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Consumption trends of steel and aluminium in the context of decarbonization

Fraunhofer
ISI

Abstract

In order to be able to analyze future ecological as well as economic aspects of the climate protection potential through decarbonisation of German industries, the aluminium and steel industry must be investigated in detail. The construction and mechanical sectors are among the biggest consumers of aluminium and steel in Germany. Consequently this paper examines the future consumption trends of steel and aluminium for these sectors.

To project the consumption trends for a long-term perspective (2050), a simple regression model is developed. The model consists of four steps. First, the future German GDP is projected. Secondly, overall aluminium and steel consumption is calculated based on a linear regression function with GDP as the explanatory variable. Third, the future sector shares of each material are calculated with the help of a trend analysis. Finally, the results of steps two and three are combined to derive the future material consumption of each sector by multiplication.

According to the simple regression model developed in the paper the consumption of both analyzed materials will increase until 2050 - in case of steel by 41 % and of aluminium by 95 %. The construction sector will increase its absolute amount of steel consumption, but reduce its aluminium consumption. These consumption patterns are the exact opposite for the mechanical engineering sector, albeit on a different scale. The presented results show their plausibility when compared to those in the literature. Although a high uncertainty implies the results due to the lack of data, especially in the case of the projected steel consumption trends.

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1 Introduction

In the context of climate change mitigation, the reduction of green house gas (GHG) emissions from energy intensive industries, such as the steel and aluminium industry, plays a pivotal role. In addition to more efficient production processes for these metals, two other effects drive the reduction possibilities in this domain: While dematerialisation refers to the reduction of steel and aluminium as input materials in downstream production sectors, transmaterialisation is characterized by using alternative materials. Therefore, the analysis of consumption trends of steel and aluminium is relevant for the examination of policy instruments which support the GHG emission reduction while safeguarding the sectors' competitiveness and avoiding production off-shoring and carbon leakage.

The research project "DECARBONISE– Climate Protection through Decarbonisation of German Industries", led by the Karlsruhe Institute of Technology (KIT)[1], considers both, the ecological as well as the economic aspects of the aluminum and steel industry, in an integrated way. Assuming a long-term perspective (2050), a simulation model is developed in which various political instruments for the decarbonisation of German industries can be evaluated based on scenarios. Within this project, the Fraunhofer ISI analyzed the general consumption trends of aluminium and steel. The results of this work package are documented in this paper.

Section 2 explains the selection of consumption sectors subject to further analysis and describes them briefly. Section 3 discusses consumption trends in these sectors on a qualitative basis. A quantitative model for future consumption trends is developed in section 4. The last section summarises the results.

2 Selection of consumption sectors

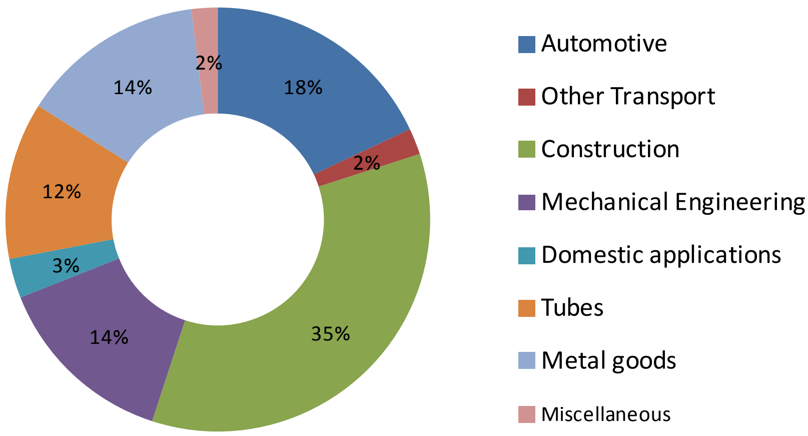
The transport sector is the main customer of the aluminium and steel industry. Its consumption trends are analysed in greater detail in another part of the project and are therefore excluded from this paper. Given the wide range of applications of steel and aluminium, the examination of consumption trends beyond the transport sector must be limited to selected applications and simple assessments.

A preliminary evaluation of mass balances of aluminium and steel on the European level shows two consuming sectors which are important for both materials. These are the construction and mechanical engineering sectors (see Figure 1 and Figure 2).

1 http://www.iip.kit.edu/english/1064_1587.php. The project was financed by the German Ministry of Research and Education BMBF in the funding initiative "Economics of Climate change" (project number 01LA1111B). The financial support of BMBF for carrying out this work is gratefully acknowledged.

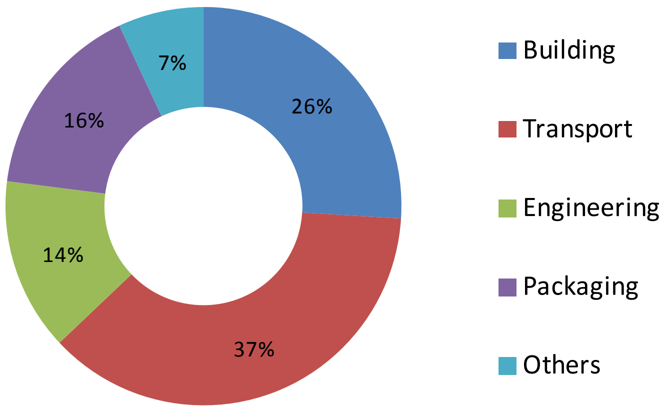
These were selected for further analysis. Some key economic figures below give a first overview of the economic importance of these sectors in Germany.

Figure 1: Overview of steel using sectors (2011)



Source: (EUROFER, 2013)

Figure 2: Overview of aluminium using sectors (2010)



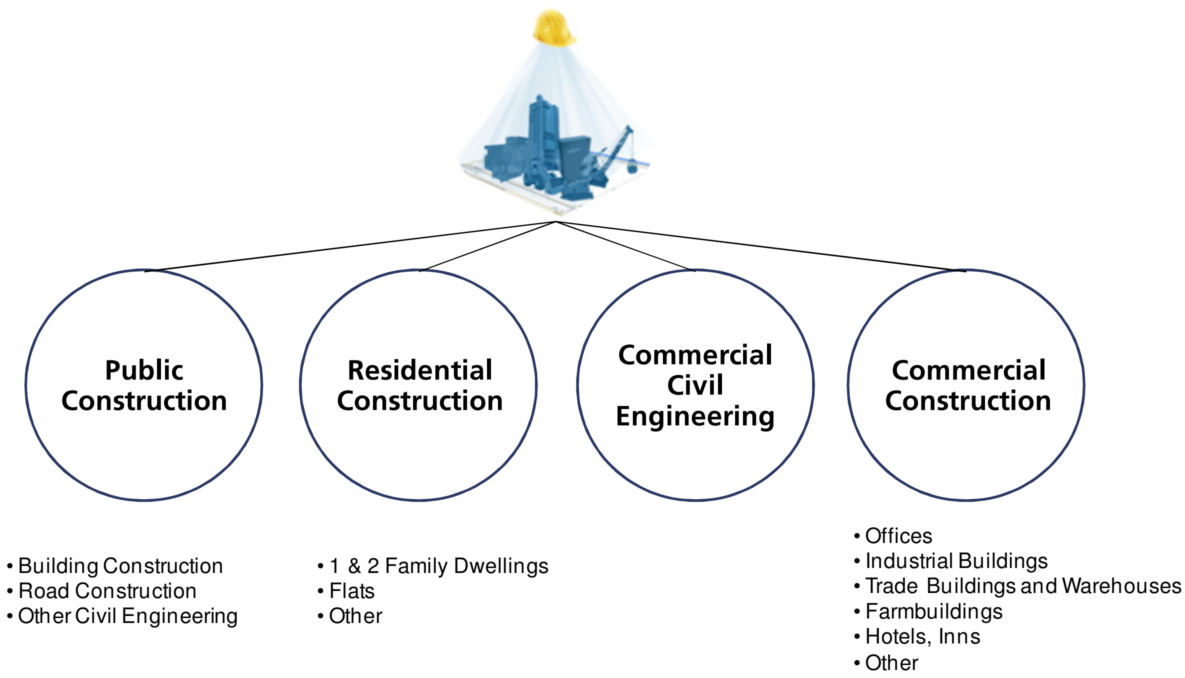
Source: (EAA, 2015)

2.1 Construction Sector

The construction sector is one of the biggest employers in Germany and about 10 % of Germany's GDP is used for construction (Hauptverband der Deutschen Bauindustrie, 2014). The construction sector can be divided into public, commercial, and residential construction as well as commercial civil engineering. This structure is shown in Figure 3, in which examples for each group are also given. All these different types of buildings and infrastructure need steel and aluminium products.

Steel products are used in multifarious applications such as elements made for roofing and façades, roof tiles, profile and structural steel for steel construction, building systems from light steel sections or steel sheet piling among others (Stahl Zentrum, 2014a). The use is driven by different properties of steel, but mostly by its good price-to-stiffness ratio. Aluminium products are mainly used in façades, doors and windows, roof and wall systems as well as bridge and support structures (GDA, 2014a).

Figure 3: Structure of the construction sector

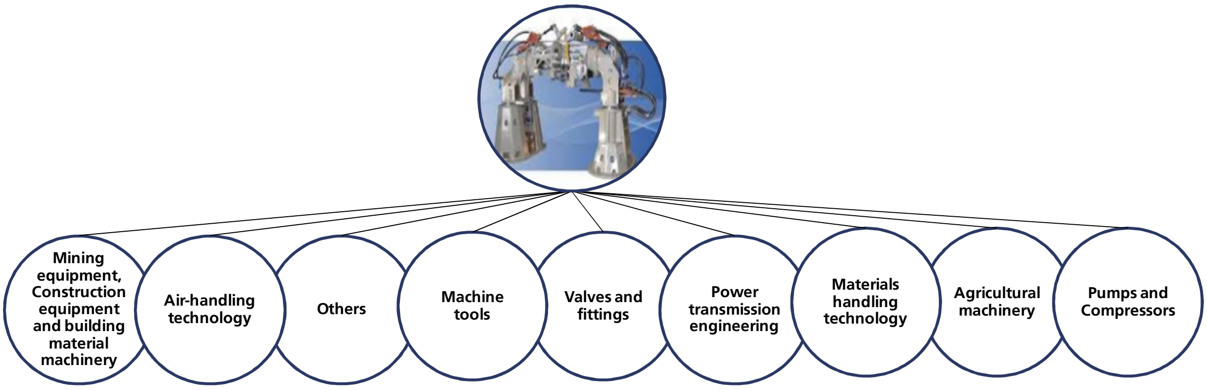


Source: Based on (Hauptverband der Deutschen Bauindustrie, 2014; Destatis, 2014)

2.2 Mechanical Engineering Sector

The mechanical engineering sector with all machine and plant manufacturers is one of the five biggest industries in Germany. As the largest industrial employer and an important player for innovations, it has a key role in Germany's economy (Krebs, 2014). Figure 4 shows the main areas of the mechanical engineering sector, in which steel and aluminium products are used. Applications are for example: containers, excavator buckets and crushers, high-pressure reactors, springs and shock absorbers or crane constructions (Stahl Zentrum, 2014b; VDMA, 2013). Aluminium products are used in industrial robots and machinery, extruded profiles, high-quality aluminium strip (used for lithographic plates in the printing industry) or precision casting (suitable for precision machines: motor housings, impellers, compressors or pumps) (GDA, 2014b).

Figure 4: Structure of the mechanical sector



Source: Based on (VDMA, 2013)

3 Development of a projection model

3.1 Options for model specification

In order to approximate the future material consumption of the construction and mechanical engineering sectors it is necessary to project the future overall development of these sectors. For this purpose, the sectors can be analyzed from a bottom-up perspective by looking at key drivers for its development. In the case of the construction sector, some of the main drivers are for example urbanization and the future demographic development. When the focus is on public facilities, the future expansion of infrastructure must be taken into account. Here, the development of the railway and road grid as well as the future consumption of pipes used for water infrastructure must be considered. An overview of drivers is presented in Figure 5. The similar multitude of drivers applies to the mechanical engineering sector. In order to project the future consumption trends from such a bottom-up perspective, the dependencies between these indicators and the material consumption would need to be derived. Only after analysing the future development of each indicator, conclusions for the future material consumption can be drawn. This multiplies the uncertainties about the future development.

Therefore, the top-down perspective, using a single macroeconomic variable as a starting point, is preferred in this paper. Different options exist of how to specify such a model. During the phase of model formulation, different types of regressions were tested to find correlations between material consumption and a proxy variable, which might explain the development of material consumption in the past. Not only linear functions and single regression functions were used, since “the relationship between steel consumption and economic growth is however not believed to be linear” (Warell and Olsson, 2010, p. 1801).

Figure 5: Indicators to project the future development of the construction sector

Key drivers in the construction sector		
Modernisation	Maintenance	Expansion (e.g. Electricity grid)
Indicators		
Top-down	• Investment • Sector share on GDP • Industrialisation • GDP • Employment • GDP/Capita • Industry structure • Energy demand	

Bottom-up	• Demographical development
	• Urbanisation
	• Industrialisation
	• Buildings
	• Infrastructure
	  • Energy
	  • Information / Communication
	  • Water / Waste water
	  • Transport
	    • Railway
	    • Road
		Privat
		Commercial
		Public

Source: Based on Amann *et al.* (2004) and Hu *et al.* (2010)

Moreover, a shift in the sectoral structure of an economy towards more service-based sectors may reduce its needs for material, since the service sector is presumed to require less material than the construction or the manufacturing sectors. However, it is possible that other factors, such as new production technologies, material substitutions, and long-run price trends, influence the intensity of use as well.

According to the theory, if a country reaches a certain GDP per capita value, the overall material consumption of a country decreases. In the literature, this approach has been applied successfully to explain the metal consumption for European countries on an aggregated level (Canas *et al.*, 2003; Warell and Olsson, 2010).

As Germany has already moved from an industrialized to a more service-based economy where metal intensity has started to decline, an intensity of use approach was tested here too. However, the regression factors turned out to be not solid enough. The intensity of use assumption could be verified for the aluminium consumption, but the regression values were weaker than for the simple approach (compare regression values of Table 4: Regression Aluminium Consumption vs. GDP Table 4 and Table 5).

When the consumption trend is simply continued without any explanatory variable, similar results are obtained as with the simple GDP-based regression model. The results based on this estimation model are reported below under the “frozen scenario”. In the case of steel consumption, projections obtained exclusively with a trend analysis are slightly lower than those obtained with the regression model effectively used (see frozen scenario in Figure 11). In the case of aluminium consumption it is the other way round (see frozen scenario in Figure 15). As the results of both approaches are similar, the model used can be considered as solid, implying also that it does not react very sensitively to changes in GDP.

3.2 Specifications of the model applied

In this study, the best estimation results are obtained with a simple linear regression analysis of GDP and material consumption to approximate the future consumption trends of steel and aluminium in the construction and mechanical sector. It is based on a time series analysis of apparent material consumption and GDP. Moreover, the sector shares of each material are obtained by a trend analysis. Only here are the regression factors solid and consequently the results reasonable.

The model consists of four steps (see Figure 6). First, the future German GDP is projected. Secondly, overall aluminium and steel consumption is calculated based on a linear regression function with GDP as the explanatory variable. Third, the future sector shares of each material are calculated with the help of a trend analysis. Finally, the results of steps two and three are combined to derive the future material consumption of each sector by multiplication. To display uncertainties, which all assumptions contain, a prognosis interval (confidence interval) is used. It is obtained by the following formula (Backhaus *et al.*, 2011, p. 129):

$$y_{T+k} = \hat{y}_{T+k} \pm t_{\alpha/2} \cdot s_p(T+k)$$
$$with \cdot s_p(T+k) = s \cdot \sqrt{1 + \frac{1}{T} + \frac{(T+k-\bar{t})^2}{(T-1)\cdot s_t^2}} \quad (1)$$

with $\bar{t}$: Average of time variable t

s: Standard error of regression

s_t: Standard error of time variable t

s_p: prognosis error

$T+k$: future periods

$t_{\alpha/2}$: quantile of the t-distribution

$\hat{y}$: prognosis value

As a result, scenarios with three different GDP-values (low, base, high) and therefore three different future material consumption values are gained. Moreover, three scenarios for the sector shares are derived as well (low, base, high). That means that nine different scenarios are analyzed in total for each material, which is shown in Figure 6. For the purpose of simplicity not all resulting funnels will be displayed in the following subchapters. Only the funnel gained through the different GDP scenarios will be shown, but each indicating line (low, base, high) will have a projection interval as well.

Figure 6: Structure of the developed model to project material consumption in each sector

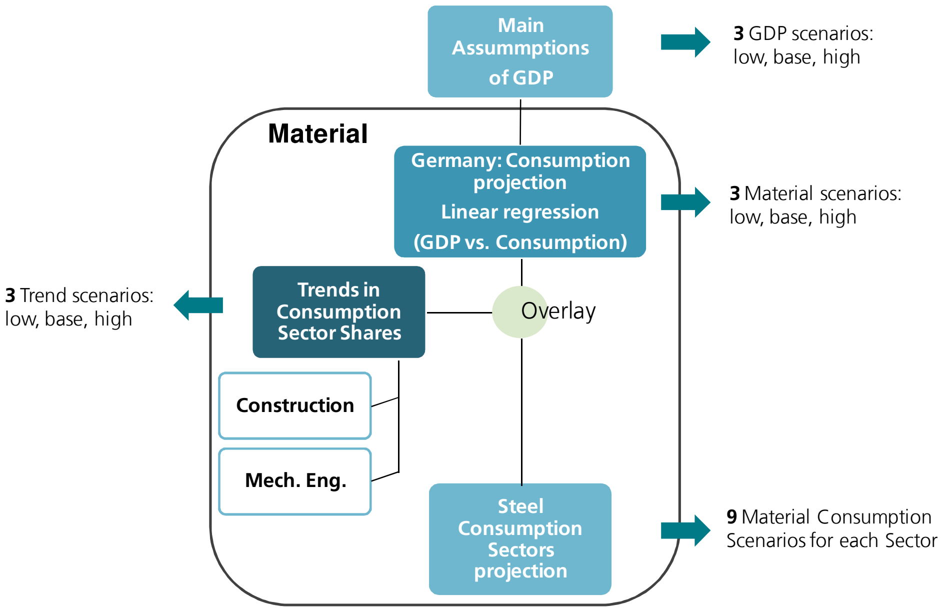
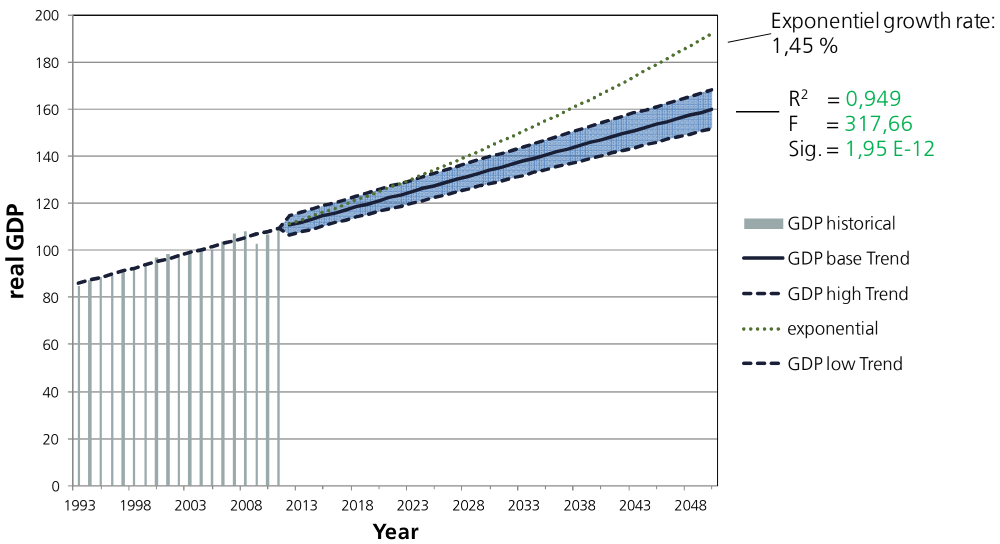


Figure 7 shows two different possible future GDP developments for Germany: an exponential development with a constant GDP growth rate of 1.45 % and a historical linear trend development of the GDP. The exponential growth scenario almost results in a doubling of GDP in the next 40 years. The exponential GDP-development therefore does not represent the future in a realistic way, so that the GDP trend scenario is used in this analysis to benefit from simple assumptions. The resulting coefficient values for the linear regression function are listed in Table 2 in the appendix.

Figure 7: Projection of German (real) GDP development (trend analysis)



Source: (Destatis, 2012), own calculations

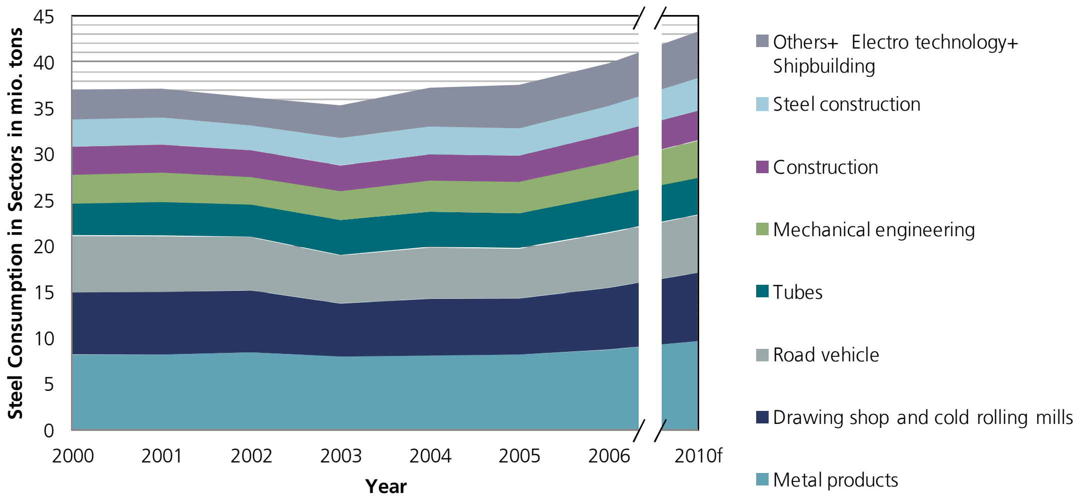
Moreover, the displayed prognosis interval is used to derive a low, base (middle) and high GDP development. With the help of these GDP-projections, the material consumption values of each sector are generated by a regression analysis, which is explained in the following chapters.

4 Consumption trends for steel

4.1 Estimation of the overall future steel consumption

The historical steel consumption in Germany was 37 million tons in the year 2000. It increased to a value of 43 million tons in 2010, which is a plus of 16 %. However, the structure remained nearly the same over the years (see Figure 8). Metal products (22 %), drawing shops and cold rolling mills (17 %) as well as road vehicles (15 %) are the most important steel consuming sectors. Steel construction and the construction sector together follow with an aggregate share of 15 %. The mechanical engineering sector accounts for 8 % of steel consumption. These figures do not easily compare to the figures presented in section 2 for the European level due to the fact that the statistics differ in terms of the sectoral split they apply. However, they still support the focus of our analysis on construction and mechanical engineering as very important users of steel.

Figure 8: Historical steel consumption development in Germany

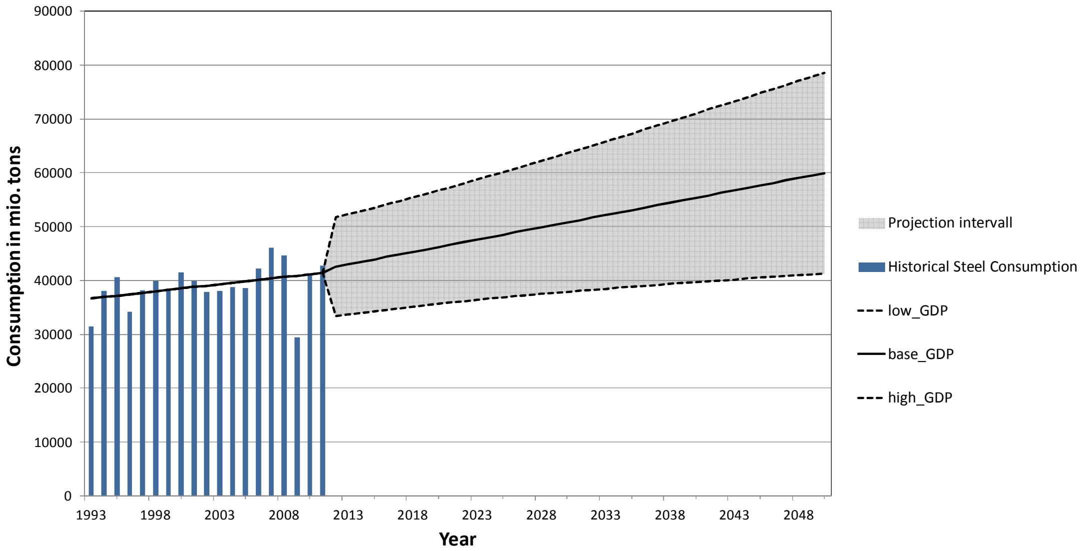


Source: (Stahl Zentrum, 2009)

Based on a regression analysis between the increment of historical steel consumption and historical GDP-development, a correlation is found. The resulting coefficient values for the linear regression function are listed in Table 3 in the appendix. The future aggregated steel consumption in Germany is illustrated in Figure 9. Based on the three different GDP-scenarios a scenario funnel is spanned. In case of the GDP base scenario, the absolute overall steel consumption in Germany increases from

41.1 million tons in 2010 to a value of 59.9 million tons in 2050. Depending on the scenario considered here it varies by a value of ±18.7 million tons in 2050.

Figure 9: Aggregated steel consumption scenarios for Germany



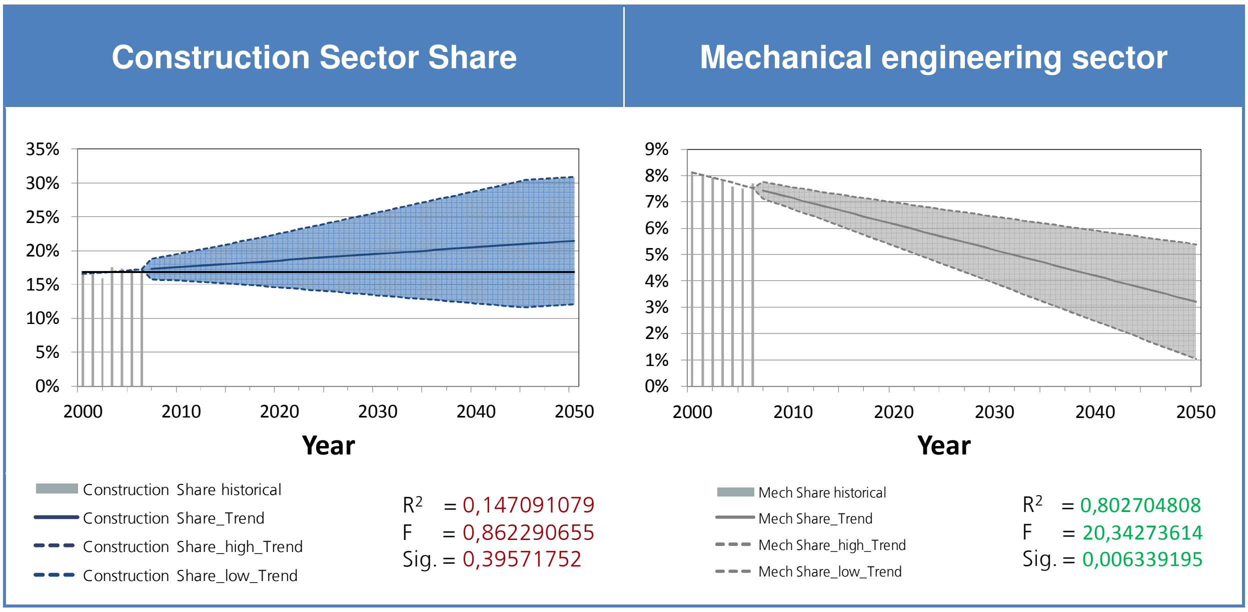
Source: (World Steel Association, 2008 - 2012; International Iron and Steel Institute, 2003 - 2007), own calculations

4.2 Estimation of the sector share

To analyze the steel consumption of the construction and mechanical engineering sector, historical data about their share of the total steel consumption must be investigated. The main problem here is data availability: sector shares of steel consumption in Germany are only available for a limited number of years, which impinges upon the quality of results. As data for seven years are provided by the German steel association (Stahl Zentrum), a trend analysis for this data set is done and a projection for the future is derived. The results are shown in Figure 10. Due to the limited data set and the resulting uncertainties, the prognosis interval is quite wide especially in the case of the construction sector. Here the regression values are quite bad. To use the average share value of the seven data points could be another alternative, which however would neglect any future developments. The regression results have the advantage that the developments of the last decade are represented in the illustrated results. Hence, they provide more information than looking just at the current situation and the average value.

In the GDP base scenario, the steel consumption of the construction sector increases from a share of 17.3 % in 2010 to a share of 21.5 % in 2050. However, the prognoses interval increases as well from a value of four percentage points to a value of 18 percentage points in 2050. This illustrates that the values become more uncertain in the future. As the total share of all sectors must sum up to a value of one, other sector shares must decrease. One of them is the mechanical engineering sector whose share declines from a value of 7.1 % in 2010 to 3.2 % in 2050 in the base scenario. Since the regression is much better in this case, the prognoses interval ranges from one percentage point in 2012 to four percentage points in 2050 only. The prognoses interval does increase in both cases due to the underlying methodology.

Figure 10: Sector share scenarios of future steel consumption in Germany



Source: (Stahl Zentrum, 2009)

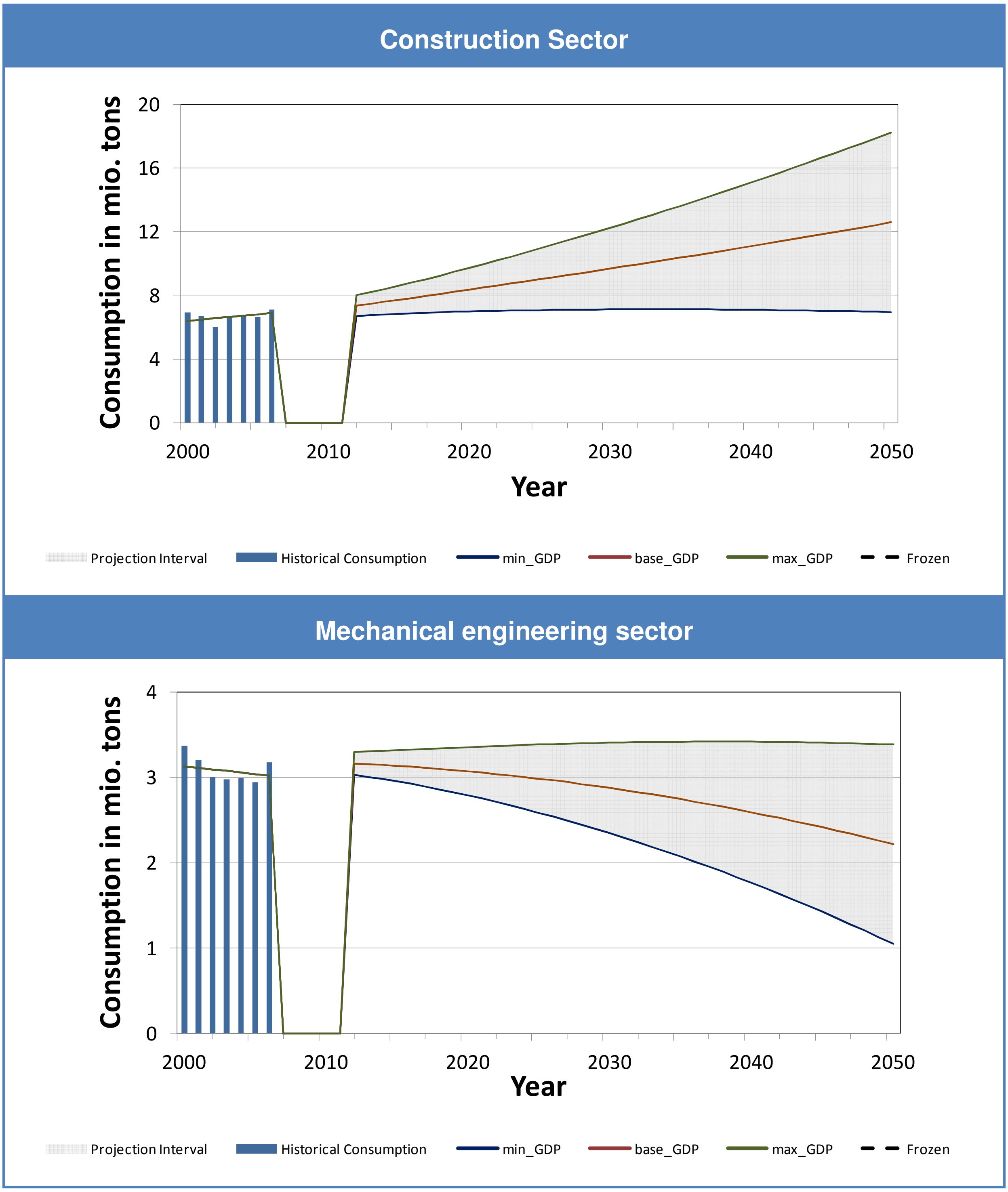
4.3 Estimation of the future steel consumption by sectors

The future steel consumption of the construction and mechanical engineering sector is illustrated in Figure 11. It shows the scenario funnel, which is spanned by three different GDP scenarios (grey funnel) assuming the base scenario for the development of sector shares. A combination with the other two scenarios for sector shares would widen the funnel further. For the purpose of simplicity this overlaying approach is not displayed here. Nevertheless, each indicating line (low, base, high) implies a projection interval.

In case of the GDP base scenario, the absolute steel consumption of the construction sector increases by 71 % from an amount of 7.4 million tons in 2012 to 12.6 million tons in 2050.

While the German overall steel consumption grows, the share of the mechanical engineering sector decreases significantly. These are opposing effects. However, the latter effect outweighs here and therefore, the absolute amount of steel which is used in the mechanical engineering sector decreases. Due to this logic of the developed model it projects a use of 2.2 million tons of steel in 2050. This is 20 % below the amounts used in 2012 in the mechanical engineering sector.

Figure 11: Steel consumption scenarios for the construction and mechanical engineering sector in Germany



Source: (World Steel Association, 2008 - 2012; International Iron and Steel Institute, 2003 - 2007)

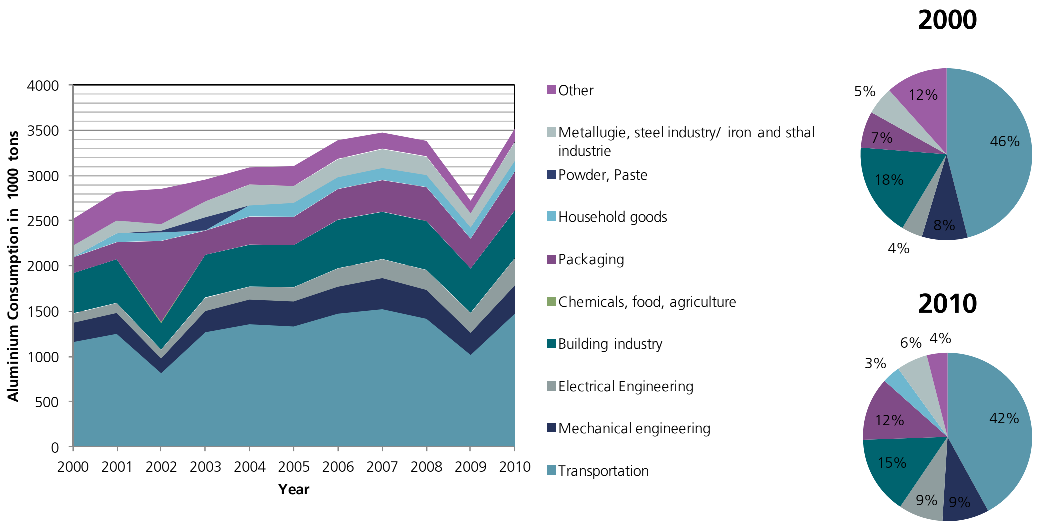
5 Consumption trends for aluminium

5.1 Estimation of the overall future aluminium consumption

The historical aluminium consumption increased from 2.5 million tons in 2000 to 3.5 million tons in 2010 (see Figure 12), with a considerable slump of aluminium consumption in 2009 caused by the financial crisis. The occurrence of such behaviour demonstrates the high substitutability of aluminium. If the price is too high, aluminium is often replaced by other metals in many applications.

The consumption structure changed slightly over the years. Although the transportation and construction sectors still are the two biggest users of aluminium (42 % and 15 %), the other sectors shifted their order of precedence. The mechanical engineering sector is in the middle field with a share of 9 %.

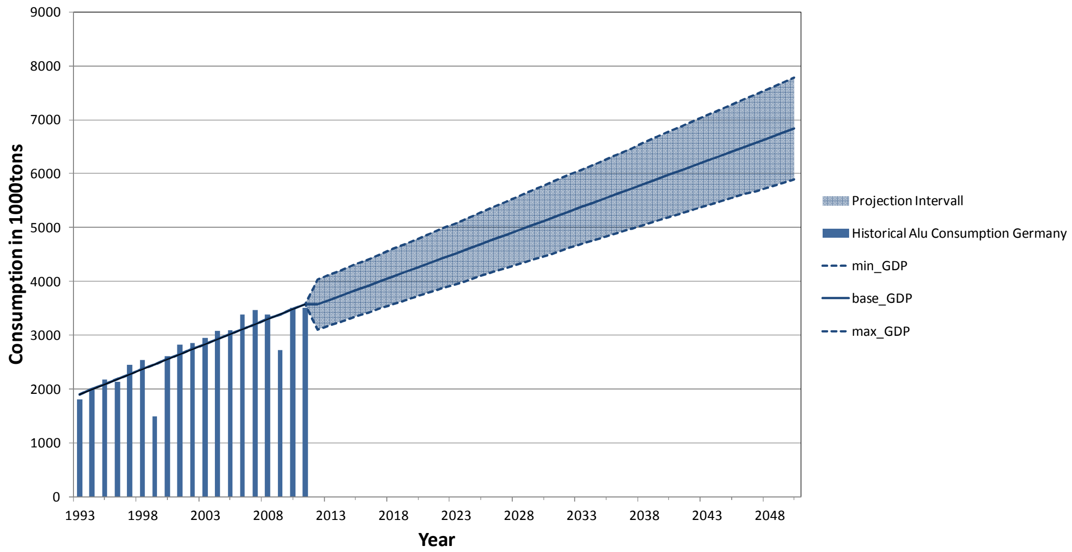
Figure 12: Historical aluminium consumption development in Germany



Source: (GDA, 2003 - 2010)

Based on a regression analysis between the increment of historical aluminium consumption and historical GDP-development, a correlation is found. The resulting coefficient values for the linear regression function are listed in Table 4 in the appendix. The projected future aluminium consumption is illustrated in Figure 13. Based on the three different GDP-scenarios a scenario funnel is spanned here again. In case of the GDP base scenario the absolute overall aluminium consumption in Germany increases from 3.5 million tons in 2010 to a value of 6.8 million tons. Depending on the scenario considered it varies by a value of ±0.95 million tons.

Figure 13: Aggregated aluminium consumption scenarios for Germany



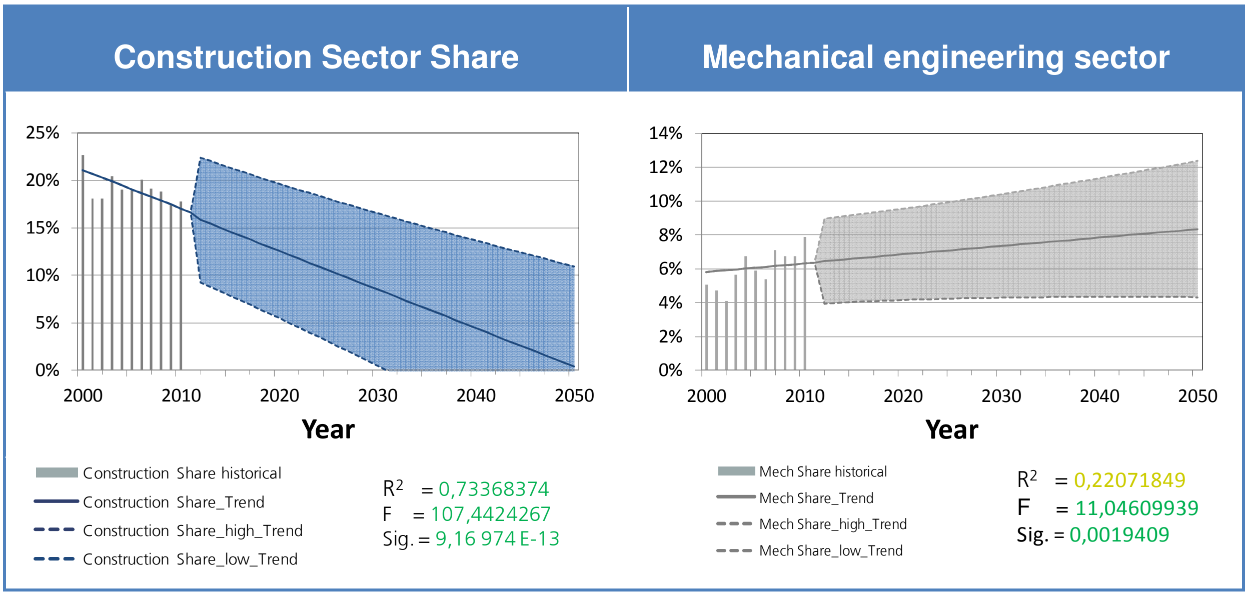
Source: (GDA, 2003 - 2010), own calculations

5.2 Estimation of the sector shares

To analyze the aluminium consumption of the construction and mechanical engineering sector historical data about their share of total aluminium consumption must be investigated. According to the data available with a time span going back to 1900 the data situation is much better than in the case of steel consumption. The whole data set is provided by the German Aluminium Association (GDA) and is limited to an interval from 1970 to 2010 here. Based on this solid interval a trend analysis is done and a projection for the future is obtained. The results of the shares are shown in Figure 14 in which a wide prognoses interval is especially displayed in case of the mechanical engineering sector. This is due to a low coefficient of determination (R^2 = 0.221).

The construction sector decreases its share of 17.8 % in 2010 to a share of only 0.4 % in 2050. The construction sector share decreases so dramatically that negative values are projected in the lower trend. This is of course not possible, but not limited by any barriers here as it would be contrary to the approach of trend analysis. The prognoses interval increases considerably from a value of 13 percentage points to a value of 21 percentage points in 2050. Again, this illustrates that the values become more insecure in the future.

Figure 14: Sector share scenarios of future aluminium consumption in Germany



Source: (GDA, 2003 - 2010), own calculations

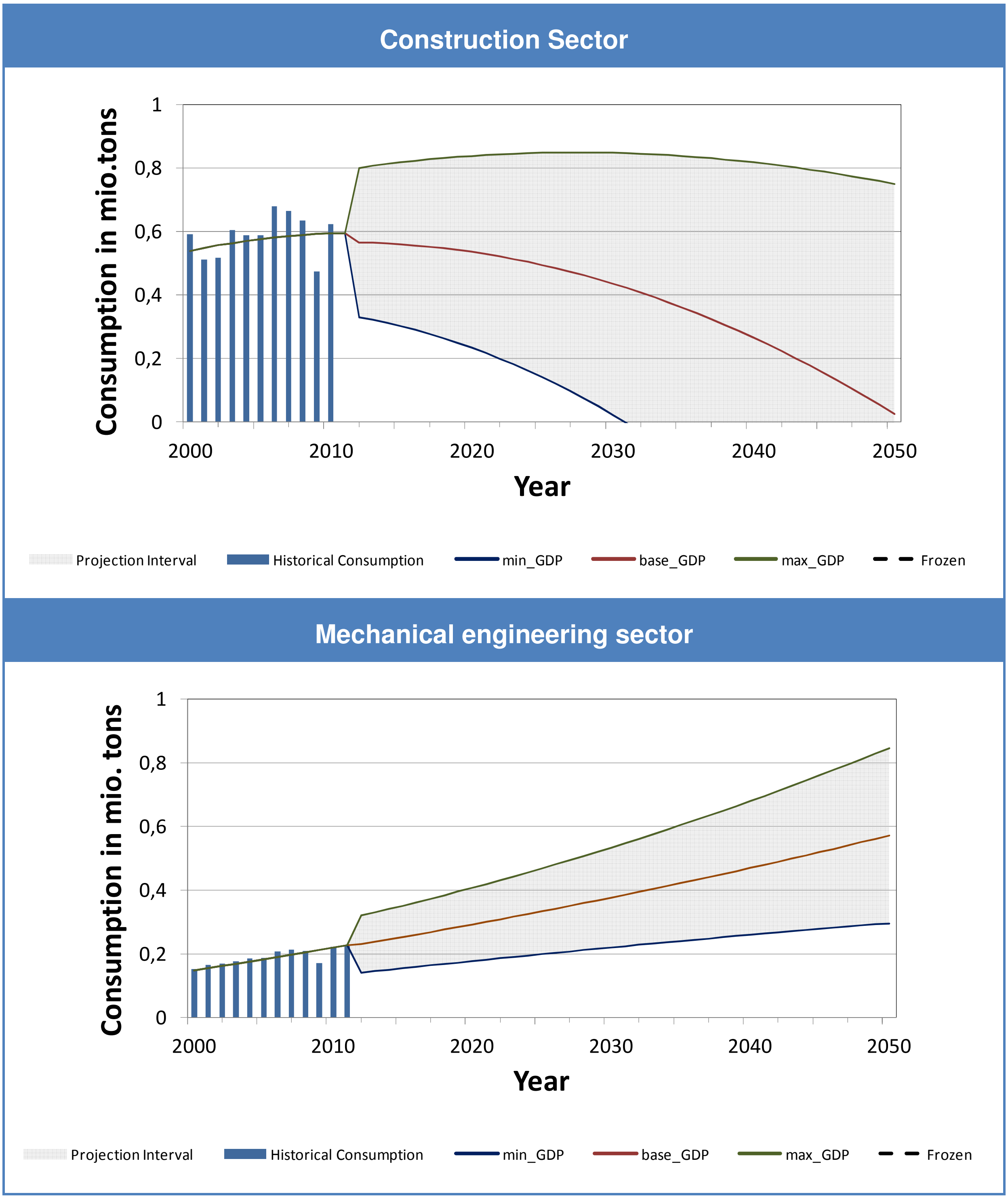
As the total share of all sectors must sum up to a value of one, other sectors must increase their shares. One of them is the mechanical engineering sector, whose share increases from a value of 7.9 % in 2010 to 8.4 % in 2050. Since the regression is not as good as in the previous case the prognoses interval absolutely ranges from five percentage points in 2012 to eight percentage points in 2050. Although this interval is smaller in absolute values, it is important to consider the relative effect the funnel has on the consumption share.

5.3 Estimation of the future aluminium consumption by sectors

The future aluminium consumption of the construction and mechanical engineering sector is illustrated in Figure 15. It shows the scenario funnel, which is spanned by three different GDP scenarios (grey funnel) assuming the base scenario for the development of sector shares. Again, a combination with the other two scenarios for sector shares is not displayed here.

In case of the base scenario for GDP, on the one hand, the absolute aluminium consumption of the construction sector decreases by 99.6 %, even though the German overall aluminium consumption grows. This occurs due to the opposing effects of a significant reduction of the construction sector's share in aluminium consumption. It results in a consumption decline from an amount of 0.62 million tons in 2010 to 0.003 million tons in 2050, i.e. almost a phase-out of aluminium in the construction sector. In case of the low GDP scenario, this phase-out would occur even earlier.

Figure 15: Aluminium consumption scenarios for the construction and mechanical engineering sector in Germany



Source: (GDA, 2003 - 2010), own calculations

The consumption of the mechanical engineering sector, on the other hand, increases due to the logic of the developed model. The result is a final consumption of 0.57 million tons in 2050 corresponding to an aggregate growth rate of 258 % compared to 2010.

Naturally, large uncertainties are implied when dealing with a long time horizon of 40 years. Nevertheless, this model is still useful to obtain the direction of future consumption trends and to obtain further insights into the relationship between GDP and aluminium consumption.

6 Conclusion

The results of the analysis are summarized in Table 1. According to the simple regression model developed in this paper the overall consumption of both analyzed materials increases in Germany - in case of steel by 41 % and of aluminium by 95 %. The construction sector will increase its absolute amount of steel consumption, but reduce its aluminium consumption. These consumption patterns are the exact opposite for the mechanical engineering sector, albeit on a different scale. However, no interdependencies between the materials are explained with the help of the developed model and therefore not projected here.

The Steel Institute expects a moderate growth of 0.8 % p.a. for the European steel production until 2050 (Ghenda, 2013). A similar development is assumed for Germany in the long-term (Sprecher, 2015), which results in the production of 60 million tons of steel in 2050. As steel consumption is the sum of domestic steel production plus steel imports minus exports, steel production does of course not equal consumption. However, the amount of steel exports and imports is almost the same (Bundesministerium für Wirtschaft und Energie, 2015). Therefore, the resulting aggregated steel consumption in this study is similar to the Steel institute expectations and reinforces the plausibility of the approach conducted here, thus the sectoral consumption strictly depends on the overall consumption.

The European aluminium association assumes a growth of 81 % for the European aluminium consumption between 2010 an 2050 (EAA, 2012). According to their calculation the consumption in Europe will increase from 10 million tons to 18.6 million tons in 2050. This study projects that Germany will have an aluminium consumption of 6.8 million tons in 2050. It is approximately the same proportion (~35 %) of the total European aluminium consumption as earlier in 2010, which supports the underlying assumptions in this paper.

Table 1: Summary of steel and aluminium consumption trends

Sector	Year	Steel				Aluminium			
		Sector Share		Absolute [mio. tons]		Sector Share		Absolute [mio. tons]	
Germany	2010			42.5	↑			3.5	↑
	2050			59.9				6.8	
Construction	2010	17.6 %	↑	7.3	↑	17.8 %	↓	0.6	↓
	2050	21.5 %		12.6		0.4 %		0.025	
Mechanical Engineering	2010	7.1 %	↓	3.0	↓	7.9 %	↑	0.2	↑
	2050	3.2 %		2.2		8.4%		0.57	

7 Appendix

Regression factors

Table 2: Regression GDP vs. year

Modell summary

Modell	R	R-Squared	Corrected R-squared	Standard error of the estimator
		0,949201758	0,946213626	1,737862817

ANOVA

Modell	Sum of Squares	df	Average of squares	F	Sig.
Regression	959,3780002	1	959,3780002	317,6572506	1,95052E-12
Residue	51,34284193	17	3,020167172		
Total	1010,720842	18			

Coefficients

Modell	not standardised errors		standardisized errors		
	Regression coefficient	standard error	Beta	T	Sig.
constant	-2499,572772	145,7282541		-17,15228654	3,62399E-12
Variable	1,297350877	0,072791063		17,82294169	1,95052E-12

Table 3: Regression delta (Steel Consumption) vs. Delta (GDP)

Model summary

Model	R	R-Squared	Corrected R-squared	Standard error of the estimator
		0,729640415	0,712742941	2981,916291

ANOVA

Model	Sum of Squares	df	Average of squares	F	Sig.
Regression	383952931,7	1	383952931,7	43,18044292	6,43448E-06
Residue	142269196,3	16	8891824,766		
Total	526222128	17			

Coefficients

Model	not standardised errors		standard sized errors		
	Regression coefficient	standard error	Beta	T	Sig.
constant	-2467,12591	846,1329769		-2,915766171	0,010104742
Variable	2254,217896	343,0459899		6,571182764	6,43448E-06

Table 4: Regression Aluminium Consumption vs. GDP

Model summary

Model	R	R-Squared	Corrected R-squared	Standard error of the estimator
		0,784540464	0,771866373	289,6379057

ANOVA

Model	Sum of Squares	df	Average of squares	F	Sig.
Regression	5192892,653	1	5192892,653	61,90112584	4,57663E-07
Residue	1426131,979	17	83890,11641		
Total	6619024,632	18			

Coefficients

Model	not standardised errors		standard sized errors		
	Regression coefficient	standard error	Beta	T	Sig.
constant	-4267,110626	892,782845		-4,779561626	0,000174226
Variable	71,67852532	9,110449137		7,867726854	4,57663E-07

Table 5: Aluminium Consumption vs. GDP/POP (2nd degree polynom)

Modell summary

Modell	R	R-Squared	Corrected R-squared	Standard error of the estimator
		0,775107703	0,746996166	305,0171772

ANOVA

Modell	Sum of Squares	df	Average of squares	F	Sig.
Regression	5130456,977	2	2565228,489	27,57258341	6,5433E-06
Residue	1488567,654	16	93035,4784		
Total	6619024,632	18			

Coefficients

Modell	not standardised errors		standardisized errors		
	Regression coefficient	standard error	Beta	T	Sig.
constant	-8576,283925	13790,44144		-0,621900608	0,542768192
variable	13046,54516	23188,71807		0,562624683	0,58148876
Variable^2	-2961,216511	9708,257785		-0,305020383	0,764282664

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