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# Aarhus University Emissions Inventory 2022

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Abstract: Greenhouse gas inventories and disclosure of these emissions are an important tool in providing the decision support for developing and implement meaningful mitigation strategies. Aarhus University's 2022 emissions inventory has developed on previous inventories with a refined method, reflecting the academic discourse in this space, while following the guidelines of the GHG Protocol. This report includes process based methods, which result in 24,782.3 $tCO_2e$ across scope 1, 2 and 3, with the exception of 3.1 purchased goods and services, and 3.2 capital goods. Spend based approaches were used in place of process based for scope 3.1 and 3.2, using EXIOBASE, and result in 50.0017.7 $tCO_2e$. Since the two approaches answer different questions, they cannot be summed, although individually present relevant foundation for defining a decarbonization plan for Aarhus University. AU should work to improve the quality of Scope 3 data.

Keywords: GHG Accounting, Emissions, Decision Support,

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# Contents

# Executive summary

This is Aarhus University's (AU's) internal greenhouse gas (GHG) inventory for 2022, using the same methodology as in 2021 including some emission factors (EF), while still adhering to the Greenhouse Gas Protocol (GHGP).

The process-based (PB) method resulted in total scope 1, 2, and 3 emissions of **24,782.3 $tCO_2e$**, and an increase of approximately 25% increase of comparable emissions from 2021.

Total PB emissions are down by also approximately 25% from 2018, when AU first began disclosing emissions.

The total spend-based (SB) emissions resulted in **50,017.7 tCO2e**. With the total scope 3.1 (purchased goods and services) and scope 3.2 (capital goods) emissions as the sources. The major contributing sub-categories are the same as last year. The emission from Scope 3.1. has increased with more than **10,000 tCO2e** compared to 2021 with the wholesale of liquids and gasses as the biggest source. Whereas scope 3.2 is not changed between 2021 and 2022. Using this method, we are unable to clearly define which specific purchases or suppliers within these categories are responsible for the greatest emissions. The increases are adjusted relative to Danish inflation but not global inflation which could also contribute to the increase in scope 3.1. We recommend that AU improve the quality of Scope 3 data in the future.

Normalizing the PB data to $tCO_2e$ per person-year across employees, students and combined results in: **2.90 ($tCO_2e$/employee-year)**; **0.90 ($tCO_2e$/student-year**), and combined **0.7 ($tCO_2e$/total-AU-year)**, which is also an increase relative to 2021 - see Table 2.

# Methods

The inventory in this report follows the same methods as reported in the AU inventory of 2021 (Stridsland et al 2021). Emissions are derived using both the Process and Spend based methodologies (SB & PB). In accordance with the methods agreed by Danish Universities, process-based assessments are prioritized where possible, followed by spend based where possible. At the start of 2020, an ad-hoc emissions group was created by Universities Denmark, with the goal of constructing a method for most effectively applying the GHGP at Danish universities. The result of this collaboration introduced the nuances between the attributional LCA (aLCA) and consequential LCA (cLCA) methods and showcased the trade-offs with using each respective method. As a result, the universities agree that both methods play an important role in a university emissions inventory. The method used depends on the data each university has access to and what kind of questions are asked recognizing that emission disclosure is an evolving area of research and will be updated in future inventories.

The Green House Gas Protocol (GHGP) provides guidance on emissions data hierarchy - with the supplier specific data being of preferable quality and spend-based conversion being applied in the absence of higher quality data – see table below:

**Table 1.** GHGP suggested data hierarchy.

| Method | Approach |
|---|---|
| Supplier specific | Collect high-quality product-level EF data from supplier directly |
| Hybrid | Combination of the above method with additional average data |
| Average data | Multiply the mass of units bought with the most relevant EF from another source |
| Spend-based | Convert economic data to EF |

The spend based method is used in the absence of supplier specific attributional LCA data or because a consequential LCA method is preferred to support decisions. In Denmark these are primarily provided by the EXIOBASE database (https://www.exiobase.eu/) and follow suggestions from the Universities Denmark group.

From an LCA methods point of view these two types of data cannot be mixed – however, the GHGP allows the mixing of data from these methods. In this report we provide both a total emission where data from both methods are aggregated in accordance with the GHGP and one where the two results are not aggregated in accordance with the LCA methods.

In summary as in the 2021 report we found and applied data according to the figure 1 below:

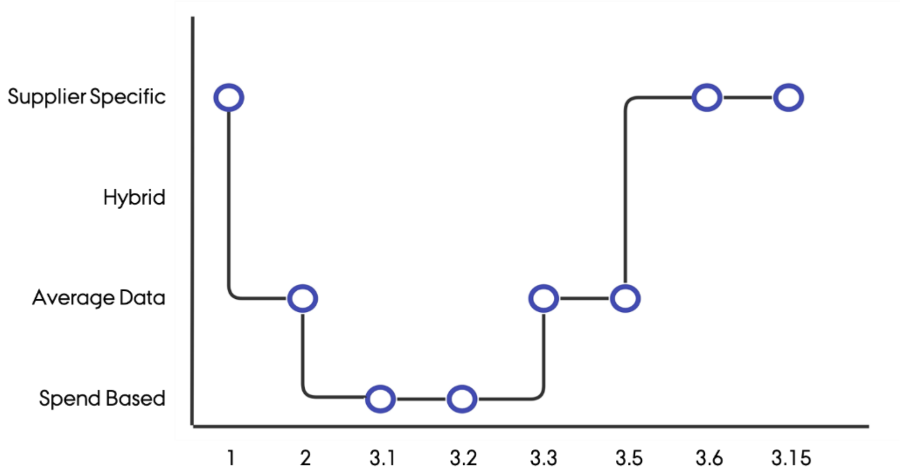


**Figure 1**: The quality and characteristics of the data used per scope. Supplier specific data indicates that emissions data was provided by the supplier. Average data is collected from industry, national, or regional databases which reflect the relevant average. Spend based uses economic data with models that convert spend to emissions. Spend based data was used to determine procurement related activities at AU.

## Results

### Total emissions 2022

The direct (Scope 1) emissions resulted in a total of **6,491.4 tCO2e** – with 1,469.8 tCO2e green biogas or biofuels which does not contribute to the total Scope 1 emissions in 2022. Gas and agriculture are the largest sources (Fig 2).

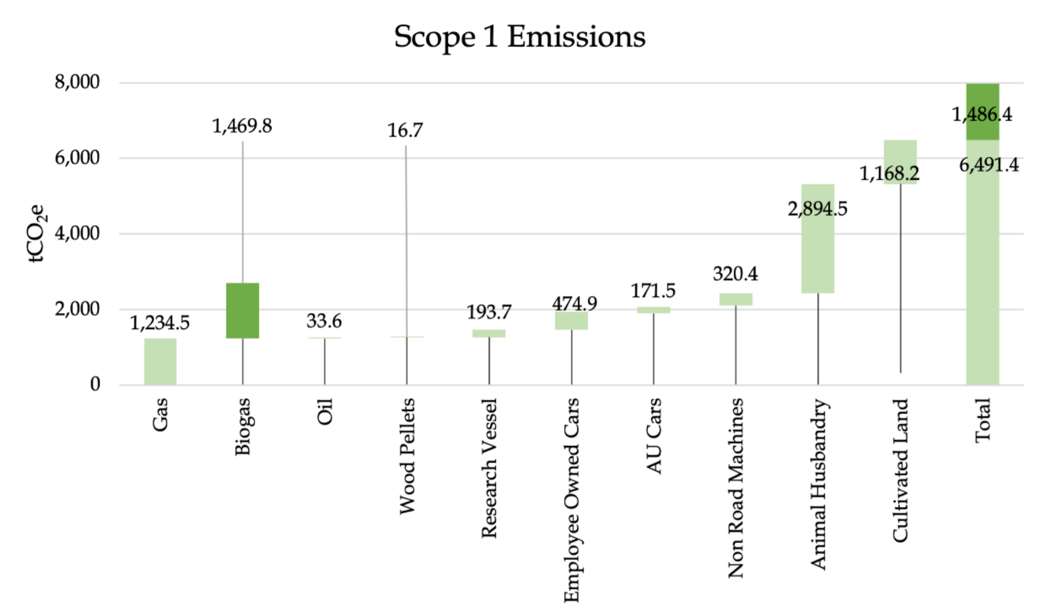


**Figure 2:** Scope 1 emissions

The indirect emissions (Scope 2) resulted in **9137.9 tCO2e** emitted by AU in 2022, dominated by electricity and heating from Kredsløb Aarhus (Fig 3).

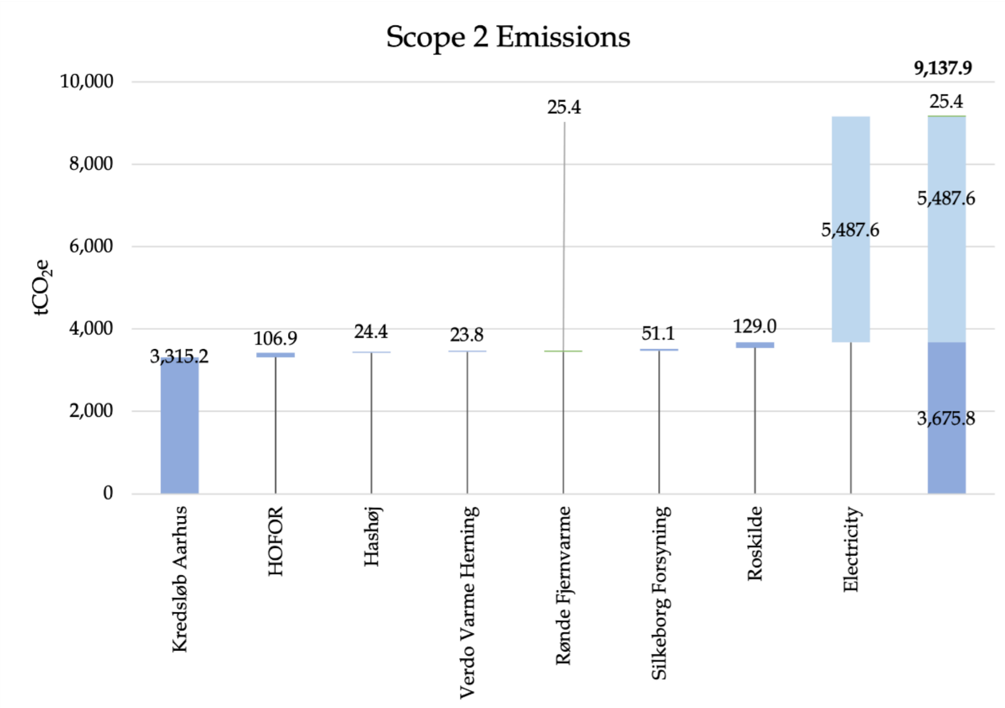


**Figure 3:** Scope 2 emissions

The total emissions from AU in 2022 from indirect Scope 3 sources. Results are based on the process based assments from suppliers and are only available for some of the 15 Scope 3 sub-categories as shown in figure 4 below. Emissions from business travel dominates these emissions, as flight activity rebounds towards pre-pandemic levels.

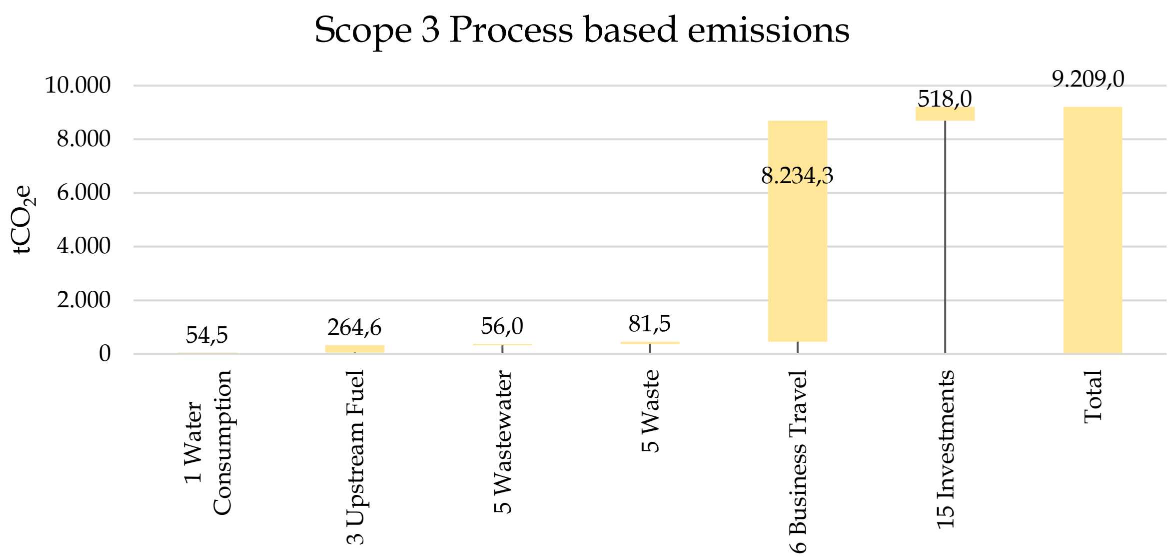


**Figure 4:** Total Scope 3 process based emisisons

For the rest of the sub-categories we did not have supplier specific process based data and thus relied on spend-based data from the EXIOBASE database which can be seen in the figure 5 below. The emissions from the spend-based (SB) approach is summarized in the figure 5 below where purchased goods and services in Scope 3.1 and 3.2 are the major contributors.

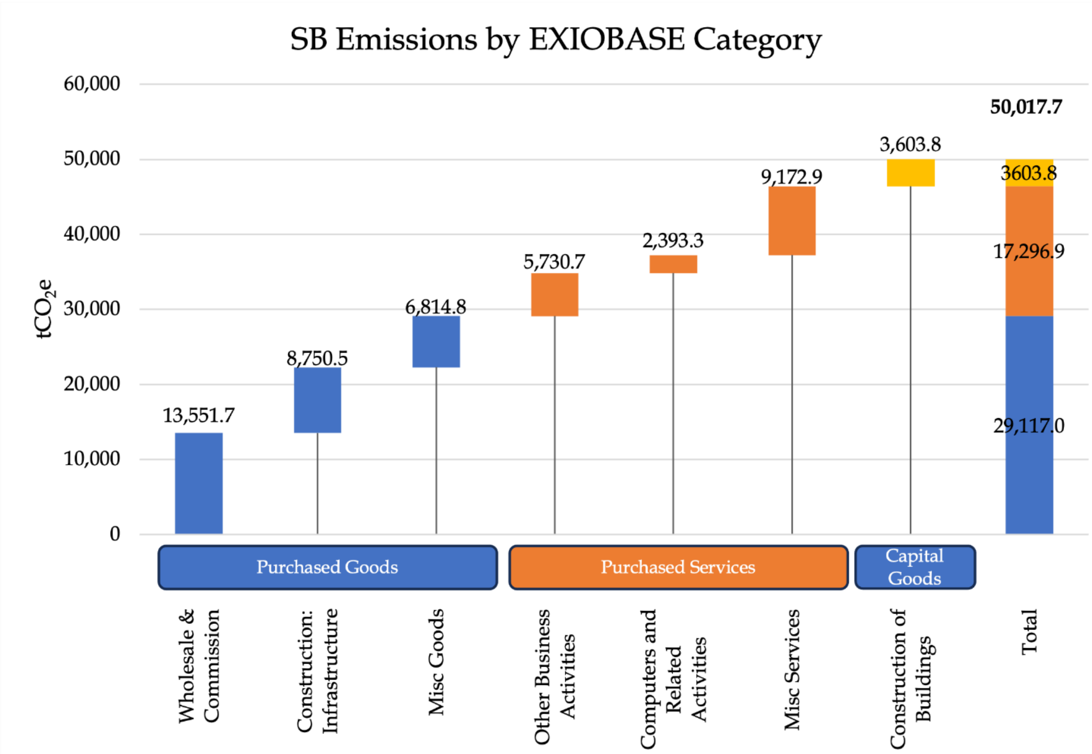


**Figure 5**: Scope 3 spend based emissions.

The total emission from all sources shown in Figure 6. The totals are split on the process and spend based methods and also includes the total Scope 1 & 2 emissions.

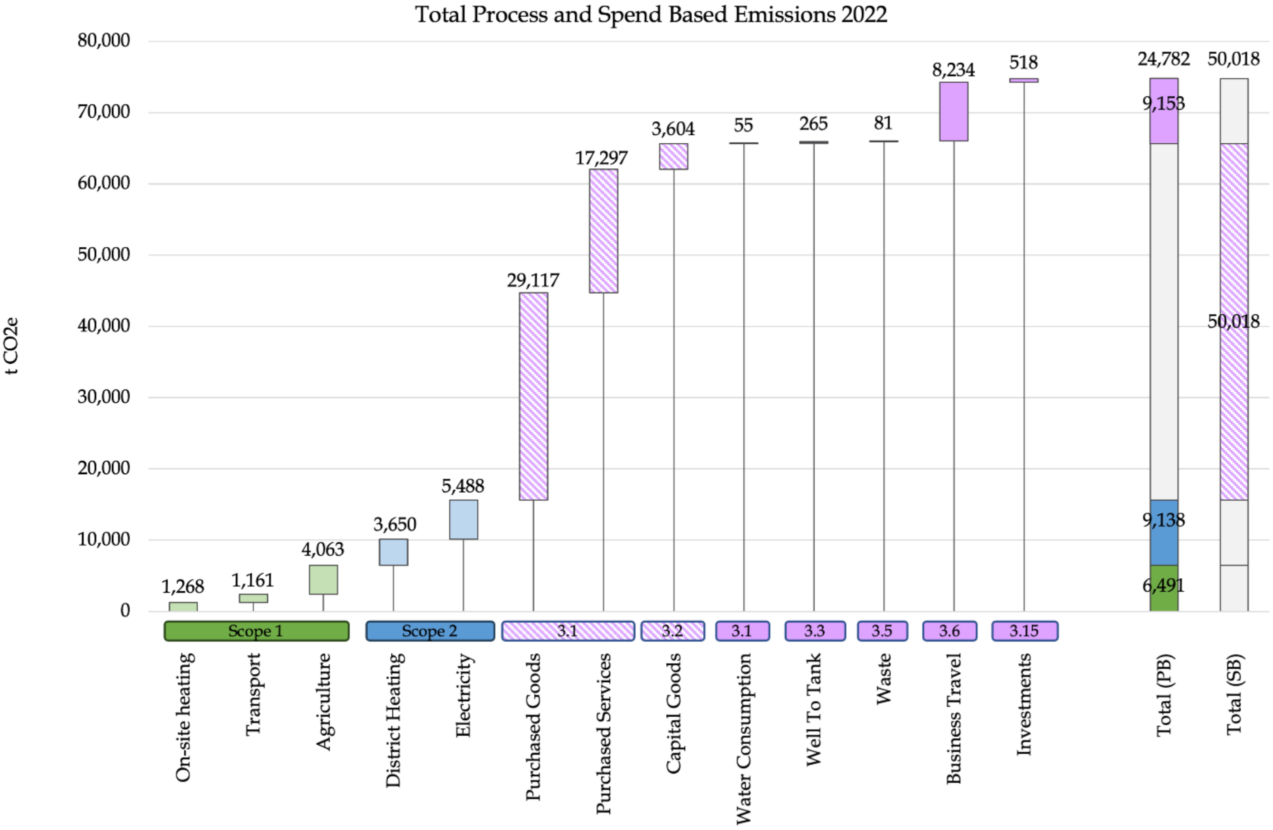


**Figure 6**. Total emissions for 2022. Scope 1 is shown in green, scope 2 in blue, and scope 3 in purple – with the striped being based on EXIO BASE.

It is clear that scope 3.1 are the largest categories, and that they are currently, as in 2021, quite aggregate. They are estimated based on EXIOBASE – hence these large categories are both inaccurate in terms of their materiality and imprecise in their actual emissions in accordance with the GHGP. However, it is the best data we have, at the moment.

## Process based emissions comparison 2021 – 2022

The following figures show the percentage development of emissions from 2021 to 2022 (activity and emissions data are shown below in table 2). Overall, emissions have risen by 50%, largely due to significant increases in air travel. The right axes indicate the positive or negative percent change in 2021 emissions and activity. Note: Right axes ranges are from -25% to 25% for all graphs, with the exception of wastewater and air travel, due to increases above 25%. The only significant parameter is the business travel related emissions which are up by more than 500%. The rest are realtively unchanged or outside of the control of AU (e.g. electricity despite a constant use the emissions dropped due to lower emission factors on electricity whereas the opporsite was the case for distric heating where a slight reduction in use was compensated by a higher emission factor and thus higher emissions – these are based on publicly available preliminary estimates of emission factors from Energistyrelsen).

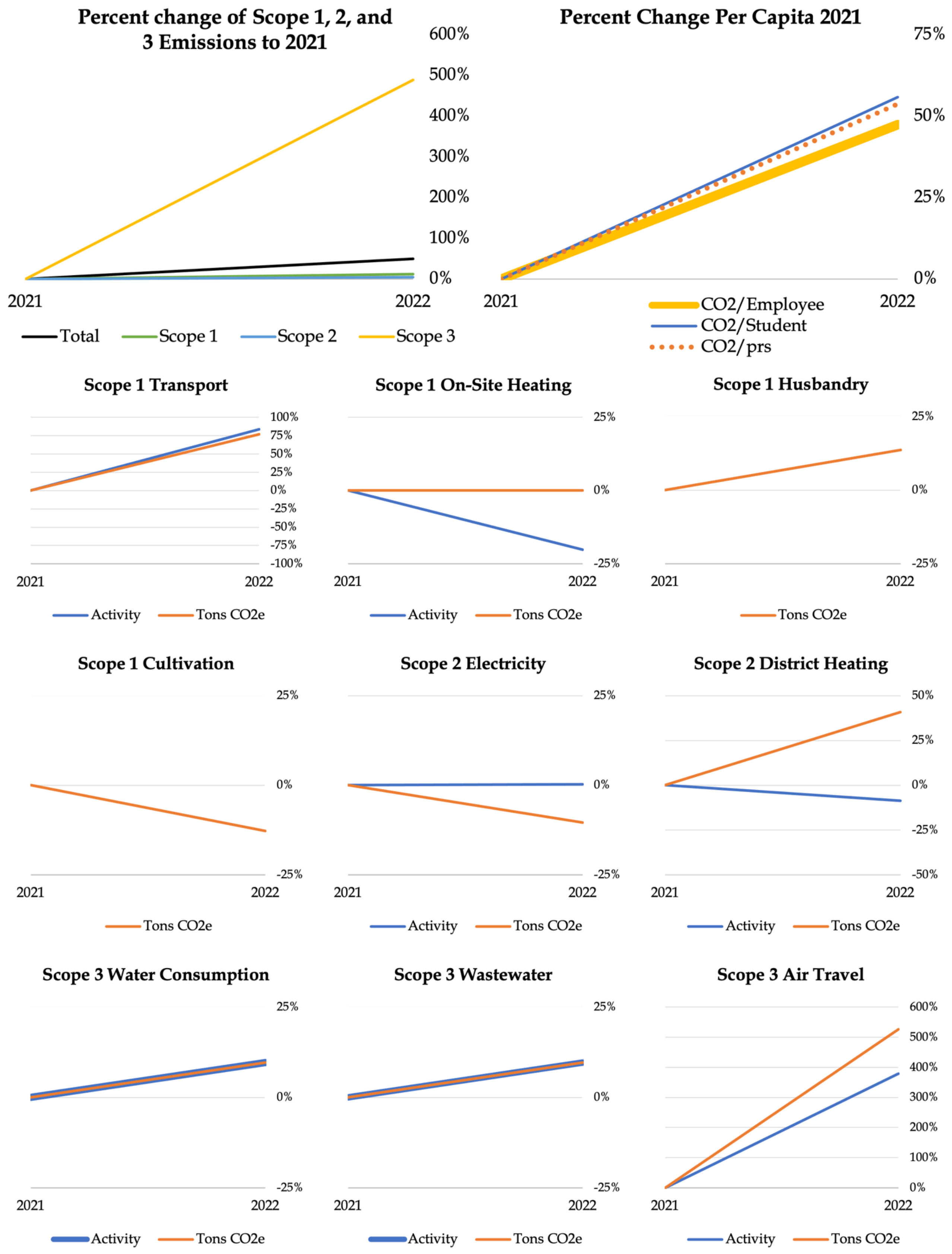


**Figure 7**. Top: Percent change in scope 1, scope 2, scope 3, and total emissions between 2021 and 2022. Total comparable includes all emission sources considered in the 2021 process-based assessment. Lower, percent change of emissions in relation to 2021 emissions per scope and category. All figures range from -25% to 25% with the exception of wastewater and air travel, which show increases greater than 25%. Flight emissions have risen disproportionately to activity due to data limitations, as emissions are based on data from CWT yet only 1/3 of AU flights are booked through CWT leading to potential inaccuracies.

## Process based emissions comparison 2018 – 2022

2022 emissions are down approximately 25% in both total emissions and per capita from 2018 emissions, among comparable parameters, and are shown in table 2 as finite numbers and the figures below as percent change from 2018, over time. The right axes indicate the positive or negative percent change in 2022 emissions and activity in relation to 2018. Scope 1 Transport activity starts in 2019 where comparable data was gathered. Right axes minimums are at -100% for the graph that include air travel missions. Investments are included from 2020 and onwards. Again the return of the business air travel after COVID is the major shift over time.

**Table 2**. Total PB emissions and comparable parameters from 2018 – 2022. Activity is reported in varied units.

| | **2018** | | **2019** | | **2020** | | **2021** | | **2022** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Activity | tCO2e | Activity | tCO2e | Activity | tCO2e | Activity | tCO2e | Activity | tCO2e |
| On Site Combustion | 13,303 | 1,677 | 15,410 | 1,522 | 14,152 | 1,520 | 14,752 | 1,268 | 11,776 | 1,268 |
| Transport | 349,656* | 918 | 322,964 | 828 | 259,037 | 675 | 255,810 | 656 | 469,797 | 1,161 |
| Husbandry | | 2,879 | | 2,862 | | 2,547 | | 2,547 | | 2,895 |
| Cultivation | | 1,435 | | 1,555 | | 1,307 | | 1,339 | | 1,168 |
| Agriculture | | 4,327 | | 4,431 | | 3,887 | | 3,886 | | 4,063 |
| District Heating | 57,365 | 2,219 | 53,502 | 1,778 | 52,615 | 2,526 | 59,477 | 2,590 | 54,376 | 3,650 |
| Electricity | 50,704 | 10,090 | 50,356 | 7,302 | 44,477 | 5,560 | 44,132 | 6,127 | 44,255 | 5,488 |
| Flights | 69,568,786 | 12,619 | 62,417,266 | 11,387 | 5,809,788 | 950 | 10,274,565 | 1,287 | 49,258,131 | 8,059 |
| Water | 404,898 | 81 | 306,535 | 61 | 262,647 | 53 | 248,705 | 50 | 272,676 | 55 |
| Wastewater | 404,898 | 37 | 306,535 | 28 | 262,647 | 24 | 248,705 | 51 | 272,676 | 56 |
| Water total | | 118 | | 88 | | 76 | | 101 | | 111 |
| Scope 1 | | 6,922 | | 6,782 | | 6,082 | | 5,811 | | 6,491 |
| Scope 2 | | 12,309 | | 9,079 | | 8,086 | | 8,717 | | 9,138 |
| Scope 3 | | 12,737 | | 11,475 | | 1,026 | | 1,388 | | 8,170 |
| **Total** | | **31,968** | | **27,335** | | **15,194** | | **15,916** | | **23,799** |
| CO2/Employee | **7,871** | **4.1** | **8,040** | **3.4** | **8,005** | **1.9** | **8,290** | **1.9** | **8,417** | **2.8** |
| CO2/Student | **26,523** | **1.2** | **26,700** | **1.0** | **26,657** | **0.6** | **27,172** | **0.6** | **26,090** | **0.9** |
| CO2/prs | **34,394** | **0.9** | **34,740** | **0.8** | **34,662** | **0.4** | **35,462** | **0.4** | **34,507** | **0.7** |

*Based on assumptions not following the methodology of corresponding years


**Figure 8**. Top: Percent change in scope 1, scope 2, scope 3, and total emissions between 2022 and 2018. Total comparable includes all emission sources considered in the 2020 process based assessment. Lower: Percent change of emissions in relation to 2020 emissions per scope and category. All figures range from -50% to 50% with the exception of air travel which shows a nearly 100% reduction in 2020

## Process based per employee, student and person comparison for 2018 – 2022

Growth and increases in consumption will be reflected in the emission inventory as an increase in emissions. To counter this, and to show potential decoupling of emissions from growth, the results are normalized against total full time equivalents of employees, students, and combined, and shown in the table below, as well as in the figures above and table 2. A 50% increase is seen from 2021, however the significant reduction seen since 2018 is a result of partially more students and employees at AU, and a significant drop in AU emissions during Covid-19 which in terms of air travel is back to normal. The energy and inflation crisis are not apparent in the overall emission assessment.

**Table S1. 2022** Total process based emissions per employee, student and person.

| | |
|---|---|
| $tCO_2e$/Employee | 2.90 |
| $tCO_2e$/Student | 0.90 |
| $tCO_2e$/prs | 0.70 |

# Conclusion

This report marks the latest development of the GHG inventory at AU, from the initial assessment in 2018. AU has initially reported on scope 1 and 2 emissions and gradually added scope. This report uses the same methodology as the 2021 report.

The analysis found that Aarhus University's emissions have increased by 50% from 2021. In total, the PB method resulted in total scope 1, 2 and 3 emissions of **24,782.3 $tCO_2e$**, showing a reduction of overall emissions from 2018 by approximately 25%. The SB method resulted in a total of **50,017.7 tCO2e** emitted. With the total scope 3.1 (purchased goods and services) and scope 3.2 (capital goods) emissions as the by far most significant and unclear sources.

Normalizing the PB results to $tCO_2e$ per person-year across employees, students and combined results in: **2.90** (**$tCO_2e$/employee-year**); **0.90** (**$tCO_2e$/student-year**), and combined **0.70** (**$tCO_2e$/total-AU-year**), which is an increase of approximately 50% from 2021.

Further expansion on the EXIOBASE categories to UNSPSC codes shows that the top 4 emission posts in Scope 3.1.and 3.2 are: computers, devices, and software at 2,385.7 $tCO_2e$, Pharmaceuticals at 2,240.3 $tCO_2e$, other machinery and equipment at 2,847.9 $tCO_2e$, and solid, liquid and gaseous fuels etc. at 3,378.9 $tCO_2e$ – with the latter as the biggest increase relative to 2021.

We recommend, that AU seeks to improve the resolution and quality of the emission data on the purchases in Scope 3.1 and 3.2 as these are represent most of the total emissions and are currently inaccurately and imprecisely quantified via the current spend-base method in EXIOBASE. These assessments are useful as hot-spot identification for further exploration and improved documentation with higher tier process-based supplier specific data provision. Hence, we recommend that AU pursue these data with their suppliers and the relevant economic departments. With better data comes better planning and more efficient results.

# References

Aarhus University. (2020). *Climate Strategy 2020-2025*. https://auinstallation40.cs.au.dk/fileadmin/www.au.dk/om_au/KLIMASTRAT2020_DK_INDHOLD_v4_UK_v5.pdf

DEFRA. (2023). Greenhouse gas reporting: conversion factors 2023. https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2022

DSB. (2023). *Miljøårsopgørelse 2023*.

Energinet. (2023). *Deklarationer*. https://energinet.dk/El/Gron-el/Deklarationer

ENS. (2023). *Standardfaktorer for brændværdier og* $CO_2$*- emissionsfaktorer til brug for rapporteringsåret 2022* . www.ens.dk

EXIOBASE. (2022). EXIOBASE v3.3 (v. 2021 m. 2011-data). https://www.exiobase.eu/

GHG Protocol. (2011). Corporate Value Chain (Scope 3) Accounting and Reporting Standard. In *WRI and WBSCD*.

HOFOR. (2020). *Vand i verdensklasse*. https://www.hofor.dk/baeredygtige-byer/vi-skaber-baeredygtige-byer/vand-i-verdensklasse/

HOFOR. (2022a). *Miljødeklaration 2021 for fjernvarme i Hovedstadsområdet*.

HOFOR. (2022b). Miljødeklaration for fjernvarme. https://www.hofor.dk/baeredygtige-byer/beregn-$CO_2$/miljoedeklarationer/miljoedeklaration-for-fjernvarme/

Kredsløb. (2022). Miljødeklaration for Kredsløb. https://www.kredslob.dk/professionel/produkter-og-services/fjernvarme/miljoedeklaration-emissionsdata

Ministry of Environment. (2021). *Punktkilder 2020*.

Nielsen, O.-K., Plejdrup, M. S., Winther, M., Nielsen, M., Gyldenkærne, S., Mikkelsen, M. H., Albrektsen, R., Thomsen, M., Hjelgaard, K., Fauser, P., Bruun, H. G., Johannsen, V. K., Nord-Larsen, T., Vesterdal, L., Stupak, I., Scott-Bentsen, N., Rasmussen, E., Petersen, S. B., Baunbæk, L., & Hansen, M. G. (2023). *Denmark's National Inventory Report 2023. Emission Inventories 1990-2020 - Submitted under the United Nations Framework Convention on Climate Change and the Kyoto Protocol.* http://dce2.au.dk/pub/SR189.pdf

Peters, G. P. (2010). Carbon footprints and embodied carbon at multiple scales. *Current Opinion in Environmental Sustainability*, *2*(4), 245–250. https://doi.org/10.1016/J.COSUST.2010.05.004

Prussi, M., Yugo, M., De Prada, L., Padella, M., Edwards, R., & Lonza, L. (2020). *JEC Well-to-Tank report v5*. https://doi.org/10.2760/959137

Verdo. (2022). Fjernvarmedekleration 2021. https://www.verdo.com/media/7819/miljoedeklaration-herning-2021_28-06-2022.pdf

Winther, M. (2022a). Danish emission inventories for road transport and other mobile sources. Inventories until 2020. *DCE – Danish Centre for Environment and Energy*, *277*.

Winther, M. (2022b). Drivhusgasemissioner for rejser med fly på Aarhus Universitet. *Annual Transport Conference at Aalborg University*. https://www.trafikdage.dk/abstracts_2022/Drivhusgasemissioner-for-rejser-med-fly-på-Aarhus-Universitet.pdf