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A.T2.2 State of the art energy report

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1. EXECUTIVE SUMMARY

The land Saxony-Anhalt is located in the east part of Germany. In Saxony-Anhalt live about 2.2 Million of inhabitants. The capital city is Magdeburg. There are 218 municipalities, only three of them have a population higher than 50.000 inhabitants: Magdeburg, Halle and Dessau-Roßlau.

The regional population development is negative. Since 2000´s about 400.000 inhabitant have leaved the region Saxony-Anhalt. The average size of households (1.9 persons) is also lower than the national value (1.99 persons).

In the last years, the regional economy has improved. It has affected the average income of the regional households. However, there is still a negative gap between the regional and the national values. The service sector gives the highest contribution to the economy of the region. Industry and construction sectors are, respectively, in the second and third place.

The infrastructures in Saxony-Anhalt are well developed. People and goods are transported using waterways, highways and railways. Even if the airport "Leipzig-Halle" is geographically located in Saxony, it is also considered as one of the airways´ infrastructures of Saxony-Anhalt.

The energetic infrastructure consists of electric networks, natural gas (pipelines and caverns) and heat districts. These entire infrastructures are well developed. Some of them (i.e. the electric network) is going to be further developed to better integrate the electric power generated by renewable energy sources.

The total energy demand in Saxony-Anhalt is estimated to a value of 143.834 GWh.

About 55% of the generated electricity is produced by renewable energy sources.

In Saxony-Anhalt, the generation by renewable energies plays an important role. By considering the electricity and the thermal energy, renewable energy generate about 43% of the total generated energy. In the electric sector, the share reaches 55%. Wind energy results to be the most used resource; indeed it covers about 34% of the entire generated electricity.

The amount of the CO_2 emissions, based on the energy consumption, is estimated to an amount of 25,4 million of tons[1]. The pro capita CO_2 emissions are about 11,5 tons.

[1] Source: https://statistik.sachsen-anhalt.de/themen/wirtschaftsbereiche/energie/tabellen-co2-bilanz/#c167144

2. INTRODUCTIONs

Introductory note:

The land Saxony-Anhalt is located in the east part of Germany. The capital city is Magdeburg. In Saxony-Anhalt there 218 municipalities, most of them have a population lower than 50.000 inhabitants. About 43% of the municipalities are village with a population lesser than 1000 inhabitants.

2.1. General description of the region

2.1.1 Geographical situation

The land Saxony-Anhalt is located in the north east part of Germany. Its capital city is Magdeburg and its largest city is Halle (Saale). Saxony-Anhalt borders Lower Saxony to the north-west, Brandenburg to the north-east, Saxony to the south-east and Thuringia to the south west (see Fig. 1).

Fig. 1 Land Saxony-Anhalt

The land Saxony-Anhalt covers an area of about 20,447 square kilometres. It is the 8th largest state and the 10th most populated land in Germany (2,21 million of inhabitants). It is divided into 11 rural districts and 3 urban districts (Magdeburg, Dessau-Roßlau und Halle).

In the north, east and south parts of the land Saxony-Anhalt the landscape are dominated by flat expanse. Differently, in the south-west part are located the mountains of the Harz region with an elevation of 1,141 meters on the sea level.

2.1.2 Settlement structure

In Saxony-Anhalt are located 218 municipalities, among them 215 municipalities have a population lesser than 50,000 inhabitants. About 43% of the municipalities are villages with a population lesser than 1,000 inhabitants (see Fig. 2).

The population density is 108 inhabitants/km². There are only two municipalities with a population larger than 100,000 ihnhabitants : Halle and Magdeburg.

Table 1 summarizes the main value for the settlment structure of the land Saxony-Anhalt.

Settlement structure	National	Regional
Area (km²)	357.386,0	20.451,6
Population (thousands)	83.019,2	2.208,3
Number of municipalities (total)	1.876	218
Municipalities with inhabitants (number)		
> 1.000.000		
500.000 to <= 1.000.000		
100.000 to < 500.000		
50.000 to < 100.000		2
10.000 to < 50.000		1
5.000 to < 10.000		52
1.000 to < 5.000		49
< 1.000		93

Table 1 Settment structure of the land Saxony-Anhalt

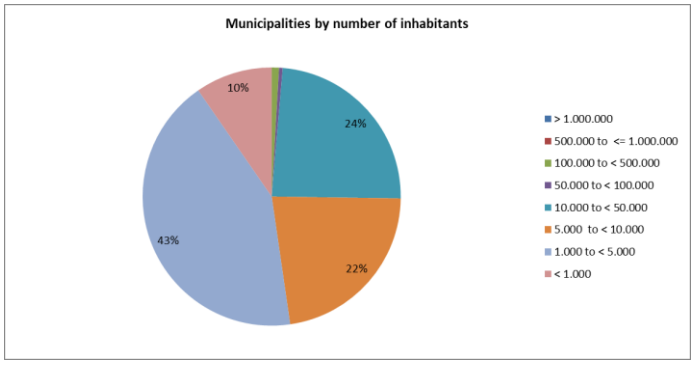


Fig. 2 Structure of the municipilities in the land of Saxony-Anhalt

2.1.3 Demographic structure and development

Population development:

After the German reunification, the population in Saxony-Anhalt has continuously decreased. In comparison to the year 2000, at the end of 2018 the population has decreased of about 16% (see Table 2). However, since 2015 the population development´s trend seems to be changed (see Fig. 3). Indeed, at the least in the biggest cities (Halle and Magdeburg) the population has slightly increased.

Population development	National in thousands	Regional in thousands
2000	8.226	2.615
2005	8.244	2.470
2010	8.175	2.335
2015	8.218	2.245
2018	8.279	2.208

Table 2 National and regional population development

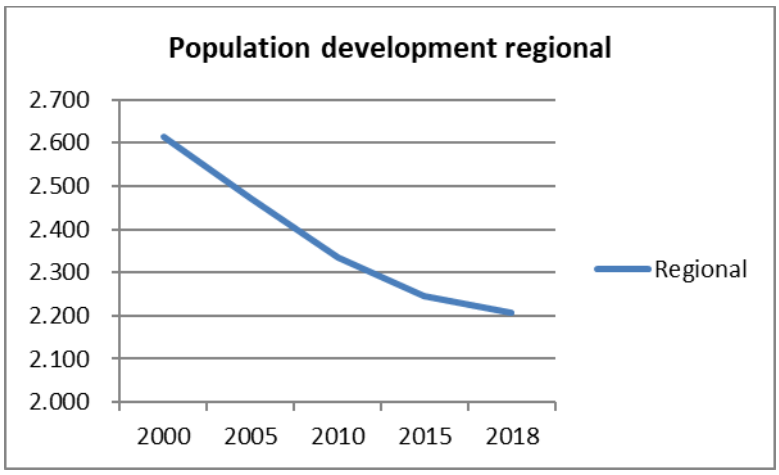


Fig. 3 Population development in Saxony-Anhalt (the value are expressed in thousands)

Households:

Similarly to the population development, in Saxony-Anhalt the number of households has decreased in the last 18 years. In addition, from 2015 the trend has slightly changed (see Fig. 4). From the national point of view, the number of households is increased by about 9% in the last 18 years. The average size of the households living in Saxony-Anhalt is significantly smaller than the national average value. Since 2010, in Saxony-Anhalt the average size of households is 1,9 persons (see Fig. 5).

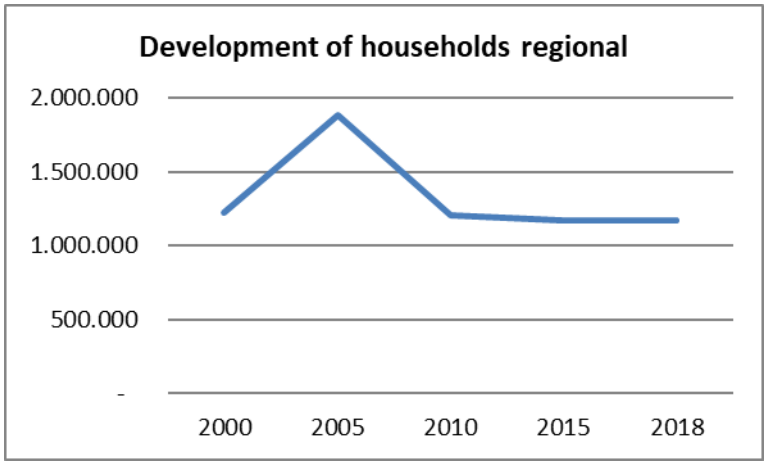


Fig. 4 Development of households in Saxony-Anhalt

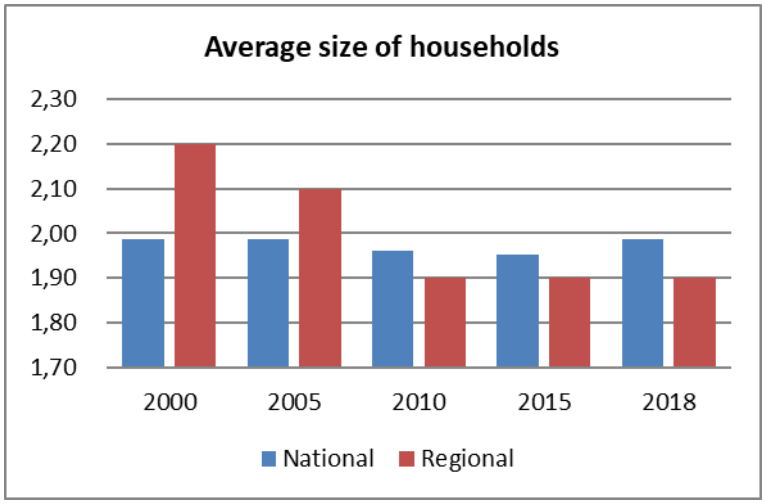


Fig. 5 Average size of households in Germany and in Saxony-Anhalt (value expressed in persons)

Average income of households:

Between the years 2000 and 2017, the average income of households has increased by 57% on regional level. On national level, the average income increased by 41% (see Fig. 6).

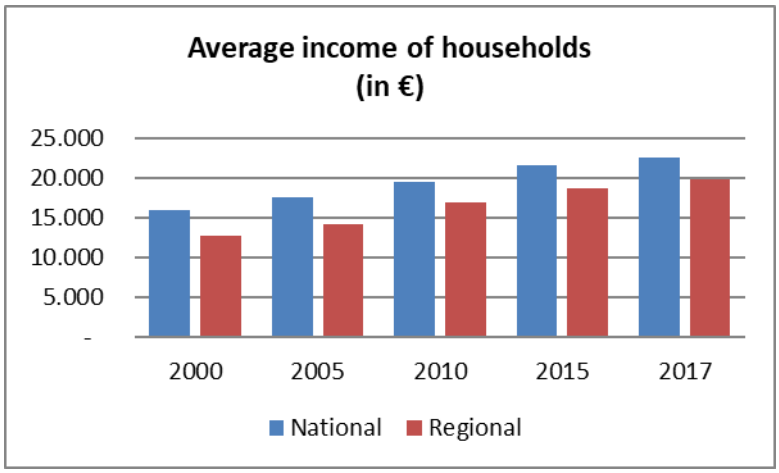


Fig. 6 Average income of households in Germany and in Sachesen-Anhalt

2.1.4 Regional economy

The regional economy is described here on the basis of three parameters:

- Gross domestic product (GDP)
- Gross value added (GVA)
- Number of employees

The share of the regional economy in the national GDP is currently around 1,7 %. Since 2000, the regional GDP has increase of about 50%, while the national one has increased of about 89%. The GDP per capita is currently is 28.756 €, the absolute value is 63.504 million €.

The gross value-added (GVA) is the measure of the value of goods and services produced in an area, industry or sector of an economy. Unlike the GDP, it is mostly available also for the sectors active in an area. Fig. 7 depicts a comparative overview on the GVA on national and regional level. By comparing the regional and the national levels, the contribution of the agriculture, construction and service sectors have a higher impact on the regional level.

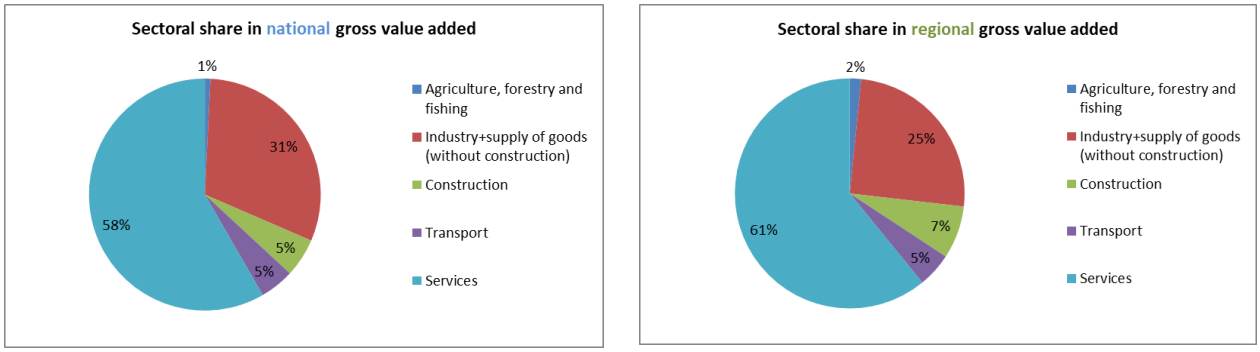


Fig. 7 Sectoral GDP share in Germany (left) and in Saxony-Anhalt (right)

The rate of employees by sector is showing a similar distribution as the sectoral share in the GVA (see Fig. 8)

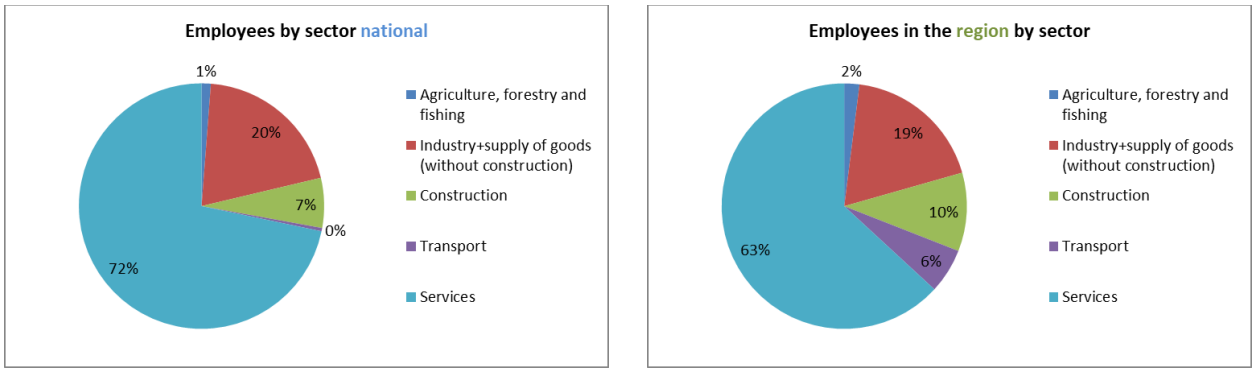


Fig. 8 Employees by sector in Germany (left) and in Saxony-Anhalt (right).

2.1.5 Particularities of the region

Since the 1990´s in Saxony-Anhalt, as many other regions belonging to the former German Democratic Republic, there has been a considerable fall in the birth rate, caused by emigration and natural decrease in the population. Since 2000´s the regional economy has increased, however more slowly than the national one. In Saxony-Anhalt, the service and industrial sectors are the principal driven sectors. These two sectors alone contribute to 86% of the regional gross added value.

3. Infrastructure

3.1. Energy related infrastructure

3.1.1 Electricity grid infrastructure

On high voltage level, the company 50 Hertz Transmission GmbH is the TSO operating in Saxony-Anhalt. It manages the grid at 220-380 kV. The medium voltage network (110 kV) is operated by two distribution companies (Avacon

Netzt AG and Mitnetz Strom). About 100 municipalities operate the medium-low voltage (20kV, 10 kV and 400 V) newtorks. Fig. 9 shows the high voltage network in Saxony-Anhalt.

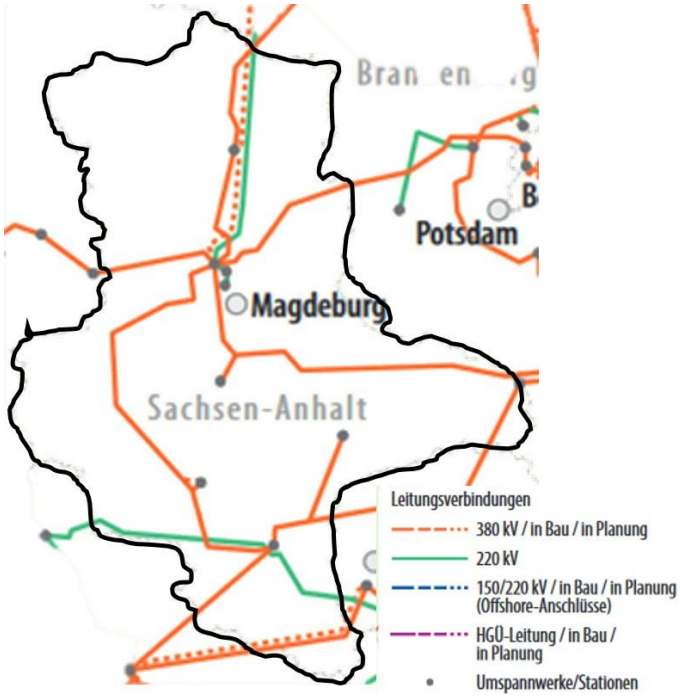


Fig. 9 High voltage network in Saxony-Anhalt.

3.1.2 Gas grid infrastructure

The region Saxony-Anhalt is supplied with H gas (11,1 kWh/m³) and L gas (8,2 kWh/m³). There are 35 companies operating the gas network in different pressure levels: high pressure (40-10 bar), medium pressure (<1 bar) and low pressure (<100 mbar). Besides it, there are 405 plants suppling biogas, which is directly burn for producing heat and electricity. Moreover, in the region operate 5 gas storage plants with a total energy storage capacity of 37 GWh. Fig.

10 shows the natural gas infrastructure in the region. The blue coloured spots indicate the undergrounded storage sites.

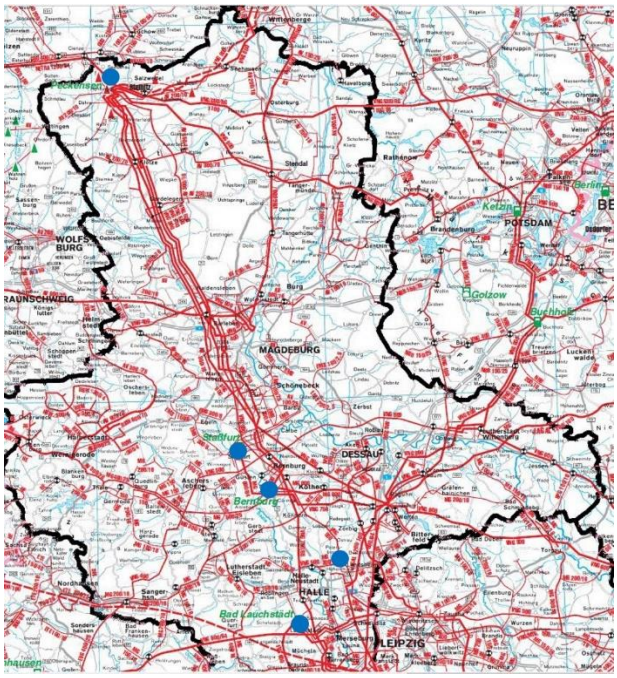


Fig. 10 Natural gas infrastructure in Sachsen-Anhalt

3.1.3 District heat infrastructure

In Saxony-Anhalt, there are about 100 large and small district heat networks in which is fed about 2600 GWh of heat every year with a maximal thermal power generation of 800 MW. Combined heat and power plants (CHP) is the most used technology to generated heat (87,1%). Natural gas, biogas and brown coal are the main energy sources used for suppling the district heat network. The thermal losses account to about 6,2%.

3.2. Mobility and transport related infrastructure

3.2.1 Rail network

The rail network of Saxony-Anhalt account to about 3100 km. Circa 2300 km are electrified, the rest is operated by Diesel trains. The railway companies operating in the region are 27, among them 16 companies are involved in the

transport of goods. Among the train stations, only in 9 stations the long-distance traffic trains stop. Fig. 11 shows the regional rail network.

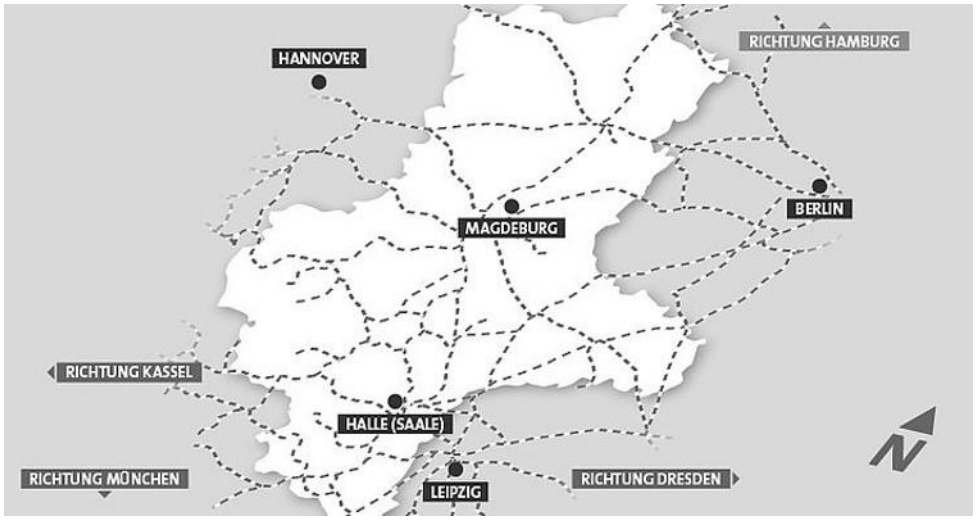


Fig. 11 Rail network in Saxony-Anhalt (Source: www.logistik-sachsen-anhalt.de)

3.2.2 Road network

The road network in Saxony-Anhalt account more than 11,000 km, which is classified as :

- Highway roads,
- Federal roads;
- State roads;
- District roads and
- Communal roads.

In the last year, no new communal, district or state roads have been build. Differently, about 83 km of new highway roads and about 79 km of new federal roads have been constructed.

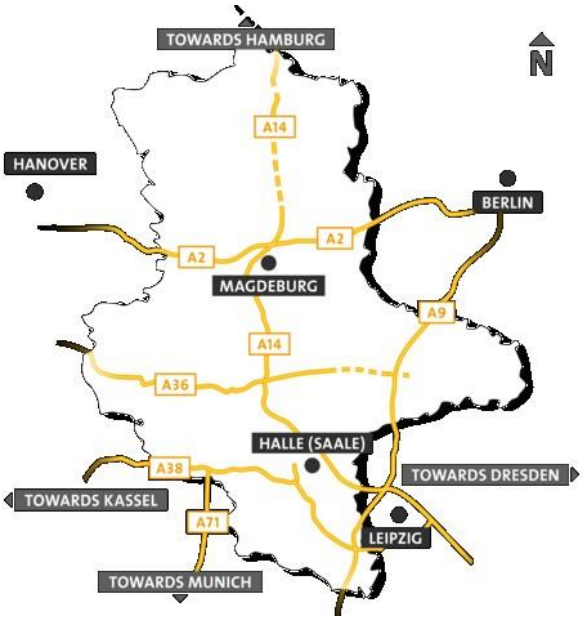


Fig. 12 Main highway roads in Saxony-Anhalt (source: https://www.invest-in-saxony-anhalt.com/location-analysis-saxony-anhalt)

3.2.3 Aviation and waterways infrastructure

The air transport in Saxony-Anhalt is served by three airports which are located in Saxony-Anhalt and an airport (Leipzig/Halle) located in Saxony at the border with Saxony-Anhalt. Besides it, in Saxony-Anhalt there are about 600

km navigable inland waterway and 18 port/loading terminals. Fig. 13 and Fig. 14 depicts respectively the airways and the waterways infrastructures in Saxony-Anhalt.

Fig. 13 Airways in Saxony-Anhalt (source: https://www.invest-in-saxony-anhalt.com/logistics)

Fig. 14 Federal waterways in Saxony-Anhalt (source: https://www.invest-in-saxony-anhalt.com/logistics)

3.3. Particularities of regional infrastructure

The energetic infrastructures in Saxony-Anhalt is well developed. Electric grid, gas networks and heat districts are well spread among the regions. The logistic infrastructures is also well developed. Further investments (i.e. on new highways) are in planning.

4. Transport

4.1. Basic data and modal split

Regarding the modal split in passenger and freight transport, there are only data available on national, but not on regional level. With reference to the freight, about 83% of the goods are transported using roadways, about 15% using train and less than 3% using waterways. Fig. 15 shows the modal split for passenger and freight in Saxony-Anhalt.

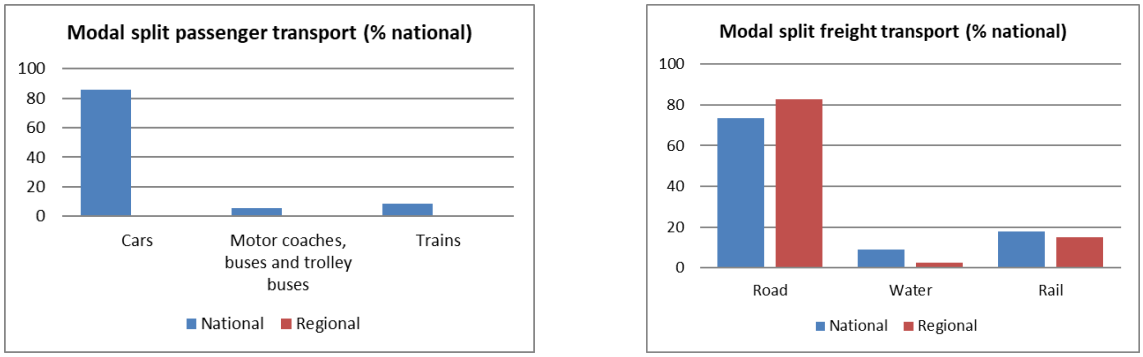


Fig. 15 Modal split for passengers and freight in Saxony-Anhalt

4.2. Road transport

Data regarding road transport are available on national and regional.

4.2.1 Motor vehicles by type and fuel

The stock of motor vehicles in Saxony-Anhalt is currently app. 1.458.520 vehicles. This is a share of 2,5% of the total number of vehicles on national level. Regarding the general fuel usage in the motor vehicles (such as e.g. the use of electricity or natural gas for transporting goods, electric motorcycles etc.) petrol and diesel are the sources, which dominate. It follows natural gas fuelled vehicles and electric cars. Fig. 16 depicts the main energy source used for vehicles in Saxony-Anhalt. Table 3 summarizes the number

of vehicles circulating in Germany and Saxony-Anhalt. Fig. 17 shows the typology of vehicles in Germany and in Saxony-Anhalt.

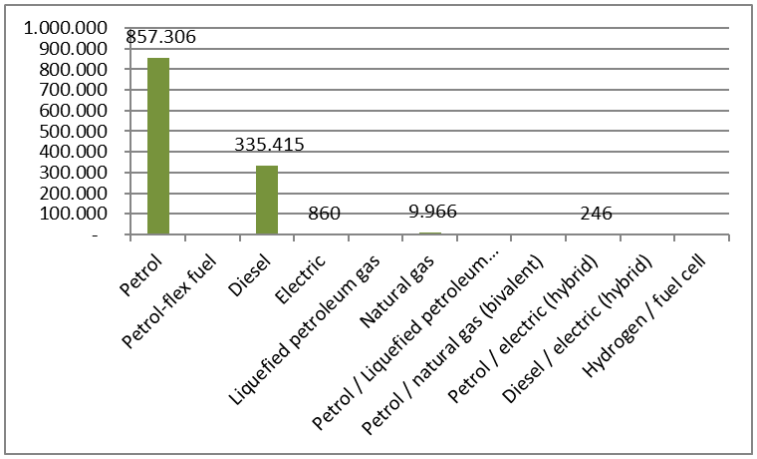
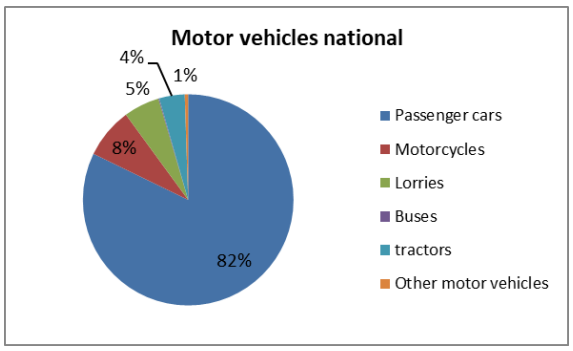


Fig. 16 Passenger cars by fuel (number)

Motor vehicles by type	National	Regional
Passenger cars	47.095.800	1.210.884
Motorcycles	4.438.600	93.303
Lorries	3.149.300	107.437
Buses	80.500	2.288
Road tractors	2.237.400	44.608
Other motor vehicles	303.600	10.979
Total	57.001.600	1.458.520

Table 3 Summary of moro vehicles in Germany and Soxony-Anhalt



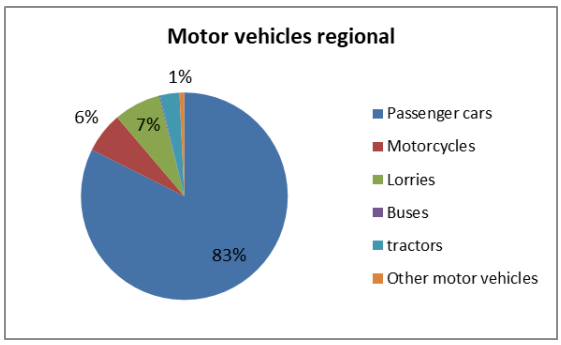


Fig. 17 Represenation of the vehicles circulating in Germany (left) and in Saxony-Anhalt (right)

4.2.2 Passenger cars by fuel, kilometre and fuel performance

The amount of passenger cars in the region Saxony-Anhalt corresponds to a share of 2,5% of the total fleet of passenger cars in Germany. The per capita figure on national level is 0,57 and on regional level 0,55 cars. Table 4 is giving an overview on the passenger cars by fuel on national and regional level.

Passenger cars by fuel (number)	*National*	*Regional*	*Average km/car*a*	*Average Consumption (l/100 km; or kWh/100 km)*
Petrol	31.031.021	857.306	10.900	7,2
Petrol-flex fuel				
Diesel	15.153.364	335.415	20.300	6,6
Electric	83.175	860		14,9
Liquefied petroleum gas	395.592			
Natural gas	80.776	9.966		69,1
Petrol / Liquefied petroleum gas (bivalent)				
Petrol / natural gas (bivalent)				
Petrol / electric (hybrid)	341.411	246		5,1
Diesel / electric (hybrid)				5,7
Hydrogen / fuel cell	386			
Total	47.085.725	1.203.793		

Table 4 Values of the passenger cars be fuel in Germany and in Saxony-Anhalt

4.2.3 Passenger- and tonnes kilometres

As the modal split gives an impression of the share of use of means of transport, passenger and tons kilometers are providing information on the intensity of the use. On regional level, about the road busses register about 857 passenger kilometer, while the rail about 1040 passenger kilometers. Fig. 18 show on

the left side the passenger kilometers distribution, while on the right side the tons kilometers distribution.

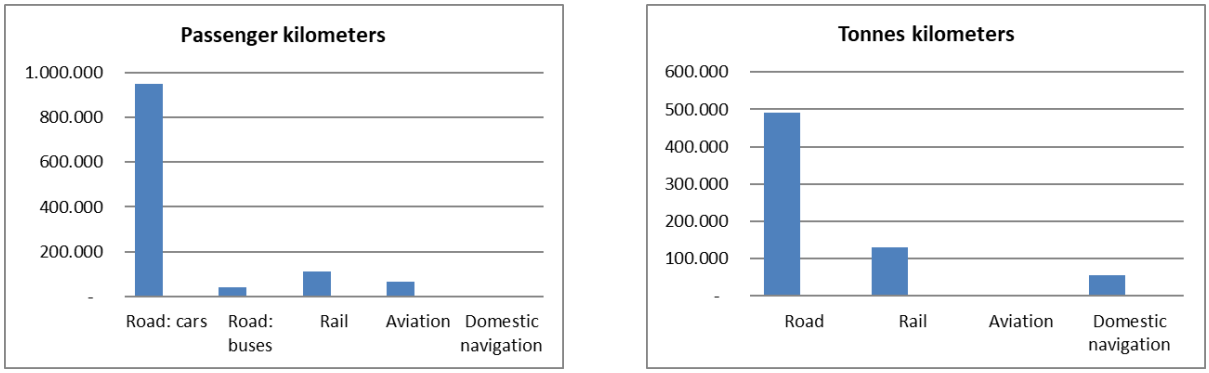


Fig. 18 Distribution of the passenger and tonnes kilometers for different transport medium

4.2.4 Modal split freight transport

Road and rail and in minimum part water are the main infrastructures used to transport freight. The percentage of transported freights by road is higher at regional level than at national level (see Fig. 19).

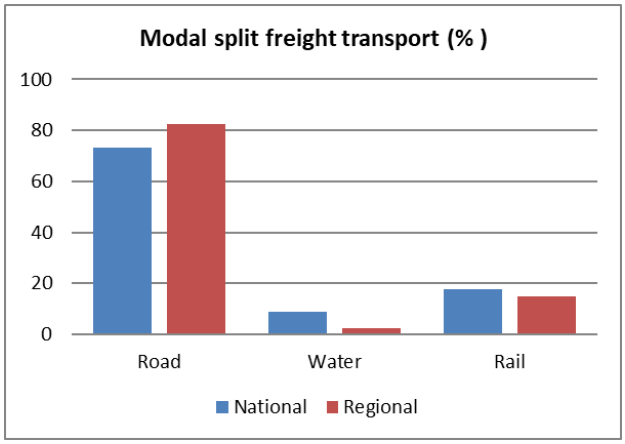


Fig. 19 Modal split freight transport in Germany and Saxony-Anhalt

4.3. Rail transport

4.3.1 Passenger and tonnes kilometres

The respective information is already comprised in the paragraph 4.2.3 above

4.3.2 Development of passenger and goods transports

On regional level, there is only the information for the rail freight transport related to the year 2010, while for the rail passenger transport there are not information. The freight transport in Germany is about

8% of the total transported freight, while the amount of rail passenger transport it reached 4% in year 2018 (see Fig. 20)

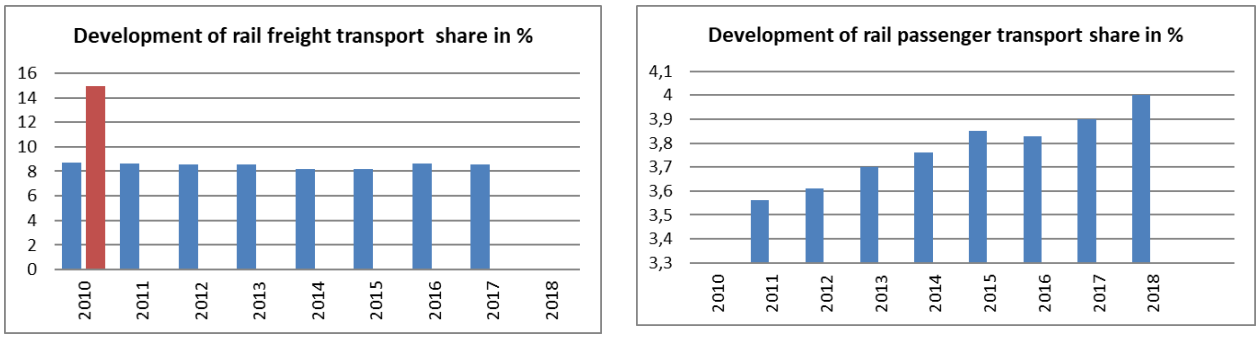


Fig. 20 Development of rail freight and rail passenger transport in Germany and Saxony-Anhalt

4.4. Air and waterway transport

About the air transport, there are not data at regional level. The transport on water way has been already explained in the section 4.2.4.

5. Energy status

5.1. Energy in the European and national context

Fig 21 is giving an overview on the shares of basic energy carriers in the European, National and Regional final energy consumption. As can be seen, the regional final energy consumption is mirroring the infrastructure regarding energy supply and mobility

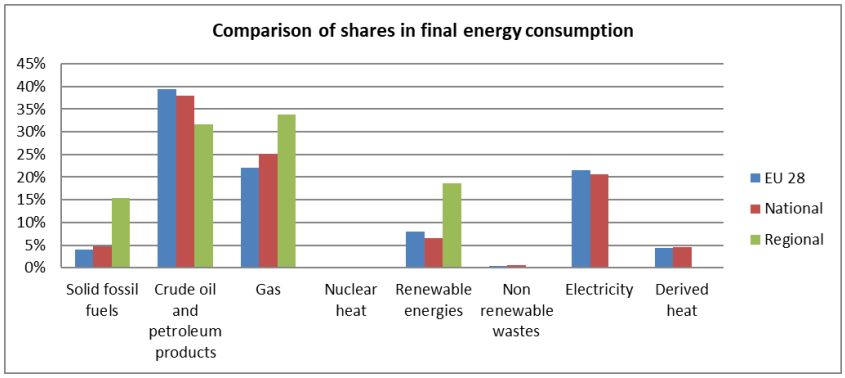


Fig. 21 Comparison of shares in final energy consumption

The following paragraphs are containing graphs regarding the main parameters of the respective simplified energy balances. The abbreviations in the graphs need to be read as follows:

- PP: Primary production (blue bar)

- GIC: Gross consumption (red bar)
- TI: Transformation input (green bar)
- TO: Transformation output (violet bar)
- FEC: Final energy consumption (light blue bar)

5.1.1. Simplified energy balance of EU 28

Fig 22 is showing the simplified energy balance of the EU 28. It shows, that the European Union is highly dependent on imports of crude oil and petroleum products, natural gas and solid fossil fuels.

Regarding nuclear heat and non-renewable wastes, the consumption, respectively the transformation output thereof, in the form of electricity and, to a small part, also derived heat equals the primary production. The demand of renewable energies is almost covered by the primary production.

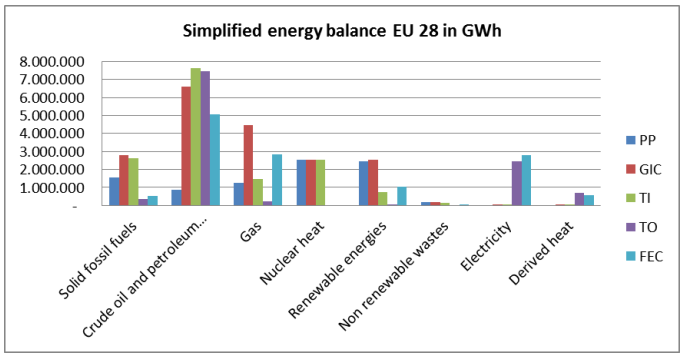


Fig. 22 Simplified energy balance in EU 28

5.1.2. Simplified national balance

Regarding solid fossils, natural gas and crude oil, the situation is similar to the one of the EU 28. The main difference are in the higher share consumption of solid fossil. Regarding the renewable energy, its penetration is higher than that of nuclear. Fig. 23 summarizes the simplified energy balance in Germany.

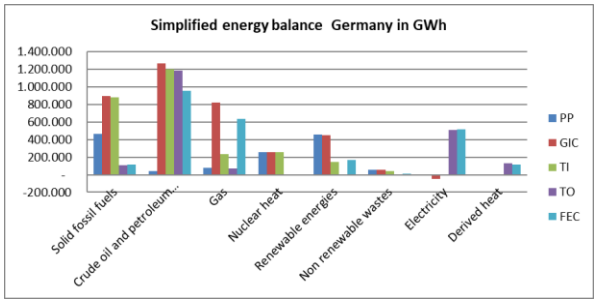


Fig. 23 Simplified energy balace in Germany

5.1.3. National electricity fuel mix disclosure

In Germany the electricity is mostly procuded by soldi fossil (40%) and nuclear energy (13%). Renewable energies, like wind, sun, hydro and biomass, accounts to about 31,2% of the national production.

Table 5 depicts the electricity mix in details, while Fig. 24 shows the distribution of the electricity generation.

Electricity fuel mix disclosure (national average)	%
Hydro	4,03
Tide, wave, ocean	-
Wind	12,11
Solar	5,87
Geothermal	0,03
Solid biofuels	1,66
Biogases (incl. sewage-gas)	5,19
Waste (renewable)	2,22
Liquid biofuels	0,08
Solid fossil	40,32
Liquid fossil	0,89
Gaseous fossil	12,53
Nuclear	13,03
Waste (not renewable)	2,04
Total	100

Table 5 Electricity sources mix in Germany

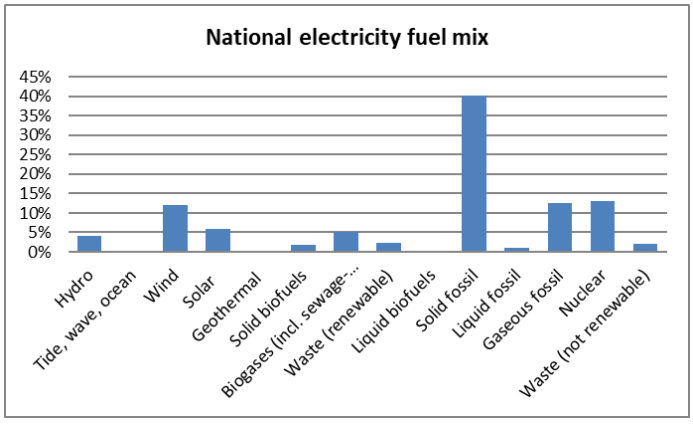


Fig. 24 Energy sources used to produce electricity in Germany

5.1.4. Time series of national final energy consumption

In Germany, by considering the time series 1990-2016, the final energy consumption has decreased by about 5% (see Fig. 25). A contribution to this result has been given by the spread of distributed generation

plants like wind turbines and photovoltaic plants and by the increased awareness on the energy efficiency, mostly in the industrial sector.

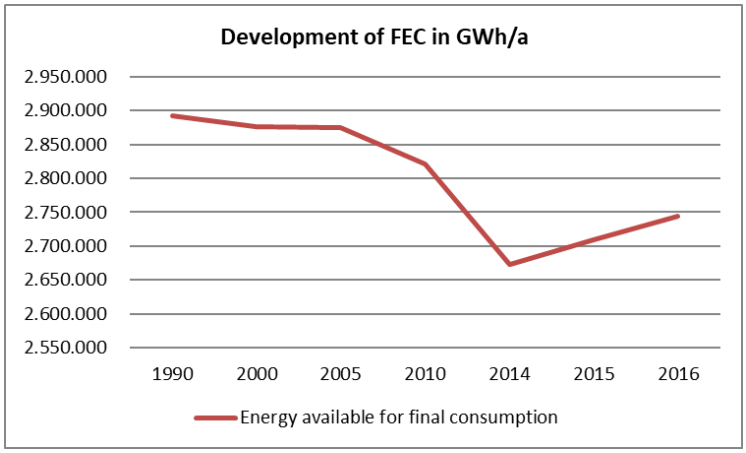


Fig. 25 Developlment of the final energy consumption in Germany

Fig 26 (left) shows the contribution on the final energy consumption given by non renewable, renewable and waste sources. The contribution of non renewable has decreased by 17%. On the same time the

contribution of renewable energies and waste is respectively increased by 378% and 310% (see Fig. 26 right).

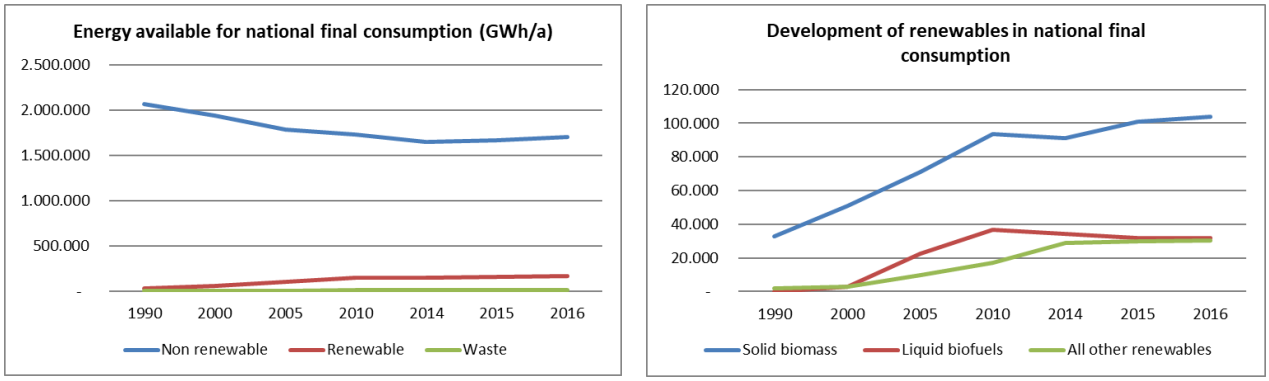


Fig. 26 Contribution of non renewable, renewable and waste on the final consumption (left) and the development of renewable (right)

On the same period (1990-2016) the efficiency in transformation has improved by circa 3% (see Fig. 27 left), while the distribution loses are on the same lavel of the year 1990 (see Fig. 27 right).

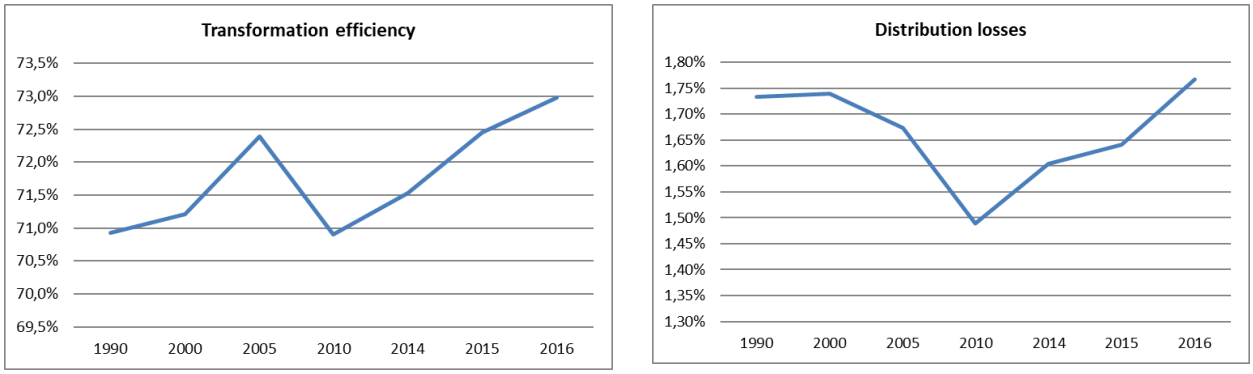
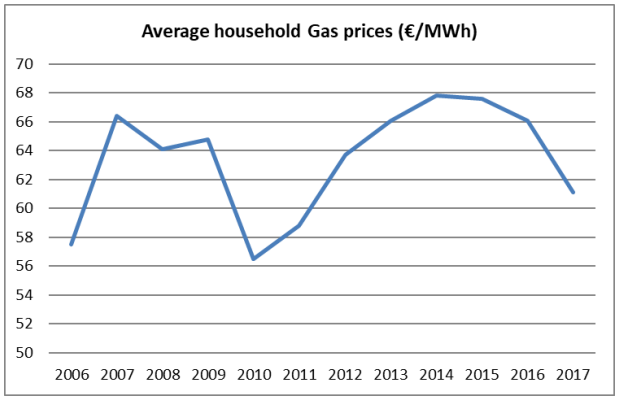


Fig. 27 Transformation efficieny (left) and distribution losses (right) in Germany in the time frame 1990-2016

5.1.5. Energy prices – status quo and development 2005 to 2017

Between 2006 and 2017 the natural gas price for the German household fluctuate between 56,5€ to 67,8 € per MWh (see Fig. 28 left), reaching the maximal peak in 2014. On the same time the electricity price

for the small consumers has increased by about 67% reaching a maximal price of 304,8 € per MWh in year 2017 (see Fig. 28 right).



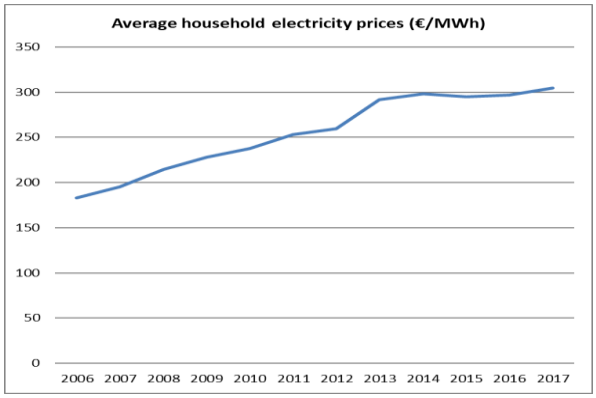


Fig. 28 Development of price (natural gas- left; electricity-right) for German housholds

Electricity:

The wholesale price for electricity is currently 70 €/MWh. The working price average is 76,1 €/MWh in industry and 64,2 €/MWh for households and other sectors. Taxes and levies account to about 78% for the houshold consumers and to 55% for the industrial consumers.

Natural gas:

Regarding natural gas, the working price average for industry is 19,3 €/MWh and for households and other sectors 32 €/MWh. Taxes and levies account to 48% for houshold consumers and to 322% for industral consumers. .

District heat:

The working prices for district heat are between 6 and 10 €/MWh.

Oil and petroleum products:

Table 6 is giving an overview at the current prices (in €cent/kWh) of the most common oil- and petroleum products. As can be seen, the taxation of transport fuel is higher than for fuels for stationary combustion.

Oil and petroleum products					
Final consumption (€ cent/kWh)	Net price	Customer end price (incl. taxes and levies)	Share of taxes and levies	Energy content	
Petrol	4,6354	12,212	62%	8,1	kWh/l
Diesel	5,6331	12,2463	54%	9,8	kWh/l
Heating oil	4,79612	6,664	28%	9,8	kWh/l
LPG	3,48568	4,148	16%	12,8	kWh/kg

Table 6 Final energy costs production

Electricity and gas grid injection tariffs

Injection tariffs are bound to contracts regarding renewable energies. Large renewable based power plants sell electricity directly to the wholesale electric market. They might receive a *bonus* or a *malus*, depending on the accuracy of their generation prediction. For smaller power plants, the incentive to feed into the network is related to the electricity only. Biogas plants receive incentives if the biogas is converted into electricity. Table 7 summarizes the injection tariff for electricity injection.

Electricity grid injection tariffs renewables	€/MWh
Hydro	106,874
Tide, wave, ocean	(35-125)
Wind	86,42
Solar photovoltaic	328,651
Solar thermal	
Geothermal	217,391
Solid biofuels	60
Liquid biofuels	60
Biogases	73,529
Renewable municipal waste	206,258

Table 7 Injection tariffes for different kinds of renewable energy sources

5.2. Regional energy demand

The regional energy demand is calculated on the basis of the analysis of effective energy by fuel and sector. These reports are usually, like the national and the EUROSTAT data, 3 years in behind. Thus, it is based on official statistics.

5.2.1. Regional energy demand by fuel and sector

Table 8 shows the final energy consumption in Saxony-Anhalt for the year 2016. The total amount is app. 143,83 TWh. Crude oil and natural gas are the most consumed energy forms. Renewable energies account to 18% of the total energy demand. Residential and transport are the two sectors that mostly demand

energy. Renewable energies give the highest contribution in the residential sector (due to the use of biomass for heating purposes) ant to the transportation sector (due to the use of biodiesel) (see Fig. 29.)

Estimation of regional energy demand (GWh)	Total	Solid fossil fuels	Crude oil and petroleum products	Gas	Renewable energies	Non renewable wastes	Electricity	Derived heat
2016								
Final energy consumption	143.834	22.192	45.626	48.679	26.855	-	16955	-
Agriculture, forestry and fishing	-	-	-	-	-	-	-	-
Industry (without construction), energy, water sewage etc	38991	-	-	-	-	-	-	-
Construction								
Transport	16.031	-	14.576	221	720	-	514	-
Services	13.039	9	2.906	5.541	113	-	3.706	764
Residential	18.351	311	2.502	7.211	3.258	-	3.069	1.999

Table 8

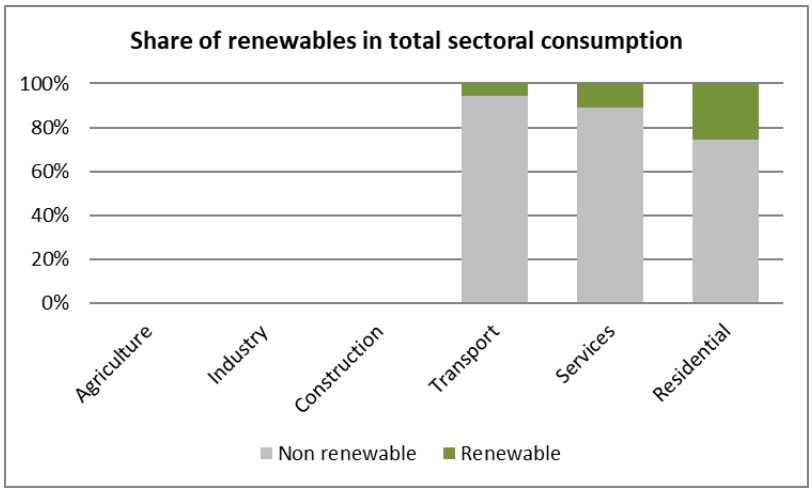


Fig. 29 share of renewable energies in different secttors

5.2.2. Regional particularities of energy demand in Saxony-Anhalt

Natural gas and crude oil are the main energy form consumed in Saxony-Anhalt. The amount of energy consumed, which is generated by renewable sources, is higher than the energy coming from fossil solid. Because of the lack of information on the distribution of the energy consumption in the agriculture, industry and construction sectors, it is not possible to assert which sector is the most demanding one.

5.3. Regional energy supply

In Saxony-Anhalt, about 43% of the produced energy (electric and thermal) is generated by using renewable energy sources namely biomass, wind and sun. Natural gas is the main consumed resource

followed by solid fossil (coal) and liquid fossil. If the only electricity is considered, wind contributes to generated about 8,8 TWh of electric power. By considering the only thermal energy then natural gas is the most used energy resource.

5.3.1. Regional generation by source, capacity and output

Table 10 depicts the installed electric and thermal capacities as well as the generated thermal and electric energy. For the electric energy, renewable covers about 55% of the generated electricity. Differently, in the thermal sector, renewable energies cover about 11,6% of the total generated heat.

Source	Electric capacity installed	Electricity MWh/a	Supply share electricity in %	Heat capacity installed	Derived heat MWh/a	Supply share heat in %
Solid biomass (residues)	25	1.580.000	6,21	22	145.381	1,85
Hydro	101	108.000	0,42			0
Tide, wave, ocean			-			0
Wind	5104	8.797.000	34,56			0
Solar photovoltaic	2240	1.970.000	7,74			0
Solar thermal			-		107	0,001
Geothermal (deep)			-			0
Primary solid biofuels			-			0
Biogases (incl. sewage-gas)	400	1.525.000	5,99	22	114.325	1,45
Waste (renewable)			-			0
Biogasoline			-			0
Biodiesel			-			0
Liquid biomass (e.g. black liquor etc.)		43.000	0,17			0
Ambient heat (heat pumps)	900	6.114.000	24,02			0
Solid fossil	134	1.404.000	5,52	200	1.344.130	17,11
Liquid fossil	739	3.910.000	15,36		55.205	0,70
Gaseous fossil			-	903	5.019.312	63,91
Waste (notren.)	183		-	331	1.174.921	14,96
Total	9.826	25.451.000	100	1.478	7.853.381	100,0
thereof non renewable	1.955	11.428.000	44,90	1.434	7.593.568	11,6
thereof renewable	7.870	14.023.000	55,10	44	259.813	88,4

Table 9 Installed electric and thermal capacity and generated electric and thermal energy,

Fig. 30 shows the distribution of the energy source in the production of electricity and heat.

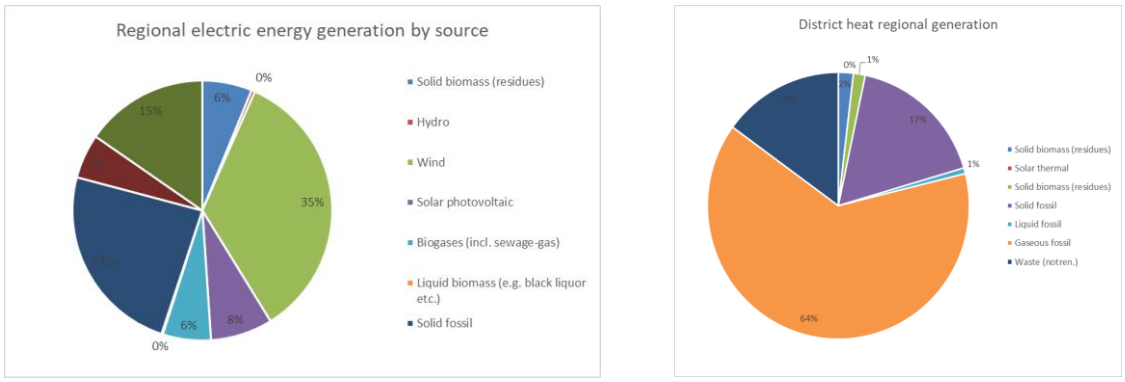


Fig. 30 Distribution of the electric generation by source (left) and of the thermal energy generation by source (right)

5.3.2. Supply mix

In Saxony-Anhalt, the generation by renewable energies plays an important role. By considering the electricity and the thermal energy, the renewables generate about 43% of the total generated energy. In the electric sector, the share reaches 55%. Wind energy results to be the most used resource, indeed it covers about 34% of the entire generated electricity.

5.3.3. Energy storage

In Saxony-Anhalt, pump hydro energy storage systems are the most used technology to store electricity. However, in the last years compressed air storage system (adiabatic) and the storage of hydrogen inside

cavern have captured the interest both of the scientific communities as well as that of the investors. Table 10 summarizes the total installed capacity in Germany and in Saxony-Anhalt.

Energy storage	National		Regional	
	Number	Installed capacity (MWh)	Number	Installed capacity (MWh)
Battery storage	21	134,47		
Pumped hydro storage	31	37740	1	523
Power-to-gas	35	230.000		
Compressed air storage				
Other				
Total	87	267874,47	1	523

Table 10 Installed energy storage capacity

5.4. Regional demand-supply balance and development potentials

5.4.1. Regional balance and self-supply rates

Table 13 is showing the regional balance. The balance is comparing the total generation with the respective sectoral demand (e.g.: total generated district heat with respective demand of the residential

sector, etc,). The last row "Total" is finally comparing the total generation with the total demand. As can be seen, there is a total surplus regarding electricity.

Regional balance (MWh) regarding:	NREC	REC	Electricity	Heat
Non-residential sectors (without transport)	8.455.833	112.500	4.789.889	7.088.937
Residential sector	10.023.889	3.258.333	22.381.833	5.854.214
Transport sector	14.796.667	720.000	24.936.556	7.853.381
Total	**33.276.389**	**4.090.833**	**1.206.278**	**5.089.770**

Table 11 Energy balance in Saxony-Anhalt

The covering rate of the demand of renewables by own generation is 105% for the electricity and 284% for heat. The total covering rate is 52%, it is also including the demand for transport fuel.

5.4.2. Resource potentials

Wind, solar and bio energies represent the most used renewable source. All the three sources have a further exploitation´s potential. The generation of electricity by photovoltaic plant seems to have the highest exploiting potential, while the bioenergy is estimated to be limited to 170 MW electric more.

5.4.3. Technology potentials

A considerable potential for the expansion of wind energy in Saxony-Anhalt in combination with a simultaneous spatial planning control effect is provided by repowering of the old wind turbines. About 900 turbines operating in Saxony-Anhalt have an age ranging between 15 and 17 years. They can be repowered after the 20-years EEG subsidy.

6. CO2 Emissions

The CO_2 emissions on national level were in 2016 around 801,7 million tons per year[2]. In the same year, the share of Saxony-Anhalt on the national emissions was 25,4 million tons per year[3], that equals 3.1%.

[2] Source: https://www.umweltbundesamt.de/en/indicator-greenhouse-gas-emissions#textpart-1

[3] Source: https://statistik.sachsen-anhalt.de/themen/wirtschaftsbereiche/energie/tabellen-co2-bilanz/#c167149

An overview on the sectoral share on NUTS 2 level is given in Fig. 31. The transport and the residential sector are the largest CO_2 emitters. The pro capita CO_2 results to be about 11,5 tons.

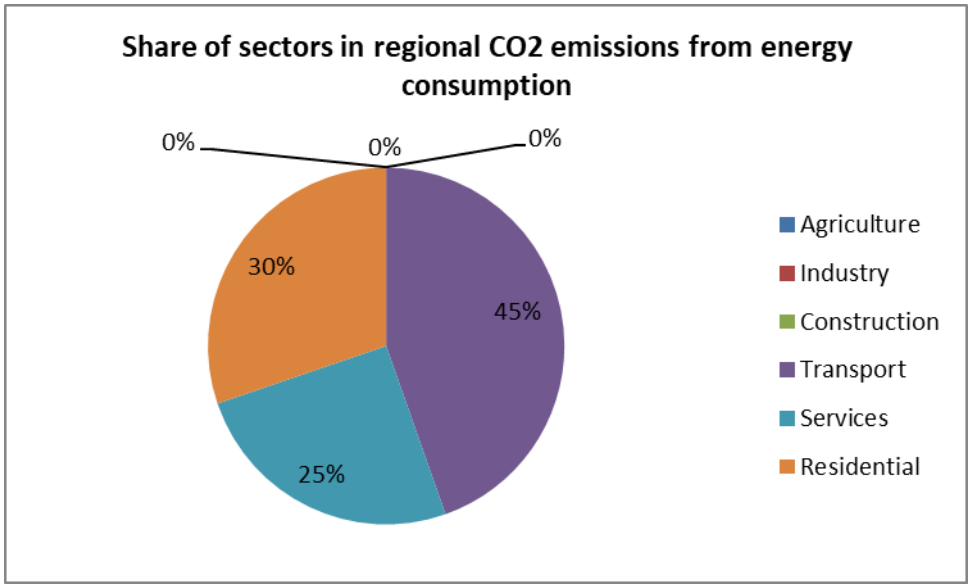


Fig. 31 CO2 distribution by sector in Saxony-Anhalt

7. Key figures and bottom line of the situation

In the land Saxony-Anhalt live about 2.2 million of inhabitants in 218 municipalities most of them with a population lower than 1000 inhabitants. The average income per household is about 17000 € pro year.

The energy costs are on the average about 2004€ per household pro year. About 1,23 cars are present pro household.

Goods are mostly transported by highways and by railways. Indeed the average per capita transport of good is 6000 tkm by highways and 1000tkm by railways.

The residential sector contribute to consume about 13% of the total energy consumed. By considering all the sectors, about 65 MWh is average consumption per capita in Saxony-Anhalt. On this consumption, renewable energies contribute for about 14.5 MWh.

The energy generated by renewable sources is mostly produced in form of electricity. Indeed, about 6.35 MWh is average value per capita.

The CO2 emission account to 11,5 tonne per capita. The residential sector contribute for about 9% of the total CO2 emissions.

8. CONCLUSIONS

Renewable energies, mostly biomass, wind and sun play an important role in the energy generation mix of the land Saxony-Anhalt. Biomass contributes both in the electric as well as in thermal sector since many of the biomass power plants generate heat and power simultaneously. Saxony-Anhalt is a land with high potential for wind energy. It is one of the German regions with the highest

concentration of wind turbines per capita. Solar energy also has a very high potential both as large plants as well as a smaller plant (residential).