WIFO AUSTRIAN INSTITUTE OF ECONOMIC RESEARCH

THE CONTRIBUTION OF WASTE ECONOMY TO CIRCULAR ECONOMY AND SUSTAINABILITY – A QUANTITATIVE ASSESSMENT FOR AUSTRIA

Ina Meyer, Mark Sommer

17TH EUROFRAME CONFERENCE ON ECONOMIC POLICY ISSUES IN THE EUROPEAN UNION

Online Conference, NIESR, London, Juni 17-18, 2021

Introduction: Rising Resource Demand, Planetary Boundaries and Resource Efficiency

- **worldwide demand for resources**
- **rising global demand for minerals and metals** for **energy system transformation** and **climate mitigation** (Arrobas et al. 2017).
- **growing risk**
  - **destabilizing the earth system resilience**
  - **planetary boundaries** (Steffen et al. 2015).
- **drastic restrictions on the exploitation and use of primary resources** are required.
- **sustainable and efficient use of resources** becomes a **key competence**

Introduction II: Circular Economy as Sustainable Economic Paradigm

- **circular economy** as key concept to a **sustainable economic paradigm**.
  - rejects “**take-make-use-dispose**”
  - proposes **circular resource flows**
- **Recycling: waste economy - important environmental function**:
  - substitution (primary by secondary).
  - reduction (waste streams)
  - shrinking demand (resources, energy)
- => emission of greenhouse gases.
- **Circular material efficiency strategies**
  - **climate mitigation strategy**
  - **local employment & added value.**
- **Yet the evidence base for these impacts remains unclear.**

Objective of the Study:

- quantitative assessment of the Austrian waste economy
  - employment,
  - value added and
  - CO_2 emissions mitigation (substitution of primary materials)
- quantify
  - economic impacts
    - investments, operation & maintenance and labour income
  - of activities
    - collection, sorting, processing and recycling of waste
  - Change of flows
    - replacing primary with secondary raw materials
- **comprehensive, cross-sectoral picture**
  - waste- and resource-related business-models.
- Economic effect of **substitution**
  - based on monetarized **physical material flow data**

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Methodological Approach:

- **Method: extended input-output analysis**
- **Applied Model**
  - Macroeconomic model **WIFO.DYNK** (DYnamic New-Keynesian)
  - one-region and multi-sector model
  - Core: Austrian Input-Output-Table (74 sectors & commodities, Supply & Use Tables)
- **Input-Output-Table**
  - Flow of goods valued in monetary terms (€).
  - Sectoral Production inputs structure (intermediate and primary)
  - Supplied commodities - directly consumed, invested or exported.

- **Waste economy** in this structure:
  - the **processing of waste into secondary raw materials**,
  - the **use of waste for thermal or electrical energy production**,
  - the **direct use of waste in certain production process** (e.g. steel production), or
  - the **trade of waste in international markets**, e.g. scrap metals, waste paper etc.

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Energy-Economic Impact Assessment of the Austrian Waste Economy

- Impact analysis : **alteration of the economic equilibrium** (shocks)
  - E.g. additional investments, change of production structures
- **Resulting** Economic impact:

  Direct impacts - directly at the plant/facility

  Indirect impacts - up-stream effects in other sectors

  Induced impacts - consumption reactions of households.
- **scope** of the impacts depends on
  - **size** of the direct 'investment shock',
  - **structure** of the commodites and services demanded
    - **E.g. labour-intensive domestic services (Construction)**
      Rather Domestic Value Added
    - **E.g. imported capital-intensive goods** (Vehicles)
      Rather Abroad Value Added

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Data – Integrating Physical and Monetary Data

Data on physical material flows is interlinked with values

- Definition of
  - **material categories (35 categories)**
    - E.g. industrial & municipal waste as steel scrap, glass scrap, biomass etc.
  - **treatment facilities**
    - E.g. Collection, glass handling, metal shredder, landfill.
  - **Entity Processes -transform input** materials to **output** materials
    - As Material balances (tons)
    - E.g. Waste => recyclable materials / thermal use fraction / landfill fractions
- **Unique mapping**
  - **Material flows** to/between **facilities** and **final output**
  - => a representation of **mass flow balance** of Austria's waste materials
- Physical flow and activity data => **monetized demand structures**
  - Input for WIFO.DYNK model.
- Materials and activities have **specific prices and costs (in €).**
  - waste collection,
  - waste treatment
  - secondary raw materials obtained.

Data II – Monetary Data

Bottum-up Data on different Cost Categories of plants (in €)

- **Total costs** are differentiated by demand categories:
  - investment and operating costs
  - personnel costs
- **Investments** and **operating costs** are **further** structured in costs for commodity groups:
  - construction services,
  - machinery,
  - mineral oil products
  - 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.

Data Source:

Expert guess with respect to secondary resource prices and other prices and costs.

Brunner, P., Allesch, A., Färber, B., Getzner, M., Grüblinger, G., Huber-Humer, M., Jand-ric, 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.

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Results – Value-added effects of the Austrian Waste Economy

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: Ow n Calculations

5 billion € equates to about 1.4% of Austria's GDP

Results – Associated Employment Effects

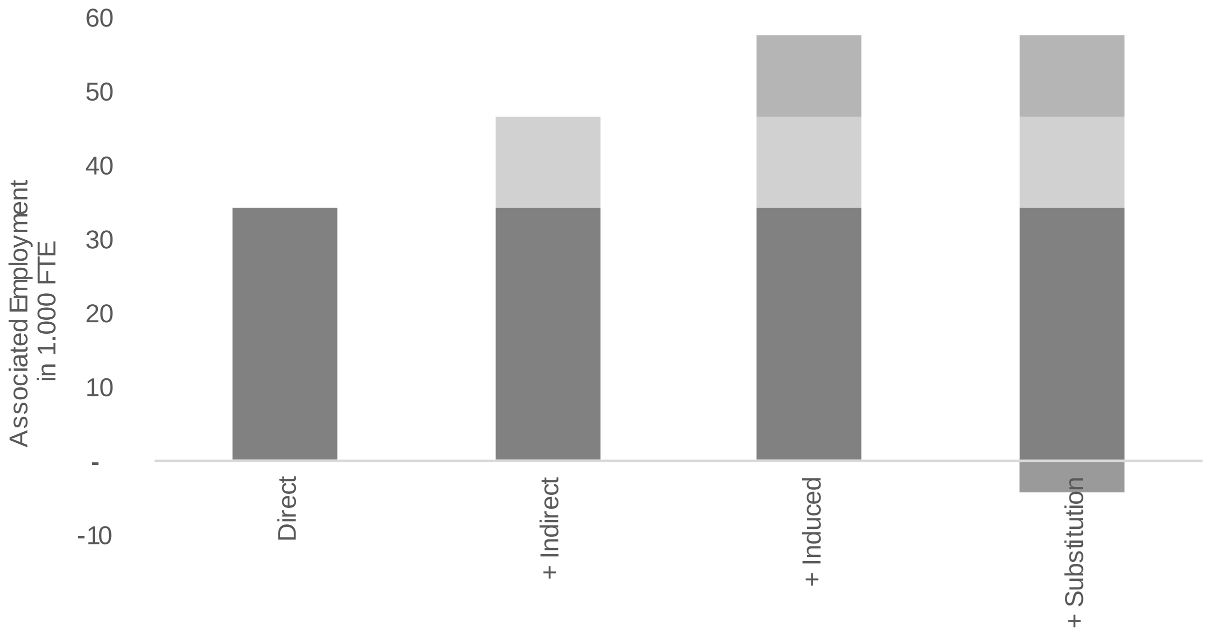


Fig. 1: Disaggregated Employment Impacts of the Austrian Waste Economy 2017, own calculations.

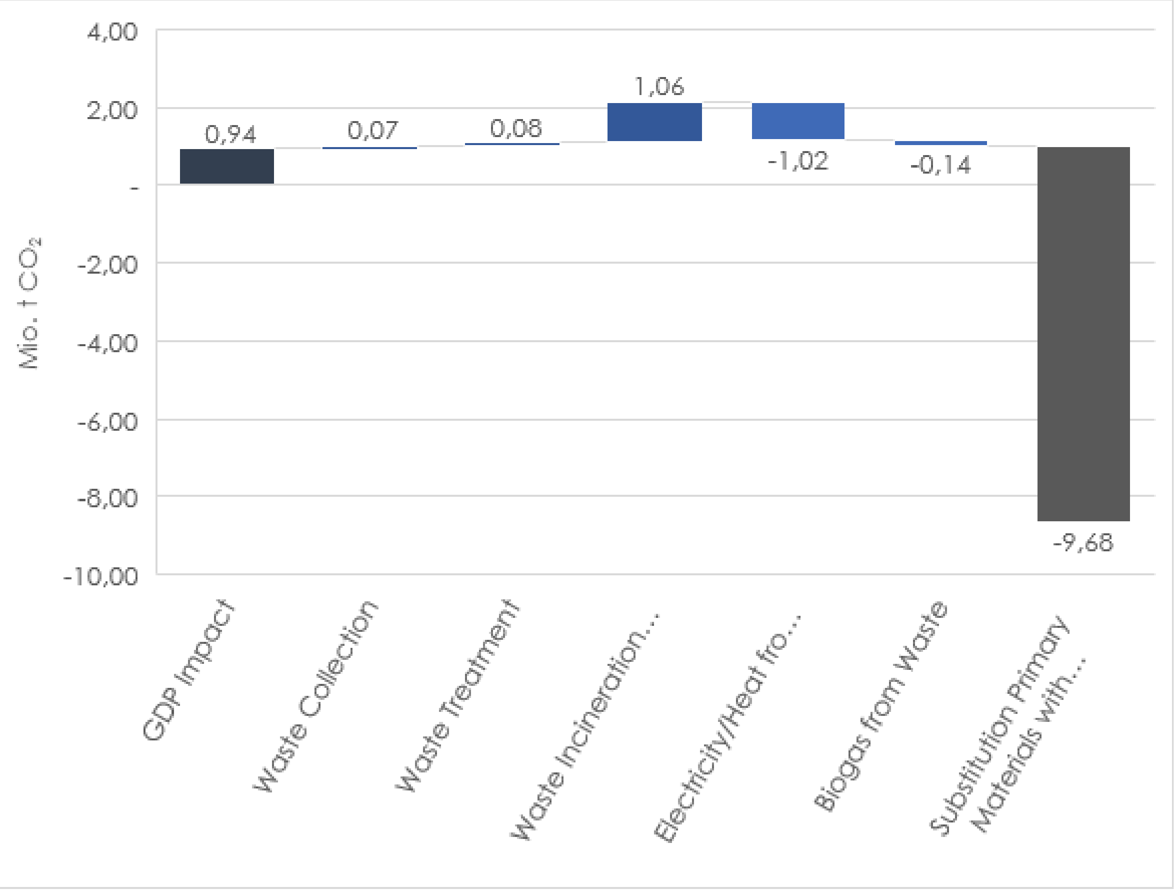
For comparison, in 2017 there were 3.85 m non-self-employed jobs. Hence about 1.4% of the non-self-employed jobs can be attributed to the waste economy.

Results – Associated CO_2-Emissions

The waste economy generates and mitigates CO_2 emissions.

Based on the economic analysis, the calculated emissions impacts considers **average CO_2 impacts** due to

- **indirect and induced** GDP impacts,
- **substituting** primary steel, aluminum, paper and glass with secondary materials in domestic industries, considering international value chain emissions (i.e. not only in AT).
- the **incineration** of **waste** and utilization of biogas produced from waste (instead of natural gas).



Source: Own calculations

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Conclusion - Governance Challenges
Waste Economy as Circular Economy Needs Clear Policy Signals

- The waste economy has – under certain policy conditions - the **potential to spur the development** of CE-oriented innovations, i.e.
  - **circular business models** such as **recycling** of e.g. car batteries…,
  - **waste processing technologies,**
  - **waste collection systems**

  thereby generating employment, value-added and CO_2 emissions mitigation.
- **Stumbling blocks** for long-term investments
  - **rapidly changing global markets**
- **Waste/secondary resource markets face**
  - **ups & downs** of the global economy
  - Volatility of **prices (virgin material**)
  - **sudden changes** in the policies of a dominant buyer like China.
- Examples:
  - the 2008/09 market crash that left thousands of tons of scrap metal stranded in ports.
  - The price volatility of (secondary) resources resulting from the Covid-19 pandemic and related lockdowns reduced demand for *inter alia* industrial and energy resources which rendered certain CE-business models uneconomic

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Conclusion II: Governance Challenges
and the EU Approach: Circular Economy Package and #Green Deal

Getting **policies** right for stable and enabling market conditions for circular business-models in the waste economy beyond pure recycling:

The new EU Circular Economy Action Plan as Policy Approach is based mostly on regulatory instruments.

- Revision of EU legislation on batteries, packaging, end-of-life vehicles, and hazardous substances in electronic equipment
- New waste reduction targets
- Requirements for extended producer responsibility schemes, provide incentives and encourage sharing of information and good practices in waste recycling

Discussion on market based incentives such as resource taxes are largely missing.

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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 Bounda-ries: Guiding human development on a changing planet. Science 347 (6223), Research Article. DOI: 10.1126/science.1259855.

Arrobas, Daniele La Porta; Hund, Kirsten Lori; Mccormick, Michael Stephen; Ningthoujam, Jagabanta; Drexhage, John Richard (2017) The Growing Role of Minerals and Metals for a Low Carbon Future, International Bank for Reconstruction and development/The World Bank, Washington. http://documents.worldbank.org/curated/en/207371500386458722/The-Growing-Role-of-Minerals-and-Metals-for-a-Low-Carbon-Future

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Extended Presentation

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Introduction: Rising Resource Demand, Planetary Boundaries and Resource Efficiency

- Global population/economic growth combined with a rising global middle class are **driving worldwide demand for resources** such as metals, minerals, biomass, land and water further.
- Additionally, there is a **rising global demand for minerals and metals** that stems from requirements for **energy system transformation** and **climate mitigation**, or digitalization (Arrobas et al. 2017).
- Facing this, there is a **growing risk** of **destabilizing the earth system resilience** by reaching **planetary boundaries** in several biophysical realms such as climate change, biodiversity loss, biosphere integrity, biochemical flows (phosphorous, nitrogen) (Steffen et al. 2015).
- Thus **drastic restrictions on the exploitation and use of primary resources** and **altered ways of economic activity** related to material flows are required.
- The **sustainable and efficient use of resources** becomes a **key competence** of forward-thinking and resilient societies, also encouraging economic competitiveness in terms of resource security.

Introduction II: Circular Economy as Sustainable Economic Paradigm

- The **circular economy** has emerged as key concept to a **sustainable economic paradigm**. It rejects the prevailing linear "take-make-use-dispose" economy and proposes a system based on **circular resource flows** which avoids excess primary resource extraction and waste production.
- By disposal of given waste streams and by recycling of waste into secondary raw materials, the **waste economy already fulfils an important environmental function** today:
  - substitution of primary raw materials with secondary raw materials.
  - reduction of waste streams
  - shrinking of primary resource and energy demand
- Primary raw material production is energy-intensive and drives the emission of greenhouse gases.
- **Circular material efficiency strategies** such as recycling are considered **as climate mitigation strategy** as they reduce demand for primary raw materials and energy.
- In addition, they **create local employment and added value.**
- **Yet the evidence base for these impacts remains unclear.**

Objective of the Study:

- Against this backdrop, the paper presents a **quantitative assessment of the Austrian waste economy** in terms of **employment, value added and CO_2 emissions mitigation from substitution of primary materials.**
- The aim was to **quantify the economic impacts of**
  - **investments, current expenditure and income regarding**
  - **the collection, sorting, processing and recycling of waste, and**
  - **of substituting primary raw materials with secondary raw materials produced by the Austrian waste economy.**
- to obtain a **comprehensive, cross-sectoral picture** of the economic impacts triggered by these waste- and resource-related business-models.
- The study thus takes a **broader perspective** and includes the effects of substitution **of primary resources with secondary resources** in relevant industries.
- The assessment of the economic impacts is based on **physical material flow data** related to the waste economy.

Methodological Approach:

- The method of **extended input-output analysis** is applied.
- 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. It includes the interrelation of 74 industrial and service sectors as well as final demand.
- The focus lies on the **flow of goods** that run through the production process, **valued in monetary terms** (€).
- **Production inputs** are **intermediate goods** and/or the **primary inputs** such as labour, capital and energy.
- 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 of waste for thermal or electrical energy production**,
  - the **direct use of waste in certain production process** (e.g. steel production), or
  - the **trade of waste in international markets**, e.g. scrap metals, waste paper etc.

Energy-Economic Impact Assessment of the Austrian Waste Economy

- 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 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.

Data – Integrating Physical and Monetary Data

Data on physical material flows is interlinked with values

- The first step is to define the material flows of waste & products thereof
  - in total about **35 material waste categories** and
  - 35 specialized treatment plants of landfill
  - Treatment plants are defined as **entities** that process/transform specific inputs such as waste fractions into defined outputs such as **recyclable materials** or **thermal use fraction** or – finally - **landfill fractions**.
    - In other words: material balances for each specific entity
- Collection of defined waste fractions from municipal and industrial waste (in tonnes) is linked to relevant treatment plants
- A **unique mapping** is conducted **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. This results in a complete material flow balance for waste and products thereof, from collection to landfill or secondary material.
- Physical flow and activity data are transferred into **monetized demand structures** to be applied in the WIFO.DYNK model.
- The Monetization is performed by valuation of Materials and Activities at **specific prices and costs (in €).** This concerns the valuation of waste collection, waste treatment and of secondary raw materials obtained.

Data II – Monetary Data

Bottum-up Data on different Cost Categories of plants (in €)

- Total costs are differentiated by demand categories:
  - investment and operating costs
  - personnel costs
- Investments and operating costs are further structured in costs for commodity groups:
  - construction services,
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  - financial services.
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Sum	1.565	2.303	1.306	-153	5.022

S: Own Calculations

⇒ **Contribution** of waste economy to the Austrian GDP
- ⇒ **5 billion €** equates to about 1.4% of GDP

⇒ Negative impact
- ⇒ The **isolated effect** of less demand for primary materials

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Results – Associated Employment Effects

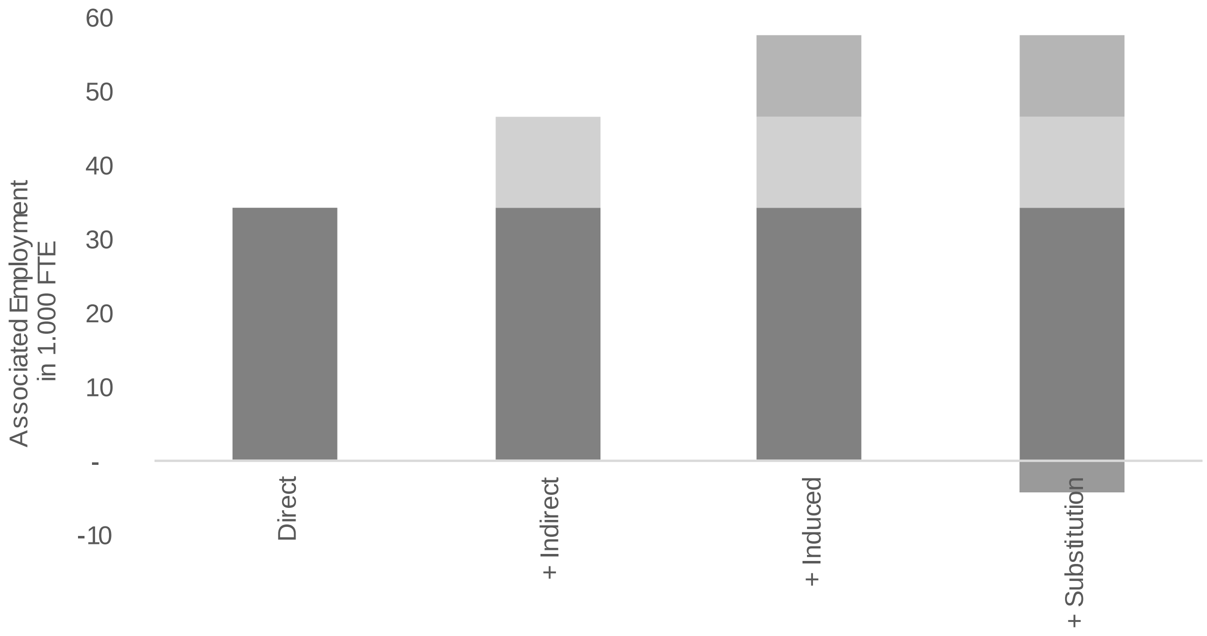


Fig. 1: Disaggregated Employment Impacts of the Austrian Waste Economy 2017, own calculations.

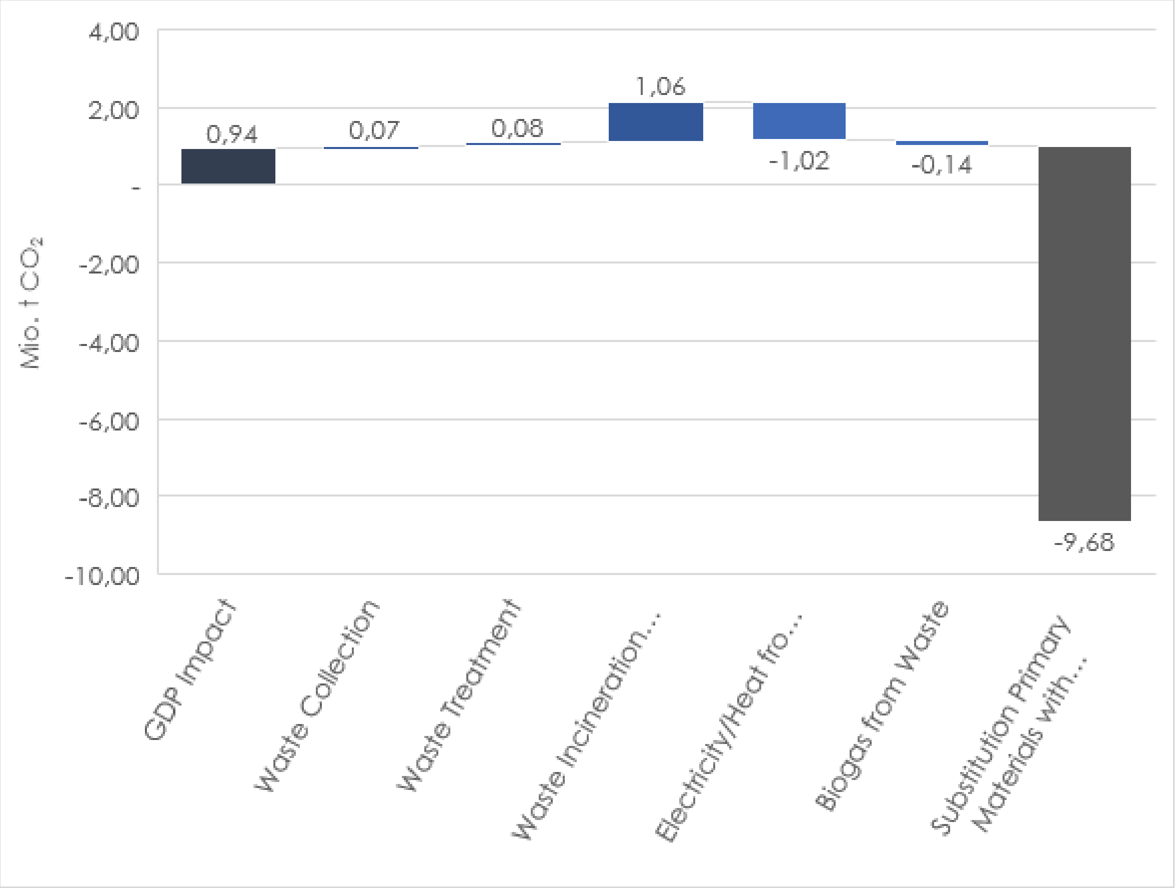
In total **1.4%** of the non-self-employed jobs can be attributed to the waste economy.

Results – Associated CO_2-Emissions

The waste economy generates and mitigates CO_2 emissions.

Based on the economic analysis, the calculated emissions impacts considers:

- average CO_2 emissions resulting from indirect and **induced GDP** impacts,
- emissions impacts of **substituting** primary steel, aluminum, paper and glass with secondary materials in domestic industries, considering international value chain emissions.
- emissions impacts from the **incineration of waste** and utilization of biogas produced from waste (instead of natural gas).



Source: Own calculations

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Conclusion - Governance Challenges
Waste Economy as Circular Economy Needs Clear Policy Signals

- The waste economy has – under certain policy conditions - the **potential to spur the development** of CE-oriented innovations, i.e.
  - **circular business models** such as **recycling** of e.g. car batteries…,
  - **waste processing technologies**,
  - **waste collection systems**

  thereby generating employment, value-added and CO_2 emissions mitigation.
- **Stumbling blocks** for long-term investments in CE-oriented business models are rapidly changing global markets, i.e. for secondary or primary raw materials.
- **Waste/secondary resource markets** remain subject to the ups and downs of the global economy and the **prices of virgin material**, or to sudden changes in the policies of a dominant buyer like China.
- Examples:
  - the 2008/09 market crash that left thousands of tons of scrap metal stranded in ports.
  - The price volatility of (secondary) resources resulting from the Covid-19 pandemic and related lockdowns reduced demand for *inter alia* industrial and energy resources which rendered certain CE-business models uneconomic

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