Position of Metaltechnology Austria

Consumption Based Greenhouse Emissions

Greenhousegasemission are an essential trigger for climate change. Therefore they have been measured for quite some years now. Though the results are questionable, since accounting is based on the "production approach" meaning effects of foreign trade are not taken into account. The GHG inventory (UNFCCC) includes only "direct emissions", not "indirect emissions" through trade. Hence the current accounting system leads to a distorted picture and favors shifting of a country's climate charges to another country. Climate change as a global challenge requires expanding the system boundary to include foreign trade. In cooperation with other associations of the Federal Industry in Austria, Metaltechnology Austria engaged in the IIÖ to show how and where those disortions accure and provide solutions.

Focus on consumption-based greenhouse gas emissions

Requirements and demands of a product-specific view on consumption-based greenhouse gas emissions

Climate change is one of the main challenges of our time and the major causes are the increasing greenhouse gas emissions (GHG) from anthropogenic activities. This dominant human influence was affirmed in the latest assessment report of IPCC (2013). For developing strategies to reduce greenhouse gas emissions, it is essential to understand the sources and origins of the emissions. Different perspectives and methods are available to account for greenhouse gas emissions. The most prominent approach is to consider activities occurring within national boundaries (production-based approach). Impacts induced abroad by imports are not included within the scope. Alternatively, one could adopt a consumption-based perspective which would include the impacts due to imports and exports in addition to national activities (see Figure 1). This perspective has become of increasing interest in the recent years. It allows the calculation of greenhouse gas emissions caused by the consumption of products (including services) for a whole country. This would help to raise the consumer’s awareness about the environmental impacts of their consumption. Thus, it is potentially relevant for diverse target groups, as e.g. policy-maker could make use of this information for understanding the most crucial areas to make consumption more environmentally sound (e.g. climate-friendly procurement).

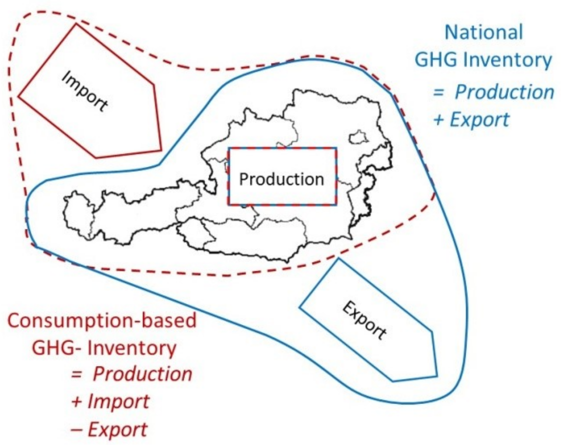

Figure 1: System boundaries for the national GHG-inventory and the consumption-based GHG-inventory

For calculation of the consumption-based emissions, different approaches have been developed. The most commonly used method is the economic input output model (IO). Basically, IO models are a top-down approach based on economic input-output analysis and can comprise single-country models (SRIO) or multi-regional input-output (MRIO) models (Davis and Caldeira 2010; Hertwich and Peters 2009; Tukker et al. 2006; Wiedmann 2009). The database used in a MRIO model includes a set of national input-output (IO) tables that are interlinked by bilateral trade data. IO tables depict the flow of goods and services between countries in monetary units. The set of IO tables is further extended with sectoral data on energy use, greenhouse gas emissions or other environmental impacts. The IO model allows production chains triggered by consumption in one country to be traced across country borders and the induced environmental impacts in all other countries to be calculated. Thus, it is possible to determine how many inputs (from various sectors and countries) are necessary to produce the required output for the respective sectors (see e.g. Bruckner et al. 2009; Lininger 2015; Lutter et al. 2016; Wiedmann 2009). IO models are suitable to deliver information for country or regional-level analysis, but are not able to provide accurate data for single products. Consequently, the "indirect" emissions due to the supply of products may not be depicted in a transparent way, as averaged emission factors on a sectoral level are used. Furthermore, another main disadvantage and source of uncertainty is the prevailing use of monetary structures of sectors to calculate environmental impacts. Monetary data are not as suitable for the calculation of greenhouse gas emissions as physical data (Lininger 2015; Lutter et al. 2016; Wiedmann 2009).

A detailed review of recent scientific literature has shown that a more detailed approach on product-level allows to depict the heterogeneity in emission intensities as well as to identify options for reducing the emissions behind the required products for consumption. Furthermore, the relation between national production and imports for specific products could help to identify global effects like "carbon leakage", which is defined as the outsourcing of national production to countries abroad with less stringent emission reduction pledges than in the original country. Consequently, this may result in increased emissions at global scale (Peters and Hertwich 2008).

Meanwhile a methodology has been developed which considers physical material flows for imports, exports and domestically produced goods and the induced GHG-emissions based on data from life cycle analysis (LCA). The most important steps in this approach are described briefly below:

1. <u>Definition of the system boundary and the level of detail</u>

As a basis, all goods produced, imported and exported in a country must be taken into account. In a first step, it is necessary to determine the degree of detail of the goods to be considered, which is determined specifically by the available physical data and LCA factors for calculating GHG emissions.

2. <u>Data extraction for physical material flows</u>

Once the scope of the analysis has been determined, physical data for the respective goods for imports, exports and national production are collected and compiled. The main focus is on merging national production with foreign trade flows, as these statistical systems are using different nomenclature.

3. <u>Development of process chains</u>

Since this approach covers all goods behind national consumption, there are goods at different stages of processing (e.g. raw material, intermediate product, consumer product) which have to be taken into account when using life cycle-based emission factors (LCA factors). This is quite important to avoid double counting, as LCA emission factors include the whole life cycle from the resource up to the considered good (Lenzen et al. 2006, Jungbluth et al. 2011). As an example, emission factors for paper include the emissions related to the production of paper and the supply chains of raw materials and energy. Emissions caused by the harvesting of the required wood and the production of pulp are therefore included and must not be counted in the calculation of emissions of raw materials separately.

Consequently, it is crucial to differentiate the final products and the goods along the supply chain to enable the calculation of LCA-based emissions correctly. By combining the physical material flows, the flow of goods through Austria can be illustrated in a material flow balance for Austrian consumption, from which the consumption-based emissions can further be calculated (consumption = production plus import minus export).

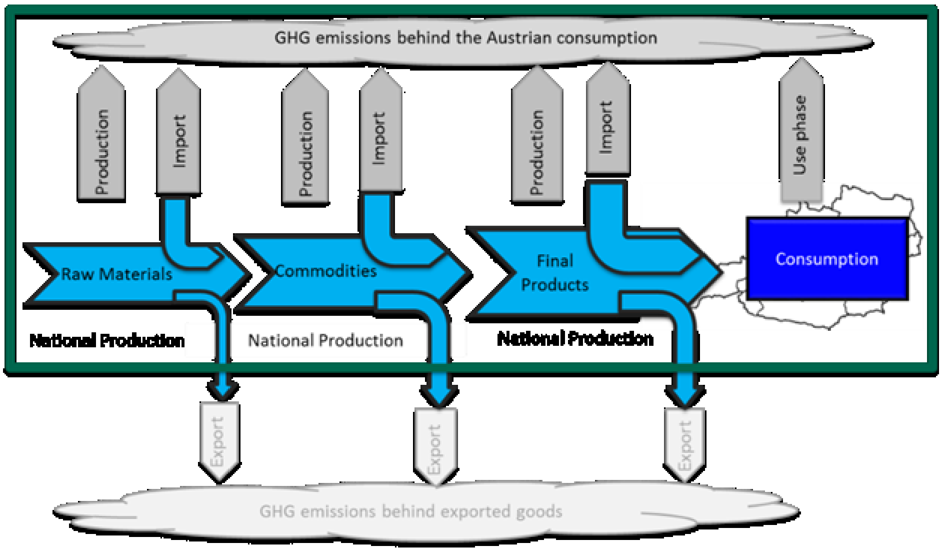

Figure 2: System structure for the calculation of consumption based GHG emissions

4. Regionalization of life cycle based emission factors (LCA-Factors) for the calculation of GHG emissions

Based on these process chains the life cycle based emissions caused by national consumption can be calculated in a next step. To account for different technological standards between each producing country, the emission factors derived from LCA data could be regionalized based on emission intensities of sector- and country-specific energy mixes.

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Tracking materials and products along physical supply chains

Physical data (mass) for and monetary value of about 1,000 materials and products manufactured in or traded by Austria in 2013 were compiled. These data were taken from national statistics. Some difficulties were encountered as the national production data are not as complete as the data from foreign trade, for reasons of confidentiality. The materials and products are further structured in different classification schemes, CPA-classification (= Classification of Products by Activities) for national production and the CN-classification (= Combined Nomenclature) of the foreign trade, varying especially in the product description and level of detail. Thus, several assumptions and allocations were required in order to merge the different levels and types of data into one consistent dataset.

In general, we assume that consumption (C) can be calculated as production (P) plus imports (I) minus exports (E). Of course, this ignores the possibility of stockpiling. However, for some products (e.g. agricultural, fossil fuels, paper, and vehicles) consumption data were used supplementary, if available. With these data the development during the last years and the process chain for the year 2013 could be produced.

As illustrated in Table 1, in 2013, Austria imported about 89 Mt of materials and products with a value of 130 billion Euros[1]. In the same year, the country exported 50 Mt with almost the same value. Thus, Austria's industry adds significant value to the exported materials. Compared to 2005, in 2013, both imports and exports were slightly more on a mass-basis and significantly more on a value-basis. Overall imports and exports have been increasing annually since 2005 with the exception of 2009 when a significant drop occurred, caused by the commercial crisis.

Year	Imports (10^6 t)	Exports (10^6 t)	Imports (10^9 €)	Export (10^9 €)
2005	82	50	97	95
2006	87	53	104	104
2007	91	59	114	115
2008	88	60	119	118
2009	80	51	98	94
2010	87	56	114	109
2011	92	57	131	122
2012	91	56	132	124
2013	89	56	131	126

Table 1: Austria's imports and exports from 2005 up to 2013

[1] Billion = 1×10^9

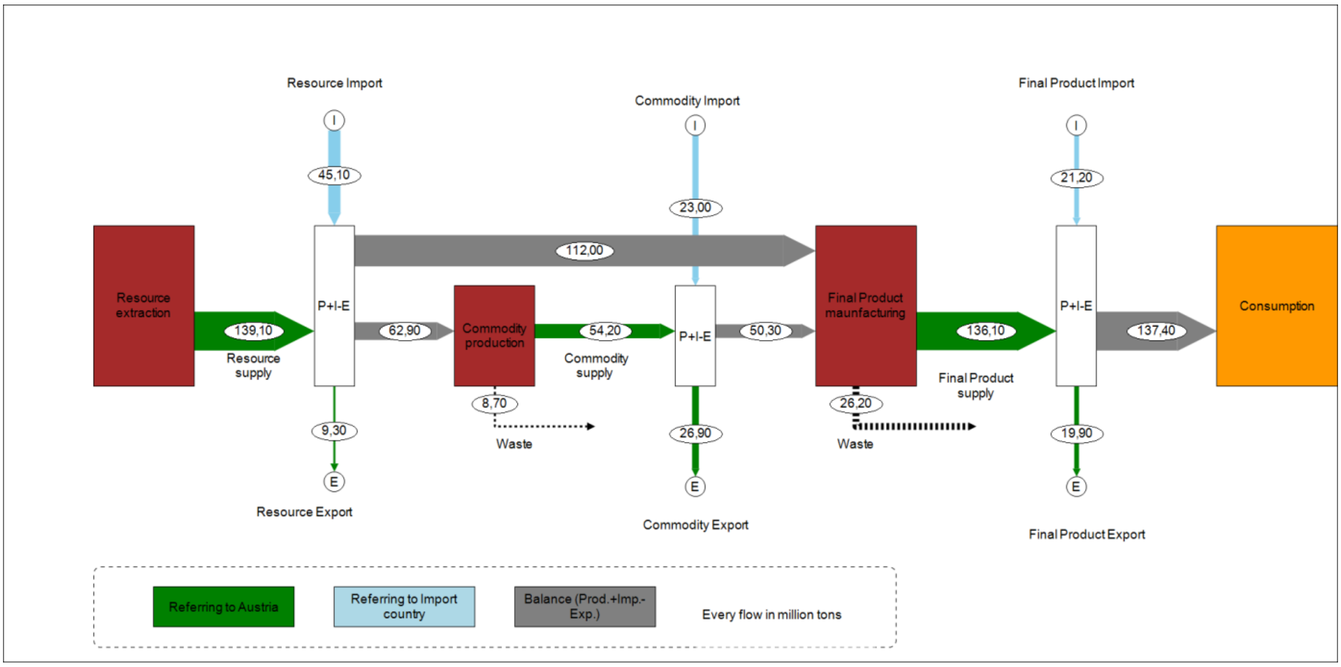

Figure 3: Material flows in million tons resulting from Austrian consumption in 2013

Figure 3 shows that about 50% of the imports by mass are raw materials, followed by commodities and final products. In contrast, for exports, about 50% would be classified as commodities. It is further obvious that the main material flows within the country are raw materials and that most of them are extracted in Austria. In contrast, Austria imports much more raw materials than it exports. This is because some of the raw materials used for the production of intermediates and final products are not available in Austria. Having a closer look at the data shows that a lot of raw materials are used as consumer products directly. This is the case for materials as e.g. gravel or crushed stone which is often used without further processing. Another example is given by vegetables, which are partly used directly for consumption without any additional processing. Other raw materials, to a smaller extent, are processed to commodities and further to consumer products.

The origin of Austria's imports and the destination of its exports are illustrated in Figure 4 and 5. It is obvious that European countries are Austria's most important trading partners (both for imports and exports). Additionally, more than one third of the imports and exports are traded with Germany. It has to be considered that our analysis only considers the first level of imports and exports. For example, if Austria imports final products from Germany, we assume that the whole process chain for that product takes place in Germany. In fact, Germany for its manufacturing of products, e.g. cars, might import some commodities, e.g. steel plates. This represents one main challenge that has not been solved for the moment, as the foreign trade statistics don't contain information about the process chains behind the final products. Further data on the interlinkage of world economy are required for further improvement. MRIO do not consider process chains themselves, but do contain information on the cascading of imports within chains, hence a hybrid MRIO / LCA process chain model should be investigated as a solution to this problem.

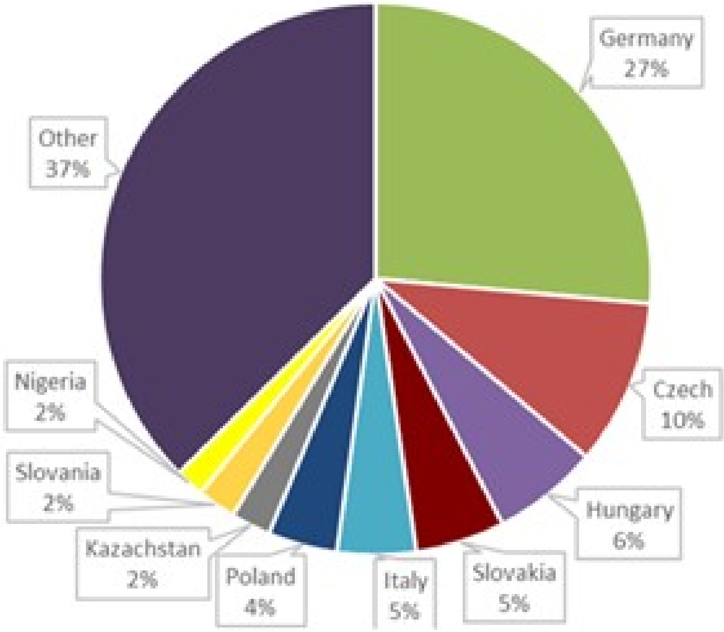

Figure 1: Origin of Imports in 2013

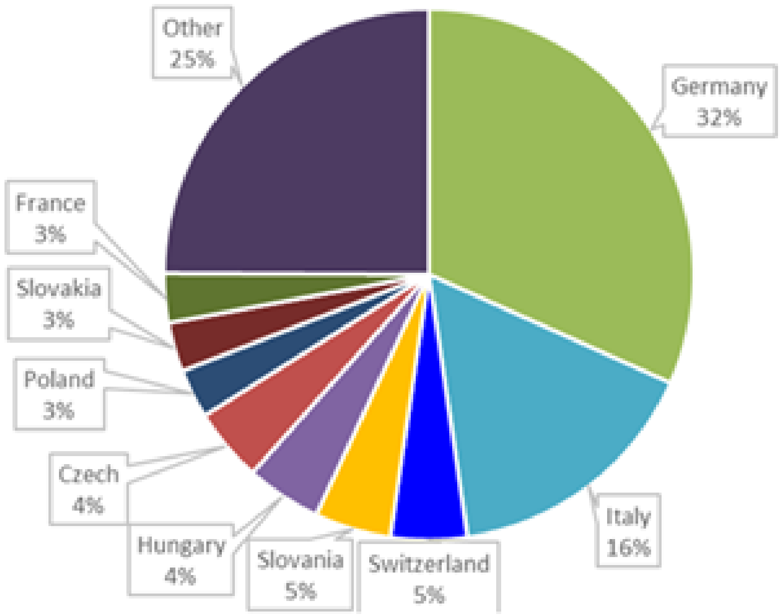

Figure 5: Destination countries for Austrian exports in 2013

Greenhouse gas emissions caused by Austria's consumption of products

In order to identify the causes and origins of the greenhouse gas emissions (GHG) caused by consumption in Austria, a detailed product-related method was applied. It was based on a life cycle-based process chain approach, which enables the calculation and modelling of GHG emissions due to the consumption of products in Austria. This approach also allows the derivation of concrete measures, for the reduction of emissions at national and global level, to be investigated.

The calculation of GHG emissions is based on the physical material flows along the entire process chain behind consumption in Austria, as described in the previous chapter. The considered materials and products (total of about 1,000 goods) are supplemented with life cycle-based emission factors (primarily from the Ecoinvent database and GEMIS), which correspond to the goods in the respective process steps (e.g. raw material, commodity). The total consumption-based emissions are calculated by adding the emissions from imports to the emissions of the national production minus those behind the exports. Because of the use of life cycle based emission factors, emissions from the whole supply chain of the products are covered. That is why the knowledge of the process chains is of special importance to avoid double counting of emissions. Emissions of products in different process steps should only be counted once, as e.g. the emissions of the raw material and commodity are already included in the final product.

Since LCA-data are usually available for just one or very few countries, a procedure to adjust LCA emission factors for all countries was developed. The emission factors were regionalized by correcting for the emission intensity of the energy mix of each industry sector in the respective country.

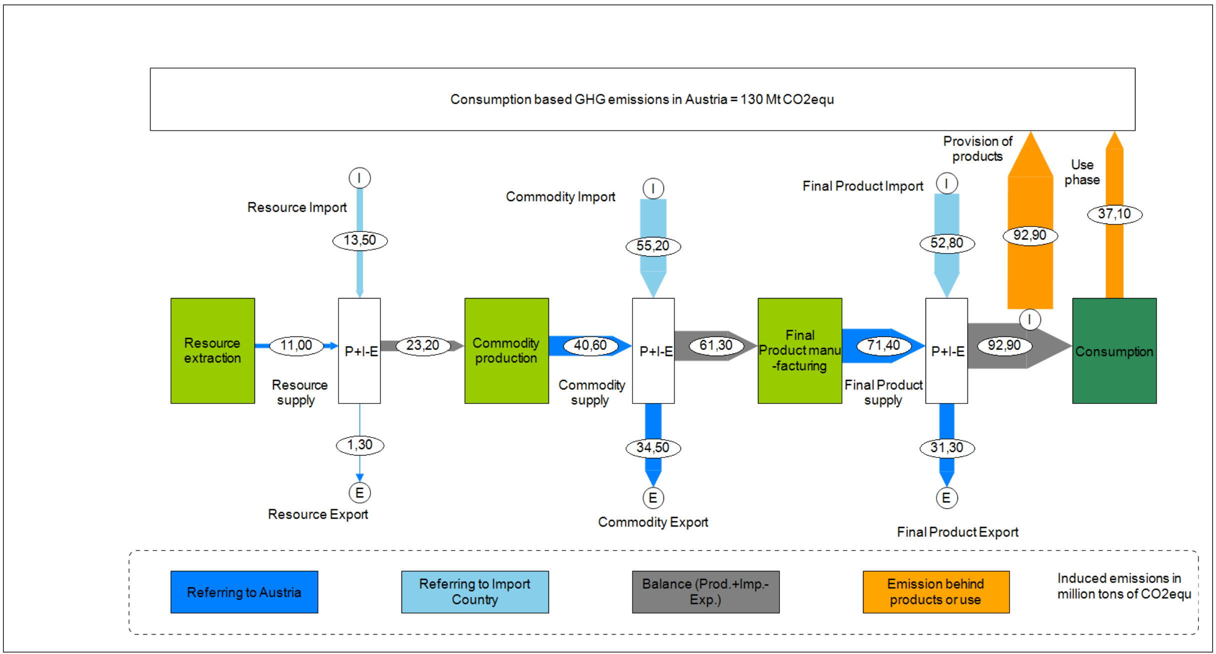

Figure 6: GHG-emissions along the process chains from Austrian consumption in 2013

In Figure 6, the emissions are shown for each step in the process chain, starting from the raw materials. The input for the next process steps, here, the basic material production, are the consumption-based emissions of raw materials (production plus import minus export). In addition to emissions from the supply of products, emissions are generated when products are used as well. This must also be taken into account (e. g. fuel consumption, space heating). These data have been taken from the national inventory.

Finally, the results for 2013 are shown in 6. The consumption-based emissions for Austria amount to almost 130 Mt CO_{2eq}. In general, emissions increase in the course of the process-chain from the raw materials up to the final products. Overall more than 90 Mt CO_{2equ} (71%) are emitted through the provision of goods (nationally and abroad) and the use of products (e.g. driving a car or heating) is in comparison rather the smaller part. The orange arrows in Figure 6 illustrate this: Product provision 92.9 mio t CO_{2eq}u, use phase 37.1 mio t CO_{2equ}. It can further be seen that the national “Final Product Supply” (Blue Arrow after Final Product Manufacturing) emits almost 72 million tons of CO2equ. 61 million out of the 72 million tons CO_{2equ} originate from the supply of commodities, both domestically and abroad. This means that commodities are responsible for about 86% of the emissions connected to the national product supply, which points out their importance in the production-chain.

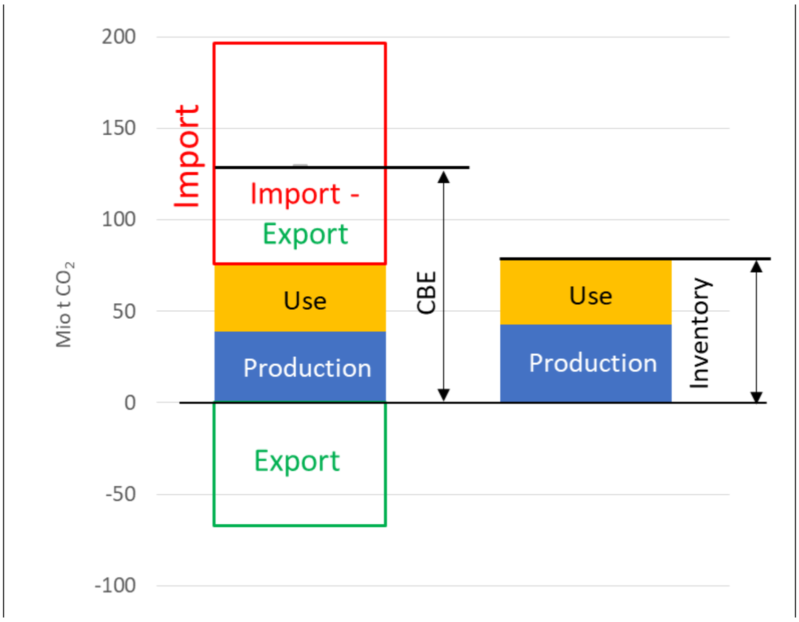

Figure 7: Comparison of the national GHG inventory and the Austrian consumption based GHG balance

Figure 7 shows the consumption-based emissions (CBE) of Austria as compared to the national inventory (production based approach), for the year 2013 more clearly. Emissions from imports (brown) dominate and emissions from the national production (blue) are comparatively small. The high technological standard and relatively clean electrical energy mix of Austria, as compared to those countries from which Austria imports, is a possible reason that emissions from national production are relatively low. From a consumption-based perspective, Austria is responsible for about 60% more emissions than from a production-based perspective (based on the year 2013). Hence, Austria is clearly a net-importer of GHG emissions.

Thus, a large part of the greenhouse gas emissions due to Austrian consumption is caused by production abroad. The results of the consumption-based emission calculation have shown that due to this approach Austria's emissions are significantly higher than those of the national inventory. Parallel to this detailed calculation for the year 2013, a somewhat simplified approach was used for the creation of a time series from 2000 to 2014 for which selected products were used instead of the entire process chain. The products were defined in line with the key categories developed by the IPCC. In turn, GHG emissions are made up of production, use, imports and exports (as shown in Figure 7). After subtracting the exports, this results in the consumption based emissions for the given time series (see Figure 8, red line).

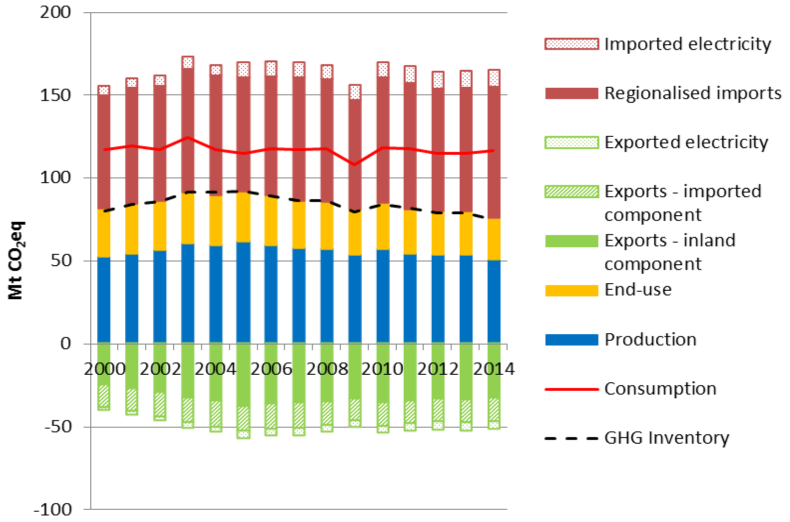

Figure 8: Consumption-based GHG emissions of Austria between 2000 and 2014

As shown in Figure 8, consumption-based emissions have remained relatively constant over the study period (2000 – 2014). The average consumption based emissions are 116.9 Mt CO_{2eq} (standard error ± 0.7%). The national GHG inventory has decreased by 18% since 2005 mostly through policies to promote renewable energy in the residential and industrial sectors. This combination means that the ratio of consumption-based to production-based emissions is increasing. In 2005 the ratio was 1.25 (i.e. 25% additional emissions are a result of imports for consumption). By 2013, the ratio was 1.45. For comparison, Munoz and Steininger (2010), using a top-down MRIO system, estimated that the ratio was 1.44 in 2004. For comparison with the "full approach", where 2013 the consumption was responsible for 130 Mt CO_{2equ} (Figure 6), the consumption-based emissions of the simplified, commodities-focused time series method were 114.9 Mt $CO_{2eq.}$ The lower results can be explained by the consideration of a limited number of "key" commodities and products to show the development during the recent years. In contrary, the first method provides a detailed picture of one year, taking into account all goods and products behind national consumption but may include double counting, even though all steps possible were attempted to reduce this possibility.

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The influence of technological standards in producing countries

A consumption-based view of national greenhouse gas emissions should incorporate the different technological standards and energy mixes in producing countries. In the project climAconsum these differences were included and possibilities for reduction the emissions coming from Austria's consumption considered. One possible way would be to lower emission intensities in the countries from which Austria imports and alternatively the countries with a less emission intensive production could be chosen for trade (i.e. a procurement policy).

These technological differences were examined with country- and sector-specific emission intensities, which were used to regionalize the life cycle based emission factors. This way each imported product obtained a distinct emission factor due to its country of production. As a consequence, even if emissions from national production are mostly decreasing; imported products however are often connected with higher emissions. This approach, certainly an advancement, still lacks of interlinkage in world trade with commodities. As mentioned in a previous article, the regionalization assumes that if a product is imported from Germany, the whole process chain takes place in Germany. This assumption does not take into account that the process chain of a passenger car may comprise imports of raw materials or commodities from countries with higher emission intensities. As the main part of Austria's imports of final products is coming from countries in Europe, the emissions might be underestimated.

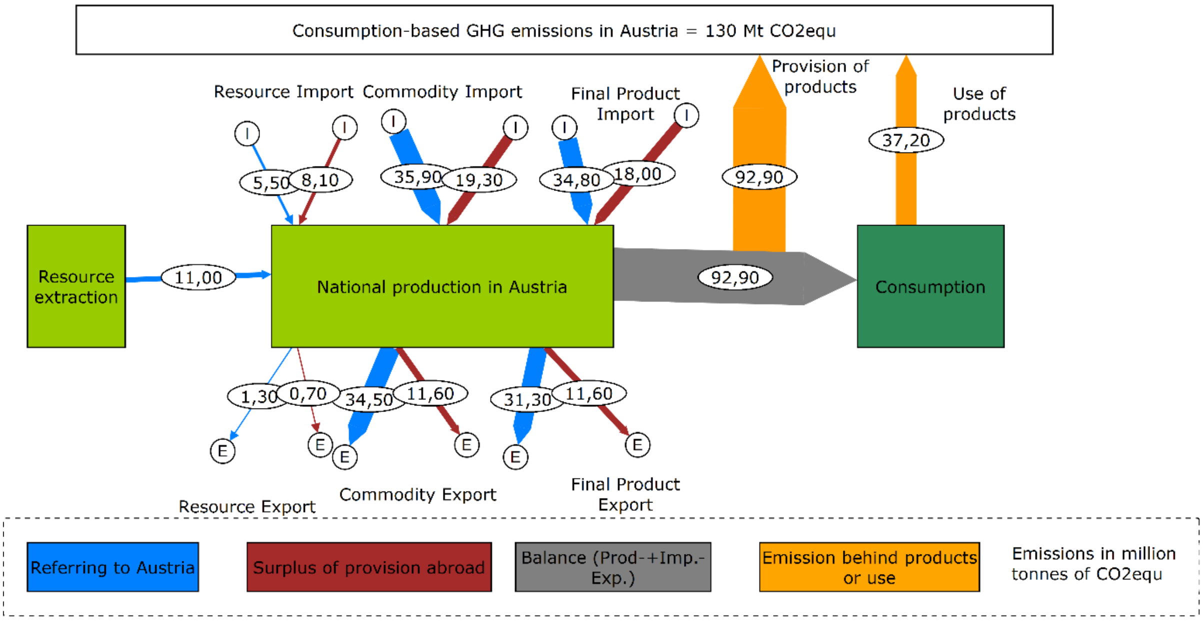

Figure 9: Influence of emission intensities on consumption based greenhouse gas emissions in Austria

Figure 9 shows a purely theoretical picture in which emissions from all imported materials and products are calculated with the Austrian equivalent emission standard. For imported raw materials for instance, more than 13 Mt CO_{2equ} are imported (5.5+8.1) in 2013. If all of these resources were provided with Austrian standard, the emissions would decrease from more than 13 to almost 5.5Mt CO_{2equ}, because of the lower emission intensity in Austria as compared to countries abroad. Overall, up to 40% of the imported emissions could get reduced globally by reintegrating production to Austria or applying similarly high technological standards and low emission intensities. However, this mainly illustrates the effects of different production standards and cannot be considered as a realistic picture of the future, as raw material availability and production capacities have not been verified. Additionally, reintegration perspectives would increase emissions in the national inventory and hinder achieving internationally announced climate targets, since these are related to production-based emissions. On the other hand, the possible relocation of Austrian production sites to countries abroad is positive for the national inventory, as domestic activities are reduced, but may result in clearly higher GHG emissions from a global perspective ("carbon leakage").

Figure 9 shows further the positive contribution through Austrian exports. If these materials and products were produced in those countries where Austria is exporting to, the GHG emissions would be clearly higher, especially for commodities and final products (both increase for 11.6 Mt CO_{2equ}). Of course, the national inventory would be reduced, but emissions on global level would rise.

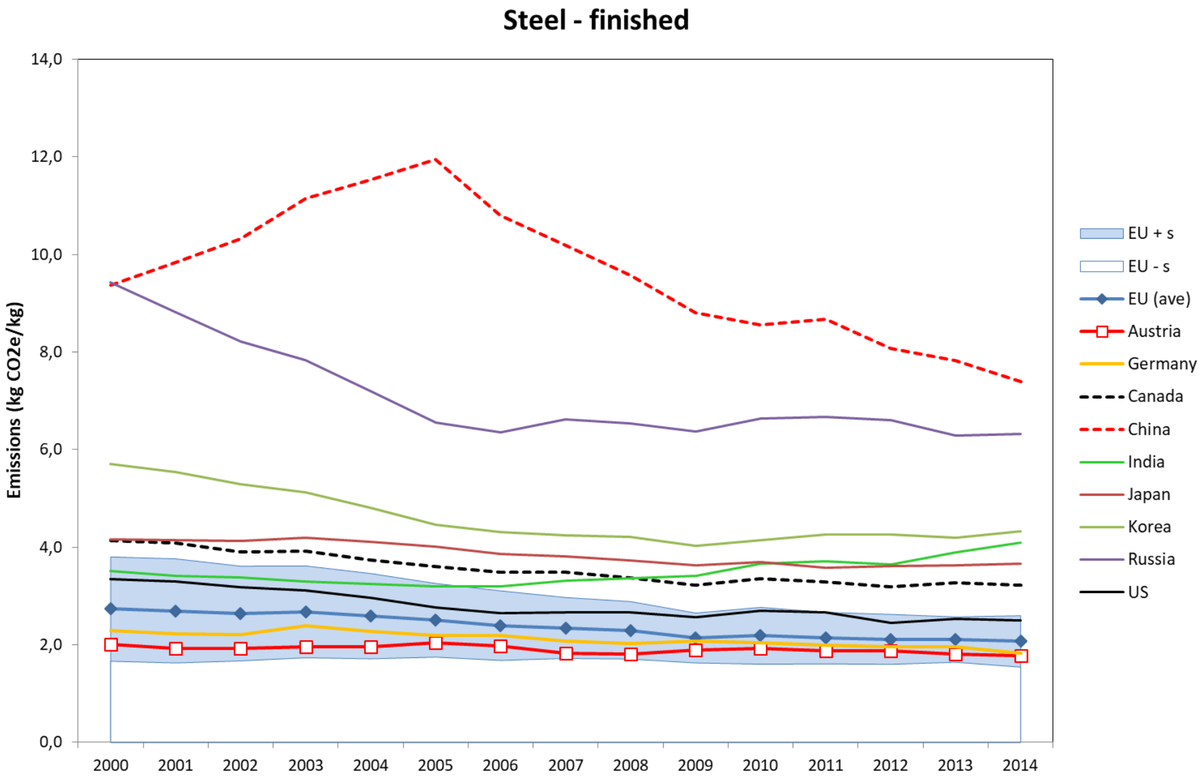

Figure 10: Influence of technology standards and energy mixes in producing countries on emission factors for steel production. EU ± s indicates the range of emission factors in the EU (i.e. the EU mean value ± 1 standard deviation)

Finally, the influence of the producing country on the emissions factors, for steel, is shown in Figure 10. The model behind this graph takes into account country-dependent industrial energy mixes, energy efficiency factors, electrical emission intensities and transportation distances and modes to Austria. The figure demonstrates that Europe is a by far the best trading option for steel in terms of GHG emissions. The figure also highlights the benefits of a national steel production as the emission factor for Austria is comparably low.

This consumption-based calculation, including industry sector- and country-specific regionalization to incorporate conditions in producing countries, points out the fundamental impact of technological standards and the emission intensity of the prevalent energy mix on greenhouse gas emissions. Austria, in particular benefits, from a very high technological standard in production and a low emission intensity of the energy mix, which leads to the advantages of national production of products.

Abstract project „climAconsum“

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An extension of Austria’s greenhouse gas emission (GHG) balance with the GHG emissions behind the foreign trade of goods will show a correct and transparent picture of the climate impacts of Austria´s consumption. To find the most climate intensive materials, their origin in domestic production or countries abroad where the imports come from and herewith potentials for global climate protection measures have to be illustrated. A product-specific and technologic view in a detailed life cycle based approach is therefore applied. It combines the physical flows of materials and products with the subsequent calculation of the greenhouse gas emissions (e.g. CO_2, CH_4, N_2O) behind the consumption of products in Austria using LCA- and technology-based emission factors.

- The consumption based GHG-emissions for Austria in the year 2013 are about 130Mt CO_{2equ} and hence close to 60% beyond the emissions of the national GHG inventory.
- The national and foreign product manufacturing is responsible for the main part of GHG emissions. Austria has therefore comparatively high technological standards.
- This approach enables to depict the major emission drivers of products and their origin and consequently the examination of future perspectives due to changes in product procurement.
- Postulating constant emission intensities, an enhanced national production to substitute imported products would be a potential for global emission reductions. However, this requires an encompassing check of the feasibility as well as an analysis of possible rebound effects.

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Final report available at: https://www.klimafonds.gv.at/assets/Uploads/Projektberichte/ACRP-2014/20170913climAconsumACRP7EBB464796KR14AC7K11791.pdf

This study contributed to the foundation of the CCCA-working group: "Consumption-based GHG accounts for Austria" with the goal to build an exchange network about consumption based GHG accounting.

See: https://www.ccca.ac.at/de/ccca-aktivitaeten/arbeitsgruppen/thematische-ags/

Metaltechnology Austria

The ASSOCIATION OF METALTECHNOLOGY INDUSTRIES represents all Austrian industrial enterprises active in mechanical and plant engineering, steel construction and metalware production, which accounted in 2017 for a total production value of 37 billion Euro. This branch with more than 1,200 mainly medium-sized companies employing over 130,000 people, is the backbone of Austrian industrial employment. The top priority of the Association is to help shape the legal and economic framework conditions required for the future success and international competitivity of Metaltechnology Austria.