SUSTAINABLE TRANSFORMATION OF SMES IN THE CONTEXT OF THE GREEN DEAL

Andreas Christian MELTZER[1,*,], Martin BEERMANN[1], Georg Maximilian EICHLER[2], Veronika DWORZAK[2]**

1. JOANNEUM RESEARCH Forschungsgesellschaft mbH, Lakeside B13b, A-9020 Klagenfurt, Austria, +436646028767636, andreas.meltzer@joanneum.at, https://www.joanneum.at/
2. UNIVERSITÄT KLAGENFURT, Universitätsstraße 65-67, 9020 Klagenfurt am Wörthersee, Austria, georg.eichler@aau.at, veronika.dworzak@aau.at, https://www.aau.at/

* Corresponding author and submitter in ConfTool

** Nominee for the Young Scientist Award

Abstract: The EU goal of climate neutrality until 2050 is a considerable challenge for many companies. Especially small and medium-sized enterprises (SMEs) lack the resources to transform their business models towards higher sustainability and climate neutrality. The region of Lower Carinthia is highly affected by the goals of climate neutrality by 2040 in Austria and by 2050 in the EU, due to the high share of carbon intensive industries. For this reason, in the course of the LOCA2-project, the CEOs of 50 companies were interviewed to identify potentials and barriers for the introduction of sustainable business models towards climate neutrality. Furthermore, the interviews allowed to gain an overview on specific processes, used energy carriers, and GHG-emissions of the participating companies. In addition, the Scope 1, Scope 2, and Scope 3-emissions of the different industry sectors in the region in 2019 were analysed. Methodologically a life cycle approach was applied combining statistical input data sources and an environmentally extended input-output-table. Based on these results, transformation paths for selected industry sectors using a dynamic LCA-model were developed. They sketch how the relevant sectors can transform towards climate neutrality. The analysis shows that the transformation is possible, however, the implementation of climate neutral energy carriers has to be accelerated and additional measures such as CCU, CCS, or CDR are necessary to reach net-climate neutrality. A handbook guiding SMEs strategically towards climate neutrality by 2040 is currently being developed.

Keywords: Climate neutrality; transformation pathways; sustainable business models; small and medium-sized enterprises; greening of supply chain; survey; dynamic LCA; EEIO-table.

1 INTRODUCTION

Climate change requires a transformation of the economy towards greenhouse gas-neutral, resource-efficient, and material cycle-oriented activities and business models. However, this aim is difficult to achieve in the existing business logics. The central aim of the LOCA2Transformation (LOwCArbon LOwerCArinthia TRANSformation) project is to enable business executives in the region of Lower Carinthia (districts St.Veit, Wolfsberg, and Völkermarkt) to transform their companies to meet the requirements of the Green Deal, thus to become carbon neutral until 2040/2050. The case of Lower Carinthia can serve as a proxy for many other affected areas worldwide that have to undergo similar transformations. Using an interdisciplinary approach, central potential and barriers of SMEs to move towards climate neutral and circular business models were identified. Furthermore, the energy flows and related emissions of various industry sectors in the region as well as emissions connected to activities in the value chain of companies (Scope 3-emissions) were detected. This data is the empirical basis for the development of so called “transformation pathways” towards climate neutrality. Using 2019 as a starting point, pathways were developed to reduce emissions until 2030 by approximately 61%[1] and to achieve net-zero greenhouse gas- (GHG) emissions in Scope 1 and Scope 2 by 2040 and in Scope 3 by 2050 (EU) and 2060 (rest of the world).[2] The pathways contain information on the technological transformations that have to be realised in order to meet the climate targets.

Energy efficiency and sustainable energy sources are in the centre of these pathways. A meta-perspective was taken to judge on the applicability of new technologies and energy carriers for individual sectors. In addition, the legislative/political requirements for the transformations of business models were considered. Based on a survey, potentials and barriers in the current system were determined and corresponding measures to enable the transformation outlined. As noted before, the concept of sustainable business models (SBMs) was used to sketch, how firms can transform their business activities towards more sustainability. Of great help was the well-known business model canvas of Osterwalder.[1] In order to outline how such a transformation can take place, several examples of companies that successfully adapted parts of their business models towards sustainability were identified in the project.

The transformation towards a climate neutral economy gained more attention in the recent years. In 2019 Geyer et al. [2] discussed the energy consumption of the Austrian industry and deducted transformation pathways based on different scenarios. They delivered an overview over the main technologies and their temporal applicability, based on their technology readiness level (TRL). In 2021, Diendorfer et al. [3] discussed technological pathways for various industry sectors to become climate neutral by 2040 and additionally investigated in “imported” GHG-emissions using an input-output-approach. Baumann et al. [4] focused on possible future supply and demand of renewable gas in Austria in 2021. They found that the production capacities in Austria for renewable gas is limited and that a considerable share of the required H2 for the decarbonisation of the industry will have to be imported. The Austrian Energy Agency [5] analysed the possibilities to substitute Russian natural gas with other energy sources and pointed out that the total energy consumption in Austria should be reduced and they stressed the need for an accelerated implementation of H2 technologies. The installation of an H2 infrastructure for the decarbonisation is also empathised by the Austrian and by the European H2 strategy.[6], [7]

It can be concluded that the decarbonisation of the Austrian industry is a pressing topic and current research shows the need to change the fossil-based system to a circular economy based on renewable energy carriers. However, we identified a research gap concerning specific guidelines for SMEs in the transformation process – especially in the Austrian context. Furthermore, the practical barriers and chances to transform the business models in the Austrian context remained yet widely

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[1] a 61% reduction compared to 2019 corresponds to the goal of a 55% reduction as compared to 1990 due to the rise of emissions between 1990 and 2019[3]

[2] For more information on the Scope 1/2/3-framework for GHG-emission reporting, refer to: https://ghgprotocol.org/

unknown. This study sheds light on the important issue of practical barriers and studied the particular situation of SMEs in the transformation process. Another new feature is the dynamic LCA-approach used for the development of transformation pathways. The transformation pathway for one sector is illustrated as an example to display the methodology used and to exemplify the outcomes of the study.

2 MATERIALS AND METHODS

2.1 Survey

The study geographically focused on Lower Carinthia and on industries characterised by high GHG-emissions and/or high pressure for business model transformations towards sustainability. Drawing on the public business register from the chamber of commerce, a total of 158 companies were identified and classified according to the IEA standard.[8] All companies were contacted personally via phone and received follow-up information with an interview invitation. 50 companies eventually agreed for an interview. These companies were be classified according to the IEA industry categories[3]:

a) *iron and steel; non-ferrous metals; transport equipment; machinery* (27)
b) *wood and wood products; paper, pulp and print; non-specified* (9)
c) *non-metallic minerals* (7)
d) commerce and public *services* (4)
e) *chemical and petrochemical* (3)

Based on recent literature on sustainable business models [9], [10] and particularly on potential and barriers of their implementation [11], [12], an interview guide containing qualitative and quantitative questions was developed and pre-tested. Qualitative questions followed an investigative-open approach, while quantitative questions were asked using a Likert-scale ranging from 1-6. Secondary data – mainly homepages, sustainability reports and press releases – were screened before the interview and proofed as highly valuable to better understand the context of the companies. Interviews were conducted by two interviewees using the online communication software zoom.

For the quantitative questions, one interviewee shared the screen guiding the interview partner(s) through the survey, while the other interviewee took notes. All interviews, lasting on average one hour, were recorded and transcribed. For the following analysis the qualitative data analysis software MAXQDA was used.[13] In a first step, upper categories were defined. In the concrete case, the suggestions of existing literature to distinguish between company external and internal potential and barriers for sustainable business model transformation was followed. Thereafter, two researchers independently analysed a selection of ten interviews. As the comparison of the created codes and corresponding text passages indicated a strong match of the procedures and assessments of the two researchers, the remaining 40 transcripts were analysed separately.

[3] Selected IEA categories were merged to guarantee anonymity of participating companies

Following the guidelines of Saldana [14] subcategories were streamlined and condensed into fewer ones.

2.2 Carbon footprint of industry sectors

A life cycle assessment (LCA) methodology was applied to determine the GHG-emissions of the industry in Lower Carinthia in 2019, which was the base year of the analysis. The above-mentioned industry sectors were analysed. Based on data retrieved from the database of the Statistik Austria [15], the GHG-emissions of the individual industry sectors were calculated. Therefore, in a first step, the consumption of different energy carriers in the whole Carinthian industry was retrieved from the database and scaled down to the share that was approximately consumed in Lower Carinthia. For the downscaling, the share of persons employed in the target region was used. In a second step, the related Scope 1/2/3-emissions were determined using standard emission factors (mainly derived from GEMIS [16] and from previous research projects). In a third step, data from a so-called environmentally extended input-output-table (EEIO-table) [17] was applied to approximate the emissions related to the up- and downstream activities in the value chains of the different sectors. An important assumption was that the average Austrian value chain was comparable to the average Carinthian value chain of the respective industry sector.

Based on the status-quo analysis the most important sectors were identified and transformation pathways were developed using a so called dynamic LCA approach. In the dynamic LCA a change over time was modeled for the life cycle inventory (in this case the energy consumption) as well as for the emission factors. The time frame for the analysis starts 2019 and ends 2060. An Excel tool was created that was used for scenario modelling. The tool allows to insert parameters on the share of fossil fuels in the electricity grid, energy efficiency, changes in emission factors, economic development of the industry sectors, and the mix of energy carriers/technologies for every single year. Thereby it is possible to determine, what measures have to be introduced in what time frame in order to achieve the political target of net climate neutrality. The introduction of new technologies was mainly based on the before mentioned strategic documents of the Austrian Republic and the European commission, as well as the state-of-the-art reports of Geyer et al. and Diendorfer et al.[2], [3]

3 RESULTS

3.1 Survey Results

The content analysis uncovered many interesting internal & external sustainable business model potential and barriers. A small excerpt is presented in the following:

<u>Internal potential:</u>

1. Many – almost half of the interviewed firms – considered it a large potential to either **install or extend photovoltaic plants** and thus employ green energy in their production processes. Four firms even saw potential for entire **energy self-support**.

2. Besides producing green energy, companies were also aware of the potential to **reduce energy consumption** (6 firms) in their production processes (e.g. by updating machinery, different production processes or deployment of new machinery).
3. A large number (13) of interviewees considered their **product(s) as central in combatting climate change** and thus expect large potential as sensibility on climate change and GHG emissions shall increase.

External potential:

1. Environmentally friendly transportation represented a large challenge for many firms. In this context, for three interview partners it was a large potential that they possessed a **cargo train station**. One interview partner mentioned the large potential for **bundling ordered goods** before they are shipped to companies, especially if they are small and the company is located in a peripheral area.
2. Every fifth interview partner saw potential due to an **increasing demand on sustainable/regional products** and several firms already experienced rising requests in this association.
3. Large external potential was found in the **recyclability of primarily used raw-materials** (11 firms). E.g. steel, one of the primarily component in mechanical engineering can be technically recycled at the end of product life.

Internal barriers:

1. One of five firms was skeptical about the **cost/benefit ratio of sustainability related adjustments & investments** and considered it as an internal barrier. This also included strongly increasing prices for certain components if they were regionally produced.
2. For several firms (5) an internal barrier related to the fact that they did not **own their office and production facilities,** which hindered investments for corresponding sustainability measures (e.g. photovoltaic, insulation).
3. Another internal barrier regarded the **non-recyclability** of certain products (4 firms). In some cases, the products were not repairable at all.
4. Interesting were the insights on **firm size**: while some companies experienced it hindering to be a small company (e.g. fewer financial means), others indicated that a large organization makes it more complicated (less flexibility).
5. Very few firms (2) also mentioned, that they did **not pay (much) attention** to the topic so far, which represented an internal barrier.

External barriers:

1. Almost every third interview partner mentioned **missing political measures** as hindering their business model transformation towards sustainability. These political measures were diverse and related to green energy or regional production (instead or globalisation).
2. For many firms (14), the **lack of climate neutral raw materials** meant a significantt external barrier. As long as the primary raw material is not climate neutral, companies find it difficult to transform their business model towards sustainability.
3. While some interview partners experienced increasing demand on sustainable products (external potential), others (11 firms) complained about a **missing customer demand on**

products with low GHG-footprints**. E.g. firms mentioned that not a single customer ever was interested in the GHG reduction of a product.

4. A further external barrier represented a **missing international definition for green electricity**. Discrepancies in this context lead to market distortions, e.g. if nuclear energy is considered as green in one country (and not-green in another country) and hinder sustainable business model transformation.

3.2 Carbon Footprint and transformation of selected industry sectors in Lower Carinthia

Figure 3-1 shows the GHG-emissions that are related to the energy consumption of the selected industry sectors in Lower Carinthia. It can be seen, that process heat and stationary engines played a major role in the overall GHG footprint in 2019.

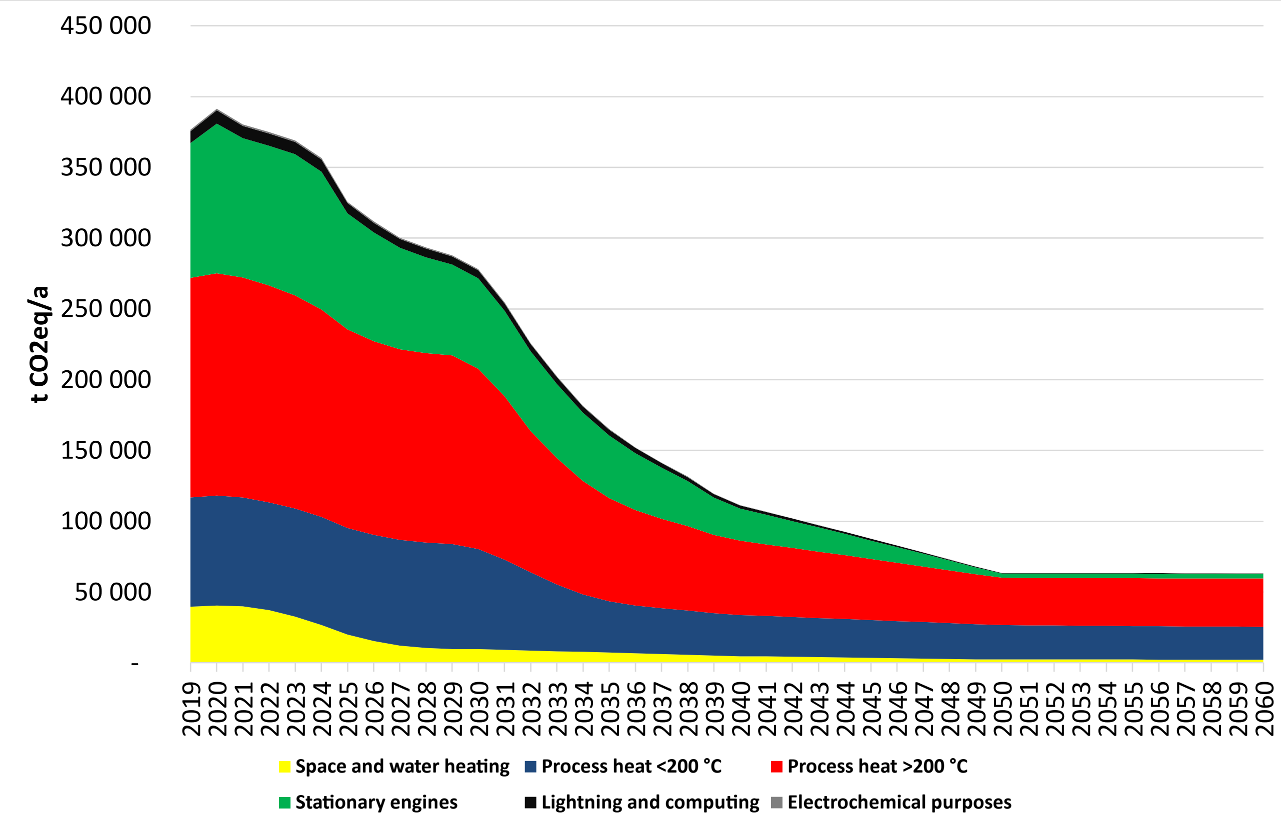

Figure 3-1: Energy related GHG-emissions of selected industry sectors in Lower Carinthia.

A significant part of the emissions was related to the use of fossil energy carriers, such as coal, natural gas, waste, and electricity that was partly generated using fossil energy carriers. However, also biomass played a role in the GHG-emissions in 2019, mainly due to the Scope 3-emissions during the harvesting and processing of (fuel-) wood for the pulp and paper industry. We can see that the assumed transformation pathway led to a reduction in the future emissions, however, climate neutrality could not be reached without assuming CCU/CCS/CDR activities.

Table 3-1 shows the shift in the use of energy carriers that was assumed for the base scenario. Depending on the activity, a change to an adequate energy carrier was modelled in order to reach the goal of climate neutrality. For the base scenario, parameter settings that were judged as realistic and consistent with national and international climate goals were used. As can be seen in the diagram, a significant reduction of the energy related GHG-emissions is possible when a shift from fossil fuels to renewable energy carriers is assumed.

Table 3-1: Alternative energy carriers that substitute fossil energy carriers until 2040.

Activity	Energy carrier 2019	Substitute	Time of implementation
Process heat >200 °C	coal	biomass-wood	2022-2031
Stationary engines	gasoline/diesel	biofuel	2022-2031
Space and water heating	heating oil	heat pump COP 3.5	2022-2031
Process heat <200 °C	heating oil	heat pump COP 2.3	2030-2039
Process heat >200 °C	heating oil	wood chips	2022-2031
Space and water heating	LPG/natural gas	heat pump COP 3.5	2022-2031
Process heat <200 °C	LPG/natural gas	heat pump COP 2.3	2030-2039
Process heat >200 °C	LPG /natural gas	67% H2, 33% biomethane	2030-2039
Stationary engines	LPG/natural gas	electricity	2022-2031
Lightning and computing	natural gas	electricity	2022
Space and water heating	waste	heat pump COP 3.5	2022-2031
Process heat <200 °C	waste	heat pump COP 2.3	2030-2039
Process heat >200 °C	waste	50% H2, 50% biomethane; not fully substituted	2030-2034

Figure 3-2 shows the emissions of the sector machinery from 2019 to 2060. In addition to Figure 3-1, not only the energy related Scope 3-emissions are indicated, but also the emissions related to other activities in the value chain, such as raw material procurement and transports.

However, Table 3-2 indicates that the Austrian goal to achieve a GHG-emission reduction of 61% (based on the goal of 55% reduction compared to 1990) between 2019 and 2030 cannot be reached using the parameters of the base scenario. At the aggregated level of all selected industry sectors, the goal of net carbon neutrality of Scope 1 and Scope 2-emissions until 2040 was not reached in the model. This was mainly due to the high emissions related to process energy.

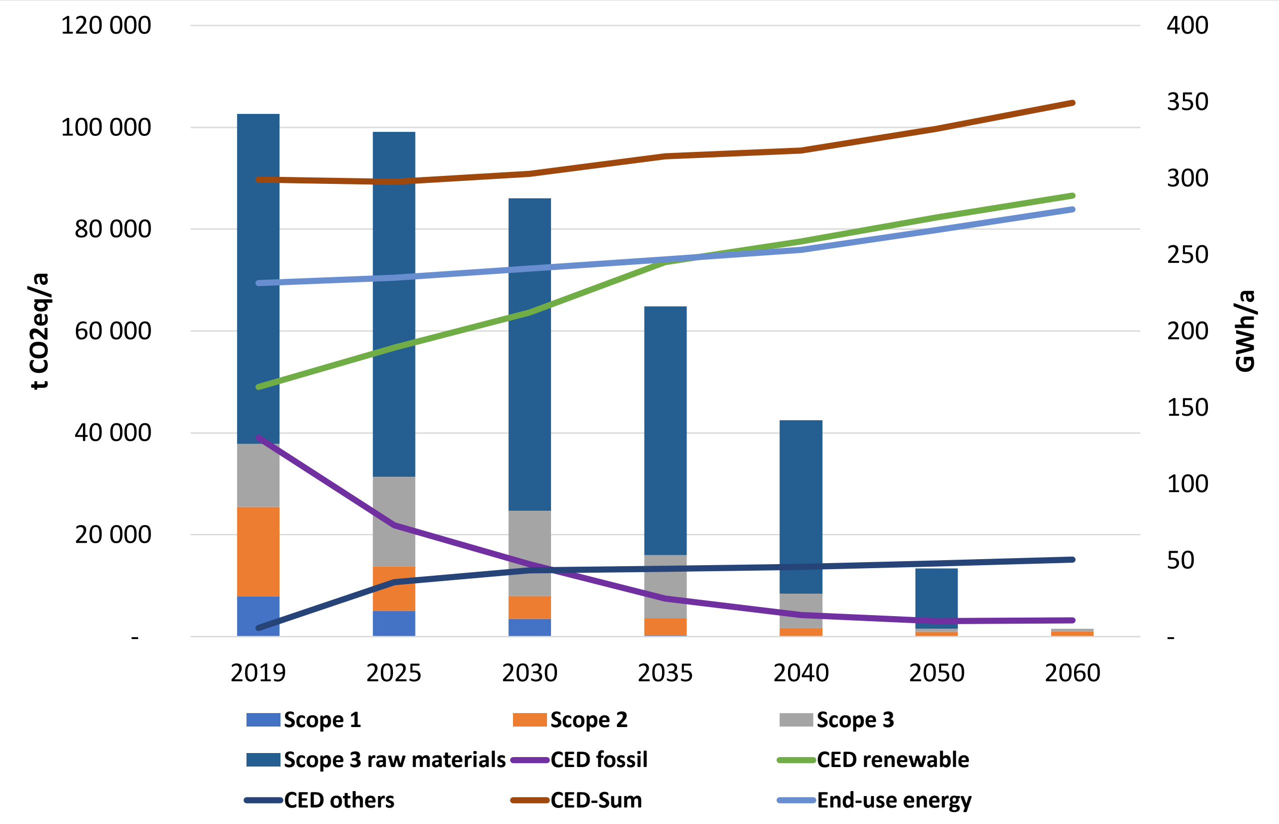

Figure 3-2: Energy related Scope 1/2/3-emissions of the sector machinery including Scope 3-emissions for up and downstream value chain "raw materials", cumulative energy demand, and consumed end-use energy.

Table 3-2: GHG-Emissions reduction of selected industry sectors/machinery as compared to the base year 2019 and required CCU/CCS/CDR to meet climate goals.

Year	Total Selected Industries: Reduction of Scope 1 and 2-Emissions compared to 2019 [%]	Machinery: Reduction of Scope 1 and 2-Emissions compared to 2019 [%]	Reduction plan Austria [%]	CCU/ CCS/CDR for all selected industry sectors [t CO2eq]
2025	29	46		0
2030	46	69	61	38 358
2035	82	86		0
2040	88	93	100	30 870
2050	89	96		27 361
2060	89	96		28 760

The table furthermore shows that there is a demand for CCU/CCS/CDR to meet the climate goals. On the one hand, due to the late implementation of renewable energy systems and on the other hand, for the compensation of the remaining GHG-emissions, that are costly or hard to reduce. It can be seen that for this particular industry sector the non-energy related Scope 3-emissions (mainly the production of raw materials) were higher than the energy related Scope 1/2/3-emissions in 2019. Hence, it can be concluded that there is a strong need for an emission reduction in the up- and downstream value chain of the sector machinery, so that it can meet the goal of overall climate neutrality. In addition, the cumulative energy demand (CED) is indicated in the graphic, showing a significant increase in renewable energy consumption, stressing the need for an expansion of renewable energy carriers.

Table 3-3 shows the share of different activities in the total non-energy Scope 3-activities of the sector machinery. It can clearly be seen, that a major share of the Scope 3-emissions is related to the use of fabricated metal products, basic iron and steel, aluminium and electrical equipment. Hence, an emission reduction in the whole value chain of the sector machinery requires a significant transformation of the metal producing industry that supplies the machinery sector.

Table 3-3: Share of different activities (mainly raw material production) in the non-energy related Scope 3-emissions of the industry sector "machinery".

Industry Sector	**Share in Scope 3-emissions [%]**
Fabricated metal products	17
Basic iron and steel and ferro-alloys	14
Electrical machinery	8
Aluminium	8
Machinery	7
Wholesale trade	7
Other business services	5
Rest	29

Another aspect of the project was to identify the amount of renewable energy needed in the future. The model shows that an increase of more than 42% of the current amount of electricity is needed to serve the future electricity and H2 consumption as assumed in the base scenario. Biogen energy carriers (mainly from wood) show an increase of 16%.

4 DISCUSSION AND CONCLUSION

The results of the survey showed many different barriers and potentials for the transformation of business models. Some even contradicted each other as it was the case for the firm size. It was found that the potential of reducing the energy amount used and of producing at least some of the energy used autonomously was rather high. In addition, there is a significant potential regarding transportation. Barriers comprised a lack of knowledge and financial means on the one hand and missing political measures and a lacking availability of climate neutral raw materials on the other hand. Different recommendations for future actions of diverse actors can be derived from the results. These recommendations will be of interest for both policy makers and the funding body. Policy makers shall offer informative material on the requirements of the Greed Deal for companies. Further, individual consultation on potential changes and on the variety of funding options may be favourable for the transformation. Funding bodies may be well advised to offer training for and/or promote the introduction of an energy expert within the companies. Especially the certification of such an expert may be an incentive for employees to take part in a training. In addition, also the introduction of a pool of experts that can be contacted from each company, if required, may be helpful. This may also increase the distribution of knowledge between different companies.

The GHG emission-model shows how a possible transformation can look like for the carbon-intense industry sectors in Lower Carinthia. Based on realistic assumptions, a base scenario was modelled to clarify whether the political goals of climate neutrality can be reached. The results indicate that for the entire region it is hardly possible to reach the climate goals in the given time frame without additional measures (such as CCU/CCS/CDR) or a drastic reduction of the emission factors of renewable energy sources. Further measures, such as highest possible reduction of GHG-emissions of renewable energy carriers, extensive efficiency gains, CCU/CCS/CDR and possibly also a rethinking of the type of products that are manufactured should be considered. However, for single industry sectors like the sector machinery, the goal of 61% reduction in Scope 1 and Scope 2 by 2030 seems reachable supposing the assumptions of the base scenario. The results urge the need for the further development of renewable electricity and biomass to meet the future industry demand. The model furthermore shows the highest contributors to the non-energy related Scope 3-emissions of the individual sectors. Based on these results, measures in the upstream- and downstream value chain can be derived, e.g. the necessary supply of green steel in order to reduce the Scope 3-emissions of the machinery sector.

This study has a number of limitations. It can be assumed that especially companies that were already interested in the topic or even already took steps to a more sustainable business model agreed to an interview (self-selection bias). Therefore, results may only reflect barriers and potentials for these firms. Furthermore, knowing from the ex-ante phone call, interview partners knew that the interview was about sustainability and therefore presented themselves from a sustainable viewpoint (social desirability bias). Also concerning the carbon footprint of the industry sectors, several limitations can be named. One is the lacking of detailed data on energy consumption in the region of Lower Carinthia, which made it necessary to approximate the consumption as described above. Furthermore, the choice of emission factors (especially for renewable energy carriers) can have a significant influence on the overall results. Another limitation is that the used EEIO-table represents a very rough estimation on the related average Scope 3-emissions of Austrian industry sectors and therefore the applicability in the specific region of Lower Carinthia is very limited. In addition, for this paper the process emissions of the non-metallic minerals sector were not considered.

The study was a first approach to develop a framework for the decarbonisation of a region with a high share of GHG-intense industries. We were able to identify potentials and barriers to a transformation towards climate neutrality and we outlined possible transformation pathways. Our study design proved as useful to sketch the necessary technological developments in the transformation. However, due to the limitations of our methodological framework, we recommend to focus on the generation of more reliable data on energy consumption and Scope 3-emissions for future studies.

For future research it may be of interest to further analyse which specific changes are most difficult due to a lack of financial means. Thus, a more purposeful funding could be offered. Learnings from the LOCA2 project are transferable to other regions easily, especially in the Austrian context, as a broad variety of industry sectors was analysed on a macro-level. The handbook can serve as a guideline towards climate neutrality for the different industry sectors and will be available by the end of 2022. We hope that decision makers will use it as a blue print for the transformation towards climate neutrality and circular economy.

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6 REFERENCES

[1] A. Osterwalder and Y. Pigneur, *Business Model Generation: Ein Handbuch für Visionäre, Spielveränderer und Herausforderer*. Campus Verlag, 2011.

[2] R. Geyer, S. Knöttner, C. Diendorfer, and G. Drexler-Schmid, 'Energieinfrastruktur für 100 % Erneuerbare Energie in der Industrie', 2019.

[3] C. Diendorfer *et al.*, 'Klimaneutralität Österreichs bis 2040. Beitrag der österreichischen Industrie', 2021.

[4] Martin Baumann, Karin Fazeni-Fraisl, Thomas Kienberger, and Peter Nagovnak, 'Erneuerbares Gas in Österreich 2040. Quantitative Abschätzung von Nachfrage und Angebot Endbericht', 2021. Accessed: Jul. 13, 2022. [Online]. Available: https://www.bmk.gv.at/dam/jcr:2486be49-85cd-41d6-b2af-a6538757e5cd/Erneuerbares-Gas-2040.pdf

[5] 'Strategische Handlungsoptionen für eine österreichische Gasversorgung ohne Importe aus Russland', Wien, 2022. [Online]. Available: www.energyagency.at

[6] Bundesministerium für Klimaschutz, 'Wasserstoffstrategie für Österreich', Wien, 2022.

[7] 'Eine Wasserstoffstrategie für ein klimaneutrales Europa', Brüssel, 2020. [Online]. Available: https://www.eu2018.at/de/calendar-events/political-

[8] Statistik Austria, 'Standard-Dokumentation. Metainformationen (Definitionen, Erläuterungen, Methoden, Qualität) zur Nutzenergieanalyse', Wien, 2013. [Online]. Available: www.statistik.at

[9] N. Sinkovics, D. Gunaratne, R. R. Sinkovics, and F.-J. Molina-Castillo, 'Sustainable Business Model Innovation: An Umbrella Review', *Sustainability*, vol. 13, no. 13, p. 7266, Jun. 2021, doi: 10.3390/su13137266.

[10] L. C. Comin, C. C. Aguiar, S. Sehnem, M.-Y. Yusliza, C. F. Cazella, and D. J. Julkovski, 'Sustainable business models: a literature review', *Benchmarking: An International Journal*, 2019.

[11] V. Rizos *et al.*, 'Implementation of Circular Economy Business Models by Small and Medium-Sized Enterprises (SMEs): Barriers and Enablers', *Sustainability*, vol. 8, no. 11, p. 1212, Nov. 2016, doi: 10.3390/su8111212.

[12] D. A. Vermunt, S. O. Negro, P. A. Verweij, D. V. Kuppens, and M. P. Hekkert, 'Exploring barriers to implementing different circular business models', *J Clean Prod*, vol. 222, pp. 891–902, Jun. 2019, doi: 10.1016/j.jclepro.2019.03.052.

[13] H.-F. Hsieh and S. E. Shannon, 'Three Approaches to Qualitative Content Analysis', *Qual Health Res*, vol. 15, no. 9, pp. 1277–1288, Nov. 2005, doi: 10.1177/1049732305276687.

[14] J. Saldana, *The coding manual for qualitative research*, 2nd ed. London: Sage Publications, 2013.

[15] Statistik Austria, 'Nutzenergieanalyse'. STATISTIK AUSTRIA, 2022.

[16] 'GEMIS 4.9.3'. https://www.umweltbundesamt.at/angebot/leistungen/angebot-cfp/gemis (accessed Jul. 13, 2022).

[17] 'Exiobase 3.3.18'.