Evaluating Energy-economic Impacts of the Austrian Waste and Resource Economy

Ina Meyer and Mark Sommer

Austrian Institute of Economic Research - WIFO, Research Group Environment, Agriculture, and Energy, Vienna, Austria

Abstract

The paper presents two complementary quantitative analyses using a macroeconomic model of the Austrian economy, which links monetary and physical waste-related data. 1) The economic and environmental impacts of the current Austrian waste economy are evaluated in terms of business-models for waste collection, treatment and secondary raw material use. Related impacts on CO_2 emissions are quantified. 2) Potential future employment effects that can result from further development of the Austrian waste economy are assessed.

1. Introduction

Against the background of planetary boundaries (Steffen et al. 2015) such as climate change or biodiversity loss, a reduction in resource consumption, material efficiency strategies and increased use of waste as a source of secondary materials is urgently required to stay within safe planetary boundaries. Global population and economic growth and a constantly rising and thriving global middle class are driving demand for resources such as metals, minerals, biomass, land, and water further. Added to this comes demand for critical resources from the decarbonization of the energy system, or digitization. For instance, a concerted global effort to reach the goals of the Paris Agreement would mean a quadrupling of mineral requirements for clean energy technologies by 2040 (IEA 2021, World Bank 2020). Growing competition over critical mineral supply and instability in the global supply chains, as conveyed by the Covid-19 pandemic, have triggered a re-appraisal of mitigation strategies with a focus on resource efficiency (Nakano 2021).

Resource extraction and processing are also responsible for a substantial amount of greenhouse gases (GHG) and many local environmental and health problems (IRP 2015). Producing metals from recycling, in contrast, requires less energy as converting it from ore. By recovering resources from end-of-life (EoL) waste streams, recycling relieves pressure in primary resource supply, and in environmental impacts from (growing future) waste streams. The sustainable and efficient use of resources, thus, appears as a key strategy of competitive and resilient societies.

The waste economy already pursues today several types of business-models that contribute to improving the environmentally sound use of materials that are already in circulation, while also generating local employment and value-added. Through the professional collection and treatment of current waste streams, and through the recycling and processing of waste into secondary raw materials, the waste economy fulfils an important environmental function: CO_2 emissions mitigation by substituting primary raw materials with secondary raw materials.

Material efficiency strategies such as the return of a larger proportion of materials al-ready in circulation through recycling but, not least, the reduction of production waste in principle through lifetime extension strategies such as repair, re-use and refurbishment, constitute elements of a circular economy, which has evolved as an economic para-digm with declared benefits for local employment, value creation and the environment (EMA 2019; EC 2020).

Given this background, the paper presents two quantitative analyses using a macroe-conomic model (WIFO.DYNK), which links monetary and physical waste-related data for Austria. 1) The economic and energy-related effects of the current Austrian waste economy are evaluated. The aim is to obtain a comprehensive, cross-sectoral picture of the economic impacts triggered by waste- and resource-related business-models based on currently available data. Related impacts on CO2 emissions are quantified. 2) Future employment effects that can result from further development of the Austrian residual waste economy are assessed.

2. Model Approach

The assessment of the economic impacts of the Austrian waste economy is based on a broad picture of all the interactions of all sectors of the economy based on physical material flows related to the waste economy. For this purpose, the method of extended input-output analysis is applied, which provides a detailed description of the interdependencies between economic sectors. The focus lies on the flow of goods that run through the production process, valued in monetary terms (€). Production inputs are either intermediate goods, i.e. goods and services that are processed or transformed during production, or the primary inputs, i.e. the production factors labour, capital and energy. The produced goods or services are the output of each sectors' activity. The so called 'value-added' is the sum of the gained operation surplus and labour compensation.

Goods and services of each sector are supplied to production entities in other sectors, are directly consumed, invested, or exported. This applies, in the case of waste, to the processing of waste into secondary raw materials, the use for thermal or electrical energy production, the direct use in a production process or the trade of waste in international markets, e.g. scrap metals, waste paper and waste glass.

The dynamic macroeconomic one-region and multi-sector model WIFO.DYNK (dynamic new-Keynesian) was adapted to model the employment and value-added impacts of the Austrian waste economy in this respect. It is based on the most recent input-output tables of Statistics Austria. Areas of application of the model are in different energy-economic analyses, e.g. simulation of energy scenarios (Sommer et al. 2018, Meyer et al. 2018a), or material flow analyses (Meyer – Sommer 2018).

The impact analysis simulates an alteration of the economic equilibrium by economic changes, so-called shocks, which impact on output and demand in different ways. The economic impact analysis of such a 'shock', for example investments in waste treatment, recycling or processing, the use of secondary raw materials in production or in international trade, is usually broken down into different effects:

- Direct impacts arise directly at the plant, landfill or collection point and include the corresponding investment costs, operating costs, and direct employment.
- Indirect impacts or up-stream effects comprise the production of all the inputs necessary for direct activities.
- Induced impacts in this study comprise the consumption reactions of private households that are related to changes in income from direct and indirect activities and are calculated using a historic average propensity to consume.

The aim was to quantify the economic impacts of investments, current expenditure and income regarding the collection, sorting, processing, and recycling of waste in terms of the associated indirect and induced employment and value-added impacts. In addition, the impacts from substituting primary raw materials for secondary raw materials produced by the Austrian waste economy are quantified.

The scope of the indirect and induced economic impacts depends on the size of the direct 'investment shock', and on the structure of the (intermediate) goods and services in processing and production. If labour-intensive domestic services, such as in construction activities, are applied, the employment impact is higher than if capital-intensive goods are imported. If mainly import-intensive goods, such as vehicles, are used, the value-added impact (in terms of gross domestic product (GDP)) is relatively small because the value-added is generated abroad.

The point in time at which the impacts occur cannot be determined by model analysis. Some impacts can occur at very short notice, e.g. from expenditures on investment or transport, others can occur with a time delay, e.g. if machines or building materials are used from stocks and additional production is triggered in the corollary, and labour income and consumption react with a corresponding delay. As the induced impacts trigger indirect impacts, which generate further income and trigger induced impacts, several model 'rounds' have to be run until the final impact is fully settled. The full unfolding of the economic impacts hence does not necessarily take place in the short term, e.g. in the same year.

3. Data

Two central flows of physical data are quantified in the material system. Firstly, the collection of defined waste fractions is linked to the respective treatment plants. Secondly, treatment plants are defined as entities that transform specific inputs such as waste fractions into defined outputs such as recyclable materials or landfill fractions. Thus, a unique process is mapped between each collected waste fraction and a specific type of process plant and the final output, e.g. landfill or thermal use fraction, or recyclable material. The status report "Inventory of Waste Management in Austria" (BMNT 2019) serves as the data base for these assignments of quantities to plants and output with respect to the year 2017. As the level of detail of the data representation varies, some waste categories' assignment to plants needed assumptions to be established (e.g. hazardous waste).

Physical flow and activity data are transferred into monetized demand structures to be applied in the WIFO.DYNK model. Materials and activities are valuated at specific prices and cost rates. This concerns the valuation of waste collection, waste treatment and of secondary raw materials obtained. The data for prices and costs are largely based on the study "Benchmarking for the Austrian waste management" (Brunner et al. 2015), in which the costs of waste collection and treatment were examined in detail. As these prices and costs are dating back to 2012, an average price level increase of 2% p.a. was applied until 2017. Prices for recyclable materials were upgraded based on expert opinions. This monetization makes it possible to estimate total costs for collection, transport, and treatment of the waste streams in plants.

These total costs are differentiated by demand categories, namely investment and operating as well as personnel costs. Investments and operating costs are further structured in costs for commodity groups as for instance construction services, machinery, mineral oil products or financial services. The final cost structure of groups of goods corresponds to the structure of the input-output tables and can be fed into the economic model WIFO.DYNK. For investments, these structures can, for example, describe the cost shares for buildings, vehicles, or machines. For operating costs, the structure can represent expenditure for fuel, insurance, or maintenance services. In addition to these cost structures, personnel costs are applied to the WIFO.DYNK model.

4. Results

In the present study a data system was compiled that simulates the treatment of an emerging waste volume. Foreign trade activities in waste, which currently take place on a larger scale, are not considered, i.e. the results of this study show potential effects of treating the entire domestic waste volume of the year under consideration abstracting from imports and exports of waste.

This system boundary of trade also applies to the use of secondary materials. Here it is assumed that the secondary raw materials obtained from treating domestic waste are used as input to the domestic industry, an assumption that does not necessarily correspond to the secondary raw materials use in 2017. However, for scrap iron, aluminum, glass, and paper it can be asserted that the calculated volumes are similar in size of those volumes really used in 2014 (Meyer et al. 2018b).

Interpreting model results, it is crucial to remind that the calculated impacts are not to be understood as 'additional' effects that have a 1:1 impact on gross domestic product (GDP) and employment growth. Rather, they denote 'associated' impacts that may or may not be additional to the baseline economic activities. They can also represent an increased utilization of the existing capacity or relocation effects.

Again, with respect to employment results, a certain amount of caution in interpreting results is advisable. Employment effects are not necessarily additional jobs created, rather, it is the number of required employees for the simulated economic activities (number of sector-typical employment), which may be covered by a mix of new hires, overtime, or the elimination of underutilization of existing employment contracts. This employment mix will not least be determined by the economic cycle in the concerned sectors.

On the basis of the described input data, in particular investments and operating costs for transport and waste treatment in plants or other processes amounting to approx. 4 billion €, and taking into account the revenues resulting from the sales of secondary materials or energy generated from waste, the overall impact on the GDP from the Austrian waste economy is calculated to about 5 bn € (Tab. 1).

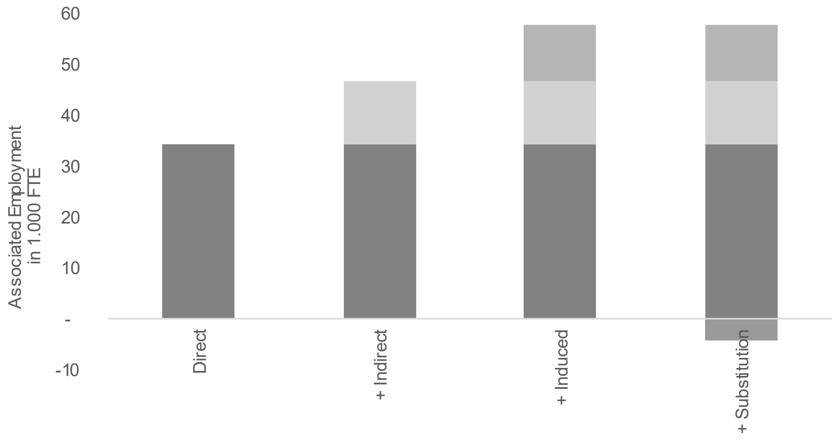
Tab. 1: Disaggregated GDP Impacts of the Austrian Waste Economy 2017, in million €

	GDP Impacts from				
	Investements	Personnel Costs	Operating Costs	Substitution of Primary Raw Materials	Total Impacts on GDP
1) Direct Impacts	1.024	1.612	0	0	2.636
2) Indirect Impacts	383	0	926	0	1.309
3) Induced Impacts (Consumption)	158	691	381	0	1.229
4) Impact from Substitution of Primary Raw Materials	0	0	0	-153	-153
Sum	1.565	2.303	1.306	-153	5.022

S: Own Calculations

Personnel costs (1.6 bn €) and average yearly investments (1.0 bn €) are directly attributable to value-added and thus represent a direct GDP impact of 2.6 bn €. The direct GDP impacts also include operating profits; however, these could not be recorded and were thus excluded from the analysis. The indirect GDP impacts which stem from the value-added generated along the up-stream input chain generate about 1.3 bn €. If both direct and indirect impacts are considered, the waste economy generates a GDP impact of 3.9 bn €. The induced impacts generated by private consumption are calculated to contribute about 1.2 bn € to the Austrian GDP. These first three impacts include the positive effects of producing and providing secondary raw materials, whereas the fourth impact represents the isolated GDP impact of decreased demand for primary materials and energy alone (–153 m €). This isolated impact comprises the effects of substituting primary raw materials with secondary raw materials in domestic industries, or primary fossil energy for electricity and heat production by waste input. The negative impact occurs due to the isolated impact of material substitution in domestic production, where already produced secondary materials substitute primary sources. Even though import shares of some primary materials are high (as iron ore or natural gas), there is also considerably less demand for some domestic products or services, e.g. fewer metal ores are mined domestically. This ultimately leads to a lower generation of domestic value-added and thereby to lower GDP. Overall, GDP impacts of the Austrian waste economy sum up to appr. 5 bn € which equates to about 1.4% of GDP. Associated employment impacts are pictured in Fig. 1.

Fig. 1: Disaggregated Employment Impacts of the Austrian Waste Economy 2017

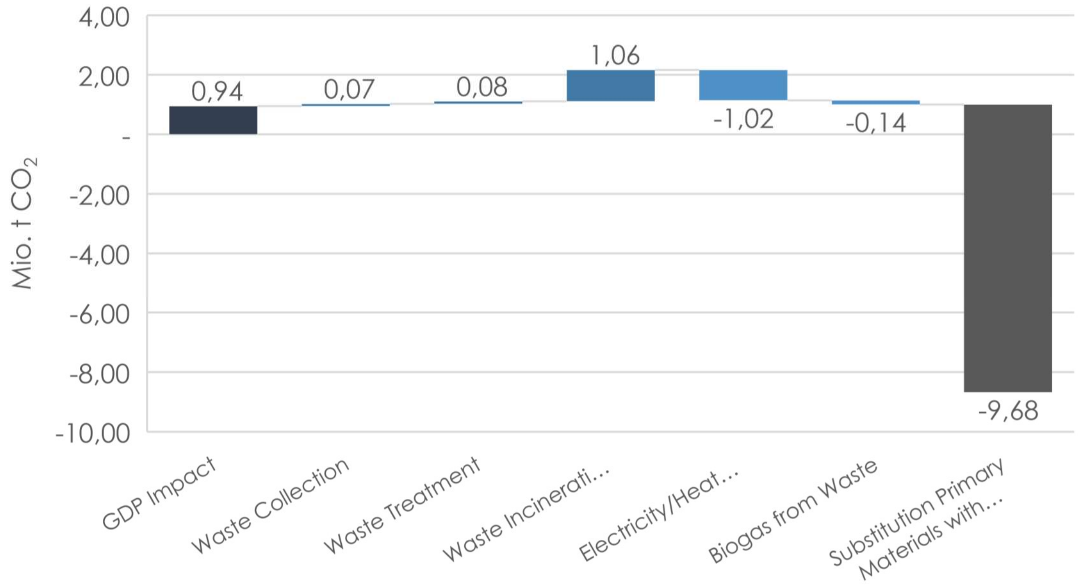


S: own calculations

The employment effects directly related to the Austrian waste economy were calculated based on average gross earnings of the sector "waste collection" (NACE 38.2). This calculation yields slightly more than 34,000 full-time equivalents (FTE), which are mainly caused by the large volume of transport services for the waste fractions. The indirect and induced impacts were calculated with the WIFO.DYNK model and are in the order of 24,000 associated jobs (FTE). With respect to the substitution impact, one would expect an employment impact in relation to the negative GDP impact from substitution. But negative employment is relatively more pronounced (4,000 FTE) because the negative GDP contribution is moderated by the reduction of imports of primary raw materials. Although falling imports have a positive effect on GDP, they do not have a direct or indirect effect on employment. This means that the moderation is relatively weaker and the negative employment impact relatively higher. In sum, a total 53,000 associated jobs are calculated for the Austrian waste economy. For comparison, in 2017 there were 3.85 m non-self-employed jobs. Hence about 1.4% of the non-self-employed jobs can be attributed to the waste economy.

The waste economy generates and mitigates CO_2 emissions. According to the economic analysis presented, the calculated emissions impacts consider the average CO_2 emissions resulting from indirect and induced GDP impacts, the emissions impacts of substituting primary steel, aluminum, paper and glass with secondary materials in domestic industries, and the emissions impacts from the incineration of waste and utilization of biogas produced from waste (instead of natural gas). Hence, these emissions calculations, based on an extended, cross-sectoral approach to the waste economy, are not directly comparable to the Austrian Greenhouse Gas Inventory (UBA 2020) for the waste sector (category 5). According to the presented economic analysis, only small quantities are emitted through waste collection and treatment (150,000 tCO_2). The incineration of waste emits just over 1 $mtCO_2$, but CO_2 emissions are reduced by the displacement of fossil fuels for electricity and heat production (–1.02 $mtCO_2$). The use of biogas avoids emissions of approx. 140,000 tCO_2. The greatest effect of CO_2 mitigation is generated by the substitution of primary materials especially by scrap metals. The avoided energy-intensive processes for primary steel and aluminum production, considering international up-stream value-chains, avoid approx. 10 $mtCO_2$. These impacts are, however, counteracted by GDP impacts of the waste economy (0.94 $mtCO_2$). In sum, the Austrian waste economy avoids around 8.7 $mtCO_2$ emissions in 2017, including international up-stream supply chains, and thus already makes a significant contribution to climate mitigation and sustainable use of materials.

Fig. 2: CO_2-Emissions associated with activities in the waste economy



5. Prospects for Residual Waste Treatment

Prospects for a further development of the Austrian waste economy were assessed in a quantitative analysis of potential employment and value-added effects of different typified waste management models of residual waste treatment for Austria. The analysis was carried out for waste incineration, mechanical-biological waste treatment, and enhanced separate waste collection, partly further differentiated (Meyer – Sommer 2019). The overall picture of employment effects follows the structure: the more complex and costly the residual waste treatment is and the higher the derived amount of recycled materials, the higher is the employment impact. For example, in the model of improved separate collection, labour demand is highest (317 FTE/100,000 t of residual waste) and lowest in the case of pure waste incineration (197 FTE/100,000 t of residual waste).

6. Conclusions

Against the background of persistently growing waste volumes, future waste, and associated adverse environmental impacts, and against the backdrop of European legal amendments (EU Circular Economy Package), the waste economy has the task of ensuring a continuous improvement in the quality and quantity of recycling of municipal and commercial waste, thereby contributing to material efficiency, climate mitigation, and beneficial effects to the local economy, also by technological innovations. However, producing and consuming less energy-, emissions- and material-intensive commodities and services applying *inter alia* lifetime extension of products through repair and reuse is even more material efficient than treating wastes. The prevention of waste must be the primary objective.

Acknowledgements

This work was supported by ARGE Österreichischer Abfallwirtschaftsverbände, Kompost & Biogas Verband Österreich, Verband Österreichischer Entsorgungsbetriebe, Fachverband Entsorgungs- und Ressourcenmanagement (WKO), and the Montanuniversität Leoben.

Literature

Brunner, P., Allesch, A., Färber, B., Getzner, M., Grüblinger, G., Huber-Humer, M., Jandric, A., Kanitschar, G., Knapp, J., Kreindl, G., Mostbauer, P., Müller, W., Obersteiner, G., Pertl, A., Pomberger, R., Plank, L., Salhofer, S., Schwarz, T. (2015) Benchmarking für die österreichische Abfallwirtschaft. DOI: 10.13140/RG.2.2.31286.55367.

Bundesministerium für Nachhaltigkeit und Tourismus (BMNT) (2019) Die Bestandsaufnahme der Abfallwirtschaft in Österreich, Statusbericht 2019, Wien.

EC (2020) A new Circular Economy Action Plan. For a cleaner and more competitive Europe, COM(2020) 98 final, Brussels, 11.3.2020.

EMA (2019) Completing the Picture: How the Circular Economy Tackles Climate Change, Ellen Macarthur Foundation, Isle of Wight, United Kingdom.

IEA (2021) The Role of Critical Minerals in Clean Energy Transition, International Energy Agency, Paris.

IRP (2015) 10 Key Messages on Climate Change, International Resource Panel.

Meyer, I., Sommer, M. (2018) Macht Recycling Sinn. Eine Analyse aus volkswirtschaftlicher Sicht. In: Pomberger, R., Adam, J., Aldrian, A., Kranzinger, L., Lorber, K., Neuhold, S., Nigl, T., Pfandl, K., Sarc, R., Schwarz, T., Sedlazeck, P., Wellacher, M., Curtis, A., Friedrich, K., Küppers, B., Möllnitz, S., Rutrecht, B., Sattler, T. M., Viczek, S. A., Höllen, D., Weißenbach, T. (2018). Recy & DepoTech 2018: VORTRÄGE-Konferenzband zur 14. Recy & DepoTech-Konferenz, November 2018, Leoben, 77-84.

Meyer, I., Sommer, M. (2019) Zur umweltökonomischen Relevanz der Abfall- und Ressourcenwirtschaft. Beschäftigungseffekte durch Restmüllverwertung, WIFO-Monatsberichte, 92(11), 833-843.

Meyer, I., Sommer, M., Kratena, K. (2018a) Energy Scenarios 2050 for Austria, WIFO, Wien.

Meyer, I., Sommer, M., Kratena, K. (2018b) Volkswirtschaftliche Effekte durch Recycling ausgewählter Altstoffe und Abfälle. In: Thiel, S., Thomé-Kozmiensky, E., Goldmann, D. (2018) Recycling und Rohstoffe, Band 11, 49-63.

Nakano, J. 2021, The Geopolitics of Critical Minerals Supply Chains, A Report of the CSIS Energy Security and Climate Change Program, Center for Strategic & International Studies, March 2021.

Sommer, M., Meyer, I., Kratena, K. (2018) Neue Energieszenarien 2050 für Österreich, WIFO-Monatsberichte 91(5), 375-385.

Steffen, W., Richardson, K., Rockström, J., Cornell, S.E., Fetzer, I., Bennett, E.M., Biggs, R., Carpenter, S.R., de Vries, W., de Wit, C.A., Folke, C., Gerten, D., Heinke, J., Mace, G.M., Persson, L.M., Ramanathan, V., Reyers, B., Sörlin, S. (2015) Planetary Boundaries: Guiding human development on a changing planet. Science 347 (6223), Research Article. DOI: 10.1126/science.1259855.

UBA (2020) Austria's National Inventory Report 2020, Submission under the United Nations Framework Convention on Climate Change and under the Kyoto Protocol, Report Rep- 0724, Austrian Environment Agency, Vienna.

World Bank (2020) Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition, Climate-Smart Mining Facility, Washington, DC.