Carbon footprint of the Royal Institute of Technology for 2015 and 2019

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1 Background

The following document presents the carbon footprint of the Royal Institute of Technology (hereon referred to as KTH), including a description of the methodology and the assumptions that were made. An analysis of the results in terms of KTH's climate targets and the potential for future emission reductions will also be presented.

2 Process description

The carbon footprint has been calculated according to the principles of the Greenhouse Gas Protocol[1].

The information has been collected from the real estate department, the finance department's procurement group, the department for research support and from the finance department's salary system, as well as from a survey regarding KTH's business trips and commuting. Information has also been collected from KTH's property owner Akademiska hus. Some assumptions have been estimated based on discussions with KTH, including that the distribution between KTH's 5 schools regarding energy and waste would be made based on the floor area occupied by the schools in each facility and that the emissions from purchased goods and services would be based on the analysis of the procurement group's report of purchased goods and services, so called spend report, with VAT excluded.

All gathered data has been evaluated by 2050 Consulting through plausibility assessments. Data sources and emission calculations are presented in the document. The tool that has been used for the calculations is an excel model developed and used by 2050 Consulting in climate calculations of similar size, customized for KTH's activities.

[1] The Greenhouse Gas Protocol is the most used and acknowledged international standard for calculations and accountings of a company's or an organization's emissions of greenhouse gases.

3 Greenhouse Gas Protocol - scope 1, 2 and 3

The Greenhouse Gas Protocol recommends dividing the emissions in three main groups – so called scopes. Scope 1 includes the emissions that KTH has direct control of, such as emissions from own facilities and emissions from cars owned and operated by the company. Scope 2 shows the emissions from the production of the electricity, district heating and cooling used in KTH's facilities. Lastly, scope 3 includes all other indirect emissions, such as emissions from the purchase of raw materials, air travel, waste management, employee commuting, etc. **Figure 1** shows how different emission sources are divided between the scopes.

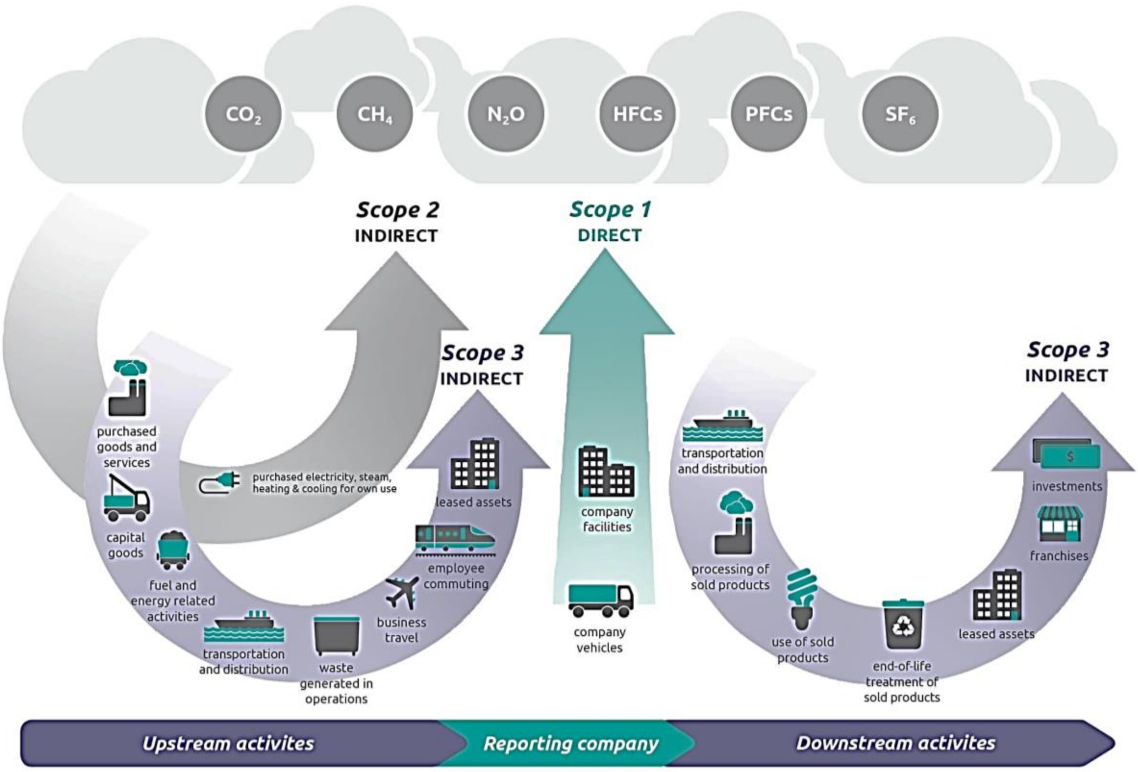


Figure 1 *Classification of emission sources as defined in the GHG Protocol.*

4 System boundary, what is included in the calculations

The climate accounting includes emissions from scope 1, scope 2 and parts of scope 3. Emission data that is included in the calculations are:

- Energy consumption (electricity, district heating and district cooling) in KTH's facilities located in the university campuses in Stockholm, Kista, Solna, Flemingsberg, Södertälje and Albanova. Please note that KTH's Haninge campus, which was closed in 2019, is also included in calculations for the year 2015.
- Construction and maintenance of buildings, including emissions from raw material extraction, purchased goods and the manufacturing processes.
- Refrigerant leakage from cooling machines.
- The production of the chemicals used in laboratories.
- Waste from offices, lecture halls, and other activities carried out by KTH.
- Business travel (cars, taxi, hotel stays, air travel and train travel) as well as student exchange trips (both inbound and outbound).
- Employees' commuting.
- Purchased goods and services, including emissions from raw material extraction and manufacturing processes.
- The foundation´s asset management (investments and managed assets).

5 Methodology

5.1 Control approach

The distribution of emissions between the scopes depends on which control approach is used: an operational or financial control approach.

- Financial control approach – emissions are classified as direct emissions based on *ownership*.
- Operational control approach – emissions are classified as direct emissions based on *operation*.

In the climate accounting for KTH the operational control approach has been used. This implies that emissions from energy consumption through the activities of KTH are classified as scope 2 emissions instead of scope 3 emissions and that direct emissions from cars that are not owned but leased by KTH also are reported as scope 1.

5.2 Emissions from electricity consumption

According to the Greenhouse Gas Protocol's guidelines for emissions assessed in scope 2 the emissions can be calculated either through a *location-based* or *market-based method*. One method must be stated but the emissions should be presented according to both methods.

- **Market based method** – Under the market-based method of scope 2 accounting, an energy consumer uses the GHG emission factor associated with the qualifying contractual instruments it owns. This means that if the company procures electricity (or district heating, district cooling or steam) with Guarantees of Origin (GOO), the specific emission factor of that GOO shall be used, for example hydro power. If the company does not procure GOOs the emissions factors shall be based on the residual mix, i.e., the average emissions factor for the grid mix after exclusion of production that balances the GOOs that were already sold.

- **Location-based method –** For the location-based method, the average emission factor of the grid is used to calculate the emissions in scope 2, regardless of whether the company, or any other company, has procured GOOs.

The method that has been used in the climate accounting for KTH is the market-based method. However, in accordance with the Greenhouse Gas protocol, emissions calculated with the location-based method are also presented separately for comparison purposes.

6 Results

6.1 Emissions of greenhouse gases in 2015 and 2019

KTH's greenhouse gas (GHG) emissions for the years 2015 and 2019 are presented in table 1 and 2 respectively. The emissions are divided by emission source and scope. Please observe that the numbers are rounded and thus the results may not always add up as shown in the tables.

GHG emissions from investments are not included in the total but are instead shown at the bottom of each table, to reflect that these emissions occur independently from KTH's own activities.

Table 1 *Greenhouse gas emissions 2015.*

KTH 2015 Emissions of green house gases (tonnes CO_2e)	**Scope 1**	**Scope 2**	**Scope 3**	**Total**	**Percentage of total emissions**
Facilities	**Not applicable**	**1 659**	**12 693**	**14 352**	**43%**
Facilities - Electricity	Not applicable	163	320	483	1%
Facilities - District cooling	Not applicable	Not applicable	22	22	<0,5%
Facilities - District heating	Not applicable	1 496	136	1 632	5%
Facilities - Refrigerant leakage	No data	Not applicable	Not applicable	No data	0%
Facilities - New constructions	Not applicable	Not applicable	9 743	9 743	29%
Facilities - Renovation, refurbishment and retrofit	Not applicable	Not applicable	2 472	2 472	7%
Chemicals	**Not applicable**	**Not applicable**	**19**	**19**	**<0,5%**
Production of chemicals	Not applicable	Not applicable	19	19	<0,5%
Waste	**Not applicable**	**Not applicable**	***11***	***11***	***<0,5%***
Waste - Landfill	Not applicable	Not applicable	No data	Not applicable	0%
Waste - Destruction	Not applicable	Not applicable	6	6	<0,5%
Waste - Material & energy recovery	Not applicable	Not applicable	5	5	<0,5%

Business travel and commuting	**6**	**-**	**13 442**	**13 448**	**40%**
Business travel total	6	Not applicable	11 973	11 979	36%
Business travel - whereof car	*6*	Not applicable	*25*	*31*	*<0,5%*
Business travel - whereof bus	Not applicable	Not applicable	Not applicable	Not applicable	*0%*
Business travel - whereof taxi	Not applicable	Not applicable	*5*	*5*	*<0,5%*
Business travel - whereof train	Not applicable	Not applicable	*9*	*9*	*<0,5%*
Business travel - whereof air (excluding student travel)	Not applicable	Not applicable	*8 459*	*8 459*	*25%*
Business travel - whereof hotel	Not applicable	Not applicable	*353*	*353*	*1%*
Business travel - whereof student travel	Not applicable	Not applicable	*3 123*	*3 123*	*9%*
Commuting total	Not applicable	Not applicable	1 468	1 468	4%
Commuting - whereof car	Not applicable	Not applicable	*530*	*530*	*2%*
Commuting - whereof bus	Not applicable	Not applicable	*935*	*935*	*3%*
Commuting - whereof MC	Not applicable	Not applicable	*1*	*1*	*<0,5%*
Commuting - whereof train	Not applicable	Not applicable	*3*	*3*	*<0,5%*
Purchased goods and services	**Not applicable**	**Not applicable**	**5 719**	**5 719**	**17%**
Purchased goods and services	Not applicable	Not applicable	5 719	5 719	17%
Total	**6**	**1 659**	**31 883**	**33 548**	

Scope 2 emissions market based	1 659
Scope 2 emissions location based	2 884

Investments	Not applicable	Not applicable	5 431	5 431	14%
Total including investments	**6**	**1 659**	**37 314**	**38 979**	

Table 2 *Greenhouse gas 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**	**1 570**	**2 098**	**3 673**	**16%**	**-74%**
Facilities - Electricity	Not applicable	14	379	393	2%	-19%
Facilities - District cooling	Not applicable	Not applicable	9	9	<0.5%	-60%
Facilities - District heating	Not applicable	1 556	110	1 666	7%	2%
Facilities - Refrigerant leakage	6	Not applicable	Not applicable	6	<0.5%	No data 2015
Facilities - New constructions	Not applicable	Not applicable	Not applicable	Not applicable	0%	-100%
Facilities - Renovation, refurbishment and retrofit	Not applicable	Not applicable	1 600	1 600	7%	-35%
Chemicals	**Not applicable**	**Not applicable**	**28**	**28**	**<0.5%**	**49%**
Production of chemicals	Not applicable	Not applicable	28	28	<0.5%	49%
Waste	**Not applicable**	**Not applicable**	***19***	***19***	***<0,5%***	***74%***
Waste - Landfill	Not applicable	Not applicable	Not applicable	Not applicable	0%	No data 2015
Waste - Destruction	Not applicable	Not applicable	11	11	<0.5%	90%
Waste - Material & energy recovery	Not applicable	Not applicable	8	8	<0.5%	55%
Business travel and commuting	**38**	**0**	**13 588**	**13 626**	**59%**	**1%**
Business travel total	38	0	12 673	12 711	55%	6%
Business travel - whereof car	*31*	*0*	*6*	*38*	*<0.5%*	*21%*
Business travel - whereof bus	*7*	Not applicable	*3*	*9*	*<0.5%*	*No data 2015*
Business travel - whereof taxi	Not applicable	Not applicable	*27*	*27*	*<0.5%*	*483%*
Business travel - whereof train	Not applicable	Not applicable	*2*	*2*	*<0.5%*	*-82%*
Business travel - whereof air (excluding student travel)	Not applicable	Not applicable	*9 057*	*9 057*	*39%*	*7%*
Business travel - whereof hotel	Not applicable	Not applicable	*302*	*302*	*1%*	*-14%*
Business travel - whereof student travel	Not applicable	Not applicable	*3 276*	*3 276*	*14%*	*5%*

Commuting total	Not applicable	Not applicable	915	915	4%	-38%
Commuting - whereof car	Not applicable	Not applicable	*437*	*437*	*2%*	*-18%*
Commuting - whereof bus	Not applicable	Not applicable	*475*	*475*	*2%*	*-49%*
Commuting - whereof MC	Not applicable	Not applicable	*1*	*1*	*<0.5%*	*95%*
Commuting - whereof train	Not applicable	Not applicable	*2*	*2*	*<0.5%*	*-42%*
Purchased goods and services	**Not applicable**	**Not applicable**	**5 676**	**5 676**	**25%**	**-1%**
Purchased goods and services	Not applicable	Not applicable	5 676	5 676	25%	-1%
Total	**44**	**1 570**	**21 409**	**23 022**		**-31%**

Scope 2 emissions market based	1 570
Scope 2 emissions location based	3 756

Investments	Not applicable	Not applicable	4 513	4 513	16%	**-17%**
Total including investments	**44**	**1 570**	**25 922**	**27 535**		**-29%**

In 2015, the largest share of GHG emissions comes from Facilities (43%), where the largest contributor, New constructions, represents 29% of the total emissions. The second largest share is Business travel and commuting (40%), with Air travel, which stands for 25% of the total emissions, being the largest contributor.

In 2019, the largest share of emissions comes from Business travel and commuting (59%), with Air travel alone representing 39% of KTH's total emissions. In 2019 the second largest share comes from Purchased goods and services (25%), while Facilities stands for a mere 16% of the total emissions.

This change is primarily the result of an accounting decision whereby the emissions from a new construction project are only included in the results the year the project is completed. In this case, no new constructions were finished during 2019, and thereby the emissions from KTH's facilities were limited to energy use, refrigerant leakages, and renovation projects.

Emissions that have been excluded from the calculations are:

- Emissions from franchises and from the processing, use and end-of-life treatment of sold products are not relevant since KTH does not conduct this type of activities.
- Emissions from assets leased by KTH to other organizations as well as from the transportation and distribution of goods to and from KTH are considered negligible.
- Emissions of volatile organic compounds (VOC), e.g., solvents used in laboratories, where not considered due to lack of data.

6.1.1 EMISSIONS IN SCOPE 2 CALCULATED WITH THE ALTERNATIVE METHOD

As mentioned in the methodology section, the market-based method was chosen to calculate KTH's scope 2 emissions. Table 3 shows how those results compare to the values obtained with the location-based method.

Table 3 *Emissions in Scope 2 with the different methods.*

Scope 2 emissions (tonne CO_2e)	2015	2019
Emissions - Market based method	1 659	1 570
Emissions - Location based method	2 884	3 756

Table 3 shows that emissions in scope 2 would have been higher if the location-based method had been applied. Specifically, KTH's emissions from energy use in 2015 and 2019 would have been up to 74% and 139% higher, respectively.

The following sections take a closer look at the seven emission sources (facilities, chemicals, waste, business travel, commuting, purchased goods and services and Investments and managed assets) presented in tables 1 and 2.

6.1.2 EMISSIONS FROM FACILITIES

This group includes the emissions from energy use, refrigerant leakage, completed new construction projects, and rebuilding (i.e., renovations, refurbishments and retrofits). Construction waste from new constructions and rebuilding is also included in this group.

In 2015, KTH’s schools occupied an approximate usable floor area of 218 236 m^2. By 2019, the occupied area was ca. 312 863 m^2 usable floor area, a 52% increase. The increase in occupied area was also reflected in KTH’s energy consumption. In 2015, KTH’s total energy consumption was 65 983 MWh, while in 2019 the energy consumption went up to 82 711 MWh. However, the increase in total energy consumption did not result in a corresponding increase in emissions.

On the contrary, the emissions from electricity, heating, and cooling, while relatively low compared to other emission sources both in 2015 and 2019, were even lower in 2019.

In 2019, the carbon dioxide equivalent (CO_2e) emissions from energy use per m^2 usable floor area were 7 kg CO_2e/m^2, a 33% reduction compared to 2015’s value (10 kgCO_2e/m^2).

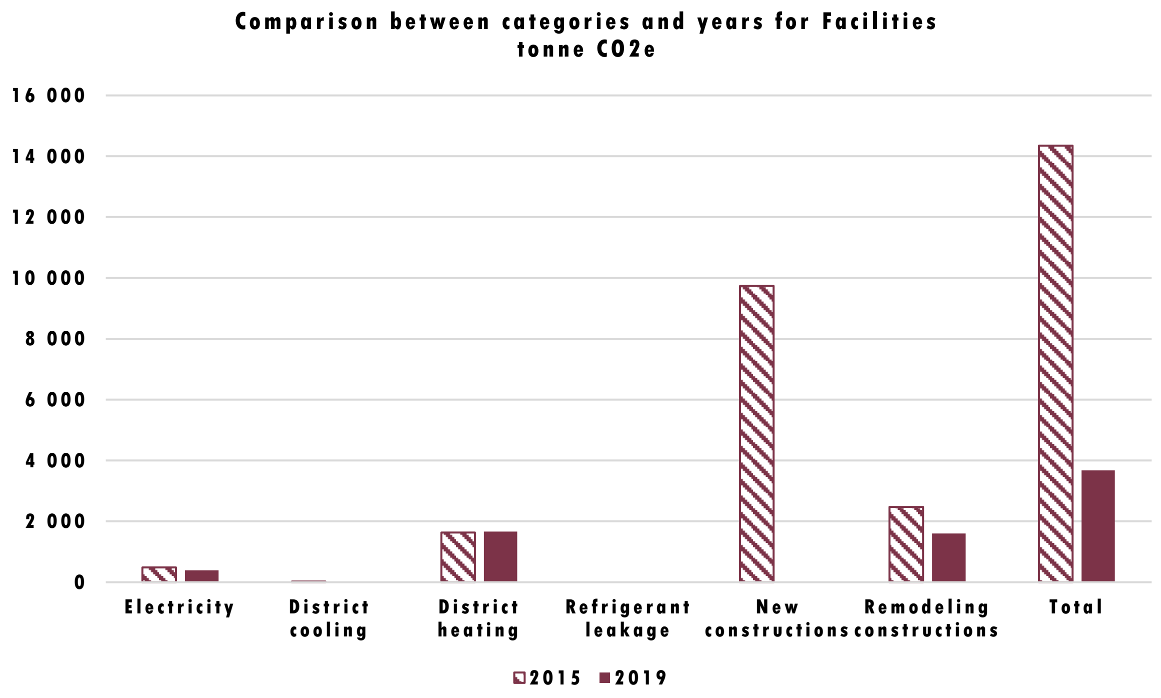
This is explained by the fact that KTH requires the purchase of electricity with guarantees of origin from renewable power production and that district heating and district cooling come from Swedish energy providers in the Stockholm region, mainly Stockholm Exergi. In other words, the electricity consumed by KTH’s facilities has a low fossil carbon content while the emissions from district heating and district cooling also reflect the decreasing use of fossil fuels by energy providers in Sweden.

Table 4 Energy consumption and emissions.

Energy consumption	2015			2019		
	MWh	kWh/ m²	tonne CO2e	MWh	kWh/ m²	tonne CO2e
Total electricity consumption	31690	154	483	37962	121	393
Electricity consumption - GOOs for renewable energy	99%	152	356	99%	121	386
Electricity consumption - residual electricity mix	1%	2	127	0	0	0
Electricity consumption - solar PVs	no data	no data	no data	1%	0,8	7
Energy consumption - district heating	21303	103	1632	27777	89	1666
Energy consumption - district cooling	12990	63	22	16972	54	9
Total energy consumption	**65983**	**320**	**2137**	**82711**	**264**	**2068**

For the rest of the categories included in this group, the CO_2e emissions for 2015 and 2019 varied depending on the gross floor area of new construction and rebuilding that were completed as well as the amount of refrigerant that was refilled during the year.

Figure 2 Emissions from Facilities in 2015 and 2019.



6.1.3 EMISSIONS FROM THE USE OF CHEMICALS

The absolute emissions from the production of the chemicals used in laboratories were 28 tonnes CO_2e in 2019 and 19 tonnes CO_2e in 2015. The emissions per fulltime employee (FTE) plus fulltime student were 1.6 kg CO_2e/FTE plus fulltime student in 2019 and 1.1 kg CO_2e/FTE plus fulltime student in 2015.

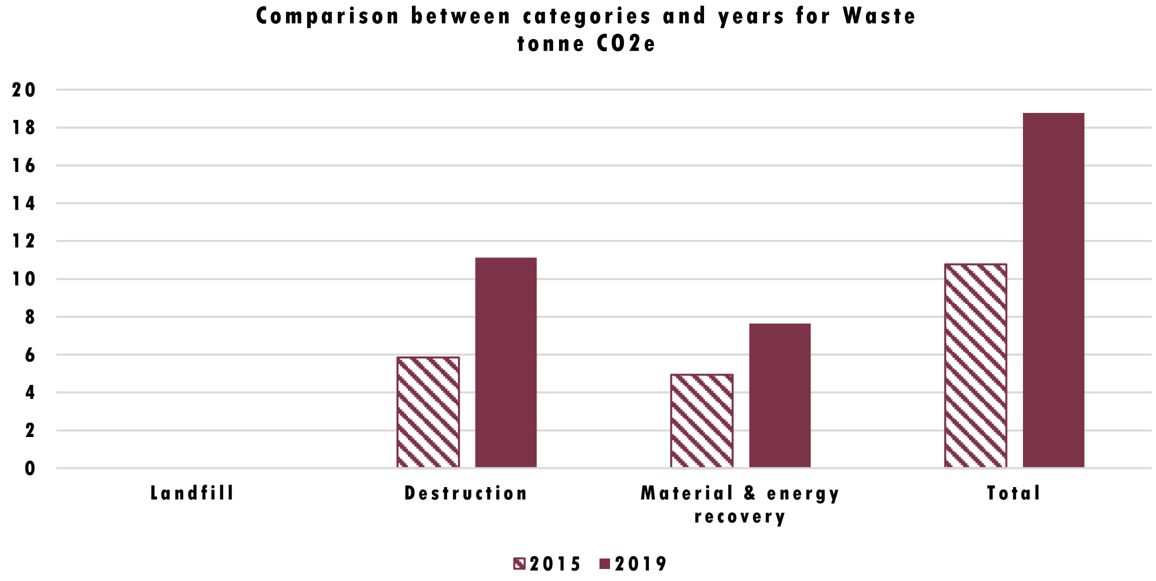
Both in absolute and in relative terms, the increase in emissions from the use of chemicals between 2015 and 2019 is over 45%. A possible explanation for the higher emissions may be that the use of chemicals in laboratories increased between 2015 and 2019, which in turn may be due to more students enrolled at KTH or more laboratory-based courses, among other explanations. Based on available information, the exact cause is difficult to determine.

6.1.4 EMISSIONS FROM WASTE

The emissions from waste were 19 tonnes CO_2e in 2019 and 11 tonnes CO_2e in 2015.

The highest contributor of emissions in this category is construction waste sent to destruction, as shown in figure 3.

Figure 3 Emissions from Waste in 2015 and 2019.



The emissions per FTE plus fulltime student were 1.1 kg CO_2e/FTE plus fulltime student in 2019 and 0.7 kg CO_2e/FTE plus fulltime student in 2015.

In absolute and relative terms, the emissions in this category have increased between 2015 and 2019, but the increase (73% for the former and 67% for the latter) seems to be mainly due to more construction waste being sent for destruction.

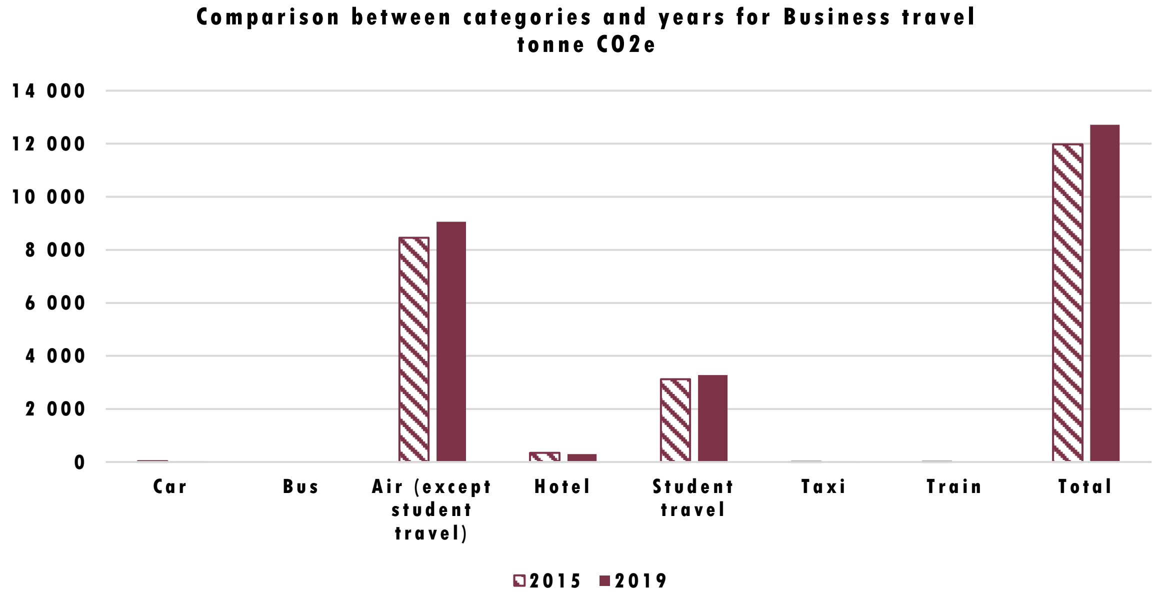
Please note that the emissions from waste sent for material or energy recovery only include the emissions from the transportation of the waste to the recycling center/waste incineration facility and exclude the emissions from waste incineration for energy recovery or from the processing needed for material recovery. The Greenhouse Gas Protocol mandates that those emissions are instead allocated to the organization that receives and handles the waste.

6.1.5 EMISSIONS FROM BUSINESS TRAVEL

The emissions from business travel are dominated by air travel.

During the year 2019, 9 057 tonnes CO_2e where due to air travel. The corresponding emissions for 2015 are 8 459 tonnes CO_2e. Air travel emissions represented almost 40% of total business travel emissions in 2019, an increase of 7% compared to the corresponding value for 2015 (25%). Please note that air travel emissions only include air travel from employees.

Figure 4 Emissions from Business Travel in 2015 and 2019



Emissions from exchange student travels (both inbound and outbound) are also included in this category. In 2015 these travels amounted to 3 123 tonnes CO_2e (ca. 1 tonne CO_2e/student)[2]. Student travel emissions represented 26% of the total emissions from business travel. In 2019, exchange student travel emissions amounted to 3 276 tonnes CO_2e (also ca. 1 tonne CO_2e/student). Again, emissions from student travels represented 26% of total business travel emissions. The total business travel emissions per FTE were 3.4 tonnes CO_2e/FTE in 2019 and 3.3 tonnes CO_2e/FTE in 2015.

[2] Calculated with emission factors for air travel between airports. Source: Network for Transport Measures, NTM.

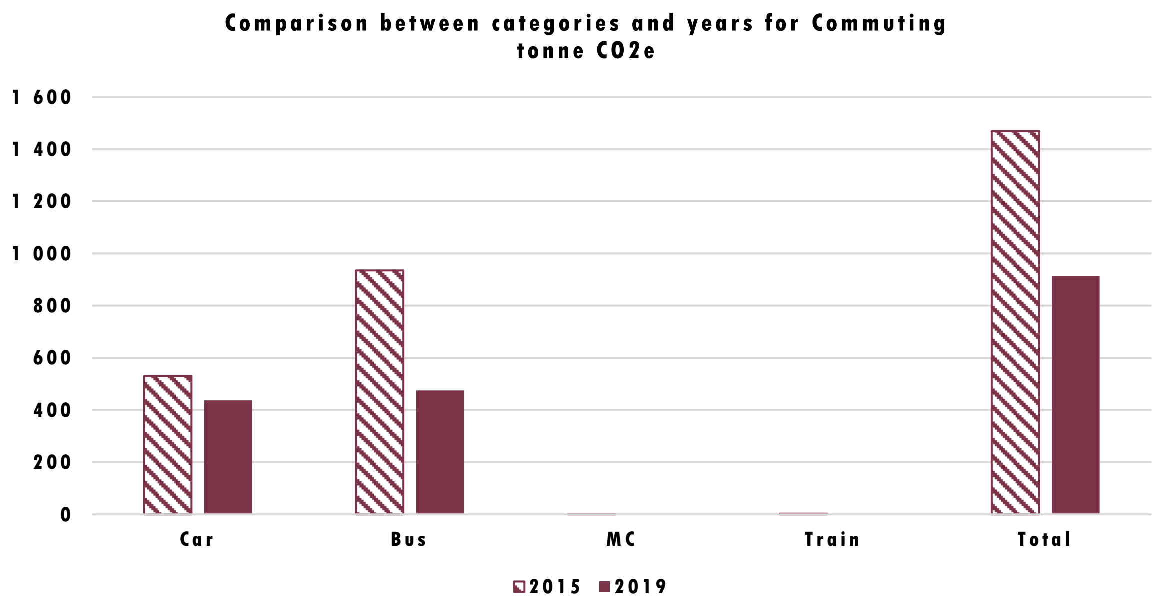
6.1.6 EMISSIONS FROM COMMUTING

The emissions from commuting were 915 tonnes CO_2e in 2019 and 1 468 tonnes CO_2e in 2015. The emissions come mainly from commuting with bus and car.

Please note that this category only includes commuting from employees. The corresponding figures for students are excluded due to lack of data.

The emissions per FTE were 0.24 tonne CO_2e/FTE and 0.40 tonne CO_2e/FTE in 2019 and 2015, respectively.

Figure 5 Emissions from Commuting in 2015 and 2019.



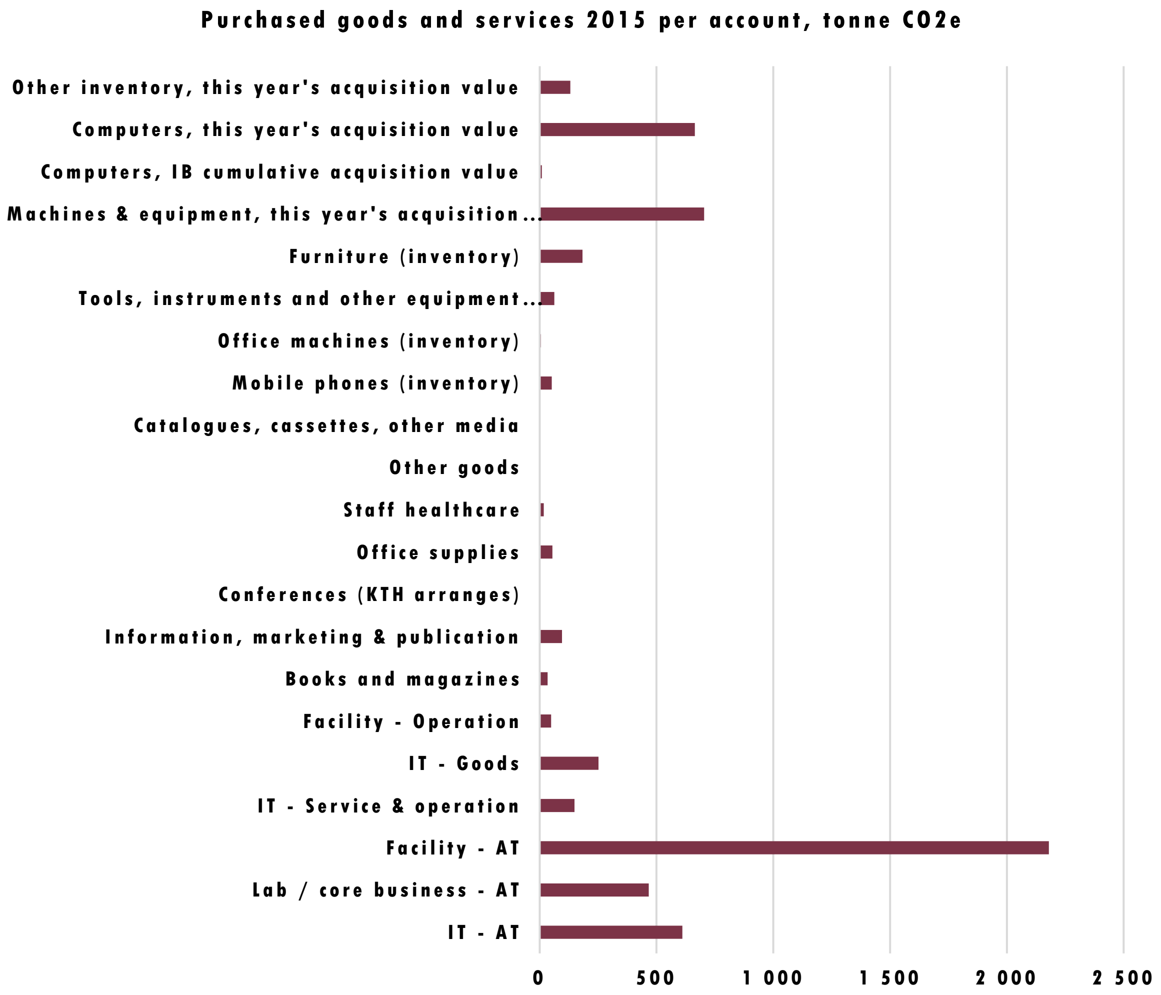
6.1.7 EMISSIONS FROM PURCHASED GOODS AND SERVICES

The emissions from purchased goods and services were 5 676 tonnes CO_2e in 2019 and 5 719 tonnes of CO_2e 2015.

The emissions per FTE plus fulltime students were 330 kg CO_2e/FTE plus fulltime student in 2019 and 347 kg CO2e/FTE plus fulltime student in 2015.

Both in absolute and relative terms the emissions in this category have been reduced by 1% and 5% respectively, but the available information was not sufficient to determine the reason for this slight reduction and whether it is a trend or a fluke.

Figure 6 Purchased goods and services per account 2015.



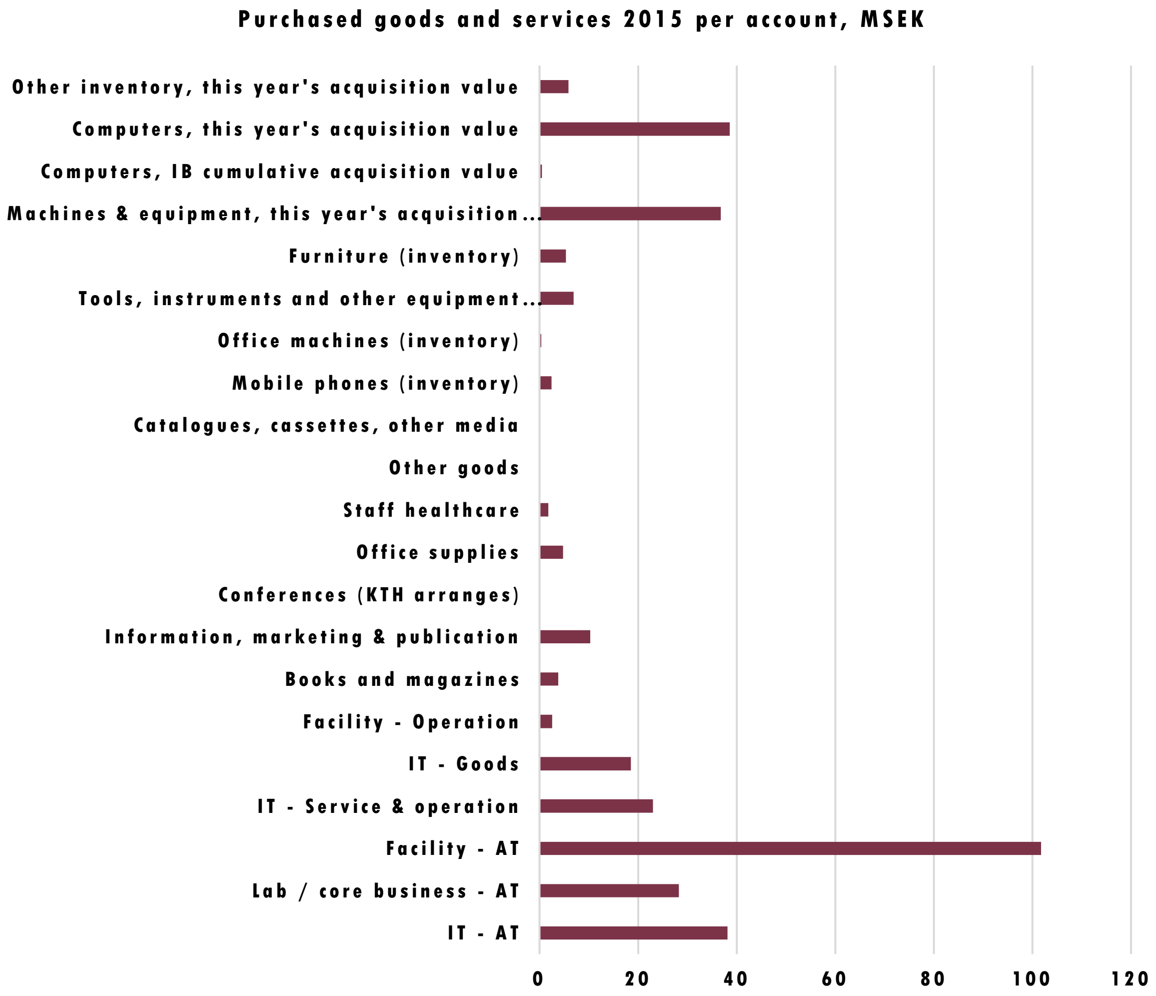
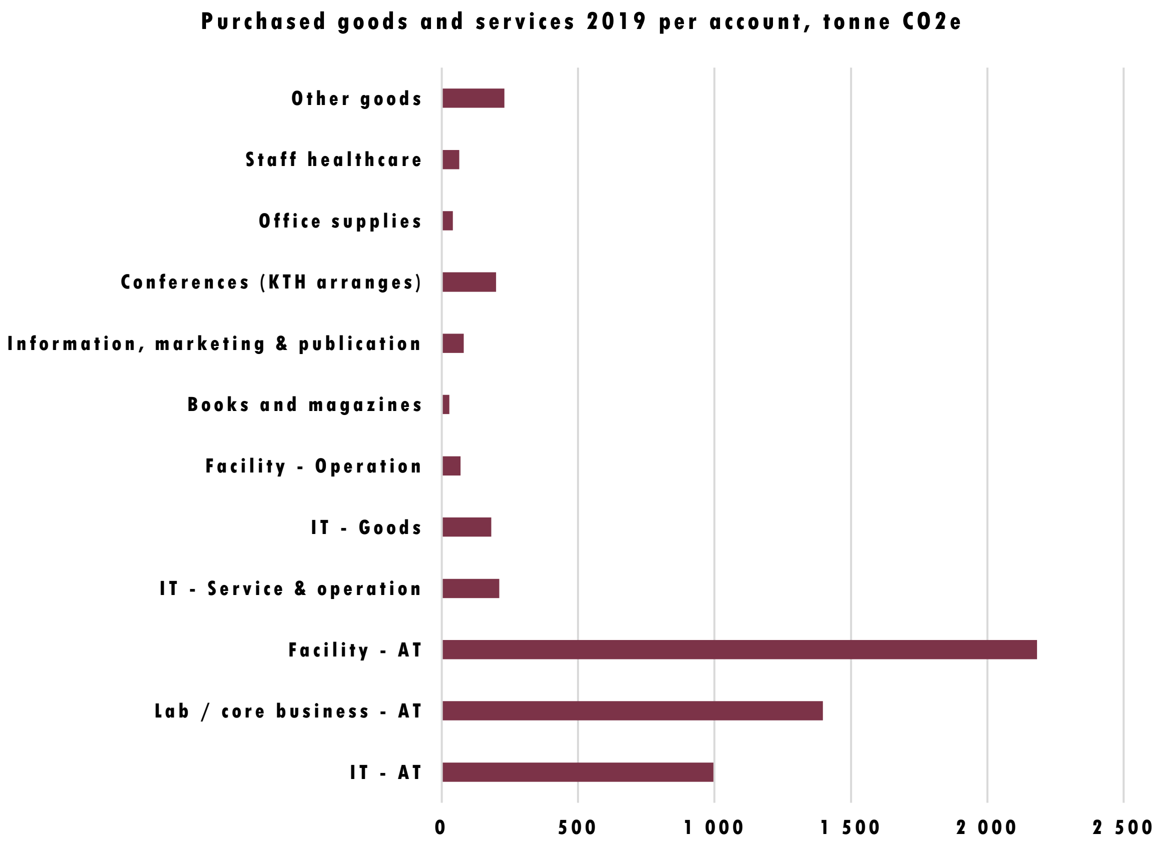
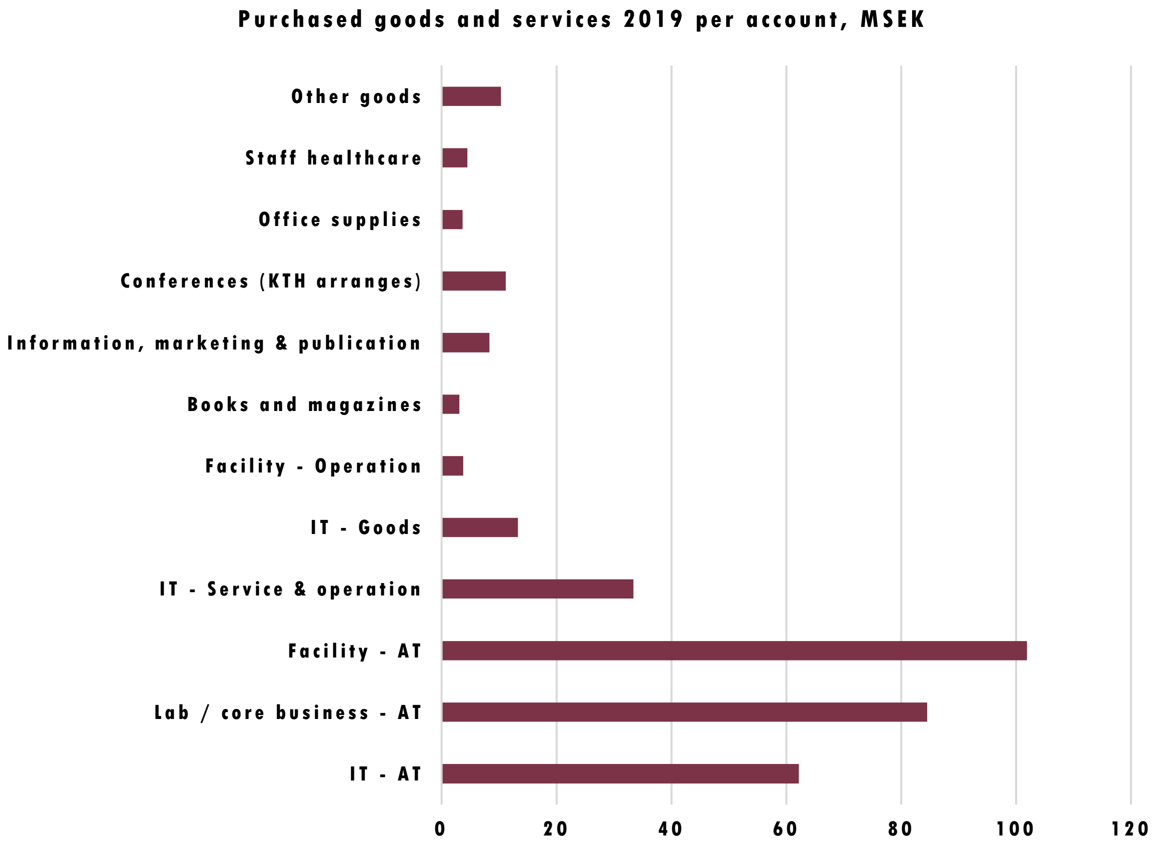

Purchased goods and services 2015 per account, MSEK
Other inventory, this year's acquisition value
Computers, this year's acquisition value
Computers, IB cumulative acquisition value
Machines & equipment, this year's acquisition...
Furniture (inventory)
Tools, instruments and other equipment...
Office machines (inventory)
Mobile phones (inventory)
Catalogues, cassettes, other media
Other goods
Staff healthcare
Office supplies
Conferences (KTH arranges)
Information, marketing & publication
Books and magazines
Facility - Operation
IT - Goods
IT - Service & operation
Facility - AT
Lab / core business - AT
IT - AT
0
20
40
60
80
100
120

Figure 7 Purchased goods and services per account 2019.





Figures 6 and 7 show the emissions per account for 2015 and 2019 respectively. In 2015 there are more accounts than in 2019 due to a different split in account numbers between the years. As shown, Fixed Assets (FA), particularly Facility – FA, stands for most of the emissions in 2015 and 2019.

6.1.8 EMISSIONS FROM INVESTMENTS

The emissions from investments were 4 513 tonnes CO_2e in 2019 and 5 431 tonnes CO_2e in 2015, a decrease by 17%.

The emissions per market value were 5.7 tonnes CO_2e/MSEK in 2019 and 8.9 tonnes CO_2e/MSEK in 2015, a decrease by 36%.

6.2 Results per school

KTH's emissions were distributed between the current 5 schools (ABE, CBH, EECS, ITM and SCI) as well as the joint operational support function, GVS. The results for 2015 are also presented according to the current organization to enable an easier comparison between both years. Emissions from investments have not been distributed between schools as the schools have no influence over the investments.

Figures 8 and 9 show that in 2015 the emissions were more evenly distributed between the different emission sources, with Facilities and Business travel being the main contributors, closely followed by Purchased goods and services. In 2019, Business travel dominates as the main emission source.

Both in 2015 and 2019, EECS and CBH emerge as the schools with the largest emissions in absolute terms.

Figure 8 Absolute emissions per school 2015.

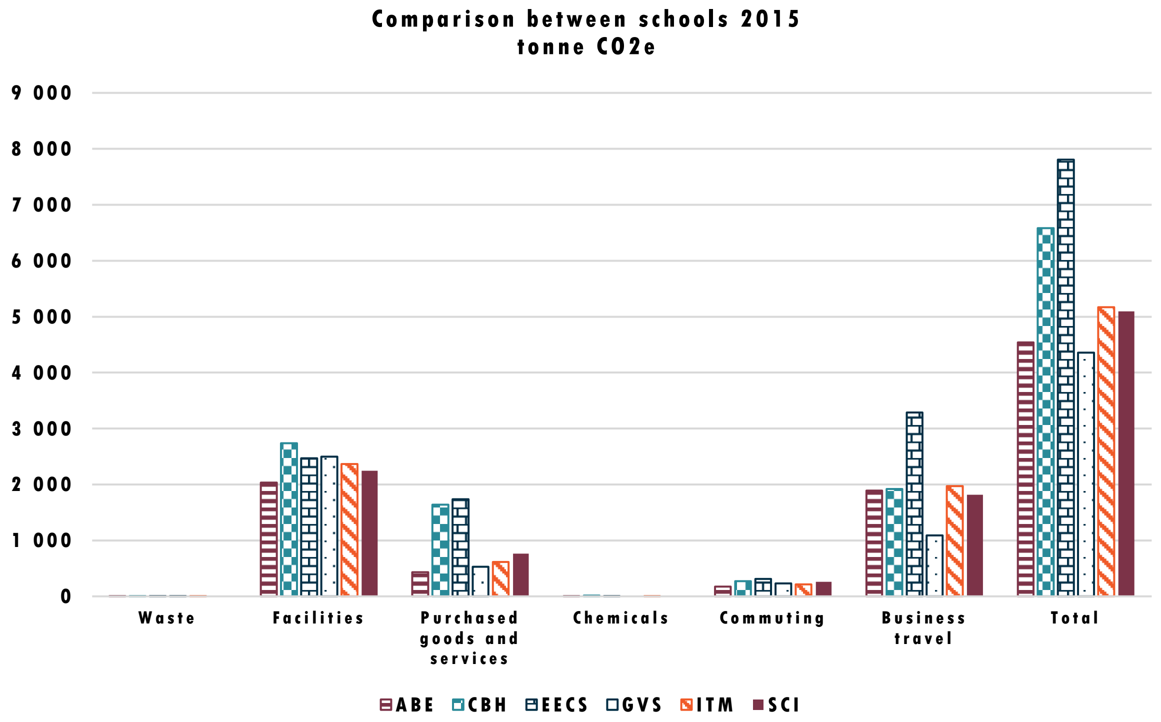
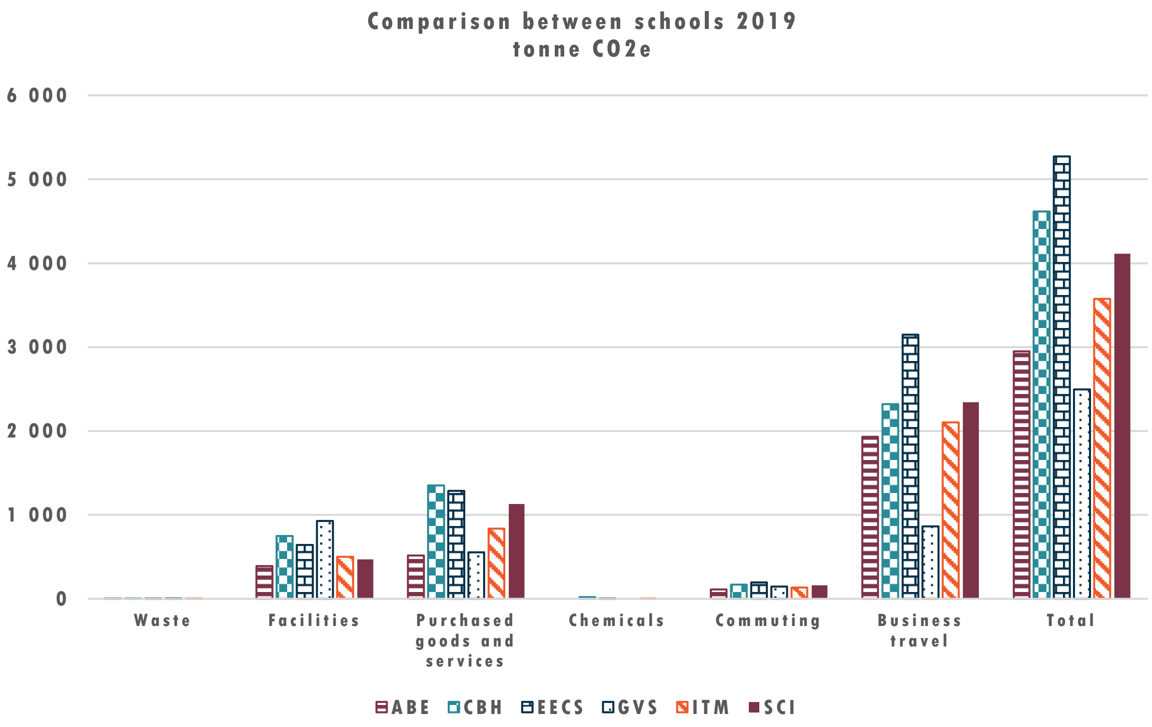


Figure 9 Absolute emissions per school 2019.



To give a more nuanced picture of the distribution of emissions between schools, the results per FTE were also calculated, see figure 10 and 11.

ABE was found being the school with largest share of emissions in relative terms in 2015 and CBH in 2019. ABE is the school having the least number of employees and thus a larger emission per FTE. In contrast, EECS has the largest number of employees. Therefore, for EECS, a likely reason for its relatively high placement in terms of emissions per FTE is that the school, due to its size, is responsible for a larger share of KTH's activities.

Please note that the category Commuting was calculated using number of employees as a parameter and therefore all schools have the same emissions per FTE in this category in figures 10 and 11.

Figure 10 Emissions per FTE 2015.

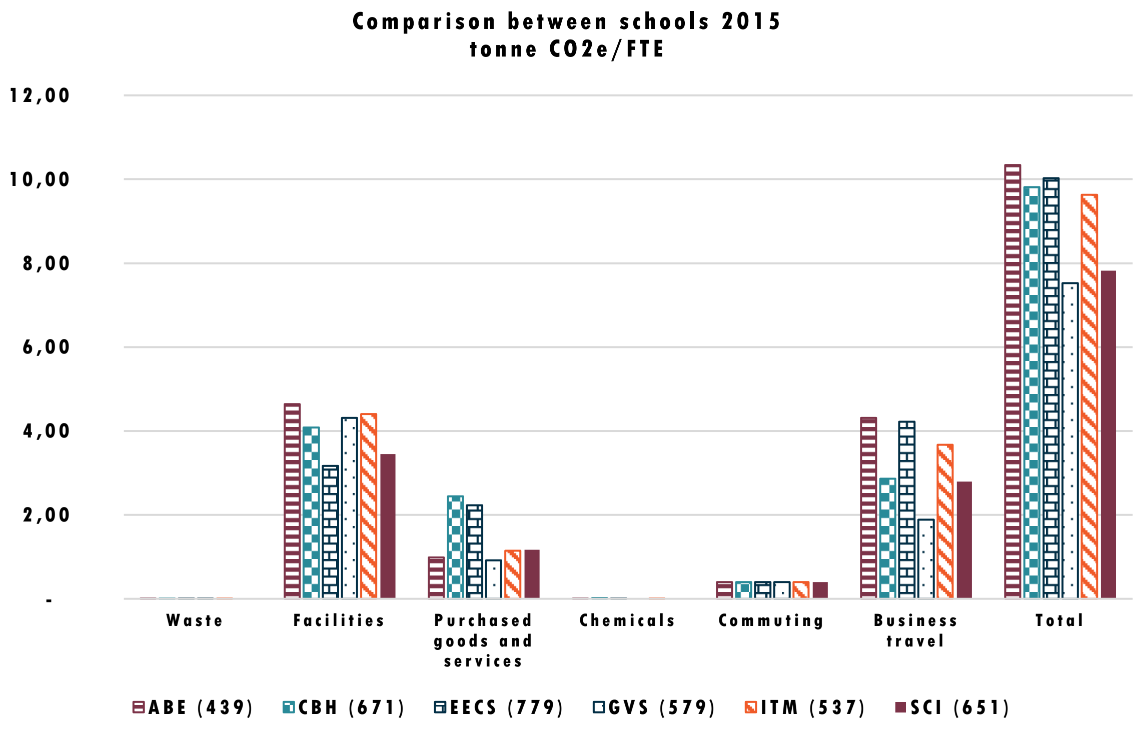
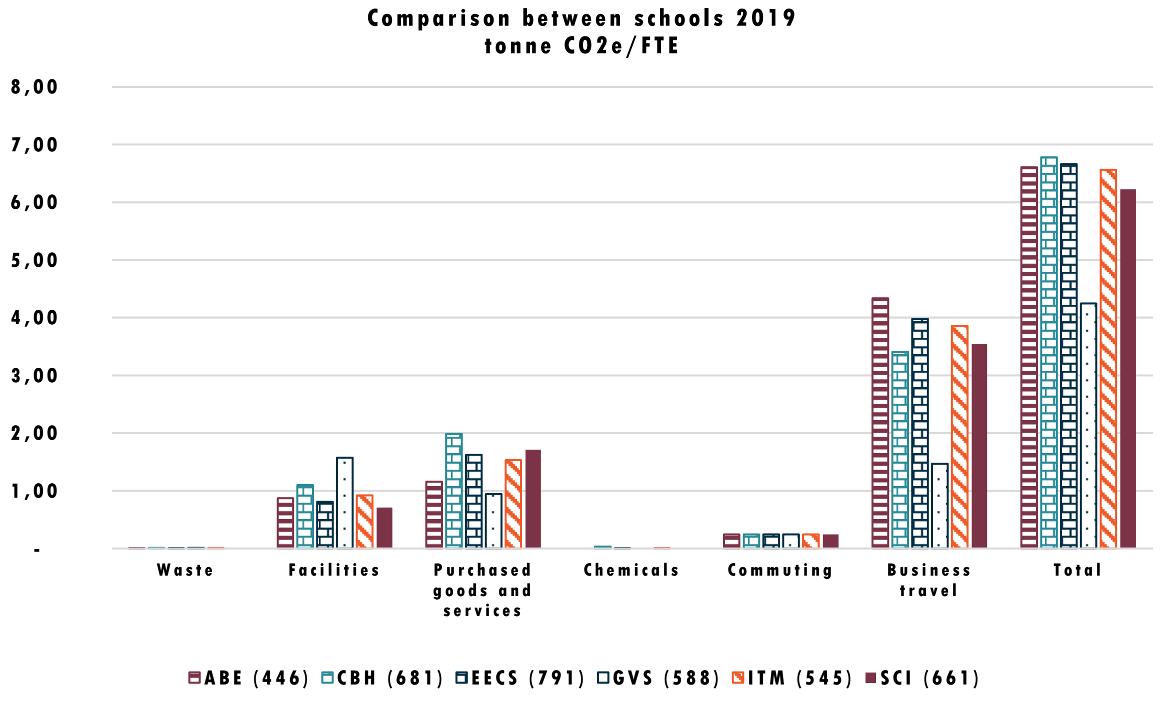


Figure 11 Emissions per FTE 2019.



7 Future possibilities and outlook for climate targets

KTH’s overall climate targets lay a pathway of emission reductions up to 2045. Thereafter, the university has the climate target of achieving negative emissions.

The following analysis focuses on the period up to 2030.

Already in 2022, KTH has the target to be climate neutral in scope 1, and to achieve significant reductions in scope 2. By 2025, the climate target is that both scope 1 and 2 are climate neutral.

From the results, these two targets appear to be within reach.

The emissions in scope 1 are already low and mostly limited to emissions from company vehicles (i.e., cars and buses owned or leased by KTH for business travel).

Therefore, to ensure that the target for scope 1 is met, KTH should consider a rapid phasing out of fossil fuel vehicles, by purchasing or leasing electric vehicles or other fossil fuel-free alternatives.

As for Scope 2, KTH already requires the purchasing of renewable electricity for its facilities and the emissions from energy use have been on a downward trajectory since 2015, despite the university’s growth and increasing energy consumption. KTH should continue this trajectory, by purchasing fossil-free energy for electricity, and even for space heating and space cooling as far as possible, while also implementing energy efficiency measures.

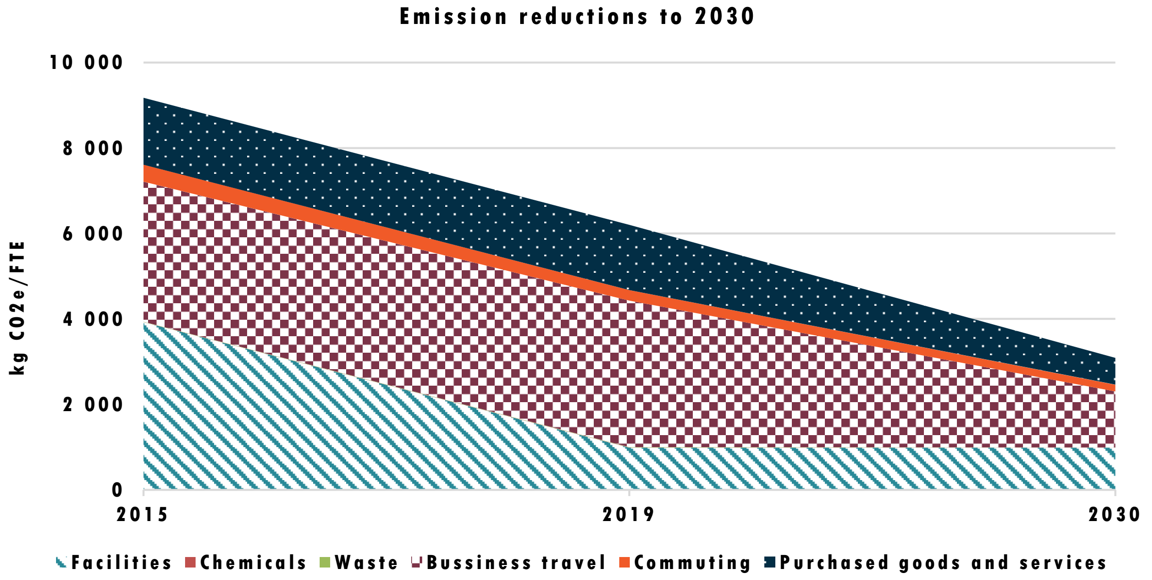
Since district heating is the most significant source of emissions in scope 2 it is welcoming news that Stockholm Exergi has a target to be climate positive by 2025. This will be achieved through measures such as sorting out plastic waste and phasing out the last remains of fossil oil, but mainly through carbon capture and storage systems (CCS) at the biofuel and waste incineration plants. KTH could also consider alternative heating methods such as heating pumps or geothermal energy. However, it should be noted that district heating offers advantages from an energy system’s perspective that heating pumps and other systems that rely on electricity lack. Namely, district heating can be produced in combined heat and power (CHP) plants using secondary fossil-free fuels. Electricity produced in CHP plants replaces fossil marginal electricity production in the grid, thereby contributing to an overall reduction of GHG emissions. Heating solutions that instead increase electric consumption, particularly during colder weather when other renewable power production is less available, can lead to the opposite effect.

Moving on to 2030, KTH has the target to reduce Scope 1, 2 and 3 emissions by 60% per year workforce compared to 2015 levels. From the results, the achievement of this target seems more uncertain.

Assuming that year workforce can be represented by FTEs, in 2015 KTH's total emissions per FTE were 9.2 tonnes CO_2e/FTE[3]. The corresponding value for 2019 was also 9.2 tonnes CO_2e/FTE[3]. In other words, between 2015 and 2019 practically no emission reductions in Scope 1, 2 and 3 per FTE were achieved. Therefore, KTH needs to decrease its total emissions by approximately 6% per year between 2020 and 2030 to reach the target emission level of 3.7 tonnes CO_2e/FTE in 2030.

[3] Excluding emissions from investments since these are not part of KTH's operational activities.

Figure 12 Roadmap 2015-2030.



As figure 12 shows, an important success factor for KTH will be to tackle and reduce the emissions from business travel in general, and from air travel in particular. The existing travel guidelines should be developed to encourage digital meetings, urge employees to choose trains before planes, car-pooling before solo car journeys, etc., even more clearly. The follow-up of guidelines from KTH's top management will also be important in this respect. Other possibilities are KTH's CERO project, flight project, flight carbon budgets, nudging and other behaviour-based measures, among other tools and methods.

Examining and applying the lessons in digitalization and travel avoidance learned during the COVID pandemic will also be necessary.

New constructions are also important in this context, although this is difficult to see in the figure 12 due to no such projects being completed in 2019. Nevertheless, it should be remembered that in 2015 new constructions were the second largest contributor to GHG emissions from KTH. While new constructions will reportedly be less frequent in the coming years, further analysis of this category is recommended. On the construction material side there are several interesting projects planned such as cement production with CCS, carbon free steel and increased use of wood as a construction material. In general, more detailed analysis would also be advisable for Purchasing of goods and services.

8 Detailed methodology description

8.1 Calculations

This section describes how the calculations for each emission category have been made and which data has been used. To calculate the emissions from each emission category, relevant activity data has been multiplied with an emission factor. The emission factors that have been used are detailed in the following section.

8.1.1 CALCULATIONS FOR FACILITIES

Energy consumption for all campuses was obtained from energy reports used for KTH's annual reporting to the Swedish Environmental Protection Agency. Refrigerant leakage was obtained from refill reports. Construction data, with details including gross floor area, was provided by KTH.

8.1.2 CALCULATIONS FOR CHEMICALS

Data regarding purchased chemicals was not possible to acquire. Instead, the amount of chemicals going to waste was used to calculate the emissions from manufacturing the chemicals. It was not possible to find emissions from manufacturing for all chemicals. For the chemicals lacking emission factors, a weighted average from the other chemicals was used.

8.1.3 CALCULATIONS FOR WASTE

The waste data was collected from waste rooms. The data was divided into different addresses and waste fractions. The waste fractions where then divided into either material or energy recovery, landfill or destruction. Emissions from material or energy recovery are only calculated from the transportation of the waste. The reason for this is that the emissions from waste processing are allocated to the new products that are obtained from recycling. This can be new plastic, cardboard or metal obtained from material recycling, and for energy recycling electricity and district heating produced from the waste treatment process. For landfill and destruction, emissions are reported both in terms of transport and processing.

The system boundaries used for emissions from waste treatment processes with material and energy recovery can be problematic when evaluating how well waste management works from a climate perspective. 2050 therefore recommends KTH to continue to follow up and act to ensure that waste management follows the waste hierarchy, where reuse goes before material recycling and material recycling goes before energy recovery. For landfill and destruction, emissions both regarding transportation and processing are accounted for.

The transportation for all waste fractions has been calculated from generic data since no primary data regarding this could be acquired. For the emissions from landfill and destruction, generic data has also been used. Emissions from these processes should be seen as conservative estimations and thus might be higher than they actually are. When it comes to destruction, emissions are considered to come from oil. Emissions from landfill are very hard to determine since there is a large variation regarding what is being placed in the landfill. In KTH's case however, no waste other than waste from rebuilding and new construction went to landfill. The waste that comes from rebuilding and new construction has been attributed to emissions under the categories rebuilding and new construction.

8.1.4 CALCULATIONS FOR BUSINESS TRAVEL AND COMMUTING

Business travel has been calculated from data from KTH's procured travel agencies and KTH's mileage allowance. The emissions have been calculated from fuel usage or traveled distance, but some data has been calculated by the travel agencies. For flights, an RFI factor[4] of 2.0 has been used.

Regarding exchange student travels, a two-way trip either to Arlanda from the country of their home university or from Arlanda to the country of exchange was assumed for every exchange student (both inbound and outbound from KTH). All trips were assumed to be direct flights except trips to and from Denmark and Norway (exchange student trips to and from these two countries were excluded from the calculations). A calculation tool by NTM was used to calculate the emissions from the flights. An RFI factor of 2.0 has been used.

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[4] RFI stands for Radiative Force Index and is the ratio of total climate impact effect (measured as heat radiation) to that from CO2 emissions alone. It has been employed by the Intergovernmental Panel on Climate Change (IPCC) as a way of describing the total climate impact from aircraft at high altitudes (approximately 8 000 – 12 000 m above sea level) other than that from the release of fossil carbon alone.

Commuting has been calculated from the CERO survey[5]. From the survey an average travel distance per vehicle type and per employee could be calculated. This data was extrapolated to cover the whole of KTH by multiplying the travel distance per employee by the total number of full-time employees. The extrapolated travel distances were then used to calculate the emissions.

8.1.5 CALCULATIONS FOR PURCHASED GOODS AND SERVICES

Data regarding purchased goods and services has been used to cover emissions not included in the other categories. KTH provided expense data from 2015 and 2019 divided into different accounts and account numbers. The emission factors used were calculated using data on household expenses and household emissions from Statistics Sweden (SCB)[6]. Two sets of approximately 100 emission factors were calculated, one for 2015 and one for 2019. Each account and account number at KTH was then mapped to these emission factors.

The use of spend data is an established method for calculating emissions in this category. Note, however, that according to the GHG protocol, this method should only be used when other, more specific methods, such as the use of supplier data, are not feasible. The reason for this is that the spend analysis method does not take into account the effect on carbon dioxide emissions of existing environmental requirements for purchased goods and services since the method only considers their market value, ultimately at the expense of other characteristics such as better climate performance.

8.1.6 CALCULATIONS FOR INVESTMENTS

The emissions from the foundation´s asset management have been calculated from the market value for the stocks and bonds that the foundation holds per December 31, 2015 and 2019.

Calculations of the climate impact from stocks:

[5] Source: Robèrt and Jonsson, 2019, Follow-up analysis of travel at KTH, Climate and Economic Research in Organisations (CERO).

[6] Sources: SCB, Household consumption expenditure by purpose. SCB, Environmental impact from household consumption by purpose and subject.

Scope 1 and scope 2 emissions for the company that the stock belong to are from 2019 and gathered by the MSCI and presented at “DI:s klimatindex”. As no such compilation for 2015 could be found, the emissions for 2019 are used for 2015 as well. The emissions for the foundation´s holdings in the stock are calculated by dividing the market value for the holdings by the total stock value for the company at the stock market and then multiplying the quota with the scope 1 and scope 2 emissions for the company.

Calculations of the climate impact from bonds:

Primarily the emissions for the bonds are calculated from emission factors from the fund manager (tonne CO_2e/invested MSEK). Secondarily the emissions for the bonds use the emission factor representing the portfolio of Mistra by 2020. The emission factors for the bonds are multiplied with the market value of the bonds in 2015 and 2019.

The calculation method described above has been developed to best meet the GHG protocol's criteria for completeness and accuracy based on the data that was available. Despite this, there are reasons to review and develop the method, not least considering that the holdings' scope 3 emissions are not included in the calculations. For many sectors, scope 3 emissions are significantly larger than scope 1 and scope 2 combined.

For parts of KTH’s holding, a generic emission factor that reflects Mistra's portfolio 2020 has been used, due to a lack of emission values from KTH's fund managers.

8.2 Emission factors

8.2.1 EMISSION FACTORS FOR FACILITIES

Energy

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

- For the market-based method, a generic renewable electricity mix calculated from the emission factors for hydro-, wind, solar and biopower, using a weighted average based on their production in Sweden in 2018 according to the

Association of Issuing Bodies (AIB). The emission factor for the Nordic residual mix originates from the Swedish Energy Markets Inspectorate (EI).
- For the location-based method, a Nordic average mix, based on emission data provided by the International Energy Agency (IEA), European Network of Transmission System Operators (ENTSOE) and AIB, was used.

For district heating and district cooling, the specific emission factors from the assumed energy provider, according to Swedenergy's "Local environmental values" report, were used. The assumptions for each campus site are listed below:

- Stockholm, Kista and Albanova: Stockholm Exergi
- Solna and Haninge: Södertörn Fjärrvärme
- Flemingsberg: Norrenergi
- Södertälje: Telge Nät

Construction (new construction and renovation)

KTH provided construction data from 2015 and 2019 with details such as gross area. These constructions were divided into new constructions, minor constructions, and renovations. KTH's property owner, Akademiska Hus, then provided emission factors based on their calculations. The same emission factors were used for both 2015 and 2019[7].

Refrigerant leakages

The global warming potential (GWP) factor for the relevant refrigerants was obtained from the Swedish Environmental Protection Agency (data from 2017).

8.2.2 EMISSION FACTORS FOR CHEMICALS

Emissions from chemicals have been calculated from manufacturing the chemicals, in other words emissions from cradle to gate. Sources have been Winnipeg municipality, the Swedish Energy Agency, MSI/Higgs Index, the Swedish Environmental Protection

[7] Emission factors for constructions calculated by Akademiska hus for 2019. These factors have also been used for the 2015 calculations.

Agency and Stena Real Estate[8]. It was not possible to find emissions from manufacturing for all chemicals. For those that were not found, a weighted average from the other chemicals was used.

8.2.3 EMISSION FACTORS FOR WASTE

Emissions from material or energy recovery are only calculated from transportation of the waste. The reason for this is that the emissions from waste processing are allocated to the district heating company. Emission factors for transportation were therefore obtained from the Heating Market Committee, VMK (from Värmemarknadskommittén in Swedish).

For landfill and destruction, emissions for both transportation and processing are included. Emissions from these processes should be seen as conservative and might be higher than they actually are. For destruction, emissions are considered to come from oil while emissions from landfill are taken from Ecoinvent 2.0.

8.2.4 EMISSION FACTORS FOR BUSINESS TRAVEL AND COMMUTING

For cars, emission factors from the Swedish Energy Agency[9] have been used. The cars have different emission factors depending on what fuel has been used. For cars using diesel or petrol in the year 2019 the emission factors have taken mandatory reduction quotas for diesel and petrol into consideration.

The emission factor for buses have been calculated from average fuel use from the Network for Transport Measures (NTM) and fuel emissions from the Swedish Energy Agency. NTM also been used for trains for the average consumption and then multiplied with the emission factor for renewable electricity.

[8] Sources: Winnipeg municipality, 2011, South End Plant Process Selection Report, Appendix 7: CO_2 emission factors database. Swedish Energy Agency, Fuels 2018, Report ER 2019: 14. Sustainable Apparel Coalition, Higg Materials Sustainability Index (MSI) database. Swedish Environmental Protection Agency and Swedish Environmental Emissions Data (SMED), Emission factors and calorific values 2018. Stena Real Estate Renovation tool.

[9] Sources: Swedish Energy Agency, Fuels 2019, Report ER 2020: 26. Swedish Energy Agency, Fuels and biofuels 2015, Report ER 2016: 12.

For air travel emissions were collected from KTH's procured travel agencies. These values did not include RFI factor, and therefore the carbon dioxide emissions were multiplied by 2.0 to capture the impact from cloud formation at high altitudes.

Emission from exchange student trips were calculated with emission factors based on NTM data. An RFI factor of 2.0 has been used.

The emission factor for taxi travels is represented by emissions generated per driven kilometer. It is calculated based on fuel consumption data and the division on different fuels used in taxi cars in Sweden from the yearly report "Branch Status" presented by the Taxi Union. Emission data on fuels is based on data from the Swedish Energy Agency.

8.2.5 EMISSION FACTORS FOR PURCHASED GOODS AND SERVICES

Emission factors were calculated using data from Statistics Sweden (SCB)[10]. The total amount of emissions from households per product category was divided by the total amount of money spent on the same product categories by households. The result gives emissions per SEK. It should be noted that these figures are for household consumption and not public expenses.

8.2.6 EMISSION FACTORS FOR INVESTMENTS

The emission factor that was used from Mistra was 5.1 tonnes CO_2e/MSEK.

[10] Sources: SCB, Environmental impact from consumption by product group. SCB, Household consumption expenditure by purpose.