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KTH Royal Institute of Technology´s Carbon Footprint for 2019 and 2022	2024-11-13	V-2024-0894 KS-kod 2.2

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KTH Royal Institute of Technology's Carbon Footprint for 2019 and 2022

Description of the Assignment:

2050 Consulting AB previously prepared carbon accounts for 2015 and 2019 and during the spring of 2024 prepared this carbon account for 2022. This report describes the methodology, results, and analysis for the 2022 carbon account and includes the accounts for 2019 and 2015. The 2019 account has been updated based on the revised methodology used during the work on the 2022 account.

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1 Background

This report presents the carbon footprint of KTH Royal Institute of Technology (hereinafter referred to as KTH), including a description of the methodology and assumptions made. An analysis of the results, in terms of KTH's climate goals and the potential for future emission reductions, will also be presented.

KTH plays an important role in driving sustainable societal development to actively contribute to achieving Agenda 2030 and the 17 global goals (Chapter 1, Section 5 of the Higher Education Act). This is expressed in KTH's core values as well as in KTH's vision. According to the sustainability policy, KTH aims to be a leading university in sustainable development by actively and responsibly contributing to sustainable development through education, research, collaboration, and by reducing environmental impact from its operations as well as promoting social responsibility. The strategic work is based on the overarching sustainability goals for the period 2021–2025 and the climate goals for 2021–2045. KTH's climate goal (2021–2045) comprises the overarching goal: “KTH is a leading technical university for climate transition and a climate-neutral society.” The climate goal is broken down into six quantitative interim goals for emission reductions 2021–2045 (base year 2015):

2022: KTH is climate-neutral concerning Scope 1 (direct emissions from KTH's own operations) and significantly reduces emissions from Scope 2 (emissions from the production of purchased electricity, heat, and cooling).

2025: KTH is climate-neutral concerning Scope 1 and 2.

2030: KTH has reduced its climate impact by 60% concerning Scope 1, 2, and 3 (emissions from other goods and services purchased by KTH) per full-time equivalent compared to 2015.

2040: KTH has reduced its climate impact by 90% concerning Scope 1, 2, and 3 per full-time equivalent compared to 2015.

2045: KTH is climate-neutral (Scope 1, 2, and 3).

After 2045, KTH has negative emissions.

Organization

KTH is Sweden's largest institution for technical education and research. The principle is the head leading KTH's operations under the University Board, KTH's highest decision-making body. KTH's core activities, education, and research are organized into five schools:

- Architecture and Civil Engineering (ABE School)
- Chemistry, Biotechnology, and Health (CBH School)
- Electrical Engineering and Computer Science (EECS School)
- Industrial Engineering and Management (ITM School)
- Engineering Science (SCI School)

Each school is at an overarching level organized into departments and led by school heads, who report to the principle. School heads have access to operational support (VS), previously Joint Operational Support (GVS). Operational support is organized into functional departments responsible for coordinating and preparing issues at an overarching level, as well as VS departments providing targeted support to the schools (previously local operational support at the schools). In 2022, the principle decided that operational support at the schools and joint operational support (GVS) would merge to form a new organization.

KTH operates on five campus areas: KTH Campus, KTH Kista, KTH Solna, KTH Flemingsberg, and KTH Södertälje. KTH is also present at AlbaNova University Center (jointly with Stockholm University). KTH does not own its buildings but rents them from property owners such as Akademiska Hus, Hemsö, and Samhällsbyggnadsbolaget. Akademiska Hus is KTH's largest property owner. Until 2016, KTH also operated in Haninge, which is included in the climate calculations for 2015.

2 Process description

The carbon footprint has been calculated according to the principles of the Greenhouse Gas Protocol (GHG Protocol)[2]. data has been collected from KTH's operations, the property department, the finance department, and all property owners. Some assumptions have been estimated from discussions with KTH, including how the distribution between schools regarding energy and waste would be made based on the floor area the schools occupy in each location and that emissions from purchased goods and services would be based on the analysis of the spending data excluding VAT.

All collected data has been evaluated by 2050 Consulting through reasonableness assessments. Data sources and emission calculations are presented in the document.
The tool used for calculations is an Excel model developed and used by 2050 Consulting in climate calculations of similar size, adapted for KTH's operations. The model is adapted to the GHG Protocol and includes emission factors that are updated and adapted to the Swedish context as far as possible. Examples of sources for emission factors are the Swedish Environmental Protection Agency, the Swedish Energy Agency, the Energy Market Inspectorate, and the Swedish Procurement Agency.

3 Greenhouse Gas Protocol – scope 1, 2 och 3

According to the Greenhouse Gas Protocol[3], emissions should be divided into three main groups - so-called scopes. Scope 1 encompasses the emissions that KTH has direct control over, such as emissions from their own premises and emissions from cars owned or controlled by employees in service. Scope 2 shows the emissions from producing the electricity, district heating, and district cooling used in KTH's premises. Finally, scope 3 includes all other indirect emissions, such as emissions from the purchase of raw materials, business travel, waste management, employee commuting, etc. The figure below shows how different emission sources are divided among the scopes.[4]

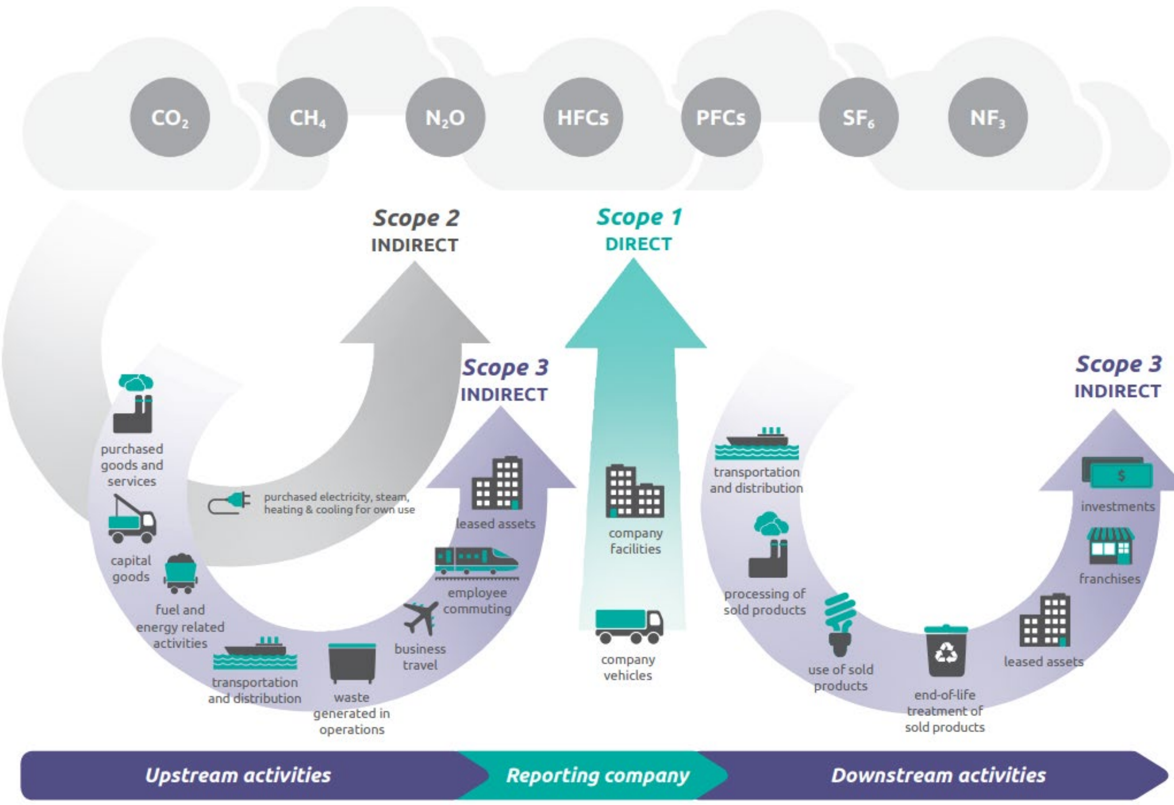


Figure 1 Overview of GHG Protocol scopes and emissions across the value chain.

4 System Boundary

According to the Greenhouse Gas Protocol, emissions should be divided into three main groups - so-called scopes. Scope 1 encompasses the emissions that KTH has direct control over, such as emissions from their own premises and emissions from cars owned or controlled by employees in service. Scope 2 shows the emissions from producing the electricity, district heating, and district cooling used in KTH's premises. Finally, Scope 3 includes all other indirect emissions, such as emissions from the purchase of raw materials, business travel, waste management, and staff commuting.

5 Method

5.1 Consolidation Approach

The allocation of emissions between the different scopes depends, to some extent, on which consolidation approach is used: "equity share approach", "financial control approach", or "operational control approach":

- "Equity share approach" – all emissions from subsidiaries are included in the parent company's respective scope, but only in proportion to the parent company's ownership share.
- "Financial control approach" – emissions are consolidated and classified based on financial control and economic interest. This means that for subsidiaries where the parent company has financial control, the entire emission is reported in the parent company's respective scope regardless of ownership share.
- "Operational control approach" – emissions are consolidated and classified based on operational control, such as operational responsibility. This means that for subsidiaries where the parent company has operational control, the entire emission is reported in the parent company's respective scope regardless of ownership share.

In KTH's carbon reporting, the "operational control approach" has been used. This means that emissions from energy use in KTH's operations are classified as scope 2 instead of scope 3 and that direct emissions from cars that are not owned but rented by KTH are also reported as scope 1.

5.2 Calculation of Emissions from Purchased Energy

Use According to the GHG Protocol's guidelines for scope 2, emissions can be calculated using either a location-based method or a market-based method. One method must be chosen, but emissions should be presented according to both methods.

- **"Market based method"** – According to the market-based method for scope 2, the consumer of electricity, district heating, cooling, and steam should use the emission factor associated with approved origin agreements. This means that if the company procures electricity (or district heating, cooling, or steam) with guarantees of origin, the specific emission factor for that guarantee should be used, for instance, hydropower.

- **"Location based method"** – in this method, the average emission factor for the energy mix in the grid is used to calculate emissions in scope 2, regardless of whether the company, or another company, has procured guarantees of origin.

  The method used in KTH's carbon reporting is the "market-based method." However, in accordance with the GHG protocol, the emissions calculated according to the other method are also presented for comparison.

6 Results

6.1 Greenhouse Gas Emissions 2015, 2019 and 2022

KTH's greenhouse gas emissions for the years 2015, 2019, and 2022 are presented in the following tables. The emissions are classified according to the emission source and scope. Note that the figures are rounded to whole numbers.

***Table 1** GHG emissions 2015.*

KTH 2015 Emissions of green house gases (tonnes CO_2e)	Scope 1	Scope 2	Scope 3	Total	Percentage of total emissions
Facilities	**-**	**1 659**	**12 693**	**14 352**	**43%**
Facilities - Electricity	-	163	320	483	1%
Facilities - District cooling	-	-	22	22	<0,5%
Facilities - District heating	-	1 496	136	1 632	5%
Facilities - Refrigerant leakage	-	-	-	-	0%
Facilities - New constructions	-	-	9 743	9 743	29%
Facilities - Renovation, refurbishment and retrofit	-	-	2 472	2 472	7%
Chemicals	**-**	**-**	**19**	**19**	**<0,5%**
Production of chemicals	-	-	19	19	<0,5%
Waste	**-**	**-**	***11***	***11***	***<0,5%***
Waste - Landfill	-	-	-	-	0%
Waste - Destruction	-	-	6	6	<0,5%
Waste - Material & energy recovery	-	-	5	5	<0,5%
Business travel and commuting	**6**	**-**	**13 442**	**13 448**	**40%**
Business travel total	6	-	11 973	11 979	36%
Business travel - whereof car	*6*	-	*25*	*31*	*<0,5%*
Business travel - whereof bus	-	-	-	-	*0%*
Business travel - whereof taxi	-	-	*5*	*5*	*<0,5%*
Business travel - whereof train	-	-	*9*	*9*	*<0,5%*
Business travel - whereof air (excluding student travel)	-	-	*8 459*	*8 459*	*25%*
Business travel - whereof hotel	-	-	*353*	*353*	*1%*
Business travel - whereof student travel	-	-	*3 123*	*3 123*	*9%*
Commuting total	-	-	1 468	1 468	4%
Commuting - whereof car	-	-	*530*	*530*	*2%*
Commuting - whereof bus	-	-	*935*	*935*	*3%*
Commuting - whereof MC	-	-	*1*	*1*	*<0,5%*
Commuting - whereof train	-	-	*3*	*3*	*<0,5%*
Purchased goods and services	**-**	**-**	**5 719**	**5 719**	**17%**
Purchased goods and services	-	-	5 719	5 719	17%
Total	**6**	**1 659**	**31 883**	**33 548**	
Total excluding student travel	6	1 659	28 760	30 425	

Table 2 *GHG emissions 2019.*

KTH 2019 Emissions of green house gases (tonnes CO_2e)	Scope 1	Scope 2	Scope 3	Total	Percentage of total emissions	Change from 2015 to 2019
Facilities	**6**	**1 618**	**2 103**	**3 728**	**10%**	**-74%**
Facilities - Electricity	-	14	385	399	1%	-17%
Facilities - District cooling	-	-	7	7	<0.5%	-66%
Facilities - District heating	-	1 604	111	1 716	5%	5%
Facilities - Refrigerant	6	-	-	6	<0.5%	No data 2015
Facilities - New constructions	-	-	-	-	0%	-100%
Facilities - Renovation, refurbishment and retrofit	-	-	1 600	1 600	4%	-35%
Chemicals	**-**	**-**	**28**	**28**	**<0.5%**	**49%**
Production of chemicals	-	-	28	28	<0.5%	49%
Waste	***-***	***-***	***19***	***19***	***<0,5%***	***74%***
Waste - Landfill	-	-	-	-	0%	No data 2015
Waste - Destruction	-	-	11	11	<0.5%	90%
Waste - Material & energy recovery	-	-	8	8	<0.5%	55%
Business travel and commuting	**51**	**-**	**9 093**	**9 144**	**26%**	**-32%**
Business travel total	51	-	8 148	8 199	23%	-32%
Business travel - whereof car	*45*	-	*11*	*56*	*<0.5%*	*80%*
Business travel - whereof bus	*7*	-	*3*	*9*	*<0.5%*	*No data 2015*
Business travel - whereof taxi	-	-	*27*	*27*	*<0.5%*	*483%*
Business travel - whereof train	-	-	*0*	*0*	*<0.5%*	*-100%*
Business travel - whereof air (excluding student travel)	-	-	*4 528*	*4 528*	*13%*	*-46%*
Business travel - whereof hotel	-	-	*302*	*302*	*1%*	*-14%*
Business travel - whereof student travel	-	-	*3 276*	*3 276*	*9%*	*5%*
Commuting total	-	-	*944*	*944*	*3%*	-36%
Purchased goods and services	**-**	**-**	**22 930**	**22 930**	**64%**	**301%**
Purchased goods and services	-	-	22 930	22 930	64%	301%
Total	**57**	**1 618**	**34 172**	**35 848**	**100%**	**7%**
Total excluding student travel	57	1 618	30 896	32 571	91%	2%

Table 3 *GHG emissions 2022.*

KTH 2022 Emissions of green house gases (tonnes CO_2e)	Scope 1	Scope 2	Scope 3	Total	Percentage of total emissions	Change from 2019 to 2022	Change from 2015 to 2022
Facilities	**31**	**1 217**	**2 060**	**3 307**	**8%**	**-11%**	**-77%**
Facilities - Electricity	-	17	344	361	1%	-9%	-25%
Facilities - District cooling	-	-	13	13	<0,5%	75%	-41%
Facilities - District heating	-	1 200	92	1 292	3%	-25%	-21%
Facilities - Refrigerant leakage	31	-	-	31	<0,5%	403%	No data 2015
Facilities - New constructions	-	-	-	-	0%	-	-100%
Facilities - Renovation, refurbishment and retrofit	-	-	1 610	1 610	4%	1%	-35%
Chemicals	**-**	**-**	**382**	**382**	**1%**	**1266%**	**19**
Production of chemicals	-	-	382	382	1%	1266%	1929%
Waste	***-***	***-***	***58***	***58***	***0%***	***210%***	***4***
Waste - Landfill	-	-	8	8	<0,5%	No data 2019	No data 2015
Waste - Destruction	-	-	39	39	<0,5%	249%	563%
Waste - Material & energy recovery	-	-	11	11	<0,5%	47%	128%
Business travel and commuting	**47**	**-**	**7 839**	**7 886**	**20%**	**-14%**	**- 0**
Business travel total	47	-	7 121	7 168	18%	-13%	-40%
Business travel - whereof car	*47*	-	*12*	*59*	*<0,5%*	*6%*	*89%*
Business travel - whereof bus	-	-	*1*	*1*	*<0,5%*	*-87%*	*No data 2015*
Business travel - whereof taxi	-	-	-	-	*0%*	*Included in car*	*Included in car*
Business travel - whereof train	-	-	*0*	*0*	*<0,5%*	*13%*	*-100%*
Business travel - whereof air (excluding student travel)	-	-	*4 643*	*4 643*	*12%*	*3%*	*-45%*
Business travel - whereof hotel	-	-	*352*	*352*	*1%*	*16%*	*0%*
Business travel - whereof student travel	-	-	*2 113*	*2 113*	*5%*	*-35%*	*-32%*
Commuting total	-	-	*717*	*717*	*2%*	*-24%*	*-51%*
Purchased goods and services		**-**	**27 856**	**27 856**	**71%**	**21%**	**387%**
Purchased goods and services	-	-	27 856	27 856	71%	21%	387%
Total	**78**	**1 217**	**38 194**	**39 489**	**100%**	**10%**	**18%**
Total excluding student travel	78	1 217	36 081	37 375	95%	46%	50%

The total emissions for 2015 were 33,548 tons CO_2e, with the largest emissions found in business travel and commuting. In 2019, emissions were 35,848 tons CO_2e (32,571 tons CO_2e excluding student travel). The largest share of emissions comes from purchased goods and services, at 64%, followed by business travel and commuting (23%), where flights alone represent 13% of KTH's total emissions. Note that the methodology for emissions from purchased goods and services was updated during the work on the 2022 report, and the figures for 2019 have been updated according to the new methodology. This has affected the 2019 results, which show higher emissions in the purchase of goods and services. The 2015 data has not been updated according to the new methodology.

The emissions for 2022 were 39,489 tons CO_2e (37,375 tons CO_2e excluding student travel), indicating an increase in emissions of approximately 18 percent from 2015 and 10 percent from 2019. The largest share of emissions comes from purchased goods and services (71%), followed by business travel and commuting (20%) and facilities (8%).

A major difference in the reports prepared for 2015, 2019, and 2022 is the methodology for purchased goods and services. Access to more detailed and improved emissions data for purchased goods and services has contributed to a new methodology, resulting in changes in the magnitude of the results between 2015, 2019, and 2022. During the 2022 report's work, the 2019 values were also updated, making these emissions comparable.

Emissions that have been excluded from the calculations, or are irrelevant to KTH, include:

- Emissions from sold products (processing, use, and disposal) and franchising, as KTH neither sells any products with emissions nor conducts franchise operations.
- Emissions from assets rented out by KTH to other organizations and emissions from the transport and distribution of goods to and from KTH, as these emissions are considered negligible.
- Emissions of volatile organic compounds, such as solvents used in laboratories, which have been excluded due to insufficient information and because they are not among the greenhouse gases required for reporting under the GHG Protocol.
- Emissions arising from the capital of KTH's affiliated foundations have been excluded for 2022 because the affiliated foundations are separate legal entities and not part of the authority.

6.1.1 Emissions in Scope 2 calculated by alternative methods.

As mentioned in the methodology section, the "market-based method" was chosen to calculate KTH's emissions in scope 2. The following table shows how these results compare with those calculated using the "location-based method."

Table 4 *GHG emissions in scope 2 with both scope 2 methods, 2015, 2019 and 2022.*

Scope 2 emissions (tonne CO_2e)	2015	2019	2022
Market based method	1659	1618	1217
Location based method	2884	3837	3601

The table shows that emissions in Scope 2 would have been higher if the "location-based method" had been applied; 74% higher in 2015, 137% higher in 2019, and 195% higher in 2022.

In the following section, detailed information is presented regarding the seven emission sources (facilities, chemicals, waste management, business travel, commuting, purchased goods, and services) for which overall emissions are presented in Tables 1 and 2.

6.1.2 Facilities

This category includes emissions from energy use, refrigerant leakage, completed new construction, and renovations.

There has been an emission reduction in this category of -11 percent between 2019 and 2022, from 3,728 to 3,307 tons CO_2e. The largest emissions from this category come from renovations, closely followed by emissions from district heating. This is a significant change from 2015, when emissions from new construction were the driving category for emissions.

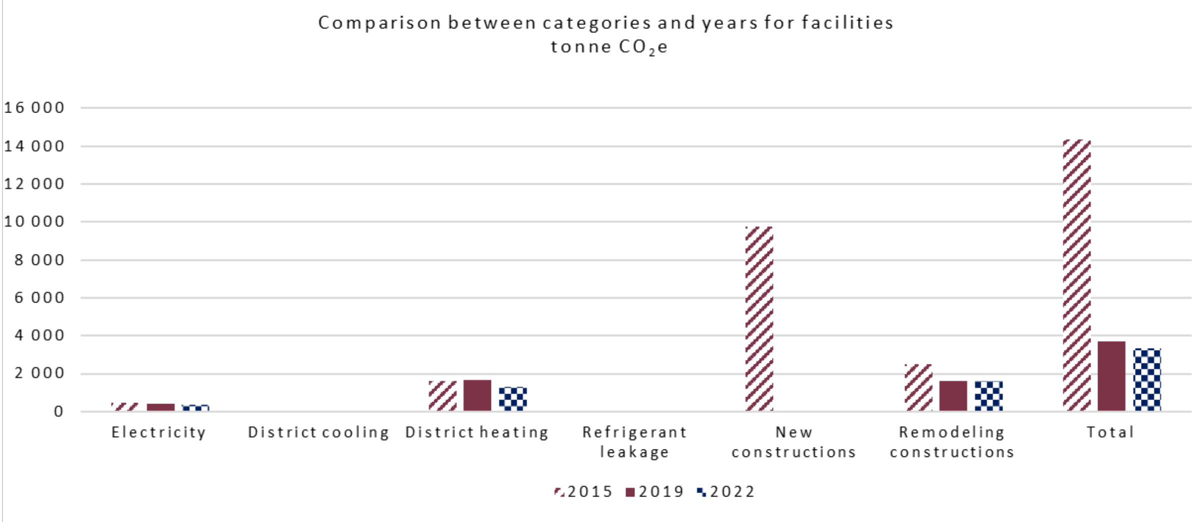


Figure 2 *GHG emissions from facilities during 2015, 2019 and 2022.*

In 2019, KTH's schools had an approximate area of 312,863 m² of usable floor space. In 2022, the occupied area was about 282,400 m² of usable floor space, a reduction of 10%. Emissions from energy use, in turn, decreased by 20%. In 2019, KTH's total energy use was 83,838 MWh, while the energy use in 2022 amounted to 72,351 MWh, representing a decrease of 13%.

In 2022, the carbon dioxide emissions intensity from energy use per m² was 5.9 kg CO_2e/m^2, which is a reduction from the 2019 value (6.8 kg CO_2e/m^2).

***Table 5** Energy consumption and emissions during 2022 and 2019.*

Energy consumption	2022			2019		
	MWh	kWh/m²	Tonne CO_2e	MWh	kWh/m²	Tonne CO_2e
Total electricity consumption	34 493	122	361	38 536	123	399
- Whereof renewable	*99%*	*121*	*356*	*99%*	*121*	*392*
- Whereof residual mix	*0%*	*0*	*0*	*0%*	*0*	*0*
- Whereof from solar power	*1%*	*1*	*6*	*1%*	*0,8*	*7*
District heating	23 461	83	1 292	29 209	89	1 716
District cooling	14 397	51	13	16 093	54	7
Total	**72 351**	**256**	**1 666**	**83 838**	**264**	**2 122**

6.1.3 Chemicals

The absolute emissions from the production of chemicals consumed in laboratories were 19 tons in 2015, 28 tons CO_2e in 2019, and 382 tons CO_2e in 2022. Emissions per employee plus full-time student were 1.6 kg CO_2e/person in 2019 and 21.6 kg CO_2e/person in 2022.

Emissions between 2015, 2019, and 2022 have increased significantly, with one explanation being a purge of chemicals in 2022, leading to higher emissions within the chemicals category due to the method used to estimate emissions. Based on available information, the actual cause is difficult to determine, and for KTH to evaluate emissions from the production of chemicals, data on purchased chemicals should be collected with higher granularity, such as the type of purchased chemicals and the volume and weight of those chemicals. For example, "x kg of ethanol for 2022" is information that can be used to better estimate emissions.

For a more accurate analysis, information on which chemicals are purchased, details about them, and in what quantities is required.

6.1.4 Waste Management

The largest source of emissions in this category for both years is chemicals and other waste sent for destruction without material or energy recovery, as shown in Figure 3 below. For the years 2015 and 2019, data on the amount of waste sent to landfills was lacking, making it difficult to draw conclusions about the changed emissions.

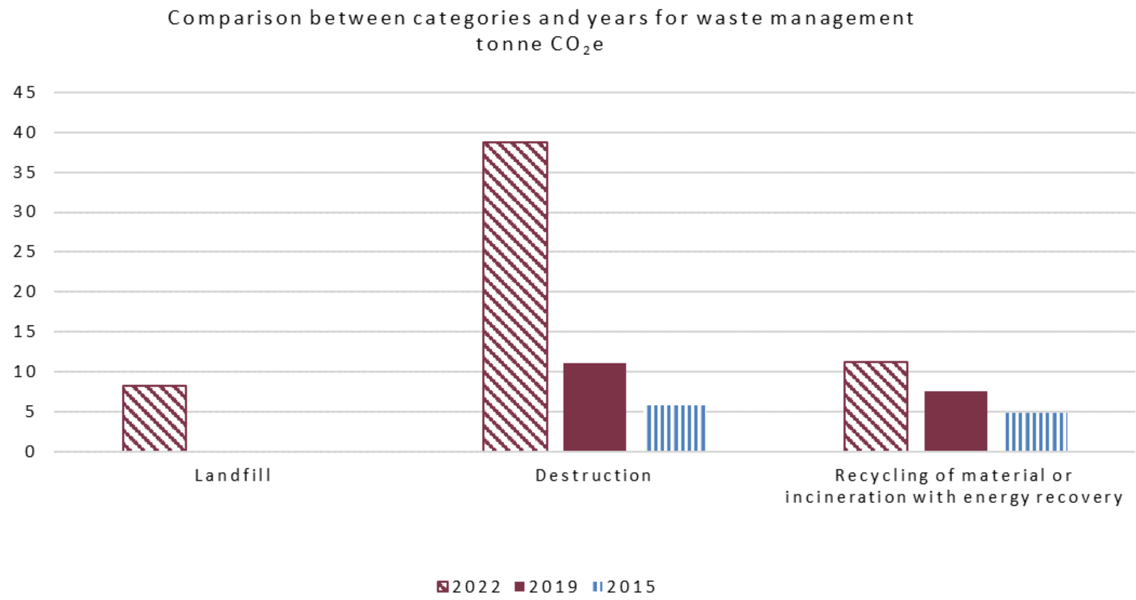


***Figure 3** GHG emissions from waste management 2015, 2019 and 2022.*

Emissions per full-time employee and full-time student were 1.1 kg CO_2e/full-time employee plus full-time student in 2019 and 3.3 kg CO_2e/full-time employee plus full-time student in 2022.

In both absolute and relative terms, emissions in this category have increased between 2019 and 2022, but the increase (210% in absolute terms) appears to be primarily due to the larger quantity of chemicals used in 2022, which then generated waste for destruction.

The emissions in the carbon account are divided for the various schools based on area. It may also be appropriate to view the results based on the number of individuals. Therefore, in Table 6, the emissions for waste management are reported based on the number of employees and the number of students registered at the different schools.

***Table 6** GHG emissions from waste management distributed on number of employees and students per school.*

Emissions from waste management [Tonne CO_2e]	2022					
School	**ABE**	**CBH**	**EECS**	**GVS**	**ITM**	**SCI**
Landfill	1,5	1,3	1,9	0,2	1,6	1,6
Recycling of material or incineration with energy recovery	2,1	1,8	2,6	0,3	2,2	2,2
Destruction	7,2	6,2	9,0	1,2	7,5	7,7
Total	**10,8**	**9,3**	**13,5**	**1,8**	**11,3**	**11,5**

Note that emissions from waste sent for material or energy recovery only include emissions from the transport of the waste to the recycling facility and exclude emissions from waste incineration for energy recovery or from the processing needed for material recovery. The GHG Protocol specifies that these emissions are instead allocated to the recycling company that receives and processes the waste and the party purchasing the recycled material, or if the waste is incinerated for energy production, to the energy customer. For emissions arising from other waste management that does not lead to further utility, such as landfilling or destruction without recycling, complete waste management emissions are included.

6.1.5 Business Travel

Emissions from 2015 were 13,448 tons CO_2e, while emissions in 2019 totaled 4,923 tons CO_2e and 5,055 tons CO_2e in 2022, indicating an increase of 3 percent between 2019 and 2022 and a decrease of 62 percent between 2015 and 2022. As the calculation methodology has been adjusted for the 2019 and 2022 calculations for business travel, the emissions for this category differ from what was reported in the 2019 climate account report but are comparable due to the adjustment.

The majority of emissions from business travel come from flights (see Figure 4), which accounted for 24 and 10 percent of KTH's total emissions in 2019 and 2022, respectively. The second largest source of emissions within the business travel category is hotel nights.

Total emissions from business travel per full-time employee were 2.2 tCO_2e/full-time employee in 2019 and 1.9 tCO_2e/full-time employee in 2022.

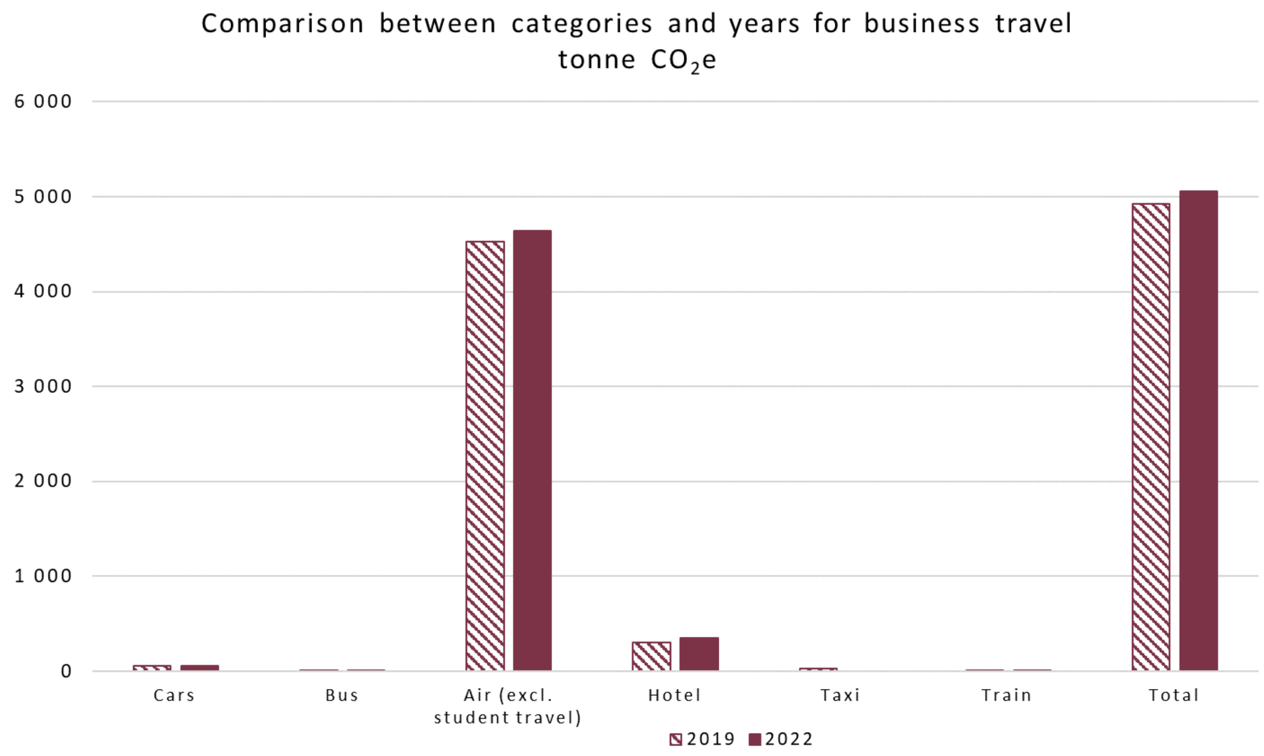


Figure 4 *GHG emissions from business travel for 2019 and 2022. 2015 is not included in the graph as the methodology for air travel emissions was different.*

6.1.6 Student Travel

Emissions from student-related travel are based on information about incoming and outgoing exchange students with the assumption that travel has been made by air between two major airports in the countries. Work is ongoing to gather more comprehensive data.

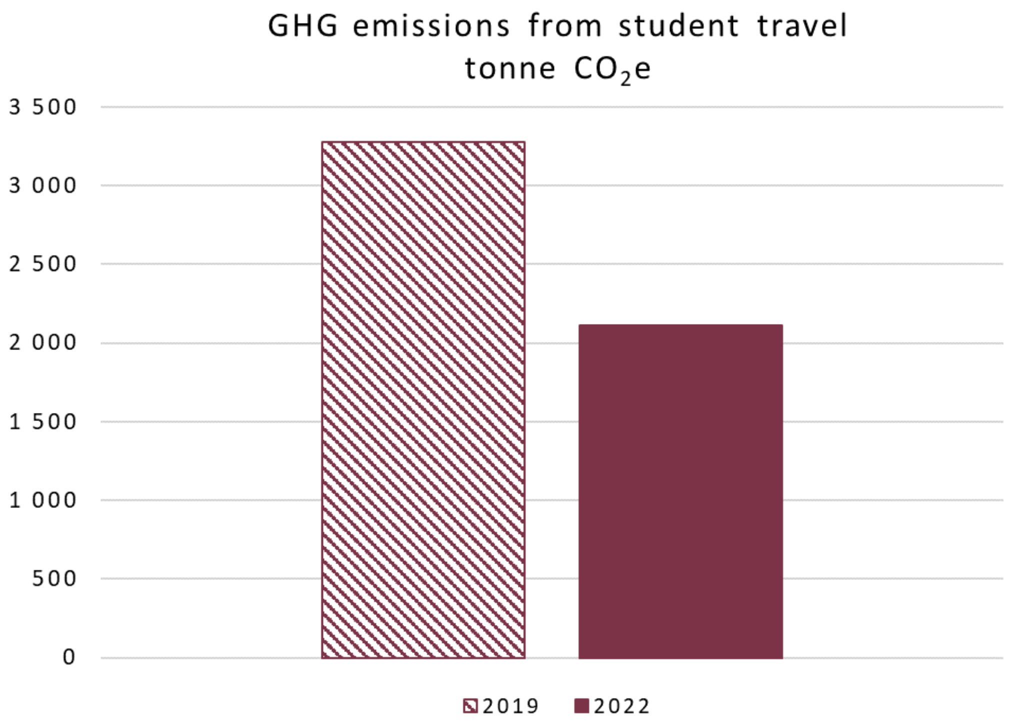


Figure 5 *GHG emissions from student travels for 2019 and 2022. 2015 is not included in the graph as the methodology for air travel emissions was different.*

6.1.7 Commuting

Emissions from commuting trips were 1,468 tons CO_2e in 2015, 944 tons CO_2e in 2019, and 717 tons CO_2e in 2022, which means that emissions have decreased by 51 percent between 2015 and 2022.

Emissions per full-time employee have also decreased between 2019 and 2022, from 0.25 tCO_2e/full-time employee to 0.17 tCO_2e/full-time employee.

Note that this category includes only commuting for employees. Corresponding figures for students are excluded due to a lack of data. According to the GHG Protocol, only employee travel should be included in the category "commuting." Student travel to and from KTH should be accounted for in the category "Downstream Transport," where the GHG Protocol indicates that "customer travel" can, but does not have to, be reported.

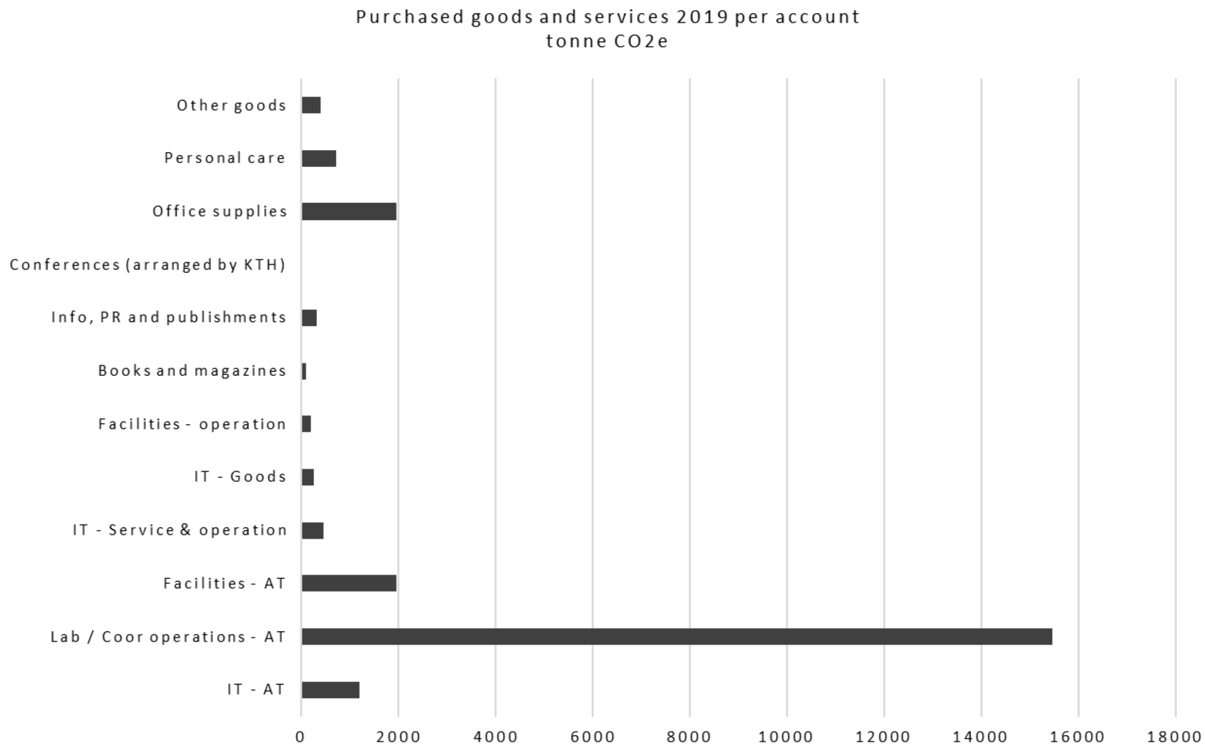
This category is calculated using the CERO model for both 2019 and 2022 and is comparable due to the unchanged methodology. For more detailed information, see the full report from the conducted travel habits survey at KTH.

6.1.8 Purchased Goods and Services

There has been an increase in emissions from purchased goods and services from the 2019 value of 22,953 tons CO_2e to the 2022 value of 27,856 tons CO_2e. Note that the 2019 value has been updated in this report compared to the previously reported climate account for 2019, where the earlier reported value was 5,676 tons CO_2e. The significant change is due to a methodology update that occurred in 2022, which meant that more purchasing items were included in the analysis. The value for 2015 was 5,719 tons CO_2e and has not been updated in this year's analysis.

Emission items corresponding to 432 million SEK were included in the 2019 value, and for 2022, the corresponding figure was 369 million SEK. However, emissions have increased during the period despite the input sum decreasing. This is because purchases were made in more emissions-intensive categories in 2022 than in 2019.

Emissions per full-time employee plus full-time students were 1,582 kg CO_2e/full-time employee plus full-time student in 2022 and 1,332 kg CO_2e/full-time employee plus full-time student in 2019.



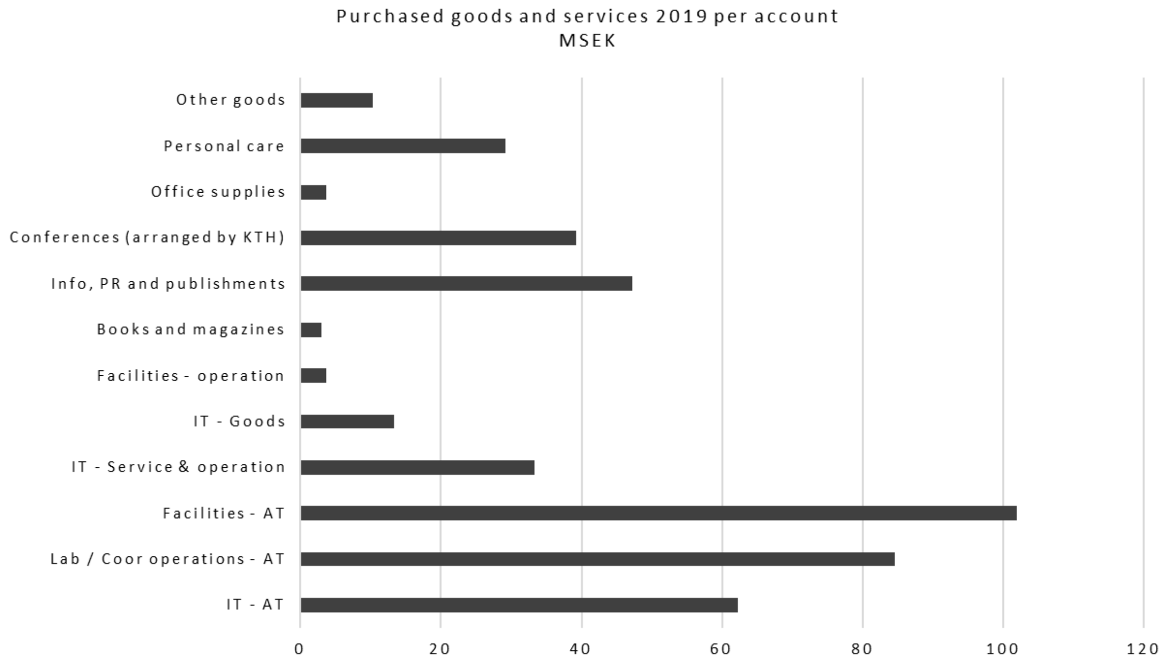
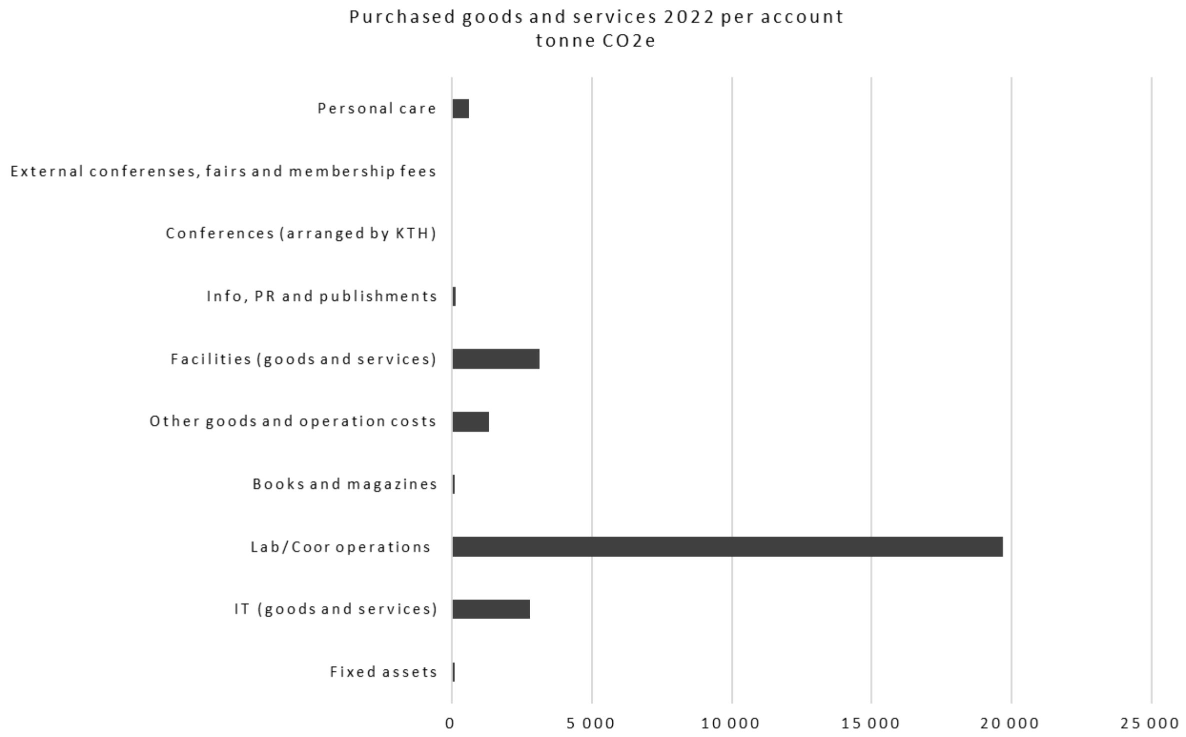
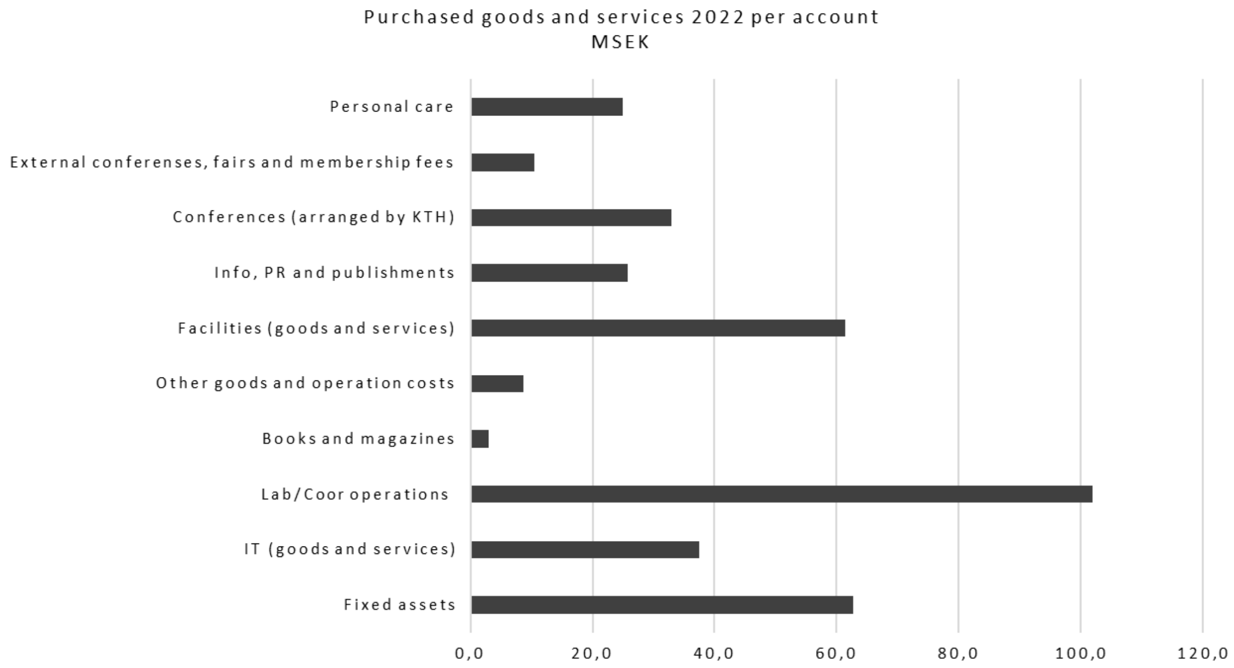


Figure 6 *Purchased goods and services per account 2019, tonne CO_2e and spend MSEK.*

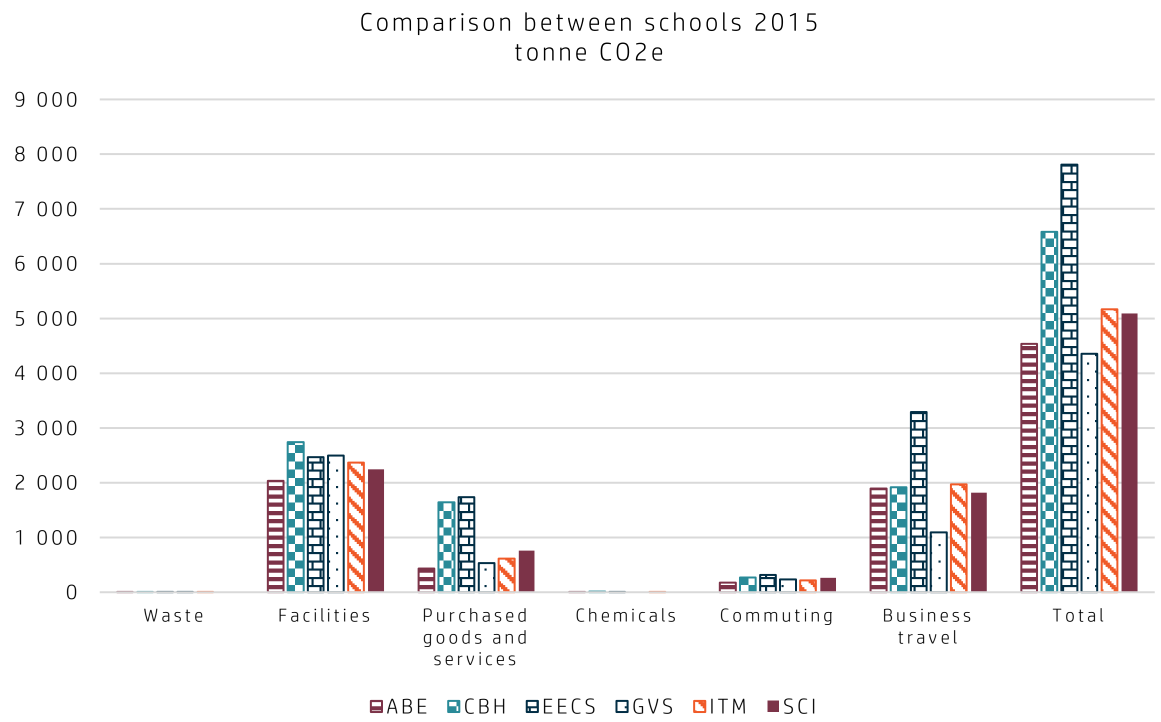




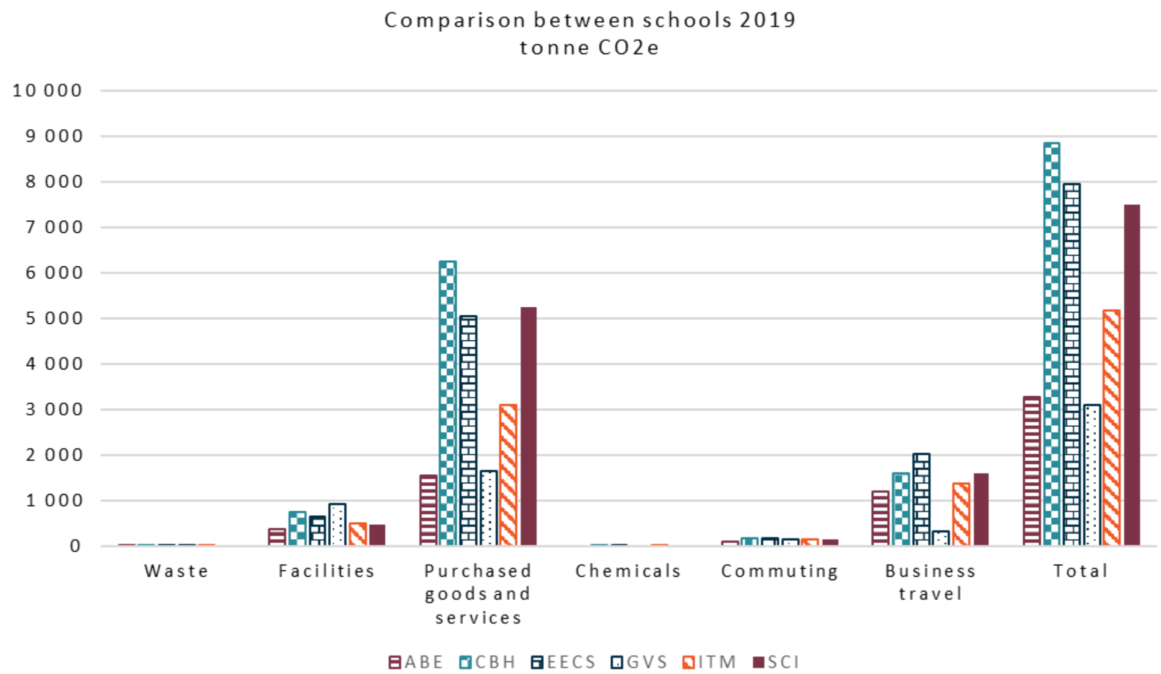
Figur 7 Purchased goods and services per account 2022, tonne CO_2e and spend MSEK.

6.2 Results per school

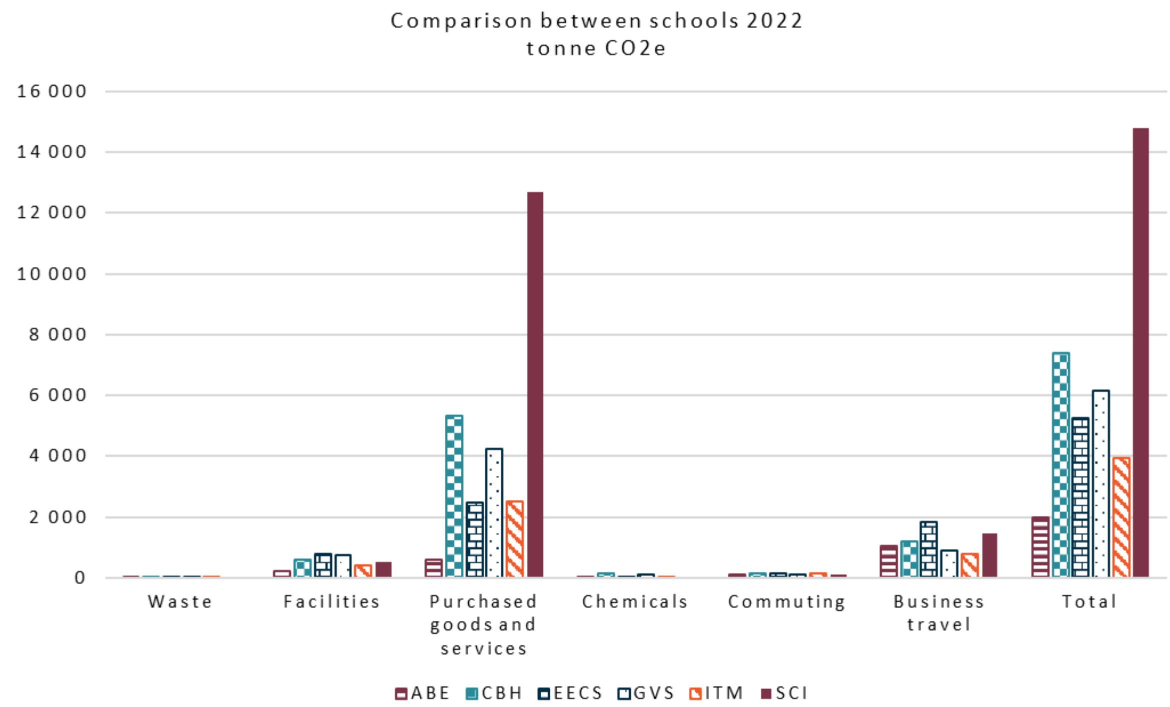
In this chapter, KTH's emissions have been allocated among the current schools: Architecture and the Built Environment (ABE School), Chemistry, Biotechnology and Health (CBH School), Electrical Engineering and Computer Science (EECS School), Industrial Engineering and Management (ITM School), and Engineering Sciences (SCI School), as well as the administrative function GVS for 2015, 2019, and 2022.



***Figur 8** Absolute emissions per school 2015.*



***Figur 9** Absolute emissions per school 2019.*



***Figur 10** Absolute emissions per school 2022.*

The results show that emissions between different schools have changed between 2015, 2019, and 2022 (see figures 8, 9, and 10). The total emissions for KTH have, as previously mentioned, increased by 18 percent between the years 2015 and 2022; however, differences vary between the schools.

In absolute terms, the CBH School and the EECS School accounted for the highest emissions in 2019. In 2022, the CBH School continued to have the highest emissions, now together with the SCI School. The increase in the SCI School is mainly based on a significant rise in emissions from purchased goods and services.

To provide a more nuanced picture of the emission distribution between schools, the results were also calculated per full-time employee.

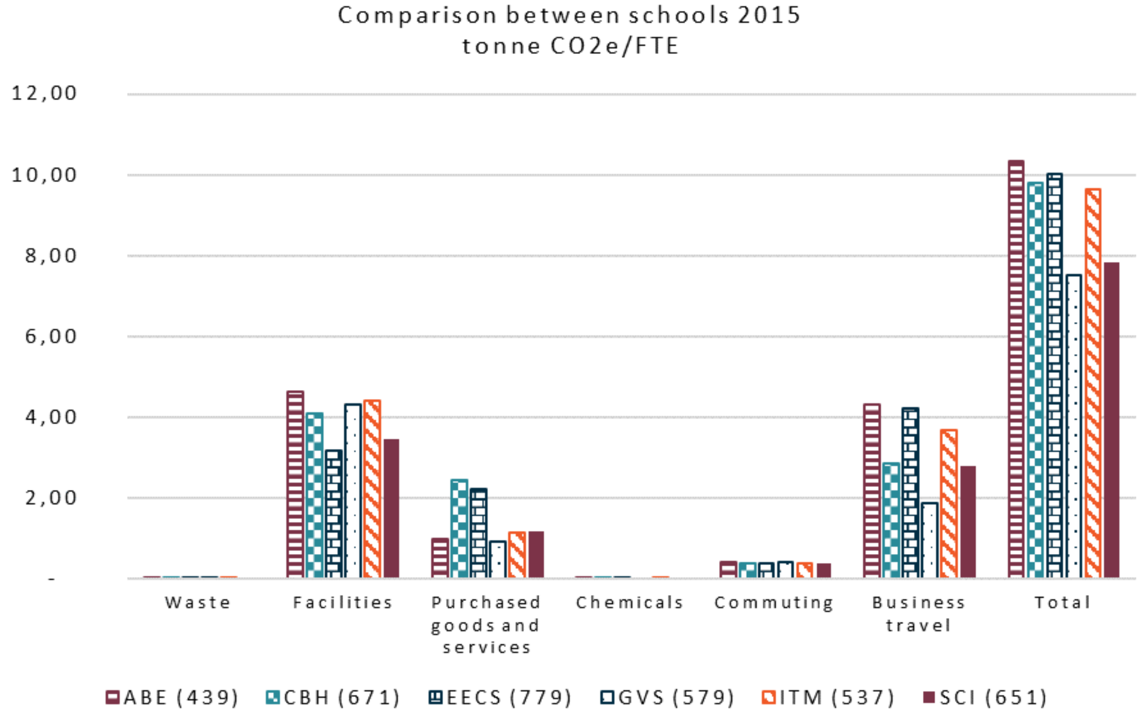


Figure 11 *Emissions per full-time employee and school 2015.*

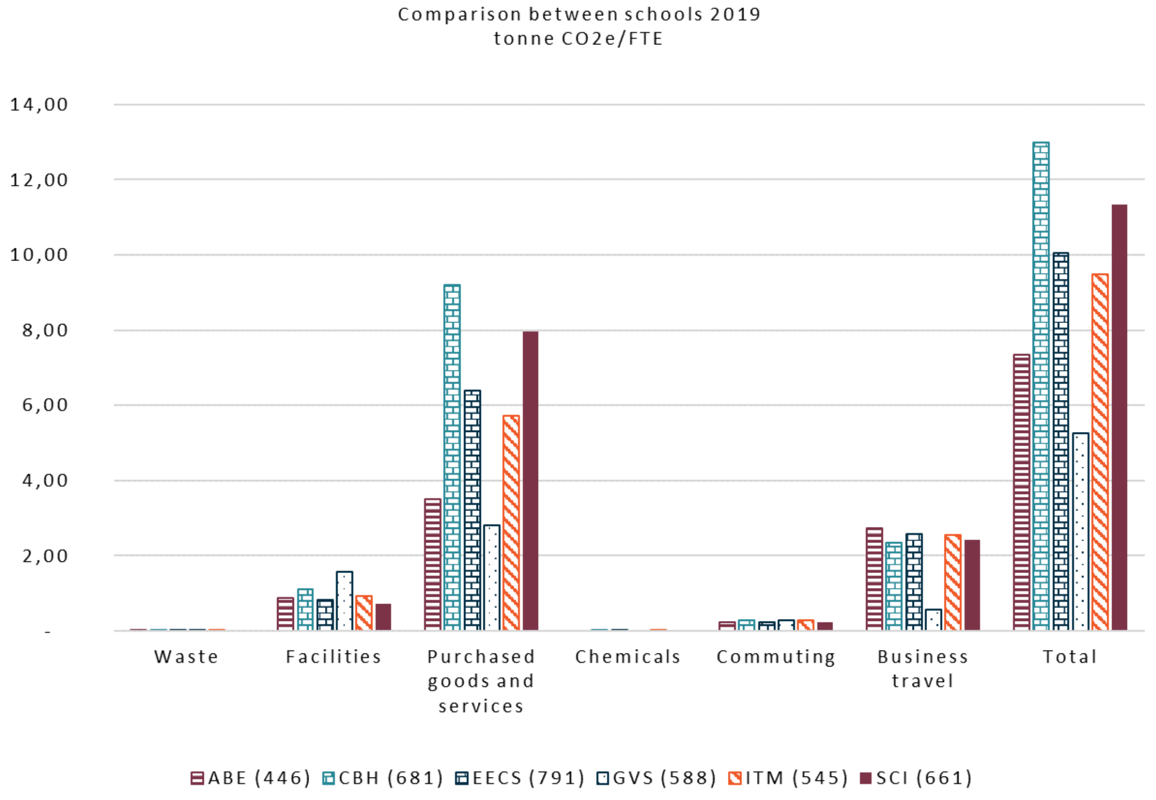
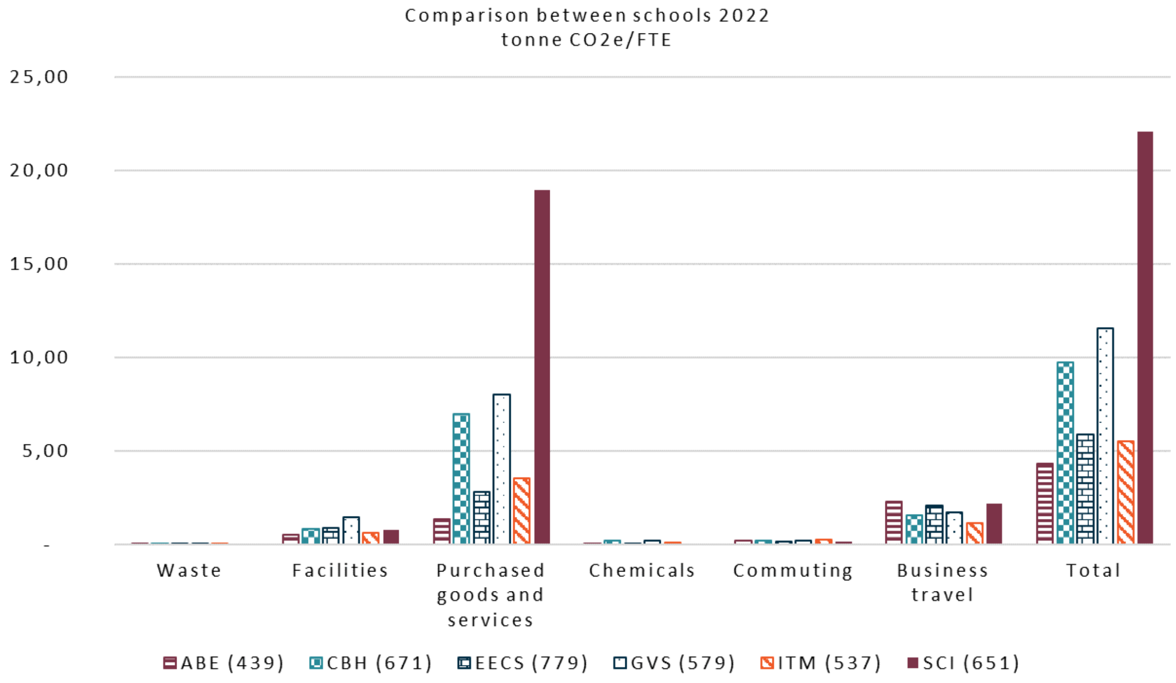


Figure 12 *Emissions per full-time employee and school 2019.*



Figur 13 *Emissions per full-time employee 2022.*

As shown in the figures above, the CBH School becomes the school with the highest emissions in relative terms in 2019, and the SCI School in 2022. In line with the results of total emissions in absolute terms, the reason for this is attributed to the large share of emissions from purchased goods and services within each respective school.

7 Future opportunities and outlook for Climate Goals

KTH's overarching climate goal outlines the path to emission reductions until the year 2045. After that, the university aims to achieve negative emissions as a climate goal.

The following analysis focuses on the period until 2030.

Already by 2022, KTH had the goal of being climate neutral in Scope 1 and achieving significant reductions in Scope 2. By 2025, the goal is for both Scope 1 and 2 to be climate neutral.

The results show that the 2022 goal has not been met, and the 2025 goal primarily requires that emissions from district heating be reduced. Similar to electricity, where KTH already purchases renewable electricity with a guarantee of origin, a solution could be to purchase an allocated district heating product. This means the district heating supplier has a system for allocating different production streams that is validated to achieve traceability and avoid double counting. This type of solution can at least be an option until Stockholm Exergi has implemented the measures described below, which will not be sufficiently launched by KTH's 2025 goal. However, agreements with guarantees of origin should not be seen as the only measure for both electricity and district heating emissions, as energy efficiency is an important measure for many other reasons.

KTH could also consider alternative heating methods such as heat pumps or geothermal energy. However, it should be noted that district heating offers advantages from an energy systems perspective that heat pumps and other systems dependent on electricity lack. District heating can be produced in cogeneration plants that use secondary renewable fuels. Electricity produced in cogeneration plants replaces fossil marginal electricity production in the grid, thus contributing to an overall reduction in greenhouse gas emissions. Heating solutions that, instead, increase electricity consumption, especially in colder weather when other renewable power production is less available, may lead to the opposite effect.

A critical success factor for KTH's climate efforts is managing emissions from business travel in general, and from air travel in particular. Following guidelines from KTH's top management will also be important in this regard. Other possibilities include KTH's CERO project, flight budgets, nudging, and other behavior-influencing measures. It will also be necessary to explore and apply the lessons in digitalization and travel avoidance that occurred and were developed during the COVID-19 pandemic.

Regarding emissions from construction, new constructions are reportedly less frequent in the coming years, and renovations and more efficient use of existing space will be more current. On the building materials side, several interesting projects are planned, such as cement production with CCS, carbon-free steel, and increased use of wood as a building material, which could be applied during renovations.

A more detailed analysis may also be appropriate for purchased goods and services. It is recommended that KTH collect data based on the type of purchase and volumes going forward instead of using spending data, to better calculate and analyze emissions that occur during the production and origin of purchased goods and services.

8 Detailed Method Description

8.1 Calculations

The section describes how the calculations for each emission category have been conducted and what data have been used. To calculate the emissions from each emission category, relevant activity data points were multiplied by an emission factor. The emission factors used are described in more detail in the following section.

8.1.1 Facilities

Energy use for all campuses was obtained from energy reports used for KTH's annual reporting to the Swedish Environmental Protection Agency. This data has been allocated per school based on the buildings used and the area occupied in shared spaces. Refrigerant leakage data was obtained from refill reports. For renovation projects, emission data was obtained from the relevant property owners.

8.1.2 Chemicals

Data on consumed chemicals were not possible to obtain. Instead, the amount of chemicals that went to waste was used to calculate the emissions from the production of the chemicals. For chemicals without specific emission factors for production, a weighted average from other chemicals was used.

8.1.3 Waste Management

The data for waste refers to the waste collected from waste rooms and has been gathered by waste distributors. The data was divided into different waste fractions: material or energy recovery, landfill, or destruction. Emissions from material or energy recovery are calculated only from the transportation of the waste. The reason for this is that emissions during waste processing are allocated to the new products resulting from the recycling process. This includes new plastic, cardboard, or metal for material recycling, and electricity and district heating produced from the waste treatment process for energy recovery. For landfill and destruction, emissions are reported both in terms of transport and processing.

The system boundaries used for the emissions from waste treatment processes with material and energy recovery can be problematic when evaluating how well waste management functions from a climate perspective. Therefore, 2050 recommends that KTH continues to monitor and act to ensure that waste management follows the waste hierarchy, where reuse takes precedence over material recycling and material recycling over incineration. Transportation for all waste fractions has been calculated using templates as no primary data on this could be collected. For emissions from landfill and destruction, templates have also been used.

Emissions from these processes should be seen as cautious estimates and may therefore be higher than they actually are. Emissions from landfills are very difficult to determine due to the large variation in waste that goes to land fill. However, no waste other than waste from reconstruction and new construction went to landfill. The waste from reconstruction and new construction has been attributed to emissions under the categories of reconstruction and new construction. When allocating emissions from waste management per school, the analysis was based on a percentage distribution by area.

8.1.4 Business Travel

Information about emissions from business travel has been provided by KTH. Due to methodological changes and more granular data, emissions for business travel by air have been recalculated using an updated method developed by researchers at KTH for the years 2019 and 2022. For the year 2015, there is no basis for recalculating the data.

Data on student-related travel includes only incoming and outgoing exchange students, and thus does not include, for example, course-related travel. Regarding exchange student travel, it was assumed that each exchange student (both incoming and outgoing from KTH) participated in a round trip either to Arlanda from the home country or from Arlanda to the exchange country. All trips were assumed to be direct flights, except for trips to and from Denmark and Norway (exchange trips to and from these two countries were excluded from the calculations). Flights were assumed since the available data could not specify any other mode of transport.

8.1.5 Commuting

Emissions from commuting have been calculated based on the CERO survey, provided by KTH. From the survey, an average distance traveled per vehicle type and per employee was calculated. Using this data, emissions were calculated by scaling the distances to the total number of employees.

8.1.6 Purchased Goods and Services

Data on purchased goods and services have been excluded from purchases already covered by other categories, such as energy, waste, and travel. KTH provided expenditure data for 2022 divided into different accounts and account numbers. The emission factors used were calculated using emission factors from the Swedish Procurement Agency. Each account and account number at KTH was matched to these emission factors. The values for 2019 were updated according to the same method.

8.1 Emission Factors

8.2.1 Energy

The emission factors for electricity have been collected from several sources:

- For the Market-based method, a generic renewable electricity mix was calculated based on Vattenfall's EPD factors for hydropower and wind, solar, and biopower, using an average based on their production in Sweden during 2018 according to the Association of Issuing Bodies (AIB). The emission factor for the Nordic residual mix comes from the Energy Market Inspectorate.

- For the Location-based method, a Nordic average mix was used, based on the emission factor from the report “Emission Factor for Nordic Electricity Mix Considering Import and Export,” which was prepared by IVL on behalf of the Swedish Environmental Protection Agency.

- For district heating and cooling, specific emission factors from the energy supplier were used, according to the "Local Environmental Values" of the Energy Companies. The assumptions for each campus are listed below:

- KTH Campus at Valhallavägen in Stockholm, campus KTH Kista, and KTH Campus Albanova: Stockholm Exergi
- Campus KTH Solna and Haninge (decommissioned in 2016): Södertörn District Heating
- Campus KTH Flemingsberg: Norrenergi
- Campus KTH Södertälje: Telge Nät

8.2.2 Construction (new construction and renovation)

Akademiska Hus provided emission values at the template level, as well as calculated emissions.

8.2.3 Refrigerant Leakage

The global warming potential (GWP) factor for relevant refrigerants was obtained from the Swedish Environmental Protection Agency (data from 2022) and Linde Gas.

8.2.4 Chemicals

Emissions from chemicals have been limited to the manufacturing of the chemicals, in other words, emissions from cradle to gate. Sources included the City of Winnipeg, the Swedish Energy Agency, the MSI/Higgs Index, and the Swedish Environmental Protection Agency. It was not possible to find emission factors from manufacturing for all chemicals. For those not found, a weighted average from the other chemicals was used.

8.2.5 Waste Management

Emissions from waste that goes to material or energy recovery are calculated only from the transport of the waste. Emission factors for transport were collected from the Swedish Heat Market Committee, VMK.

For landfill and destruction, emissions include both transport and processing/storage. Emissions from these processes should be considered conservative and may be lower than they actually are. Emission factors for landfills were sourced from Ecoinvent 2.0.

8.2.6 Business Travel and Commuting

Emissions for business travel and commuting were developed by KTH using CERO, except for emissions from hotel stays. Emission factors for hotel stays come from DEFRA and their data "UK Government Conversion Factors for greenhouse gas (GHG) reporting."

8.2.7 Purchased Goods and Services

The emission factors are sourced from the Swedish Public Procurement Agency. They have developed a purchasing analysis and created the Environmental Spend Analysis method, which integrates measures of environmental effects into a regular spend analysis. This allows for a quantitative indication of the environmental impact of different purchases.