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EconTrans Working Paper #3

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Inhalt
In this paper we take up the challenge to integrate new aspects into macroeconomic modelling and to consider economic activities from an outcome-oriented perspective, so called functionalities. The basic idea is, that functionalities lie behind the demand for commodities and services and therefore are the actual reason for economic activities. Functionalities describe (basic) human needs, such as housing, nutrition, or mobility, and are determinants of human well-being. A crucial aspect of functionalities is the interaction between stocks and flows. The paper presents the operationalisation of functionalities within the framework of an Input-Output (IO) model. Three extensions of the IOT are performed: Firstly, an appropriate allocation of energy supply, transformation and demand to sectors is made. This allows linking the monetary structure with physical units of the total energy and useful energy balances. Secondly, greenhouse gas emissions and other material consumption were additionally allocated to sectoral production. Thirdly, groups of goods of private and public consumption as well as exports were allocated to specific functionalities.

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1. Introduction

Climate change and the associated risks represent a serious reason for initiating far-reaching changes in prevailing economic and social structures. The literature also speaks of a dual challenge: on the one hand it is the need to steer structural change towards a drastic reduction of greenhouse gas (GHG) emissions, on the other hand this must not jeopardize prosperity and well-being (Altenburg and Rodrik 2017). This requires a profound structural change, which raises questions about relevant valuation variables for a successful transformation as well as the mapping in macroeconomic models. In EconTrans we discuss the required transformation in the context of well-being and argue for a new perspective on measuring economic performance. In EconTrans we use the concept of functionalities (Köppl and Schleicher, 2018; Schinko et al.2021) as an extension or alternative to conventional socio-economic modelling approaches of the energy transition.

The extended modelling approach applied in EconTrans is motivated by the global and European policy targets and policy strategies. Policy objectives such as the Paris climate target to limit global warming to well below 2°C compared to the pre-industrial era or the UN Sustainable Development Goals define the direction of development. On the EU level, policy strategies such as the Green Deal (European Commission 2019) the EU Circular Economy Action Plan (Europäische Kommission 2020) and manifold EU regulations aiming at achieving the target of climate neutrality by mid-century translate the global goals into concrete policy projects. In this way, economic policy seeks to create framework conditions that drive structural change towards climate-neutrality and reduce market uncertainties about the direction of technological change, such as through a mission-oriented innovation policy advocated by Mazzucato (Mazzucato 2018) and others. Mazzucato (2018) defines mission-oriented policies "as systemic public policies that draw on frontier knowledge to attain specific goals or "big science deployed to meet big problems ". Climate change is one of these "big problems".

In the aftermath of the financial crisis 2008 critical voices on macroeconomic models as well as the underlying neo-classical macroeconomic paradigm were raised. For example (Stiglitz 2018) stresses that the currently dominating models miss insights from information and behavioral economics (e.g. bounded rationality). Explaining economic activity by optimization and prices alone might thus be a too simplified approach as other psychological (sometimes irrational) factors play also an important role. Focusing on the evaluation of climate change impacts, in a recent article, *Stern - Stiglitz* (2020) address the need for ongoing improvements of models to provide the basis for informed climate policy. They argue that Integrated Assessment models (IAMs) face limitations as guidance for climate policy (see also Pindyck 2013; 2015). An integrated analysis of the environment and the economy is complicated by several factors, such as the risks associated with climate change, the disparity of impacts within and across generations, the existence of market failures, and the limited policy options to address these market failures. They conclude that models commonly used tend to overestimate the costs and underestimate the benefits of climate policy.

In parallel to the critical voices regarding the use of macroeconomic models, there are alternative approaches of economic reasoning that have been developed in the context of climate change and the COVID crisis. One is linked to the capability of mainstream macroeconomics to deal with the United Nations (2015) Sustainable Development Goals. Raworth (2017) for example points at the shortcomings in conventional economic approaches like the rationality assumptions, the notion of equilibrium even in booms and recessions, the risks of ignoring energy and natural resources and equating economic growth with well-being and proposes instead seven ways to think like a 21st-century economist. Using the metaphor of a doughnut, Raworth proposes an enhanced economic paradigm that balances the needs for a life's essentials from food and shelter to culture – as the inner layer of the doughnut with its outer layer representing planetary and social boundaries.

A recent strand of thinking for reframing macroeconomics was triggered by the Covid-19 pandemic. *Mazzucato - Skidelsky*, (2020) open a discussion about record government spending for coping with the deep economic crisis. A new proposition for an adequate enhancement of macroeconomic thinking is required. They argue that the necessary emergency financing should be intimately tied with the role of the state for stimulating innovation and transition of the economy, the new keywords for framing economic policy.

Against the background of the diverse approaches in the literature, the question arises about relevant evaluation methods and measures for a successful transformation as well as mapping profound structural change in macroeconomic modelling. We emphasize that closing the gap between new strands of thinking and an ultimate operationalization of such thinking in macroeconomic modelling is of utmost relevance but extremely challenging. This working paper, which was prepared within the EconTrans[1] project, is devoted to the further development and integrating new aspects into macroeconomic models.

Hence, in the EconTrans project we take up the strands of thinking that motivate for a rethinking and extension of macroeconomics and macroeconomic modelling and take up the issue of what constitutes wellbeing beyond GDP growth (see also Schinko et al., 2021 or Stiglitz – Sen – Fitoussi, 2009) and what needs to be considered for not violating further the planetary boundaries. In our modelling endeavor we start out with two well established model classes, an input-output model and a CGE model and extend the model structures towards more realistic economic mechanisms, thereby not relying solely on rationality and optimization anymore. The results presented are far from "final" but should be regarded as first step towards a more relevant modelling framework for transition processes than the prevailing evaluation tools.

[1] The EconTrans project (Embedding climate policies into deep economic transformations) addresses interlinked challenges for economic modelling: rapid GHG emission reduction, coping with fundamental transformations triggered by breakthrough technologies, from plus-energy buildings to self-driving electric cars, enlarges the scope of conventional analysis by rethinking the indicators of well-being and extending the scope of resources.

2. Functionalities as reference for macroeconomic modelling

In previous work, the concept of energy services and functionalities was already discussed as an extension or alternative to conventional economic valuation variables, such as GDP (e.g. *Köppl et al.*, 2016; *Köppl - Schleicher*, 2019, 2018). A strand of literature which goes in a similar direction refers to human needs (Schinko, Weifner, and Köppl 2021) and the literature cited there) as well as approaches linking human needs to material use and material efficiency (see (Pauliuk et al. n.d.)

In this paper we take up the challenge to integrate new aspects into macroeconomic modeling and to consider economic activities from an outcome-oriented perspective, so called functionalities. Functionalities are based on the idea that they are the actual reason for economic activities. Functionalities describe (basic) human needs, such as housing, nutrition or mobility, and are determinants of human well-being. A crucial aspect of functionalities is the interaction between stocks and flows. Stocks are capital stocks such as buildings, vehicles or transport infrastructure, flows correspond to the associated required energy and material flows. A specific functionality can be provided by different combinations (quality) of stocks and flows and differs in its respective resource requirements or the emissions triggered. Combinations of stocks and flows are to be understood as pairs belonging together; for example, vehicles and their fuel consumption, or buildings and their heating energy demand.

Schinko et al. (2021) discuss the concept of functionalities in the context of the literature on well-being and human needs and extend the literature review with stakeholder interviews emphasizing the need for a better understanding of the impact of transformation processes on well-being. The literature review concludes that our approach to focus on functionalities, which are ultimately relevant for well-being, is compatible with the international literature and the view of stakeholders expressed in the stakeholder consultation process undertaken in the project EconTrans.

Literature also suggests the potential for innovation and disruptive technologies to dramatically reduce GHG emissions from functionalities (Schinko, Weifner, and Köppl 2021) and literature cited there. This was in principle also confirmed by the stakeholder consultation in EconTrans, which stressed potential rebound effects. Affordability of innovative technologies as well as climate knowledge and awareness of climate risks as a prerequisite for behavioral change were also emphasized.

In this paper functionalities are seen as relevant for well-being. Innovation and disruptive technologies provide low emission potential for providing functionalities. Together they represent the basis towards operationalization of functionalities in macroeconomic models. We aim at modelling well-being generating functionalities that result from the interaction between stocks and flows. For this purpose, the focus will be on three categories of functionalities: shelter, access (access to people, goods, services and places) and a category summarizing the rest "other life support". We thus present a first demonstration project for further development of macroeconomic models for an analysis of more differentiated functionalities and concrete transformation paths. These are mainly extensions of mainstream macroeconomic paradigms, although with much less emphasis given to the equilibria mechanisms of the neo-classical positions. Thus, the EconTrans approach is rather encompassing than abandoning current macroeconomic modeling practices.

3. Methodological Approach

The aim of this analysis is to reveal the physical amount of emissions and resource use that is connected to the satisfaction of functionalities and how a change of stocks (as buildings and vehicles) could influence these flows. The emission should correspond to the sectors defined by the UNFCCC National Inventory (Table A 2 in Appendix C).

A suitable method for this purpose would be the well-established method of "Input-Output-Analysis". The underlying Input-Output-Tables (IOT) are matrices that represent the monetary commodity flows between groups of companies and between companies and consumers as representatively shown in Figure 1. IOT's cover the whole economic activities in a region and aggregates the monetary flows into an abstract set of company groups called "sectors" that produce commodities[2]. These commodities are consumed in the "Final Demand" and as "intermediary commodity".

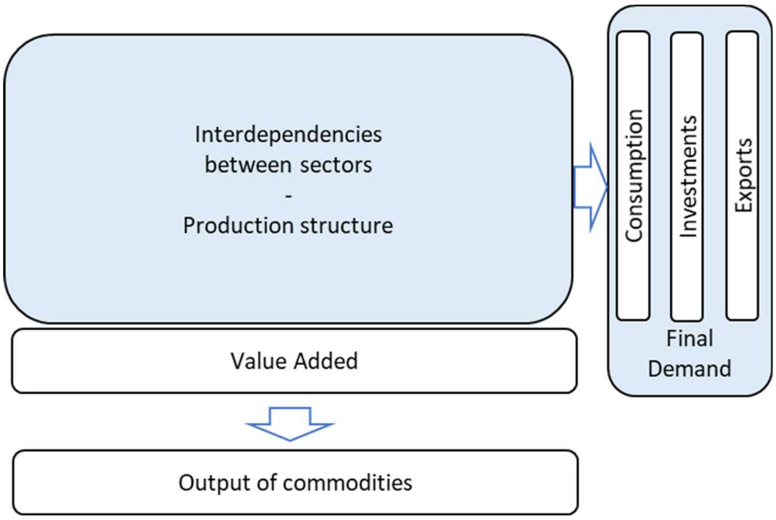


Figure 1 Structure of Input-Output-Tables

Final Demand comprises private consumers, public government, investments and exports whereas Intermediary consumption reflects the use of commodities for the production process in the sectors. This method is very useful to reveal the indirect effects of any commodity demand combination along the production chain and can shed light on the economic

[2] In the case of the official Austrian Table its 74 sectors and commodities

processes, generated value added and employment behind the consumption by applying a simple formula known as "Leontief equation" (1).

$$(I - A)^{-1} f = q \quad (1)$$

Here the term $(I-A)^{-1}$ is known as the "Leontief inverse" and comprises a unity matrix and matrix ***A*** which represents the sectoral input structure, i.e. the inputs needed to produce a sector's output. The matrix multiplication of the inverse by vector ***f***, the row-sum of final demand commodities, results in the necessary production level of each sector, ***q***.

In this analysis we apply "Supply and Use Tables", (SUT) which are also Input-Output-Tables but consist of two matrices. On one hand a "Supply" matrix and on the other "Use" matrices. The Supply matrix represents the produced commodities of each sector and the Use matrix the commodity input for production. The advantage of this structure is that it contains more information of the outputs of each sector and allows "by-products", i.e. a sector can produce more than one commodity. A slight rearrangement of (1) allows the use of SUTs instead of IOTs (2):

$$(I - DU)^{-1} Df = q \quad (2)$$

Matrix ***U*** presents the relation of used inputs (domestically produced) to the output value, i.e. the input structure. The market share matrix ***D*** contains information in which sector each commodity is produced.

Nevertheless, the usefulness of this structure to answer the question of this paper is limited, and four problems occur. First, sectors in the SUT do not fully correspond to energy statistics sectors and UNFCCC sectors. The sectors that contain energy supply and transformation are quite aggregated in the typically available national and multi-regional IOTs and SUTs. For instance, sector NACE[3] 35 comprises electricity generation/distribution, gas distribution and district heat generation/distribution. Also, all land-based transport is aggregated in one sector (NACE 49) which puts rail, freight and public transport in one sector. Hence, an analysis of the connection of energy and emissions related to specific commodity production activities is only roughly possible. This is the case in the typical official IOTs as of Eurostat[4], OECD[5] and WIOD[6] but also national SUTs from Austria's Statistical Office "Statistics Austria". The multi-regional IOT/SUT EXIOBASE[7] with over 160 sectors and 200 commodities seemed as a promising alternative and provides great detail with respect to energy related sectors. After a detailed investigation of the tables of

[3] NACE is the sectoral classification of sector used in the European Union for Input-Output Tables. See https://en.wikipedia.org/wiki/Statistical_Classification_of_Economic_Activities_in_the_European_Community

[4] At https://ec.europa.eu/eurostat/web/esa-supply-use-input-tables/data/database

[5] Inter-Country-Input-Output (ICIO)Tables at https://www.oecd.org/sti/ind/inter-country-input-output-tables.htm

[6] http://www.wiod.org/home

[7] https://www.exiobase.eu/

EXIOBASE we concluded that this data source is not suitable for the purpose of this analysis of a functionality-based perspective where we focus on Austria. The numbers for the region "Austria" in EXIOBASE do hardly match the official[8] IOT/SUT which makes it difficult to cross-reference to other official data as the energy statistics. Furthermore, the structure of the energy generation sectors does not show logical patterns. These and further aspects led to the decision not to rely on EXIOBASE.

The second shortcoming is that, in this structure the consumption of energy commodities – as natural gas and fuel oil – as well as the emissions attached to their combustion is contained implicitly hidden behind monetary values where it is unclear how much energy use in quantity terms lies behind it and at which price. This makes it difficult to clearly link SUT to energy or emissions statistics. Third, the final demand of the SUT differentiates between consumption of private households, public consumption, investments, and exports. An identification which commodities are used to satisfy which functionality is hardly possible. And fourth shortcoming, since an SUT only resembles the monetary flows of a specific year, no stock-flow relations are represented in this structure.

In this analysis we tackle each of these shortcomings and enhance the SUT and IOA in order to be able to reveal the emissions linked to functionalities. Table 1 summarizes the four steps.

	Limitations of SUT & IOA	**Solution in EconTrans**	**Chapter**
#1	Relevant sectors aggregated	Disaggregation of SUT's sectors	3.1
#2	Energy use hidden behind monetary values	Hybridization – integration of energy balance & attachment of emissions/resources	3.2
#3	No Functionalities represented	Rearrangement of Final Demand	3.3
#4	No Stock-Flow interaction	Enhancement of the IOA equations	3.4

Table 1 Limitations and Solution

The first step is to disaggregate sectors based on additional data from the statistical office in order to have a sector structure that corresponds to the sectoral structure in energy statistics. This allows to relate expanded SUT-Structure[9] with physical energy flows. This process is examined in Chapter 3.1. The aim of the second step is to replace the monetary flows of energy

[8] Publicly available at the website Austrian Statistical Institute "Statistik Austria" at http://www.statistik.at/web_de/statistiken/wirtschaft/volkswirtschaftliche_gesamtrechnungen/input-output-statistik/index.html

[9] The author is aware of the existence of the data set "physical energy flow accounts" (PEFR) that is also provided by the Austrian statistical institute. The information in PEFR will be used to allocate the final energy demand amongst the NACE sectors.

It is a great data set, however, in some parts it does not correspond to the comprehensive energy balances in a traceable way and does not easily allows to reproduce important values as "final demand".

commodities and fuels with physical values. I.e. the rows in an SUT which represent monetary values in Euro are replaced by physical values as Terajoule, cubic meters or tons. Here the full information of the energy balance can be integrated in the SUT structure. This allows a direct calculation of energy related emissions and is outlined in chapter 3.2. Chapter 3.3 outlines the approach to tackle the third limitation. Here the final commodity demand needs to be restructured to represent commodity bundles that are consumed to satisfy functionalities. To integrate stock-flow interactions to overcome the fourth limitation the attachment of gross fixed capital formation (i.e. investments) to each sector's economic activity. This simulates the assumption that a higher output level of a sector requires a higher capital stock. This allows to derive i) capital stock accumulation and ii) the final demand category "Gross Fixed Capital Formation". This means, that a specific demand, like the satisfaction of a functionality, causes not only indirect activities and emissions in sectors that produce the upstream commodities, but also those emission caused by the investments necessary to build the capital stock. Given the focus on shelter and access in EconTrans we cover the capital stocks of private cars and dwellings in this analysis. The general idea is that several stocks are available for investment. E.g. Low-Energy and a high energy dwelling. Each stock has on one hand a specific investment structure i.e. commodities needed for the investment. And on the other hand, a specific operation structure, i.e. commodities needed while operating. In each period the old stock depreciates, and new stock is added. Hence the stock in each period is a weighted mixture of stock types and their operation structures what can change over time. This structural change (in operation structure) can be introduced exogenously in the model's parameters. This enhancement and the corresponding equations are shown in chapter 0.

3.1 Disaggregation

This chapter describes the general process of the disaggregation of the monetary SUT for Austria. The sector classification in energy statistics corresponds relatively good to the UNFCCC sectors of 1A which comprise energy usage related emissions (Table A5 in Appendix C). Hence, if the SUT sector structure is corresponding well to energy statistics, it is also corresponding well to emissions statistics. The most relevant energy statistic in this analysis is the energy balance[10] for Austria. The classification in the energy balance corresponds to the 27 IEA economic and energy sectors listed in Table 2. They represent economic sectors that consume energy and energy sectors that transform and supply energy or fuels.

		Corresponding NACE Sectors	
Economic Sectors		**Original SUT**	**EconTrans SUT**
I1	Iron & steel industry	24	24A
I2	Chemical and Petrochemical industry	20,21	20,21
I3	Non-ferrous metal industry	24	24B
I4	Non-metallic Minerals	23	23
I5	Transport Equipment	29	29
I6	Machinery	27,28	27,28
I7	Mining and Quarrying	05_07, 08_09	05_07, 08_09
I8	Food and Tabaco	10,11_12	10,11_12
I9	Paper, Pulp and Print	17,18	17,18
I10	Wood and Wood Products	16	16
I11	Construction	41,42,43	41,42,43
I12	Textile and Leather	13,14,15	13,14,15
I13	Non-specified (Industry)	22,31,32	22,31,32
T1	Transport services - rail	49	49A
T2	Transport services - on land (other than rail)	05-99	49B,49C,49D
T3	Transport services - via pipes	49	49E
T4	Transport services - on water	50	50
T5	Transport services - via air	51	51
O1	Public and Private Services	36,37_39,45-47, 52-99	36,37_39,45-47, 52-99
O2	Private Households	-	-
O3	Agriculture	01-03	01-03
Energy Sectors			
E1	Mining of oil and natural gas	05_07	06A (oil), 06B (gas)
E2	Mining of coal and lignite	05_07	05
E3	Refinery of oil	19	19B
E4	Cokery	19	19A
E5	Electric power generation, transmission and distribution	35	35A
E6	Manufacture of gas; distribution of gaseous fuels through mains	35	35B
E7	Steam and air conditioning supply	35	35C

Table 2 IEA sectors of energy statistics and the correspondence to NACE sectors

[10] http://www.statistik.at/web_en/statistics/EnergyEnvironmentInnovationMobility/energy_environment/energy/energy_balances/index.html

The column "Original SUT" in Table 2 shows how sectors of the original Austrian SUT correspond to the IEA categories. E.g. the energy demand of NACE 29 corresponds to the energy demand of "Transport equipment" in the energy balances. Those SUT sectors that correspond to more than one IEA sector are highlighted in orange. The problem of such a constellation is that the energy consumption or emissions of this SUT sector cannot be allocated to a specific IEA sector, but to several sectors. This means that only an aggregated form of IEA sectors could be used. For instance, the development of NACE 24 corresponds to IEA sector I1 and I3 similarly, so both IEA sectors would have to be combined to I1_I3. The same applies for IEA sectors T1_T2_T3, E1_E2 and E4_E5_E6. Consequently, any measure or change in rail transport, steel production or electricity generation is only roughly reflected. The straightforward solution is, to disaggregate the affected sectors. For SUT sectors 35 and 49 it was possible to acquire a disaggregation from the statistical office "Statistics Austria" in form of supply and use tables. For the other sectors (NACE 24, 05_07, 08_09 and 19) a "conceptual" disaggregation was performed.

The two basic ideas behind this disaggregation are on one hand to have a conceptual representation of the sector in order to allocate emissions and energy demand or add information if available. And on the other hand, it reveals the magnitude of the sector. For the sake of reproducibility, transparency and simplicity no additional information or adjustment has been used in this analysis. The steps can be divided into disaggregation of columns and rows[11].

[11] See Table A 7 for an overview of the disaggregated sectors and commodities

3.1.1 Conceptual Disaggregation (Column)

The disaggregation of columns is very basic and can be applied in all 3 Tables Supply, Use domestic, Use-imported. Figure 2 shows the process for the Use-domestic tables

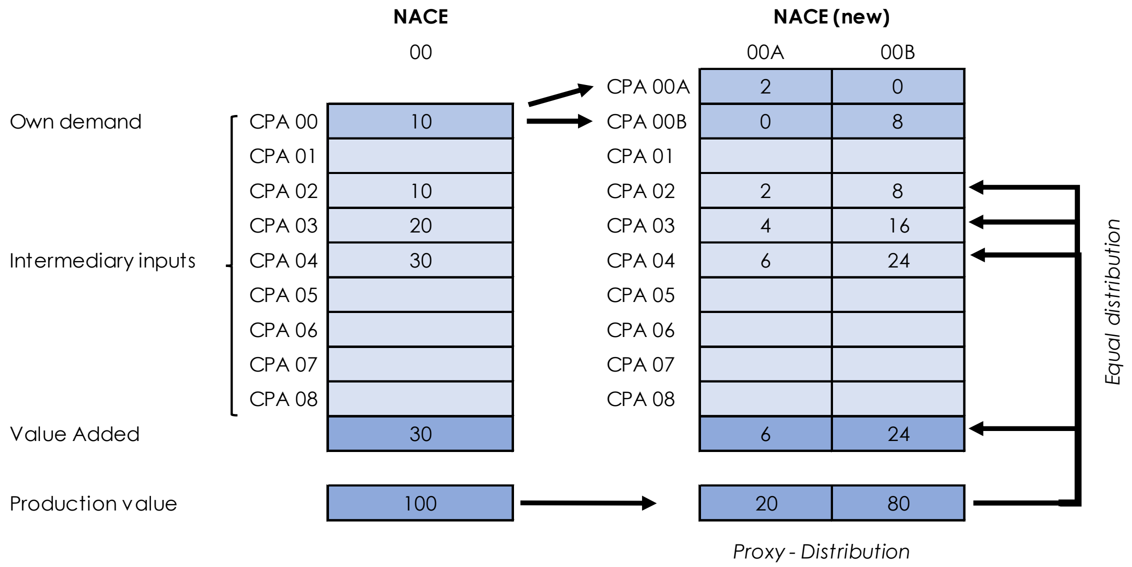


Figure 2 Principle of conceptual disaggregation (columns)

In this step we enhance columns of the Use-Table (domestic & imported) and Supply-Table. Therefore, an approximated distribution of the production value amongst the subsectors (00A und 00B) is necessary. This approximation, or proxy, can be the production value of similar or very same subsectors according to statistical data or to the production value of relatable products. The distribution of these proxy values is used to disaggregate the values of the original sector and allocate them in the subsectors structure, as indicated in Figure 2. The own demand[12] of the original column needs to be allocated among twice as much cells, because it is subject to row and column disaggregation. A simplified approach here is to distribute only diagonally and set the others to 0. The applied proxy values are listed in Table **3**.

[12] inputs from companies in the same sector

NACE/CPA	Represents	Proxy based on	Proxy value in Mio. €
05	Coal mining	Zero – no coal production in Austria	0
06A	Oil mining	Crude oil Production * international oil price	686
06B	Natural Gas mining	Crude Gas Production * international gas price	419
07	Ore mining	Turnover of company VA Erzberg[13] By-Product acc. to Supply Table (77 Mio.€)	127
08	Mining	Structural Business statistics	1.171
09	Mining services		39
19A	Cokery	Cokery is part of Basic metal company (NACE 24)	0
19B	Oil refinery	Is equal to 19	6.025
24A	Basic metals - Iron and Steel	Structural Business statistics	10.869
24B	Basic metals - Non-Ferrous metals		4.264

Table 3 **Proxy Values for conceptual disaggregation of Use- (domestic) and Supply table columns**

In Austria no coal mining (NACE 05) is active, hence the domestic production value and domestic supply are zero. Nevertheless, even though NACE 05 has a zero-production value the respective product CPA 05 is consumed in the economy via imports. Hence the row of CPA 05 in the Use-Table (imported) is not zero. For oil and gas mining[14] the actual production[15] and the average trade price for these products in the COMTRADE database are used to estimate the value of the domestic production. The production value of Ore mining comprises mainly iron ore mining. The other relevant ore mining activity in Austria (Tungsten) is not located in NACE 08 but in NACE 24 (Basic Metal Production, Non-Ferrous) because the mining company is also processing the ore and produces the metal Tungsten (company "Wolfram"). The turnover of the main iron ore producing company "VA Erzberg" is estimated to be around 50 Mio.€. According to the Supply-Table about 77 Mio. € of products that belong to CPA 08_09 (mining products and mining services). We allocate these values to NACE 05. The production value of NACE 08 and 09 are available in the "Structural Business statistics" of Statistics Austria and reveal

[13] http://www.vaerzberg.at/unternehmen/zahlen-a-fakten.html

[14] Even though oil and gas mining cannot actually be separated in two sectors since oil and natural gas occurs in the same fields and is often mined by one company, a differentiation of both commodities, natural gas and crude oil is necessary to be able to display the energy balance properly in the SUT structure.

[15] In tons according to Energy Balance 2014 (Statistik Austria)

a relatively small share of NACE 09. Sector NACE 19A would comprise Cokery, but the "Structural Business statistics" does not report any company under this subsector. The only explanation for this can be, that Cokery is part of the company that produces steel. Hence the original NACE 19 reflects oil refinery only. Nevertheless, Coke as a product (CPA 19A) will be part of the SUT. Therefore, we executed this conceptual disaggregation of NACE/CPA 19. The proxy values of NACE 24A and 24B are taken from Structural Business Statistics. NACE 24B relates to the production value of NACE C244 (Non-Ferrous Metals) and NACE 24A to the remains.

3.1.2 Conceptual Disaggregation (Rows)

The second step is the respective disaggregation of the rows and the allocation of the respective commodities – i.e. CPA 00A and 00B. In the Supply Table and Use-domestic Table the same approach as for the columns can be applied – a distribution weighted by production value proxies (see exemplarily in Supply and Use (domestic) in Figure 3). For the imports another proxy data source is needed because this information cannot be drawn from national statistics. Here the COMTRADE data set[16] is used to derive the import value proxy of each specific commodity (as crude oil, coke, natural gas or hard coal). Based on this allocation the row in Use-import Table is disaggregated.

SUPPLY (domestic)

	NACE 00	NACE 01	NACE 02	NACE 03	NACE 04	NACE 05		Domestic Supply	Imported Supply	Total Supply
CPA 00	100	5	0	0	0	0	→	105	50	155

	NACE 00A	NACE 00B	NACE 01	NACE 02	NACE 03	NACE 04	NACE 05		Domestic Supply	Imported Supply	Total Supply
CPA 00A	80	0	4	0	0	0	0	→	84	40	124
CPA 00B	0	20	1	0	0	0	0	→	21	10	31
										Trade Data (COMTRADE)	

USE (domestic)

	NACE 00	NACE 01	NACE 02	NACE 03	NACE 04	NACE 05		Domestic Demand
CPA 00	10	15	20	20	20	20	→	105

	NACE 00A	NACE 00B	NACE 01	NACE 02	NACE 03	NACE 04	NACE 05		Domestic Demand
CPA 00A	80	0	4	0	0	0	0	→	84
CPA 00B	0	20	1	0	0	0	0	→	21

USE (imported)

	NACE 00	NACE 01	NACE 02	NACE 03	NACE 04	NACE 05		Imported Demand
CPA 00	0	10	10	10	10	10	→	50

	NACE 00A	NACE 00B	NACE 01	NACE 02	NACE 03	NACE 04	NACE 05		Imported Demand
CPA 00A	0	0	8	8	8	8	8	→	40
CPA 00B	0	0	2	2	2	2	2	→	10

Figure 3 Principle of the conceptual disaggregation (rows)

[16] https://comtrade.un.org/

3.1.3 Conceptual Disaggregation (Adjustment)

After this first steps of the allocation by weights some manual adjustments are necessary. For instance, crude oil can only be an input in the oil refinery. Natural gas is either consumed directly in the refineries, by gas distribution services or power plants. After such adjustments it is possible that the row-sum of Use-domestic and supply is not equal. In that case some adjustments in the final demand category "storage" are implemented. In the case of the Austrian SUT 2014 the adjustments were minor.

3.2 Hybridization and linkage to resource use

The goal of the hybridization is, that the fuel supply, transformation and consumption processes for all fuels of the energy balance are integrated in a SUT. The advantages of such a structure is that, all energy flows relevant for an economy are represented in a single table and can be applied for Input-Output-Analysis and other modelling. By adding a link of sectoral activity to resources and emissions further aspects can be revealed.

3.2.1 Hybridisation

In the Hybridization process the values of commodities, i.e. rows in the SUT, that represent fuels or energy carriers are replaced by data sets representing physical units. The goal is that the fuel supply, transformation and consumption processes[17] for all fuels and energy carriers in the energy balance[18] are integrated in a SUT.

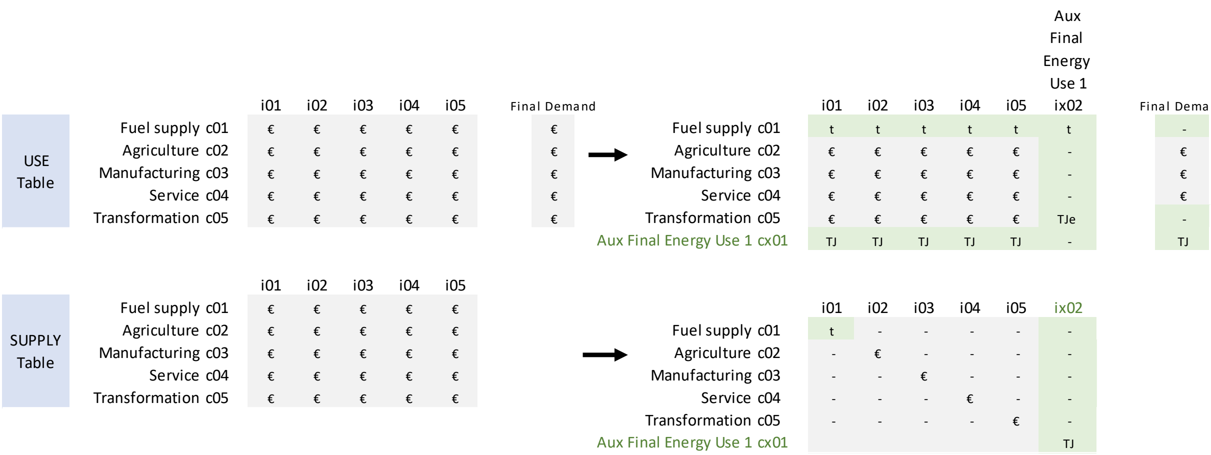


Figure 4 Simplified scheme of SUT Hybridization

Figure 4 sketches the general approach of the Hybridization process. Based on the SUT (on the left) those commodities are selected that represent fuels or energy carriers in the energy

[17] An overview of the processes per fuel/energy carrier is in Appendix in Table A 3 – Energy Balance represented in SUT (part 1)Table A 3 and Table A4

[18] 18 Fuels/Energy carriers : Coal, Coke, Blast Furnace Gas, Cokery Gas, Crude Oil, Fuel Oil, Heating Oil, Naphta, Bitumen, Natural Gas, Waste, Bio solid, Bio Gaseous, Bio Liquid, Black Liquor, Ambient heat, District Heat, Electricity

balance. The row values are replaced by values that represent physical values as tons or cubic meters. The total sum of the row is defined by the use according to the energy balance. The distribution amongst sectors is also based on the energy balance where information on transport losses, non-energy use, use of energy sectors and transformation processes is provided. In the example of Natural gas this is transport loss is consumed by sector "Gas distribution NACE 35B"; the sector "manufacturing of chemical products NACE 20" consumes Natural gas for non-energetic purposes[19]; energy sectors as "natural gas mining NACE 06B" or "oil refinery NACE 19B" consume Natural gas during their activities; and Natural gas enters a transformation process in power plants where it is transformed into electricity and/or heat; and the majority of Natural gas enters the gas pipelines for final consumption. Figure 5 provides a graphical representation of this example.

	Natural Gas Mining NACE 06B		**Oil Refinery NACE 19B**	**Chemical Products NACE 20**		**Electricity Generation NACE 35A**	**Gas distribution NACE 35B**	
	Energy Sector	…	Energy Sector	Economic Sector	…	Energy Sector	Energy Sector	…
Natural Gas (CPA 06B)	5	…	3	6	…	300	800	…
	Own demand Energy Sector Mining		Own demand Energy Sector Refinery	Non Energetic Use		Trans formation Input	Trans formation Input	

Figure 5 Graphical representation of exemplarily distribution of Natural Gas in m³

In Figure 4 the fuel is not only used for the energy system, but also for final demand. The auxiliary sector "Final Energy Demand" represents the transformation of fuels (in Tons, m³) into energy units (Terajoule). By using this auxiliary sector, it is possible to have both, the physical and the energetic representation of fuels within one SUT structure. The sum of the new auxiliary commodity "Aux Final Energy" is equal to the final energy demand of the economy, while the sum of fuel supply can be used to derive the Primary Energy Consumption or Gross Domestic Use per fuel as shown in Table 4.

[19] For the distribution of non-energetic fuel demand the Physical Energy Flow Accounts 2014 of Statistik Austria were used

Fuels/ Energy Carrier	Final Demand in 2014		Gross Energy Use 2014	
Coal	7.058	*TJ*	3.224.268	*tons*
Coke	7.215	*TJ*	1.204.007	*tons*
Blast Furnace Gas	1.145	*TJ*	0	*1000 m³*
Cokery Gas	2.578	*TJ*	0	*1000 m³*
Crude Oil	0	*TJ*	9.042.803	*tons*
Fuel Oil	343.323	*TJ*	2.671.195	*tons*
Heating Oil	56.705	*TJ*	129.406	*tons*
Naphta	0	*TJ*	-167.596	*tons*
Bitumen	0	*TJ*	124.477	*tons*
Natural Gas	183.361	*TJ*	7.435.369	*1000 m³*
Waste	10.027	*TJ*	2.156.823	*tons*
Bio solid	102.832	*TJ*	14.611.166	*tons*
Bio Gaseous	1.546	*TJ*	773.637	*1000 m³*
Bio Liquid	26.426	*TJ*	732.501	*tons*
Black Liquor	21.930	*TJ*	3.303.739	*tons*
Ambient heat	17.503	*TJ*	18.199	*TJ*
Hydro Power	0	*TJ*	147.626	*TJ*
Renewable Power	0	*TJ*	16.671	*TJ*
District Heat	66.897	*TJ*	0	*TJ*
Electricity	216.717	*TJ*	33.389	*TJ*
Total	**1.065.263**			

Table 4 Final Energy Demand and Gross Energy Use derived from Hybrid SUT

Not all fuels are represented in a commodity of the disaggregated monetary SUT. Some are side products of other activities as for instance Blast Furnace Gas, Cokery Gas or Combustible Waste. For those auxiliary commodities. These commodities are produced as a by-product of the production process of the respective sector – as basic ferrous metals (NACE 24A) or waste collection (NACE 38) - and consumed by power or heat plants.

3.2.2 Useful energy data

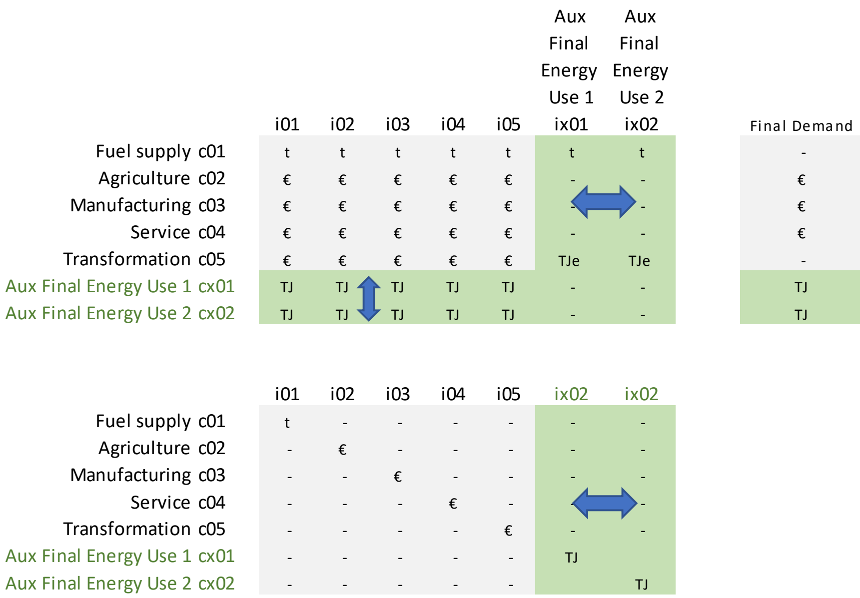
The auxiliary sector and commodity "Final Demand" has been further disaggregated. The fuels and energy carrier are allocated to "use categories" based on the "Useful Energy Analysis" Data of the Austrian Statistics Office Energy data[20]. This data set provides an allocation of final demand amongst six categories and denotes energy used for:

1. Space heating and air condition
2. Vapor production (low temperature heat)

[20] http://www.statistik.at/web_en/statistics/EnergyEnvironmentInnovationMobility/energy_environment/energy/use-ful_energy_analysis/index.html

3. Industrial furnaces (high temperature heat)
4. Stationary engines
5. Traction
6. Lighting and computing & Electrochemical purposes

Each use of each final demand fuel needs therefore an own specific auxiliary sector and commodity. A set of 84 auxiliary commodities are added to the HSUT that represent the energy use. These sectors refer for instance to "Coal for Low Temperature Heat" or "Natural Gas for Traction". Figure 6 indicates the disaggregation process graphically.



	i01	i02	i03	i04	i05	Aux Final Energy Use 1 ix01	Aux Final Energy Use 2 ix02	Final Demand
Fuel supply c01	t	t	t	t	t	t	t	-
Agriculture c02	€	€	€	€	€	-	-	€
Manufacturing c03	€	€	€	€	€		-	€
Service c04	€	€	€	€	€	-	-	€
Transformation c05	€	€	€	€	€	TJe	TJe	-
Aux Final Energy Use 1 cx01	TJ	TJ	TJ	TJ	TJ	-	-	TJ
Aux Final Energy Use 2 cx02	TJ	TJ	TJ	TJ	TJ	-	-	TJ

	i01	i02	i03	i04	i05	ix02	ix02
Fuel supply c01	t	-	-	-	-	-	-
Agriculture c02	-	€	-	-	-	-	-
Manufacturing c03	-	-	€	-	-	-	-
Service c04	-	-	-	€	-		-
Transformation c05	-	-	-	-	€	-	-
Aux Final Energy Use 1 cx01	-	-	-	-	-	TJ	
Aux Final Energy Use 2 cx02	-	-	-	-	-		TJ

Figure 6 Principe of Auxiliary Final Demand Sector disaggregation

3.2.3 Resources & emissions

The HSUT developed in this analysis aims to reproduce energy related and process CO_2 emissions in accordance to the sectoral structure of the UNFCCC National Inventory Reports (NIR)[21]. Thereby the majority of the 76,5 Mio.t. CO_2e could be represented by the HSUT.

Energy use related emissions can be derived from the HSUT. The advantage of such a Hybrid structure is, that the energy for final demand and primary energy carriers for transformation process are directly in the Use-Table. By selecting the specific "Final Demand" and "Transformation" sub-matrices in the SUT the combusted fuels for final demand or transformation can

[21] see structure and 2014 emissions in Table A 1 in appendix

be extracted. By multiplying this fuel consumption by CO_2 coefficients[22] (Table 5) the energy use related emissions can be derived[23].

Fossil Fuel	Ton CO_2 / Terajoule
Coal	94
Coke	104
Oil products	75
Natural Gas	55
Blast Furnace Gas	104
Combustable Waste	49

Table 5 CO2 coefficients for energetic use

As documented throughout the NIR and the corresponding data tables[24] (common reporting format CRF) the emission coefficients vary from country to country and depend on quality and structure of the actual used fuels. Therefore, using the coefficients from Table 5 and the energy demand according to the energy balances results in energy use related emissions (50.8. Mio.t CO_2) that deviate from the actual emission according to the NIR for 2014 (49.8 Mio.t. CO_2). The coefficients in this analysis were calibrated to reproduce the NIR 2014 values.

Process related emissions are not directly represented in the HSUT. Nevertheless, the sectors that are responsible for process emissions according the UNFCCC NIR relate quite well to NACE sectors as shown in Table 6 (see also Table A5 in Appendix C).

UNFCCC	Sector	NACE Sector
2A	Mineral Industry	23
2B	Chemical Industry	20
2C	Metal Industry	24A

Table 6 Correspondence UNFCCC NIR Sectors 2A,2B and 2C and NACE Sectors

To be able to derive process emissions that correspond with the satisfaction of functionalities (demand) a simplified approach was applied. Namely, the level of process emissions is attached to the production level of the NACE sector in the HSUT by using an emission-intensity-coefficient that represents tons CO2e per € production value).

[22] Based on National Inventory Report by Umweltbundesamt (2007) at Table 23 in https://www.umweltbundesamt.at/fileadmin/site/publikationen/REP0084.pdf

[23] See Table A2.

[24] https://unfccc.int/ghg-inventories-annex-i-parties/2021

These two emission categories, captured by the HSUT, namely energy related emissions (50 Mio.t. CO2) and process emissions of the three sectors in Table 6, make up 83 % of Austria's GHG Emissions. The remaining emissions are not analysed further and kept constant in the results.

	Domestic Extraction 2014 in Mio.t.	NACE Sector
Non-Metallic Minerals	91	08
Ferrous Ores	2.5	07

Table 7 Allocation of Domestic Mineral and Ore extraction to NACE Sectors

The same approach, a coefficient of tons per production value was used to link the domestic extraction of materials to economic activity. Even though the types of non-metallic minerals have great heterogeneity (gypsum, limestone, sand, gravel etc.) they all are produced by a single sector in the SUT, namely NACE 08 "Mining". Table 7 shows that over 90 Mio.t[25] were extracted in 2014. About 2.5 Mio.t. of iron ores were mined in Austria in the same period. These tonnages are linked to sector NACE 07 "Ore Mining".

3.3 Functionality integration

For the integration of the functionality the final demand of the SUT is restructured. This is done in two steps. The first step is to allocate the commodities from original Final Demand categories (left column in Table 8) to the functionalities.

[25] According to Material flows Accounts of Statistik Austria's Statcube ; Category MF 3 except Salt.

FINAL DEMAND	SHELTER	ACCESS	OTHER LIFE SUPPORT
Private Consumption (COICOP Categories)	Rent (04.1-04.2) Maintenance (04.3) Water supply (04.4) Energy (04.5) Furniture (05)	Vehicle Purchase (COICOP 07.1) Operation of transport equipment, incl. Fuel (07.2) Transport Services (07.3-4)	Food, Clothing, Footwear (01-03) Medical Products/Hosptial Services (06) Communication, Recreation, Education, Financial Services (08-12)
Public Consumption & Non-Profit Institutes serving Housholds (NPISH)	-	Transport services (CPA 49-52)	Other commodities - Mainly Public, Education & Health System Services
Change in Inventory/Value	-	-	allocated to Life Support
Exports	Product-wise allocation in accordance to distributions of other Final-Demand products		

Table 8 Restructuring of Final Demand categories

In the Input-Output data sets of the Austrian Statistical Office, the consumption of private households is also available in disaggregated form, namely, consumption by COICOP category[26]. In this structure 45 purposes and the corresponding commodity demand are available[27]. The full list of COICOP categories and the detailed allocation of categories to functionalities can be found in the Appendix C (Table A 6). Using this data set, the commodity demand of private households was allocated as displayed in Table 8. Public Demand and the demand for Non-Profit Institutes serving Households (NPISH) was mainly allocated to Other Life Support. An exception is the demand for Transport services which presumably relates indirectly to demand for public transport infrastructure. Changes in Inventory and Value are fully allocated to "Other Life Support" because they can be seen as a necessity of economic activities. For what purpose exported commodities are used in other countries is beyond the scope of this analysis. Therefore, a simplified assumption has been made. We assume that exported commodities are used for the satisfaction of same functionality as in Austria. This means for instance, that if a car is exported, it is used to satisfy the functionality Access. If a commodity is used for several functionalities it is distributed according to the final demand of the SUT.

Gross fixed capital formation – or gross investments – are typically also a part of a SUT's Final Demand. In the model of this analysis, investments are endogenously linked to sectoral

[26] The Classification of individual consumption by purpose, abbreviated as COICOP, is a classification developed by the United Nations Statistics Division to classify and analyze individual consumption expenditures incurred by households, non-profit institutions serving households and general government according to their purpose. It includes categories such as clothing and footwear, housing, water, electricity, and gas and other fuels.

[27] i.e. a matrix of 74 commodities by 45 categories

economic activity – i.e. If a sector's production value increases, so does the sectoral investment. Furthermore, these sectoral investments are linked to investment structures, i.e. commodities needed for the investment. The sum of the investments of each sector sums up to the final demand category "Gross Fixed Capital Formation".

FUNCTIONALITY	SATISFIER	ABBREVIATION
SHELTER	Shelter (Rent payment)	SH_RENT
	Shelter (Maintenance of Bldg.)	SH_OM
	Shelter (Energy use)	SH_ENER
	Shelter (Assessories, Furnituer etc.)	SH_ACCE
ACCESS	Access Purchase of Car	ACC_CAR
	Access Operation of Car	ACC_MIV
	Access Public Transport	ACC_PUBT
OTHER LIFE SUPPORT	Life Support Services/Products Private	LS_PRIV
	Life Support Services/Products Public	LS_PUB
	Change in inventories and values	LS_STOR
Exports	Export of Products for Shelter	SH_EXP
Exports	Export of Products for Access	ACC_EXP
Exports	Export of Products for Life Support	LS_EXP

Table 9 List of Satisfier

In the second step, the "satisfier" for the base year are defined (Table 9). These are basically a definition of a subset based on the first steps of the allocation. These satisfiers represent the commodity structures that relate to a certain aspect of the functionalities. They are indicators for the floor area of dwellings (SH_RENT), the thermal quality of buildings (SH_ENER), the motorization degree (ACC_CAR), private vehicle stock composition (ACC_MV) and population and their need for public services (LS_PUB).

These satisfiers in Table 9 represent the situation in in the base year 2014. In the model, each of these satisfiers are represented in form of level parameter and a corresponding commodity demand structure. In a simulation three aspects can be changed depending on the scenario. First, the level can be changed which reflects for instance a change in population, dwelling area or motorization degree. Second, the commodity structure of the satisfier can change due to new technologies. And third, new satisfiers can be added that replace or enhance existing ones.

By applying the model equations, the direct and indirect impact on emissions and resource use can be analyzed.

3.4 IO-Analysis and Stock-Flow Interaction

The traditional IO-Analysis (as in (1) and (2)) is only able to investigate the impact of a change of flows caused by a change of an exogenous flow demand (final demand).

In EconTrans we not only want to shed light on emissions that correspond to the satisfaction of functionalities but also investigate a more disaggregated view regarding the stock flow interactions. We aim to reveal two aspects. First, what are the necessary investments (due to stock build-up) behind the functionality satisfaction and how much emissions are connected to it. And second, what implications does a change in stock investments have due to a change of investment decisions, for instance diesel trucks vs. electric trucks or average dwellings vs. high standard dwellings with respect to emissions caused by the altered investment and with respect to the change in emissions during operation.

To enable such a perspective the traditional IO-Analysis is enhanced not only by using a Hybrid SUT (developed in Chapter 3.2) to calculate the corresponding emissions, but also expands the set of equations in order to differentiate between an investment and an operating phase. In combination with restructured final demand (chapter 3.3) this then allows to investigate emissions caused by investments for the satisfaction of functionalities and during operation.

The starting point is the calculation of the commodity demand that corresponds to the satisfaction of functionalities $\boldsymbol{f^S}$ in year t (3). There $\boldsymbol{f^S_{2014}}$ represents the sum of commodities[28] consumed in the base year (in the case of EconTrans it is 2014) by the satisfier[29] $\boldsymbol{s}$. Φ^S contains the commodity structure of the respective satisfier. I.e. the multiplication of the two right hand terms result in the commodity demand for satisfier $\boldsymbol{s}$ in 2014. $\boldsymbol{\lambda^S}$ is an exogenous parameter of the analysis and indicates the level in form of an index. I.e. $\boldsymbol{\lambda^S}$ is 1 in the base year and its development is exogenously determined depending on the scenario design. For instance, the parameter $\boldsymbol{\lambda^{Shelter\_Rent}}$. The satisfier "Shelter_Rent" represents the expenditures for imputed and actual rent and thereby is a proxy for the floor area for dwellings in Austria. An increase of this parameter rover time indicates a change in total floor area that can reflect population growth.

$$f_t{}^s = \lambda_t^s . f_{2014}^s \Phi_t^s \qquad (3)$$

$$f_t = \sum_s f_t^s \qquad (4)$$

$$(I - DU)^{-1} D f_t = q_{t,1} \qquad (5)$$

The sum of all satisfaction vectors (4) results in the final demand vector $\boldsymbol{f}$, that represents the direct commodity demand for functionalities satisfaction. However, this vector does not comprise one element of the total final demand, namely gross fixed capital formation, i.e. investments. Hence the resulting sectoral production $\boldsymbol{q_1}$ represents only the first part of sectoral activity that is linked to functionalities.

[28] Can be monetary or a combination of monetary and physical units

[29] The satisfiers are listed in Table 9

In EconTrans investments are interpreted as a necessity to sustain a certain production level. If production increases, then a higher average investment is necessary (e.g. due to depreciation) is necessary to maintain the higher production level. Equation (6) and (7) show the derivation of the final demand vector that resembles gross fixed capital formation, ***i***.

This vector ***i***, is the sum of vectors that represent several investment categories ***g.*** These categories are Gross Capital Formation of "Machinery", "Transport Equipment", "Dwellings", "Other Buildings and Structures", "Cultivated Assets" and "Intangible Assets". These categories correspond to categories that are already represented in the original SUT of Statistics Austria and to categories used in datasets as the "EUKLEMS" project[30]. Investments are directly connected to the production level caused by the satisfaction of functionalities $\boldsymbol{q_1}$ via a constant parameter $\boldsymbol{\alpha}$.

$$i_t^g = \alpha_t^g q_{t,1} \Gamma^g \quad (6)$$

$$i_t = \sum_s i_t^g \quad (7)$$

Due to the focus of EconTrans on Shelter it is important to have investments in dwellings separately. However, the available data sets on sectoral investment commodity structures[31] comprised only the commodity demand for total investments, not structures per category. To overcome this problem, the investment commodity structures of Statistics Austria were combined with the total investment per categories and sector[32] from EUKLEMS. The investment structure provides the commodities used for investment of each sector and the investment categories provide information in which of the 6 options each sector invests. Using "iterative proportional fitting"[33] was used to derive 6 investment matrices that resemble the commodity investment of each sector per investment category. The result of this process are 6 matrices that represent the commodity structure of investment per sector and category ***g***, $\boldsymbol{\Gamma^g}$.

$$(I - DU)^{-1} D(i_t) = q_{t,2} \quad (8)$$

The demand caused by the investment activities is then again used to derive the corresponding production activities $\boldsymbol{q_2}$ by applying the Leontief equation again in (8). This results in two sectoral production levels, $\boldsymbol{q_2}$ and $\boldsymbol{q_1}$. They can be used to reproduce a USE table by multiplying the ***U*** matrix and the production level ***q***. Hence, by using these sequences of equations and the HSUT, emissions, energy and material demand can be derived that corresponds to operation and investment phases.

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[30] Euklems.eu

[31] Investment matrix for 74 commodities (CPA) per 74 sectors (NACE) from the Input-Output-Table data set of Statistics Austria

[32] https://euklems.eu/downloads/ Capital data set for Austria

[33] Also known as „RAS" https://en.wikipedia.org/wiki/Iterative_proportional_fitting

4. Results - Functionality related Emissions in 2014

In this chapter the developed HSUT (Chapter 3.1, 3.2 and 3.3) and Model (chapter 3.4) were applied to derive emissions, energy demand and material extraction for the base year, 2014.

4.1 Emissions connected to functionalities

The GHG emissions of the year 2014 amount to over 76 Mio.t. CO2e. Figure 7 shows how much of these emissions could be allocated to satisfaction of the three functionalities[34] Shelter (green), Access (blue) and Other Life Support (yellow). About 8% - or 6 Mio.t. CO2e - of the emissions could not be allocated to any functionality (dark grey). They comprise non-CO2 emissions next to agriculture other CO2e emissions[35]. Over 40% of the emissions in Austria are related to commodities that are exported (light grey). 8% of those emissions originate from fuel export in vehicles tanks due to "fuel tourism" caused by relatively cheap gasoline and diesel, and freight transport that passes through Austria.

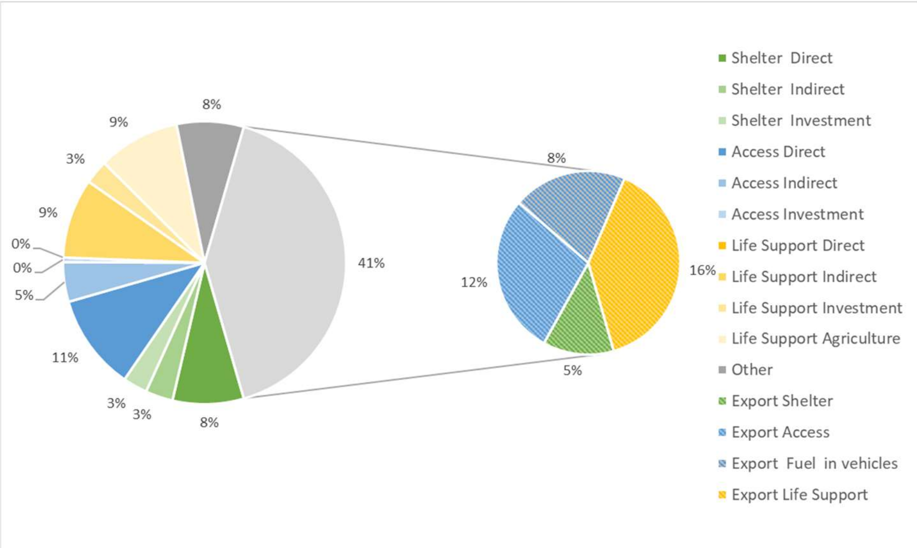

Figure 7 GHG Emissions corresponding to functionalities in 2014

The categories are further separated into direct, indirect and emissions linked to investments. Direct emissions resemble those emissions that are directly emitted for the satisfaction of the functionality. I.e. combustion in engine or heating system. Indirect emissions are those that are cause by the production of the demanded commodities. This also comprises emissions in power plants that are caused by the consumption of electricity. Investment related emissions are caused by the production of commodities for the investment activity. This can be emissions from concrete production for or emissions due to metal production for infrastructure.

[34] See Appendix **Fehler! Verweisquelle konnte nicht gefunden werden.** for a detailed representation of emissions per functionality

[35] Main sources are "Product Uses as Substitutes for ODS" (1.6 Mio.t. CO2e) and "Solid Waste Disposal" (1.3 Mio.t. CO2e)

Emissions that correspond to the satisfaction of functionality shelter amount to 14%. 8% of these are directly emitted by combustion activities for ambient room heat and hot water. The indirectly emitted 3% stem mainly from power and heat plants that produce electricity and heat for room heating and hot water. The further 3% are linked to production activities caused by the investment in dwellings and occur mainly in metal and mineral industries.

The functionality Access presents a large 11% wedge of direct emissions. That wedge represents the gasoline and diesel directly consumed by private cars in Austria [36]. 5% of Austria's emissions are emitted indirectly where almost half (~1.5 Mio.t. CO_2e) can be allocated to public transport. Public transport is also indirect, since the population is consuming a "transportation service". And this service consumes fuel (i.e. diesel) in the course of its operation. Hence, these emissions are classified as indirect. The 0.4 Mio.t.CO_2 emissions linked to investment for access satisfaction are neglectable. This is surprising since this should also comprise investments in the transport infrastructure. Either emissions related to these investments are actually minor, or the issue here can be, that in the available SUT's investments for infrastructure is not distinguished between utilization but summarized as "Other buildings and structures". Hence, due to the SUT structure and the unavailability of useable data, emissions linked to transport infrastructure might be underrepresented.

By the definition of "direct emissions" in this analysis, Other Life Support does not cause direct emissions. For instance, the heating of schools for the attending pupils are indirect emissions caused by the consumption of the service "education". Hence direct emissions here are 0. Indirect emissions amount to 9 % and investment related to 3%. Both are mainly caused in the electricity and heat generating as well as metal industries. Emissions from Agriculture are not linked to sectoral activity, but for the purpose of demonstration, presented in as a part of Life Support in Figure 7.

Emissions linked to commodity export in Austria in 2014 amount up to 33% of GHG emissions. Half of these emissions (12% of total GHG) are allocated to exports for Other Life support. The source for emissions is heterogeneously distributed amongst all UNFCCC sectors (see Table A 1 in Appendix A). The two main contributors are "Road Transport" (1.7 Mio.t CO_2e) due to transportation activities in the production process of the commodities, and the production of "Pulp and Paper" (1.2 Mio.t CO_2e) which reflects the export orientation of this sector. Of the 12% GHG emission that relate to export for the satisfaction of Access about three quarter (i.e. 9%) are surprisingly assigned to metal production whereas the 5% caused by exports for Shelter shows a heterogenous distribution amongst source industries.

Energy demand (Primary and Final) that is related to functionalities as well as domestic mineral and ore extraction have been calculated and are presented in Appendix B.

[36] Excluding 6 Mio.t.CO_2 export of fuel in (private) vehicles in accordance with the emissions report of the Environmental Agency of Austria, Umweltbundesamt in the "Klimaschutzbericht 2016" https://www.umweltbundesamt.at/fileadmin/site/publikationen/REP0582.pdf

4.2 Stock flow interaction – exemplarily application

The developed HSUT and the enhanced IO-Analysis equations can be used to simulate specific Stock-Flow constellations or developments and compare the corresponding emissions or energy demand. In the following example the implications of an improved stock of new buildings are simulated. The assumptions are a constant total building stock, a depreciation rate of the old building stock of 2% and that the new buildings need 5% more materials & costs but demand 30% less direct energy. This can be implemented in the investment equations of chapter (3.4) by an increase of the investment coefficient for the sectors NACE 68A and 68B in coefficient $\boldsymbol{\alpha}$ in (6). This increases the level of investments in dwellings uniformly. The yearly energy demand changes with the average energy demand of buildings which changes about .6%-points per year[37]. This can be realized by a respective change of coefficients that relate to the satisfier "SHELTER_ENERGY". In this case the parameter λ in equation (3).

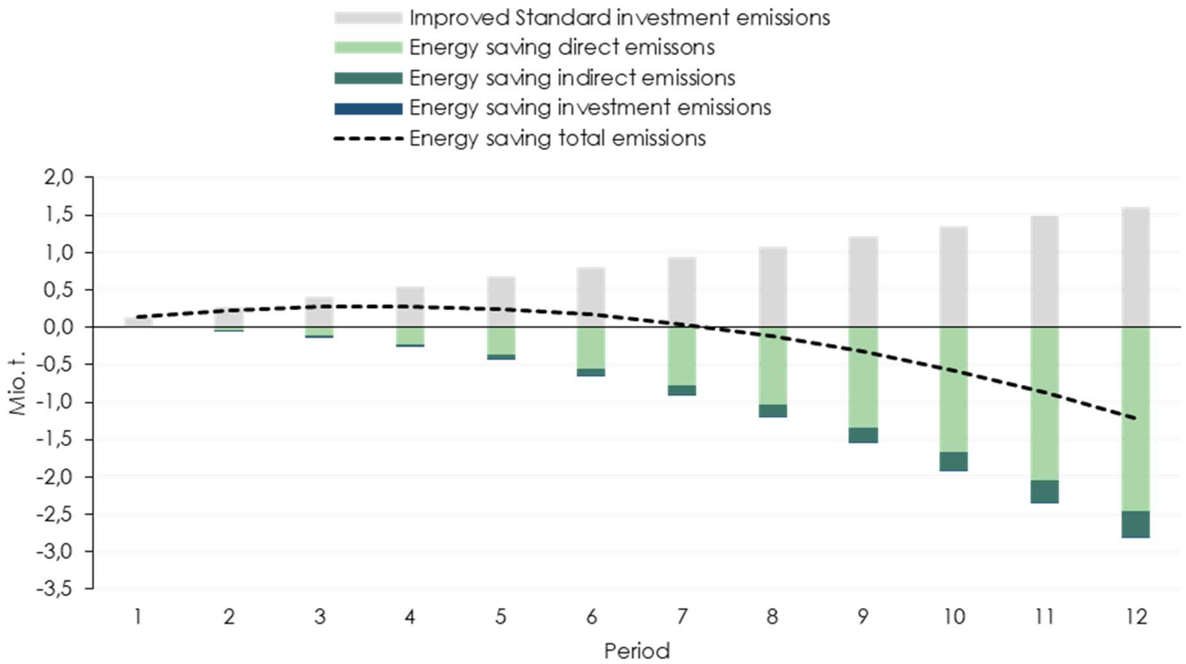

Figure 8 Example results: Increased Investments and decreased energy demand – cumulated change of emissions

For this example, a period of 12 years was simulated. For each year higher investments (+5%) and the respective decrease of direct energy demand by dwellings (~ -0.6%-points per year). Figure 1 shows the cumulative consequences of this parameter change with respect to GHG emissions. The investments increase the level of emissions by 130 kilotons of CO_2e. After 12 periods this cumulates to over 1.5 Mio.t. CO_2. The reduction of energy reduces the emission steadily since the old building stock is changing according to the depreciation and replaced by

[37] Average energy efficiency building stock = (1- 0.02 * years) + (0.02 * years) * (1- 0.3)

new buildings. After an initial increase of emissions due to investments, a net reduction of emission can be achieved after 7 years.

To summarize, based on this data set and equation structure elaborated scenarios can be developed and analyzed. In the model and data set presented here has been applied in scenarios that reflect changes in the satisfaction of Shelter and Access. (Bachner et al. 2021)

5. Conclusions and further recommendations

In this working paper we take up the functionality approach for representing well-being relevant economic structures. The challenge to translate this approach into macroeconomic modelling is demonstrated by a newly developed Input-Output model. This model includes n the one hand an extended data basis which integrates physical and monetary I-O-information. This structure is suited to represent energy related emissions and primary and final energy demand. The energy related resource data are complemented by a link to the extraction of domestic of minerals and ores.

The extended I-O analysis also depicts the differentiation between the investment phase and operating phase with respect to energy use and emissions. In this way we present a modelling framework that is suitable to capture changes in the structure and in levels of the satisfaction of functionalities and draws attention to the relevance of investment decisions on emissions over the lifetime of technologies.

The paper focuses only on a subset of functionalities of the entire economy it, however, can serve as guidance for further steps in macroeconomic modelling.

Acknowledgements

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6. References

Altenburg, Tilman, and Dani Rodrik. 2017. "Green Industrial Policy: Accelerating Structural Change towards Wealthy Green Economies." 2017.

Bachner, G., J. Mayer, L. Fischer, E. Frei, K. Steininger, M. Sommer, A. Köppl, and S. Schleicher. 2021. "Application of the Concept of 'Functionalities' in Macroeconomic Modelling Frameworks – Insights for Austria and Methodological Lessons Learned." EconTrans Working paper #3. Graz: Wegener Center.

Europäische Kommission. 2020. "Ein Neuer Aktionsplan Für Die Kreislaufwirtschaft - Für Ein Saubereres Und Wettbewerbsfähigeres Europa." COM(2020) 98 final. Brüssel: European Commission.

European Commisison. 2019. "The European Green Deal." COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE EUROPEAN COUNCIL, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS The European Green Deal COM/2019/640 Final. Brussels: European Commission.

Köppl, Angela, Claudia Kettner-Marx, Stefan Schleicher, Christian Hofer, Katharina Köberl, Jürgen Schneider, Ilse Schindler, et al. 2016. *ClimTrans2050 – Modelling Low Energy and Low Carbon Transformations. The ClimTrans2050 Research Plan*. WIFO. https://ideas.repec.org/b/wfo/wstudy/58890.html.

Köppl, Angela, and Stefan Schleicher. 2019. "Material Use: The Next Challenge to Climate Policy." *Intereconomics* 54 (6): 338–41. https://doi.org/10.1007/s10272-019-0850-z.

Köppl, Angela, and Stefan P. Schleicher. 2018. "What Will Make Energy Systems Sustainable?" *Sustainability* 10 (7): 2537. https://doi.org/10.3390/su10072537.

Mazzucato, M. 2018. "Mission-Oriented Research & Innovation in the European Union A Problem-Solving Approach to Fuel Innovation-Led Growth." Brüssel: European Commission.

Mazzucato, M., and R. Skidelsky. 2020. "Toward a New Fiscal Constitution." *Project Sindicate*, 2020. https://joserobertoafonso.com.br/toward-a-new-fiscal-constitution-mazzucato-shiller/.

Pauliuk, Stefan, Tomer Fishman, Niko Heeren, Peter Berrill, Qingshi Tu, Paul Wolfram, and Edgar G. Hertwich. n.d. "Linking Service Provision to Material Cycles: A New Framework for Studying the Resource Efficiency–Climate Change (RECC) Nexus." *Journal of Industrial Ecology* n/a (n/a). Accessed April 19, 2021. https://doi.org/10.1111/jiec.13023.

Pindyck, Robert S. 2013. "Climate Change Policy: What Do the Models Tell Us?" *Journal of Economic Literature* 51 (3): 860–72. https://doi.org/10.1257/jel.51.3.860.

———. 2015. "The Use and Misuse of Models for Climate Policy." 21097. *NBER Working Papers*. NBER Working Papers. National Bureau of Economic Research, Inc. https://ideas.repec.org/p/nbr/nberwo/21097.html.

Schinko, T., A. Weifner, and A. Köppl. 2021. "The Interaction of Energy Services, Breakthrough Technolo- Gies and Human Need Satisfaction EconTrans Working Paper #1." Working Paper. EconTrans Working Paper #1. Laxenburg: IIASA.

Stern, N., and J. Stiglitz. 2020. "The Social Cost of Carbon, Risk, Distribution, Market Failures: An Alternative Approach," National Bureau of Economic Research, , no. Working Paper 28472. https://doi.org/DOI 10.3386/w28472.

Stiglitz, Joseph E. 2018. "Where Modern Macroeconomics Went Wrong." *Oxford Review of Economic Policy* 34 (1–2): 70–106. https://doi.org/10.1093/oxrep/grx057.

7. Appendix A - Detail Results on Functionality related GHG Emissions in 2014

		SHELTER			ACCESS			OTHER LIFE SUPPORT			SHELTER	ACCESS	OTHER LIFE SUPPORT	OTHER	TOTAL
		Direct	Indirect	Investment	Direct	Indirect	Investment	Direct	Indirect	Investment	Export	Export	Export	Not Simulated	
	Total	**6.204.376**	**2.390.386**	**2.126.829**	**8.370.867**	**3.461.838**	**395.147**	**0**	**6.964.944**	**2.094.099**	**3.919.666**	**15.165.078**	**12.228.193**	**12.980.655**	**76.302.078**
1A1a	Public Electricity and Heat Production	0	1.261.531	351.052	0	199.521	81.838	0	1.709.476	422.426	506.411	323.375	1.448.913	117.869	6.422.411
1A1b	Petroleum Refining	0	208.275	50.794	0	687.493	10.940	0	195.940	56.312	232.910	829.837	441.070	6.333	2.719.904
1A1c	Manuf. of Solid Fuels a. Oth. Energy Industries	0	40.991	5.823	0	8.202	1.168	0	52.005	6.436	65.928	18.502	48.993	1.145	249.192
1A2a	Iron and Steel	0	13.735	22.954	0	6.368	15.220	0	85.238	40.800	81.417	915.737	450.047	1.564	1.633.079
1A2b	Non-Ferrous Metals	0	2.520	4.257	0	1.170	2.843	0	-2.623	7.537	14.997	171.855	83.625	502	286.684
1A2c	Chemicals	0	32.005	17.702	0	53.497	3.636	0	104.839	25.727	378.667	72.942	703.417	10.292	1.402.725
1A2d	Pulp, Paper and Print	0	22.416	16.138	0	13.334	3.364	0	155.738	25.527	302.082	31.045	1.159.943	33.338	1.762.924
1A2e	Food Processing, Beverages and Tobacco	0	9.246	2.986	0	4.845	659	0	416.908	5.130	7.656	5.382	462.211	1.423	916.446
1A2f	Non-Metallic Minerals	0	82.826	275.921	0	21.419	27.373	0	160.972	207.007	484.123	67.413	347.739	17.517	1.692.310
1A2g7	Off-road vehicles and other machinery	0	72.517	313.074	0	15.778	33.949	0	116.421	244.849	41.245	44.526	166.367	49.068	1.097.794
1A2g8	Other Manufacturing Industries	0	58.298	137.275	0	20.828	21.403	0	143.758	124.642	358.745	227.440	637.533	39.381	1.769.303
1A3a	Domestic Aviation	0	864	605	0	24.363	135	0	6.850	852	819	10.652	4.577	855	50.570
1A3b	Road Transportation	0	202.747	166.006	8370867,37	2.200.242	33.344	0	1.733.065	192.413	321.173	6.335.320	1.785.040	214.152	21.554.370
1A3c	Railways	0	2.439	2.422	0	51.811	486	0	20.189	2.856	5.026	11.406	23.073	8.995	128.702
1A3d	Domestic Navigation	0	542	305	0	1.807	59	0	2.374	368	768	2.399	2.810	725	12.158
1A3e	Other Transportation	0	31.925	5.084	0	8.930	1.175	0	18.747	5.750	17.610	170.026	244.292	498	504.038
1A4a	Commercial/Institutional	0	69.529	52.384	0	35.055	7.668	0	806.259	51.471	27.731	31.185	127.744	8.197	1.217.223
1A4b	Residential	6204375,73	0	0	0	0	0	0	0	0	0	0	0	314.975	6.519.350
1A4c	Agriculture/Forestry/Fishing	0	7.879	7.958	0	4.315	1.000	0	411.603	15.762	9.682	5.062	432.322	114.977	1.010.558
1A5a	Stationary combustion	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1A5b	Mobile combustion - Military	0	0	0	0	0	0	0	0	0	0	0	0	49.521	49.521
1B	Fugitive Emissions from Fuels	0	0	0	0	0	0	0	0	0	0	0	0	438.109	438.109
2A	Mineral Industry	0	167.453	540.949	0	35.392	51.514	0	238.404	388.983	357.073	107.147	472.701	362.316	2.721.932
2B	Chemical Industry	0	16.457	9.103	0	27.508	1.870	0	53.908	13.229	194.709	37.507	361.695	94.460	810.445
2C	Metal Industry	0	86.190	144.037	0	39.960	95.504	0	534.874	256.022	510.895	5.746.321	2.824.082	15.657	10.253.543
2D	Non-Energy Products from Fuels and Solvent Use	0	0	0	0	0	0	0	0	0	0	0	0	138.145	138.145
2E	Electronics Industry	0	0	0	0	0	0	0	0	0	0	0	0	97.121	97.121
2F	Product Uses as Substitutes for ODS	0	0	0	0	0	0	0	0	0	0	0	0	1.585.854	1.585.854
2G	Other Product Manufacture and Use	0	0	0	0	0	0	0	0	0	0	0	0	401.178	401.178
2H	Other (please specify)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Total Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	7.132.240	7.132.240
4	Land Use, Land Use Change and Forestry	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5A	Solid Waste Disposal	0	0	0	0	0	0	0	0	0	0	0	0	1.363.799	1.363.799
5B	Biological Treatment of Solid Waste	0	0	0	0	0	0	0	0	0	0	0	0	172.251	172.251
5C	Incineration and Open Burning of Waste	0	0	0	0	0	0	0	0	0	0	0	0	2.059	2.059
5D	Waste Water Treatment and Discharge	0	0	0	0	0	0	0	0	0	0	0	0	186.141	186.141
5E	Other (please specify)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	Other (please specify)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
none	none	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A 1 GHG Emissions by functionality

8. Appendix B - Results on Energy and Material Demand in 2014

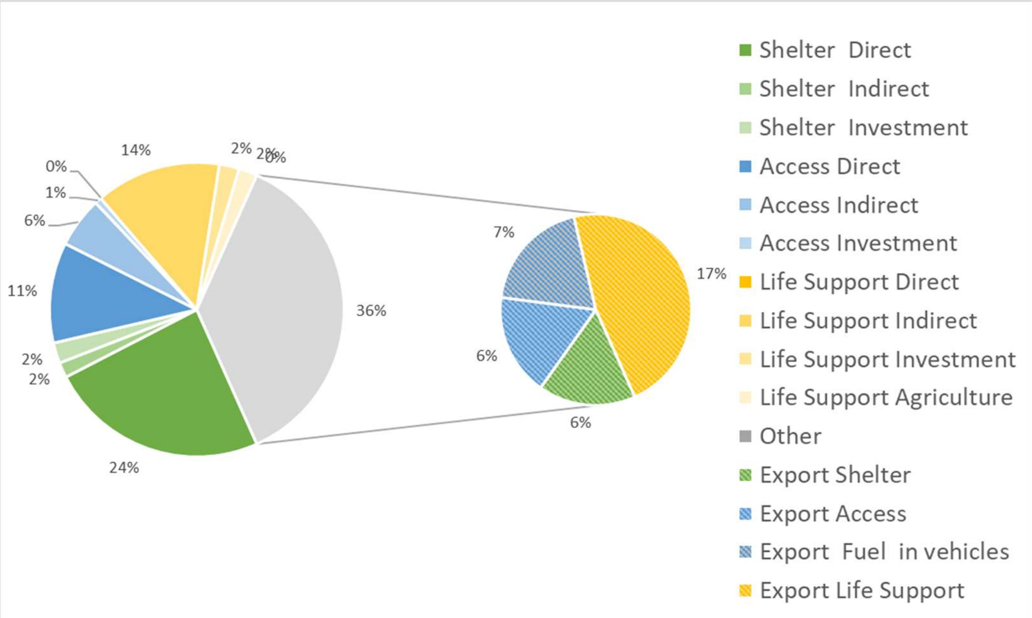

Figure A 1 Final Energy Demand related functionalities

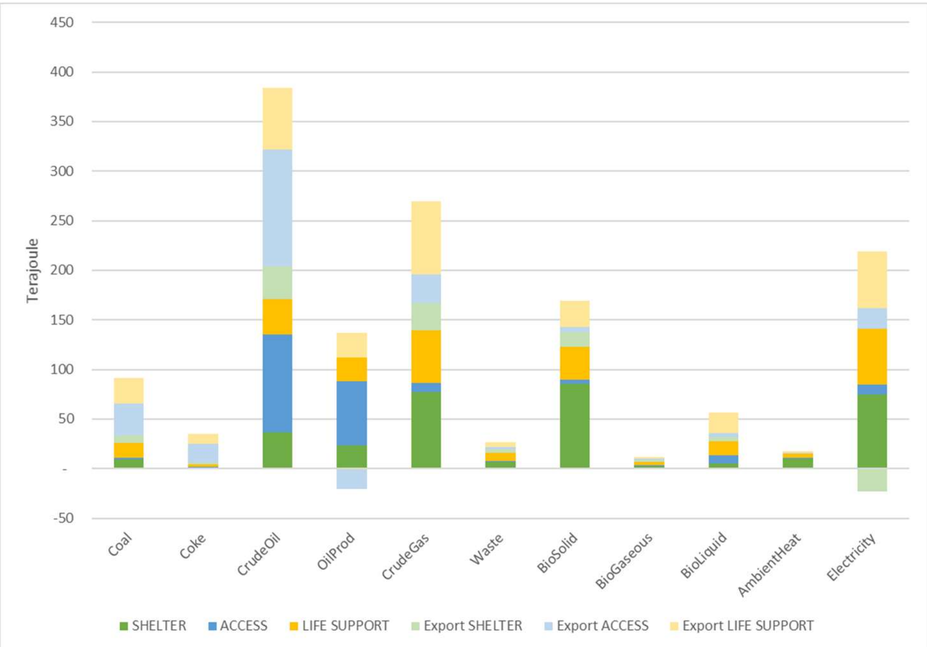

Figure A 2 Primary Energy Use related functionalities

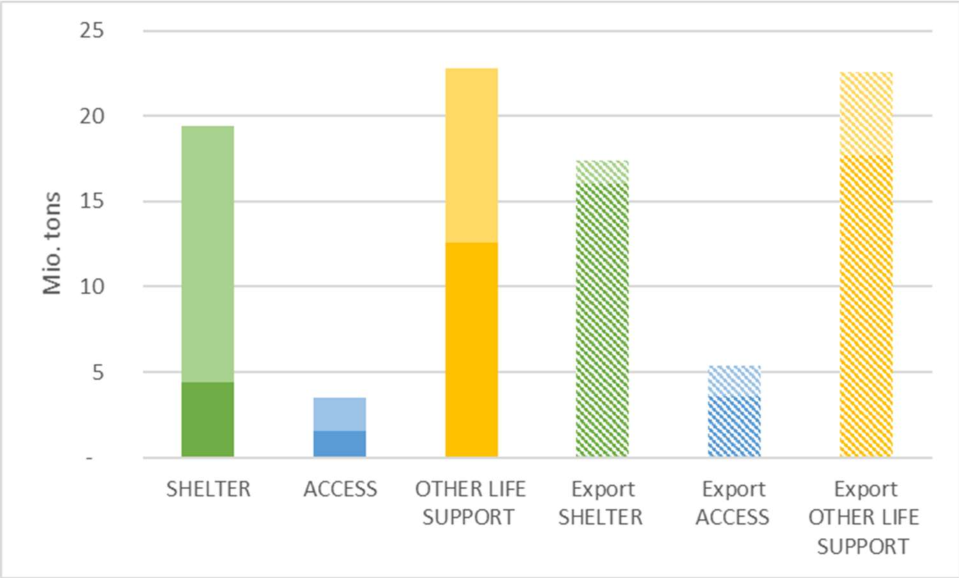

Figure 9 Minerals extraction related to functionalities

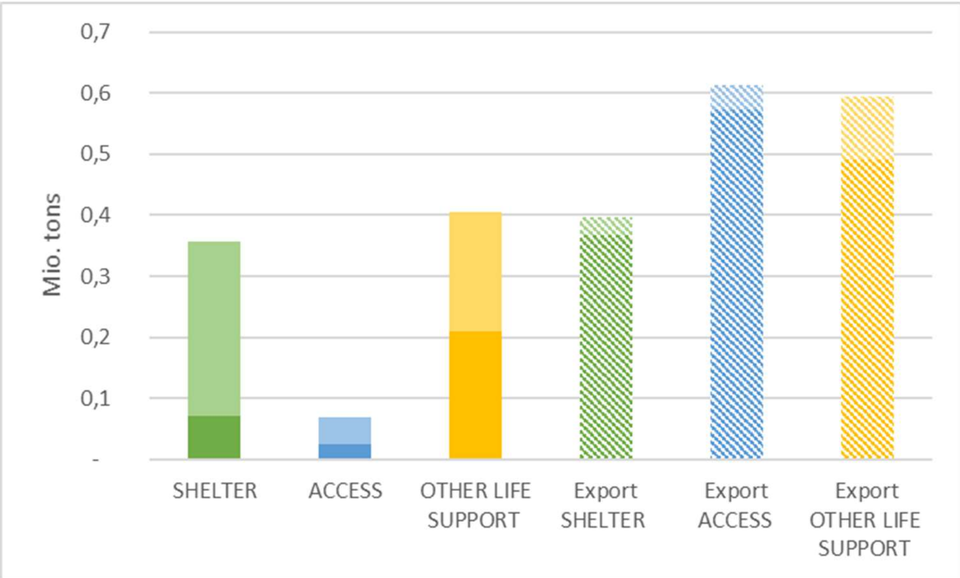

Figure 10 Iron Ore extraction related to functionalities

9. Appendix C – Auxiliary Tables and Figures

		Emissions CO2	Emissions nonCO2
		in 1000 t	
	Total (without LULUCF)	**64.084**	**12.419**
1A1a	*Public Electricity and Heat Production*	6.337	118
1A1b	*Petroleum Refining*	2.713	6
1A1c	*Manufacture of Solid Fuels and Other Energy Industries*	247	1
1A2a	*Iron and Steel*	1.632	2
1A2b	*Non-Ferrous Metals*	286	1
1A2c	*Chemicals*	1.392	10
1A2d	*Pulp, Paper and Print*	1.727	33
1A2e	*Food Processing, Beverages and Tobacco*	915	1
1A2f	*Non-Metallic Minerals*	1.613	18
1A2g7	*Off-road vehicles and other machinery*	1.103	49
1A2g8	*Other Manufacturing Industries*	1.672	39
1A3a	*Domestic Aviation*	50	1
1A3b	*Road Transportation*	21.316	214
1A3c	*Railways*	119	9
1A3d	*Domestic Navigation*	11	1
1A3e	*Other Transportation*	503	0
1A4a	*Commercial/Institutional*	1.215	8
1A4b	*Residential*	6.204	315
1A4c	*Agriculture/Forestry/Fishing*	895	115
1A5a	*Stationary combustion*	0	0
1A5b	*Mobile combustion - Military*	49	1
1B	*Fugitive Emissions from Fuels*	169	269
2A	*Mineral Industry*	2.722	0
2B	*Chemical Industry*	716	94
2C	*Metal Industry*	10.238	16
2D	*Non-Energy Products from Fuels and Solvent Use*	138	0
2E	*Electronics Industry*	0	97
2F	*Product Uses as Substitutes for ODS*	0	1.586
2G	*Other Product Manufacture and Use*	0	401
2H	*Other (please specify)*	0	0
3	*Total Agriculture*	101	7.132
4	*Land Use, Land Use Change and Forestry*	-4.761	158
5A	*Solid Waste Disposal*	0	1.364
5B	*Biological Treatment of Solid Waste*	0	172
5C	*Incineration and Open Burning of Waste*	2	0
5D	*Waste Water Treatment and Discharge*	0	186
5E	*Other (please specify)*	0	0
6	*Other (please specify)*	0	0

Table A 2 Austria's GHG Emissions acc. to UNFCCC in 2014

	Coal	Coke	last Furnace Gc	Cokery Gas	Crude Oil	Fuel Oil	Heating Oil	Naphta	Bitumen
	TJ	*TJ*	*TJ*	*TJ*	*TJ*	*TJ*	*TJ*	*TJ*	*TJ*
Supply									
Dom.Production	4	0	0	0	41.475	0	0	0	0
Imports	92.815	35.436	0	0	331.655	188.866	35.974	0	11.451
Inventory	-1.652	-500	0	0	-1.046	431	2.145	-96	-191
Change	0	0	0	0	11.887	-4.003	-7.884	0	0
Exports	14	12	0	0	41	71.767	24.821	7.681	6.057
Gross Domestic Use	**91.153**	**34.924**	**0**	**0**	**383.931**	**113.528**	**5.414**	**-7.776**	**5.203**
Transformation - Input									
Cokery	51.431	0	0	0	0	0	0	0	0
Steel - Blast furnace	0	36.269	0	0	0	0	0	0	0
Refinery	0	0	0	0	382.328	0	0	0	0
Wood Char	0	0	0	0	0	0	0	0	0
Power Plant	19.951	0	15.371	2.595	0	0	105	0	0
CHP Plant	5.991	0	781	176	0	0	7.210	0	0
Heat Plant	0	0	0	0	0	0	1.522	0	0
Gas Production	0	0	0	0	0	0	0	0	0
Transformation - Output									
Cokery	0	38.592	0	10.087	2.193	0	0	0	0
Steel - Blast furnace	0	0	34.818	0	0	0	0	0	0
Refinery	0	0	0	0	0	229.955	87.010	45.269	13.137
Wood Char	0	0	0	0	0	0	0	0	0
Power Plant	0	0	0	0	0	0	0	0	0
CHP Plant	0	0	0	0	0	0	0	0	0
Heat Plant	0	0	0	0	0	0	0	0	0
Gas Production	0	0	0	0	0	0	0	0	0
Demand of Sector Energy									
Oil Gas Mining	0	0	0	0	0	0	0	0	0
Coal Mining	0	0	0	0	0	0	0	0	0
Refinery	0	0	0	0	0	0	15.419	0	0
Cokery	0	0	3.933	288	0	0	0	0	0
Elec.,Gas,Heat .Dist	0	0	0	0	0	0	0	0	0
Steel - Blast furnace	6.683	29.337	12.808	4.446	2.439	0	4.699	0	0
Final Demand									
Steel	0	6.333	1.145	2.578	0	8	76	0	0
Chemical	832	0	0	0	0	0	736	0	0
NonFerrous	0	149	0	0	0	11	268	0	0
Minerals	2.729	3	0	0	0	21	2.463	0	0
Transport Equipment	0	0	0	0	0	1	71	0	0
Machinery	0	0	0	0	0	9	965	0	0
Mining	0	0	0	0	0	107	242	0	0
Food	0	185	0	0	0	4	1.146	0	0
Paper	2.903	0	0	0	0	9	382	0	0
Wood products	0	0	0	0	0	28	506	0	0
Construction	0	0	0	0	0	7.456	813	0	0
Textile	0	0	0	0	0	0	92	0	0
Other Manuf.	0	0	0	0	0	0	229	0	0
Rail	5	0	0	0	0	1.657	0	0	0
Land Transport	0	0	0	0	0	294.061	740	0	0
Pipe Transport	0	0	0	0	0	0	0	0	0
Internal Naviation	0	0	0	0	0	1.019	0	0	0
Air	0	0	0	0	0	28.506	0	0	0
Services	0	1	0	0	0	1.079	5.954	0	0
Private Households	577	531	0	0	0	0	41.462	0	0
Agriculture	13	12	0	0	0	9.344	560	0	0
Total	**7.058**	**7.215**	**1.145**	**2.578**	**0**	**343.323**	**56.705**	**0**	**0**
Other Demand									
Transport Loss	0	0	780	3	0	0	0	0	0
Non-Energetic	38	695	0	0	1.357	159	6.763	37.492	18.340

Table A 3 – Energy Balance represented in SUT (part 1)

	Natural Gas	Waste	Bio solid	Bio Gaseous	Bio Liquid	Black Liquor	Ambient heat	Hydro Power	Renewable Power	District Heat	Electricity
	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ
Supply											
Dom.Production	45.426	26.843	160.533	11.899	16.441	30.329	18.199	147.626	16.671	0	0
Imports	349.316	0	19.225	0	21.672	0	0	0	0	0	96.162
Inventory	-40.759	0	-4	0	49	0	0	0	0	0	0
Change	0	0	0	0	0	0	0	0	0	0	0
Exports	83.205	0	9.597	0	11.701	0	0	0	0	0	62.773
Gross Domestic Use	**270.778**	**26.843**	**170.157**	**11.899**	**26.462**	**30.329**	**18.199**	**147.626**	**16.671**	**0**	**33.389**
Transformation - Input											
Cokery	0	0	0	0	0	0	0	0	0	0	0
Steel - Blast furnace	0	0	0	0	0	0	0	0	0	0	0
Refinery	0	0	0	0	11.307	0	0	0	0	0	0
Wood Char	0	0	91	0	0	0	0	0	0	0	0
Power Plant	4.322	6.791	17.955	9.887	1	876	97	147.626	16.671	0	0
CHP Plant	43.011	6.495	24.922	389	0	7.523	0	0	0	0	0
Heat Plant	12.747	1.523	24.393	76	22	0	599	0	0	0	0
Gas Production	0	0	0	0	0	0	0	0	0	0	0
Transformation - Output											
Cokery	0	0	0	0	0	0	0	0	0	0	0
Steel - Blast furnace	0	0	0	0	0	0	0	0	0	0	0
Refinery	0	0	0	0	11.307	0	0	0	0	0	0
Wood Char	0	0	36	0	0	0	0	0	0	0	0
Power Plant	0	0	0	0	0	0	0	0	0	0	190.657
CHP Plant	0	0	0	0	0	0	0	0	0	43.794	31.148
Heat Plant	0	0	0	0	0	0	0	0	0	34.909	0
Gas Production	0	0	0	0	0	0	0	0	0	0	0
Demand of Sector Energy											
Oil Gas Mining	3.325	0	0	0	0	0	0	0	0	0	1.064
Coal Mining	0	0	0	0	0	0	0	0	0	0	0
Refinery	3.153	0	0	0	12	0	0	0	0	0	3.081
Cokery	89	0	0	0	0	0	0	0	0	0	107
Elec.,Gas,Heat .Dist	247	0	0	0	0	0	1	0	0	0	17.676
Steel - Blast furnace	5.997	2.007	0	0	0	0	0	0	0	0	4.261
Final Demand											
Steel	16.889	0	2	26	0	0	0	0	0	246	8.572
Chemical	16.573	2.575	1.461	487	0	0	0	0	0	3.105	15.951
NonFerrous	4.310	159	39	7	0	0	0	0	0	55	3.590
Minerals	14.806	6.494	3.484	20	210	0	0	0	0	21	8.747
Transport Equipment	1.460	0	53	2	0	0	0	0	0	797	3.027
Machinery	5.808	1	239	20	0	0	149	0	0	904	11.983
Mining	6.865	0	0	7	7	0	0	0	0	6	6.972
Food	12.330	0	150	348	0	0	45	0	0	1.463	6.700
Paper	20.303	217	3.981	509	90	21.930	4	0	0	1.012	17.308
Wood products	2.481	526	16.228	3	2	0	27	0	0	3.251	6.322
Construction	1.422	6	197	2	480	0	3	0	0	217	1.836
Textile	1.500	0	10	2	0	0	1	0	0	13	1.612
Other Manuf.	1.675	49	232	6	0	0	0	0	0	427	4.364
Rail	0	0	0	0	108	0	0	0	0	0	5.710
Land Transport	702	0	0	23	24.864	0	0	0	0	0	4.584
Pipe Transport	9.112	0	0	0	0	0	0	0	0	0	739
Internal Naviation	0	0	0	0	0	0	0	0	0	0	0
Air	0	0	0	0	0	0	0	0	0	0	0
Services	14.166	0	1.877	18	40	0	7.864	0	0	26.333	44.195
Private Households	52.399	0	68.176	66	0	0	9.285	0	0	28.644	60.536
Agriculture	560	0	6.701	1	624	0	125	0	0	405	3.970
Total	**183.361**	**10.027**	**102.832**	**1.546**	**26.426**	**21.930**	**17.503**	**0**	**0**	**66.897**	**216.717**
Other Demand											
Transport Loss	95	0	0	0	0	0	0	0	0	11.805	12.288
Non-Energetic	14.430	0	0	0	0	0	0	0	0	0	0

Table A4 – **Energy Balance represented in SUT (part 2)**

	UNFCCC National Inventory Report	Sectors according to IEA / Energy Balance of Austria		
Code	**Description**	**Code**	**Description**	**Correspondence**
			Economic Sectors	
1A1a	Public Electricity and Heat Production	**I1**	Iron & steel industry	1A2a; 2C
1A1b	Petroleum Refining	**I2**	Chemical and Petrochemical industry	1A2c; 2B
1A1c	Manufacture of Solid Fuels and Other Energy Industries	**I3**	Non-ferrous metal industry	1A2b; 2C
1A2a	Iron and Steel	**I4**	Non-metallic Minerals	1A2f; 2A
1A2b	Non-Ferrous Metals	**I5**	Transport Equipment	1A2g8
1A2c	Chemicals	**I6**	Machinery	1A2g8
1A2d	Pulp, Paper and Print	**I7**	Mining and Quarrying	1A2g8
1A2e	Food Processing, Beverages and Tobacco	**I8**	Food and Tabaco	1A2e
1A2f	Non-Metallic Minerals	**I9**	Paper, Pulp and Print	1A2d
1A2g7	Off-road vehicles and other machinery	**I10**	Wood and Wood Products	1A2g8
1A2g8	Other Manufacturing Industries	**I11**	Construction	1A2g7
1A3a	Domestic Aviation	**I12**	Textile and Leather	1A2g8
1A3b	Road Transportation	**I13**	Non-specified (Industry)	1A2g8
1A3c	Railways	**T1**	Transport services - rail	1A3c
1A3d	Domestic Navigation	**T2**	Transport services - on land (other than rail)	1A3b
1A3e	Other Transportation	**T3**	Transport services - via pipes	1A3e
1A4a	Commercial/Institutional	**T4**	Transport services - on water	1A3d
1A4b	Residential	**T5**	Transport services - via air	1A3a
1A4c	Agriculture/Forestry/Fishing	**O1**	Public and Private Services	1A4a
1A5a	Stationary combustion	**O2**	Private Households	1A4b
1A5b	Mobile combustion - Military	**O3**	Agriculture	1A4c
1B	Fugitive Emissions from Fuels		**Energy Sectors**	
2A	Mineral Industry	**E1**	Mining of oil and natural gas	1A1c
2B	Chemical Industry	**E2**	Mining of coal and lignite	1A1c
2C	Metal Industry	**E3**	Refinery of oil	1A1b
2D	Non-Energy Products from Fuels and Solvent Use	**E4**	Cokery	1A1c
2E	Electronics Industry	**E5**	Electric power generation, transmission and distribution	1A1a
2F	Product Uses as Substitutes for ODS	**E6**	Manufacture of gas; distribution of gaseous fuels through mains	1A1a
2G	Other Product Manufacture and Use	**E7**	Steam and air conditioning supply	1A1a
2H	Other (please specify)			
3	Total Agriculture			
4	Land Use, Land Use Change and Forestry			
5A	Solid Waste Disposal			
5B	Biological Treatment of Solid Waste			
5C	Incineration and Open Burning of Waste			
5D	Waste Water Treatment and Discharge			
5E	Other (please specify)			
6	Other (please specify)			

Table A5 UNFCCC National Inventory Sectors and IEA Energy Data sectors ; with assumed correspondence

COICOP Category		Allocation	COICOP Category		Allocation
01.1	Food	LS_PRIV	08.1	Postal services	ACC_PUBT
01.2	Non-alcoholic beverages	LS_PRIV	08.2	Telephone and telefax equipment	LS_PRIV
02.1	Alcoholic beverages	LS_PRIV	08.3	Telephone-, telefax- and internetcharges	LS_PRIV
02.2	Tobacco	LS_PRIV	09.1	Audio-visual, photographic and information p	LS_PRIV
03.1	Clothing	LS_PRIV	09.2	Other major durables for recreation and cultu	LS_PRIV
03.2	Footwear	LS_PRIV	09.3	Other recreational items and equipment, garc	LS_PRIV
04.1	Actual rentals for housing	SH_RENT	09.4	Recreational and cultural services	LS_PRIV
04.2	Imputed rentals for housing	SH_RENT	09.5	Newspapers, books and stationery	LS_PRIV
04.3	Maintenance and repair of the dwelling	SH_OM	09.6	Package holidays	LS_PRIV
04.4	Water supply and miscellaneous services relati	SH_OM	10.1	pre-primary and primary education	LS_PRIV
04.5	Electricity, gas and other fuels	SH_ENER	10.2	Secondary education	LS_PRIV
05.1	Furniture and furnishings, carpets and other flo	SH_ACCE	10.3	Post-secondary non-tertiary education	LS_PRIV
05.2	Household textiles	SH_ACCE	10.4	Tertiary education	LS_PRIV
05.3	Household appliances	SH_ACCE	10.5	Education not definable by level	LS_PRIV
05.4	Glassware, tableware and household utensils	SH_ACCE	11.1	Catering services	LS_PRIV
05.5	Tools and equipment for house and garden	SH_ACCE	11.2	Accommodation services	LS_PRIV
05.6	Goods and services for routine household mai	SH_ACCE	12.1	Personal care	LS_PRIV
06.1	Medical products, appliances and equipment	LS_PRIV	12.3	Personal effects n.e.c.	LS_PRIV
06.2	Out-patient services	LS_PRIV	12.4	Social protection	LS_PRIV
06.3	Hospital services	LS_PRIV	12.5	Insurance	LS_PRIV
07.1	Purchase of vehicles	ACC_CAR	12.6	Financial services n.e.c.	LS_PRIV
07.2	Operation of personal transport equipment	ACC_MIV	12.7	Other services n.e.c.	LS_PRIV
07.3	Transport services	ACC_PUBT			

Table A 6 Allocation of Private Households consumption categories to satisfier

10. Appendix D – SUT Disaggregation

NACE/CPA		
05-07	05	Coal mining
	06A	Oil mining
	06B	Natural Gas mining
	07	Metal ores mining
08-09	08	Minerals Mining
	09	Services for Mining
19	19A	Cokery / Coke
	19B	Oil Refinery / Mineral Oil Products
23 (only CPA)	23 A	Manu.of Glass and glass products
	23 B	Manu.of Ceramic tiles and flags
	23 C	"Manu.of Bricks, tiles and construction products, in baked clay;
	23 D	Manu.of Ceramic and glass household and ornamental articles
	23 E	Manu.of Ceramic sanitary fixtures
	23 F	Manu.of Other technical ceramic products
24	24 A	Manu.of Basic ferrous metals
	24 B	Manu.of Basic non-ferrous metals
35	35 A	Electric power generation, transmission and distribution
	35 B	Manufacture of gas; distribution of gaseous fuels through mains
	35 C	Steam and air conditioning supply
49	49 A	Rail transport
	49 B	Other passenger land transport services n.e.c.
	49 C	Taxi operation
	49 D	Passenger transport by funiculars, teleferics and ski-lifts
	49 E	Freight transport by road and removal services
	49 F	Transport via pipeline
52	52 A	"Warehousing
	5 2B	and support activities for transportation (rail)"
	52 C	"Warehousing
68	68	Real estate activities
	68 A	Imputed rents

Table A 7 Original and Sub-Sectors