013, the intensity-reducing impact of structural changes was substantial. On average, there was no energy efficiency progress at all, but energy intensity at constant structure increased by 0.1% per year (

Figure 32). This means that the observed decrease in the actual energy intensity by 1.0% per year was primarily caused by structural changes within manufacturing towards less energy-intensive branches and not by energy efficiency gains.

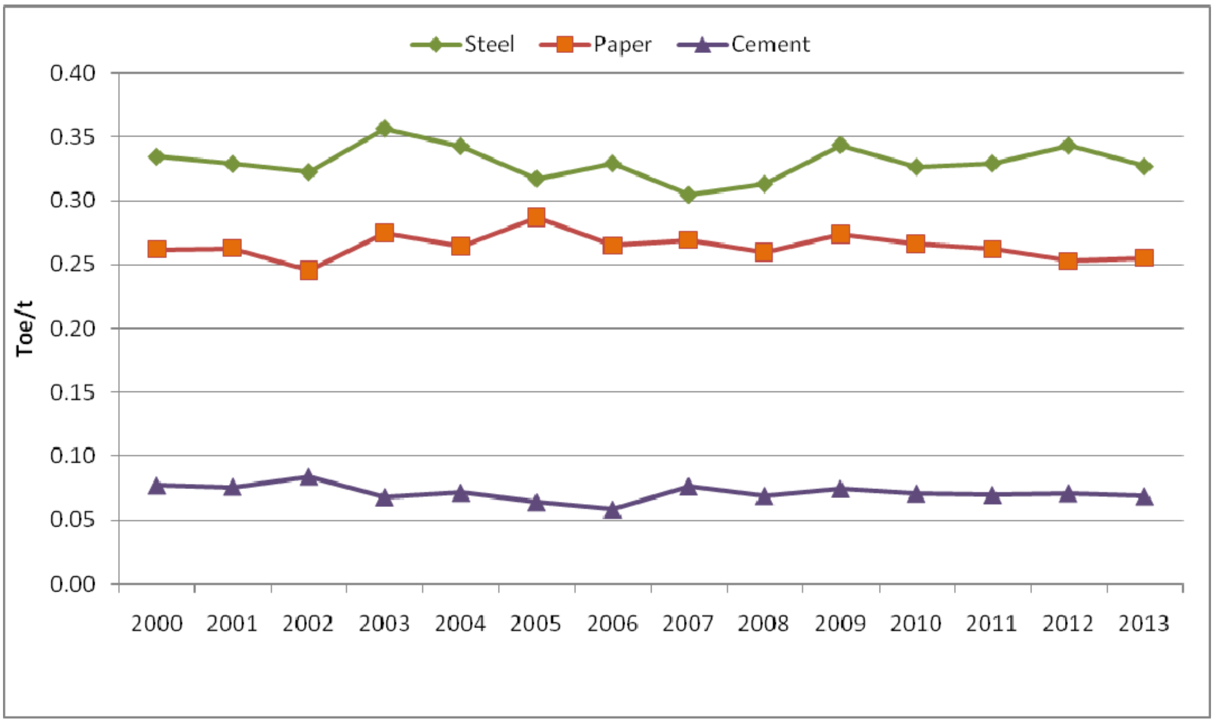
The meaningfulness of final energy intensity of manufacturing is further restricted by the fact that it is calculated based on added value, i.e. activity calculated in monetary units. The use of physical factors is widely advocated, since they better reflect the energy efficiency development (see e.g. Neelis et al., 2007; Salta et al., 2009). Therefore, unit consumption indicators (defined as energy consumption per ton) for some energy-intensive products in manufacturing are calculated in addition to energy intensities (Figure 33).

Figure 32: Change of energy intensity in manufacturing during 2000 – 2013



Source: Odyssee Database

Figure 33: Unit consumption of energy-intensive products, 2000 - 2013



Source: Odyssee Database

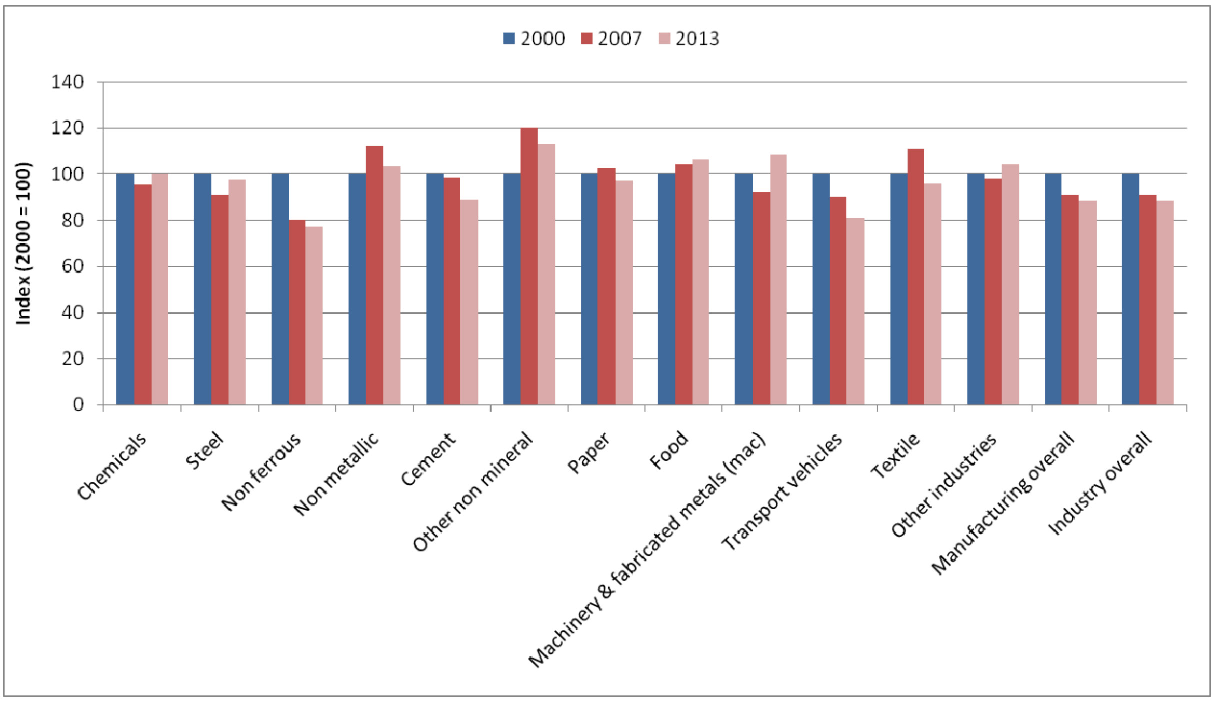
Over the whole period 2000-2013, unit consumption of the selected products (crude steel, pulp and paper, cement) did not change significantly. In fact, in some years an increase was observed, especially in the case of steel and paper, and this was mainly linked to business cycles. The trend in unit consumption confirms the observation of rather modest or no energy efficiency improvement in industry which was already shown by the intensity indicator. This was also a reversal of the trend during the 1990s, when both energy intensity and unit consumption of energy-intensive products considerably decreased and an improvement in energy efficiency was observed.

ODEX indicator

In addition to the energy intensity at constant structure and the unit consumption of energy-intensive products, the efficiency progress in the industrial sector is also measured with the ODEX. It measures the efficiency development at the level of manufacturing branches, and aggregates this development to the whole sector (Figure 34). For the energy-intensive products (cement, steel, paper), the calculation is based on unit consumption per ton. For the other branches, the energy used per production index is used instead of added value, in order to exclude the impact of a changing value of products from the ODEX.

The total ODEX for manufacturing fluctuated over these years, with the total improvement amounting to less than 4%. The development within the industrial branches, however, varied significantly, both between the branches and over the whole period under review (Figure 34). There were some branches with a considerable energy efficiency progress (e.g. non-ferrous metals, cement, transport vehicles), and others with an increasing ODEX, i.e. a worsening of energy efficiency (e.g. paper, non-metallic minerals, chemicals, food). Since the second half of the 2000s, the increasing – i.e. worsening - trend of the ODEX has strengthened in several branches.

Figure 34: Development of the energy efficiency index ODEX in manufacturing for the years 2000, 2007 and 2013



Source: Odyssee Database

4.2. ENERGY EFFICIENCY POLICIES

Many recent policy measures in the household and tertiary sector are already included in the 3rd National Energy Efficiency Action Plan (NEEAP) of Germany which was submitted in June 2014 (BMWi 2014b). Some additional policy measures have been decided in the "National Action Plan Energy Efficiency " (NAPE) which was launched in December 2014 (BMWi 2014a; also see section 1.4). In the following, some of the key energy efficiency policy measures from the 3rd NEEAP and the NAPE are be described.

Measures from the 3rd NEEAP

A joint initiative of the Federal Ministry of Economy and Energy and the KfW is the **KfW Energy Consultations for SMEs**. Small and medium-sized enterprises (SMEs) get advisory support to improve their energy efficiencies. The advisory support consists of two components, which can be taken in the claim independently. First, an initial consultation is supported with a non-repayable grant of 80% of the consultancy costs. Second, a detailed consultation lasting several days is supported in the same way with 60% of the costs. The consultation provides proposals or a specific action plan for improvements to save energy. As a follow-up, the SMEs can get financial support for the implementation by the KfW Energy Efficiency Programme.

Also the Federal Ministry of Economics and Technology (BMWi) has launched an Energy Efficiency Fund starting in 2008. Therein are two programmes called '**Promotion of energy-efficient cross-cutting technologies in SMEs**' and '**Promotion of energy-efficient and climate-friendly production processes**'. The first one provides funding in form of investment grants for energy-efficient pumps, drivers or compressed-air systems. Especially SMEs can benefit since January 2014 as additional financial incentives were created. Implementation and execution of the support program are by the Federal Office of Economics and Export Control (BAFA). Besides the promotion for investment in technologies available on the market, the exchange of individual technologies like systematic optimisation is equally promoted. Up to 30% of the investment costs will be reimbursed, if the achievable energy saving amounts at least 25% compared to the old system.

In addition, the BMWi offers a **Promotion of energy management systems (EMS)** under the Energy Efficiency Fund. The program supports the initial certification of either an energy management system (fulfilling DIN EN ISO 500001) or an energy monitoring system. Additionally there is the option of applying for the purchase of measurement technology and software for energy management systems. The funding is in form of grants and can go up to 20,000 € per company.

Measures from the NAPE

Energy audit obligation for non-SMEs mandates large enterprises that are now required till 5th December 2015 and after that at least every four years to carry out Energy audits in accordance with the energy audit standard DIN EN 16247-1. Companies that already have implemented, in accordance with the DIN ISO 50001, an Energy Management System or an Environmental Management System will be excluded from the obligation of mandatory energy audits. By definition, a large enterprise consists of more than 250 employees and the yearly revenue of greater than 50 Million euros. Regarding the implementation, 50,000 companies in Germany are estimated to fall under this obligation and about 12,500 energy audits per annum are to carried out in a four-year cycle. After execution of an energy audit, an enterprise is estimated to realize 5% of energy savings.

Upgrading KfW energy efficiency programmes aim at the deployment of KfW cheaper interest rates for the promotion of energy efficient production equipments/plants as well as process including the cross-cutting technologies with relatively high energy savings potential. The further development of the Energy Efficiency program includes the new entrance standard into the program i.e. 10% savings as well as a new premium standard (30% savings). Thereby the funding intensity will be calculated in accordance with the estimated/achieve savings and is therefore irrespective of the size of the enterprise. The aim of the program is simple, transparent and consistent verification of energy savings. Cooperation with national development institutions will be strengthened and the action will be publicly advertised. The available loan volume will be raised by 70% up to 2 Billion EUR per annum.

Funding for energy performance contracting (including default guarantees) involves the typical risks of contracting (long contract periods, the investment risk of the contractor, warranties etc.) present, specially for financing in the area of energy savings contracting, major obstacles in granting of loans. The expansion of an already existing guarantee offer by the Guarantee banks will allow the credit institutes to lead the reduction in failure-risks also enabling SMEs to offer efficiency measures in the form of a contracting. This will require the adjustment of guarantee amount. Implementation of the guarantee program will be by the guarantee banks for contract-financing by adjusting the amount of the guarantee for contracting-finance for up to two million euros for the period of three years starting from 2015. The continuation the special conditions for contracting will be based on evaluation decision.

Energy Efficiency Networks Initiative

The Learning Energy Efficiency Networks (LEEN) is a concept targeting energy efficiency in companies from different sectors. The concept was originally developed in Switzerland in the late 1980s (Bürki 1999) and is now widely applied in Switzerland due to the possibility that companies can get out of the payment of the CO_2-surcharge (presently 60 CHF per tonne of CO_2), if the company joins an energy efficiency network (EnAW 2014; Köwener 2011). In Germany, these networks are one of the immediate actions within the National Action Plan on Energy Efficiency (NAPE). In the NAPE, the idea is to extend these networks from presently around 60 to 500 in 2020. The outcome of the networks running so far in Germany, is that energy efficiency progress is doubled compared to the autonomous progress[5]. Around 75 PJ of energy savings per year are expected by the 500 energy efficiency networks in 2020 (about 3% of total industrial energy use in Germany) and avoided CO_2 emissions of around 5 million tonnes.

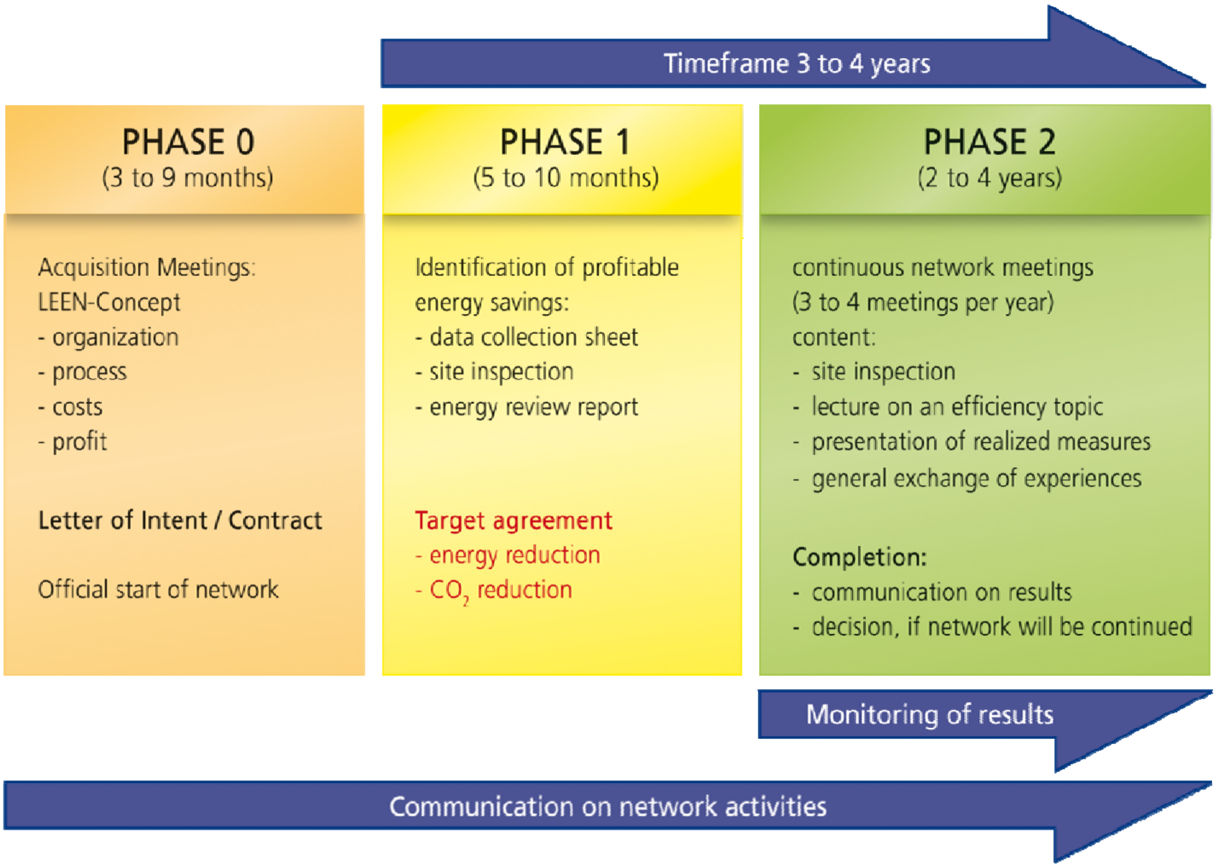
A LEEN is usually formed with 10-15 companies operating in different sectors, which are recruited by the network operator (e.g. utilities, industrial associations and platforms, Chamber of Commerce and Industry, city governments, or consulting engineers). There are presently two types of networks in Germany: for medium sized and large companies with yearly energy cost between 0.5 and 50 Mill. €/a and a slightly modified form for small and medium sized companies with yearly energy cost between 30.000 and 500.000 €/a (called “Mari:e – Mach‘s richtig: Energieeffizient!” – Do it right: Be energy-efficient!). The focus of the energy audit and the information and exchange of experience is on a set of common cross-cutting technologies, and in order to secure an open exchange of ideas plans and experiences the companies participating in the network should not be in competition in the same sector. The actual network process begins with an energy review phase 1 (Figure35). The companies fill in a data form concerning their energy situation and the certified consultant engineer carries out the energy audit. On that basis, the participants decide individually on an efficiency target (confidential) and commit themselves to a voluntary energy saving target of the network and regular exchange of experiences in their network for at least the next 3 – 4 years.

The targets which are set in the first phase are to be reached in the network operating phase 2. A LEEN-certified moderator plans and conducts the meetings. All network participants report on planned or

[5] I.e.progress that occurs on the average for non-participants

implemented measures so that the other participants can benefit from their experiences. Within the process, the participants have the chance to benefit from exchange of information and experience, site visits during the meetings, and the possibility to utilize synergies in the networks. Additionally, the peer pressure concerning the common network target promotes progress towards the common goal and facilitates the diffusion of energy-efficiency innovations as an informal competition in achieving energy efficiency progress among the companies and the energy managers can be observed.

Figure35: LEEN network process



Source: www.leen.de

The costs for participating companies are approximately € 35,000 to € 40,000 for a four-year network operating period. These costs cover the 10-12 day energy review, 16 network meetings and three assessments of the monitoring results (Köwener 2011). The success is measured through the monitoring once a year and documented by the consultant engineer. Those results are fed back to the companies' management.

Participation in the LEEN can also be used as a preparation of the implementation of energy management systems, as some requirements of DIN 16001 or (today) ISO 50001 are met (Di Nucci 2012).

In the pilot project "30 Pilot Netzwerke", energy efficiency networks were conducted under the lead of Fraunhofer ISI. The project of the 30 pilot network was funded within the National Climate Protection Initiative NKI since November 2008 until March 2014. The funding covered the cost of further development of the LEEN management system, including 17 investment calculation tools for cross cutting technologies, the evaluation of the performance of the 30 networks with its 366 companies as well as public relations to report the successes to a broader audience of the German industry. The participants were predominantly (about 75%) from the manufacturing sector (NACE sector C). A little more than half of the companies reported to be a location of a greater enterprise, the remaining are independent companies. The companies rated their own energy consumption as “rather high” (3.7 on a scale from 1 to 5). 18% of the companies already made experiences with comparable networks on different topics. For over half of the companies, energy savings have always been a relevant issue, according to their own declaration. 49% realized energy consulting within the last 5 years. 2/3 of those were satisfied with the consultation and over 60% thereupon even conducted according measures (Fraunhofer ISI, own calculations).

The participants’ motivation to participate the networks was, besides the final aim to reduce energy costs, to gather information about the energetic status quo in their production sites and to find suitable measures – the practical orientation is obviously highlighted. Those expectations were well satisfied, as calculations revealed comparing those expectations and according experiences. Especially information deficits and a lack of market overview were stated as barriers to implement energy efficiency measures which significantly decreased during the network process. Although, participants criticize the small share of energy costs in production costs – a barrier which is intangible by the means of the network aspects.

Most of the identified measures addressed cross-cutting electrical technologies, more than 30% of the measures addressed process heat and space heating. The major part (about 85%) of the recommended measures required investments below 50.000€, but a share of about 17% require investments above. While measures concerning process heat and energy carrier change deliver highest expected savings, they are also the most costly ones (Rohde et al. 2015).

The major share of participants (over 90%) stated that they accomplished the suggestions drawn out of the network process. 75% reported that a part of those measures would not have been implemented without the networks. Additionally, about 75% of the participants rated the benefits of network participation as “rather high” or “very high”. Over 60% indicated that contacts gained within the network were used beyond the meetings (Fraunhofer ISI, own calculations).

The quantitative monitoring performed jointly by the energy manager and the consulting engineer came to the conclusion that the annual average efficiency improvement of the participants was 2.1% per year in average. In absolute terms this resulted in energy savings of about 5 PJ/a after 4 years of the duration of the 30 networks.

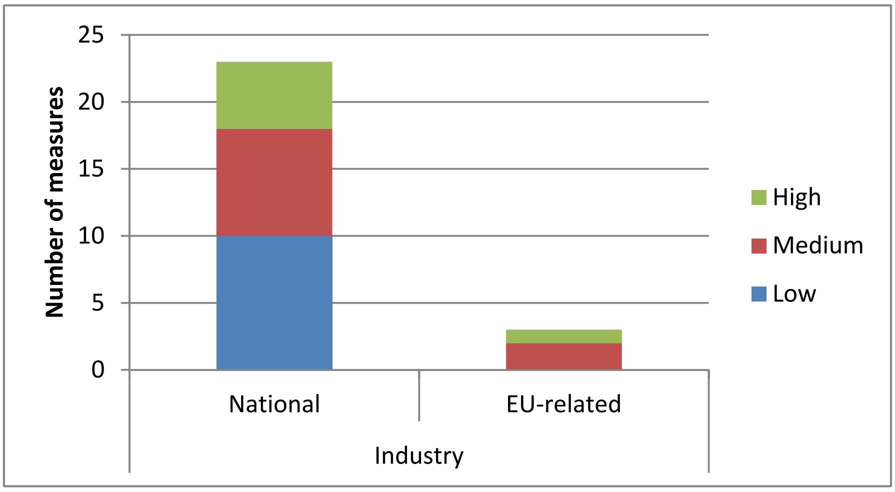
In December 2014, a voluntary agreement was signed by the German Government and 18 associations of industry to generate 500 energy efficiency networks until 2020. As further enrichment, information about financing possibilities to overcome possible financial barriers and the topics of demand side management and flexible electricity production of company owned electricity units will be added to the concept in 2015 in order to react on the increasing importance of fluctuating electricity generation by renewables which open up new energy services.

4.3. SEMI-QUANTITATIVE IMPACT OF MEASURES IN THE INDUSTRIAL SECTOR

In industry, relatively few measures are seen as a high-impact measure (Figure 36). Apart from the first voluntary agreement with German industry from 1995, these are the new KfW fund promoting energy efficiency in SMEs. In 2014 and 2015 two new high impact programmes with focus on large enterprises have been launched: The energy efficiency network initiative (information/education/training) and the energy audit obligation for non-SMEs (legislative/informative). The second voluntary agreement (cooperative measure), the market incentive programme for renewable energies in heat market and some other financial measures are estimated to have a medium impact, whereas most of the measures in industry are assessed as low-impact measures.

The industry sector is part of very few EU-related measures. Including only one high impact measure: the EU emission trading scheme (market-based instrument), which was launched in 2005. The law providing the legal framework for emission allowance trading (passed in 2004) and the Ecological Tax Reform (due to the tax exemptions for industry) are assumed to have medium impact.

Figure 36: Semi-quantitative impact evaluation of measures in the industrial sector



Source: MURE database

REFERENCES

AGEB (2014): German Energy Balances 1990-2013 and Summary Tables 1990-2013. As of September 2014. DIW Berlin, EEFA, Köln (http://www.ag-energiebilanzen.de).

AGEB (2015): Anwendungsbilanzen für die Endenergiesektoren in Deutschland. Berlin, February 2015. (http://www.ag-energiebilanzen.de/viewpage.php?idpage=255).

BMU (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety) (2011): Transforming our energy system - The foundations of a new energy age.

BMUB (Federal Ministry for the Environment, Nature Conservation, Buildings and Nuclear Safety=. The German Government’s Climate Action Programme 2020. Cabinet decision of 3 December 2014. Berlin: BMUB. Available at: (http://www.bmub.bund.de/en/service/publications/downloads/details/artikel/climate-action-programme-2020/?tx_ttnews%5BbackPid%5D=3616)

BMWi (Federal Ministry for Economics and Technology) (2014): Third National Energy Efficiency Action Plan (NEEAP) 2014 for the Federal Republic of Germany pursuant to Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency. Berlin: BMWi. Available at: (http://ec.europa.eu/energy/sites/ener/files/documents/2014_neeap_en_germany.pdf).

BMWi (Federal Ministry for Economics and Energy) (2014). Making more out of energy: National Action Plan on Energy Efficiency. Berlin: BMWi. Available at: (http://www.bmwi.de/BMWi/Redaktion/PDF/M-O/nape-national-action-plan-on-energy-efficiency,property=pdf,bereich=bmwi2012,sprache=de,rwb=true.pdf).

BMWi (Federal Ministry for Economics and Energy) (2015). Dritter Monitoring-Bericht "Energie der Zukunft". November 2015.

Bürki, T. (1999). Das Energie-Modell Schweiz als Erfahrungsfaktor für Schweizer Unternehmen. Bundesamt für Energie: Energie 2000, Ressort Industrie. Benglen.

Di Nucci, M. (2012). Evaluierung des nationalen Teils der Klimaschutzinitiative des Bundesministeriums für Umwelt, Naturschutz und Reaktorsicherheit. Anhang A-13 zum Endbericht. Einzelprojektevaluierung Lernende Energieeffizienz- und Klimaschutz-Netzwerke: 30 Pilot-Netzwerke und Entwicklung von Investitionsberechnungshilfen. NKI-Evaluierung. BMUB, 2012.

DIW Berlin, BMVBS (2015): Verkehr in Zahlen 2014/2015 (and earlier years). Bonn, Berlin.

EnAW (Energie-Agentur der Wirtschaft): Wirtschaftlicher Klimaschutz und Energieeffizienz. Zürich 2014 http://www.enaw.ch/images/Ueber_uns/broschuere-2013-2020-d.pdf

Farla, J., Cuelenaere, R., Blok, K. (1998): Energy efficiency and structural change in the Netherlands, 1980–1990. Energy Economics 20 (1) 1–28.

Farla, J., Blok, K. (2000): The use of physical indicators for the monitoring of energy intensity developments in the Netherlands, 1980-1995. Energy 25 (2000) 609-638.

Fraunhofer ISI, Technical University Munich (IfE), GfK, IREES (2015): Energieverbrauch des Sektors Gewerbe, Handel, Dienstleistungen (GHD) für die Jahre 2011 bis 2013. Final Report. Karlsruhe, Munich, Nuremberg, March 2015 (and reports for earlier years; English Summary partly available). http://www.bmwi.de/DE/Themen/Energie/Energiedaten-und-analysen/erhebungsstudien,did=578810.html.

Federal Statistical Office (Statistisches Bundesamt - Destatis) (2014): Statistical Yearbook. Wiesbaden, September 2014 and earlier years.

Federal Statistical Office (Statistisches Bundesamt - Destatis) (2014): Statistik zum Energieverbrauch und zu Stromerzeugungsanlagen der Betriebe im Bergbau und Verarbeitenden. Gewerbe. Wiesbaden, 2014 and earlier years.

Federal Statistical Office (Statistisches Bundesamt - Destatis) (2015): National Accounts. Inlandsproduktberechnung. Wiesbaden, August 2015.

Köwener, D.; Jochem, E.; Mielicke, U. (2011): Energy Efficiency Networks for companies – Concept, achievements and prospects. ECEEE Proceedings. 2011, Ed. 2, pp. 725–733.

Neelis, M., Ramirez-Ramirez, A., Patel, M., Farla, J., Boonekamp, P., Blok, K. (2007): Energy efficiency developments in the Dutch energy intensive manufacturing industry, 1980-2003. Energy Policy 35 (2007) 6112-6131.

Rohde, C., Mielicke, U., Nabitz, N, Köwener, D. (2015). Learning Energy Efficiency Networks - Evidence based experiences from Germany. Paper presented at the aceee summer study on industry. 2015.

RWI, forsa (2015). Erhebung des Energieverbrauchs für die privaten Haushalte 2011-2013. Final Report (and reports for earlier years). http://www.bmwi.de/DE/Themen/Energie/Energiedaten-und-analysen/erhebungsstudien,did=578808.html

Salta, M., Polatidis,H., Haralambopoulos, D. (2009): Energy use in the Greek manufacturing sector: A methodological framework based on physical indicators with aggregation and decomposition analysis. Energy 34 (2009) 90-111.

ZVEI, GfK (2014): Zahlenspiegel des deutschen Elektro-Hausgerätemarktes 2013 and earlier years. http://www.zvei.org.

ANNEX 1: MAIN DATA SOURCES FOR GERMANY IN THE ODYSSEE DATABASE

Data in ODYSSEE	Data source for Germany	Classification of data source*
Overall economy		
GDP, added value, private consumption	Federal Statistical Office (2015), National Accounts	A
Population	Federal Statistical Office (2014), Statistical Yearbook	A
Primary and final energy consumption by sector	National energy balances (AGEB 2014)	A
Electricity generation by energy carriers	AGEB 2014; BMU 2014	A
Degree days	Based on Deutscher Wetterdienst (DWD)	B
Tertiary sector		
Value added/employment by sub-sectors	Federal Statistical Office (2015), National Accounts	A
Floor area by subsector Energy consumption by end-uses and subsectors	Regular surveys on energy consumption in the tertiary sector (Fraunhofer ISI et al. 2015)	B
Household sector		
Number of households and dwellings, floor area	Federal Statistical Office (2014), Statistical Yearbook	A
Stock and sales of electrical appliances	ZVEI/GfK (2014)	B
Energy consumption by end-uses	National end-use balances (AGEB 2015)	A
Specific consumption of electrical appliances	Stock model data (Prognos, internal information)	B
Industry		
Value added by industrial branches	Federal Statistical Office (2015), National Accounts	A
Production index	Federal Statistical Office (2014), Statistical Yearbook	A
Physical production	Statistics of industrial associations	B
Energy consumption by branches	National energy balances (AGEB 2014); Federal Statistical Office (2014)	A
Transport		
Stock of cars and kilometres for passenger and freight traffic	Verkehr in Zahlen (DIW Berlin and BMVBS 2015)	A
Energy consumption by sub-sectors	National energy balances (AGEB 2014)	A
Energy consumption by vehicle types	Verkehr in Zahlen (DIW Berlin and BMVBS 2015)	A

* A = Official Statistics (Statistics/surveys by national Statistical Offices, Eurostat/IEA, Ministries; model estimations used as official statistics; data "stamped" by ministries)
B = Surveys/modelling estimates by research institutes, universities, consultants, industrial associations
C = Estimate / expert guess