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On behalf of the Mobility Platform of ETH Zurich

Procedure and methods for the assessment of greenhouse gas emissions of flights at ETH Zurich

Short report

Bern, 10. November 2019

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INFRAS
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Editorial Information

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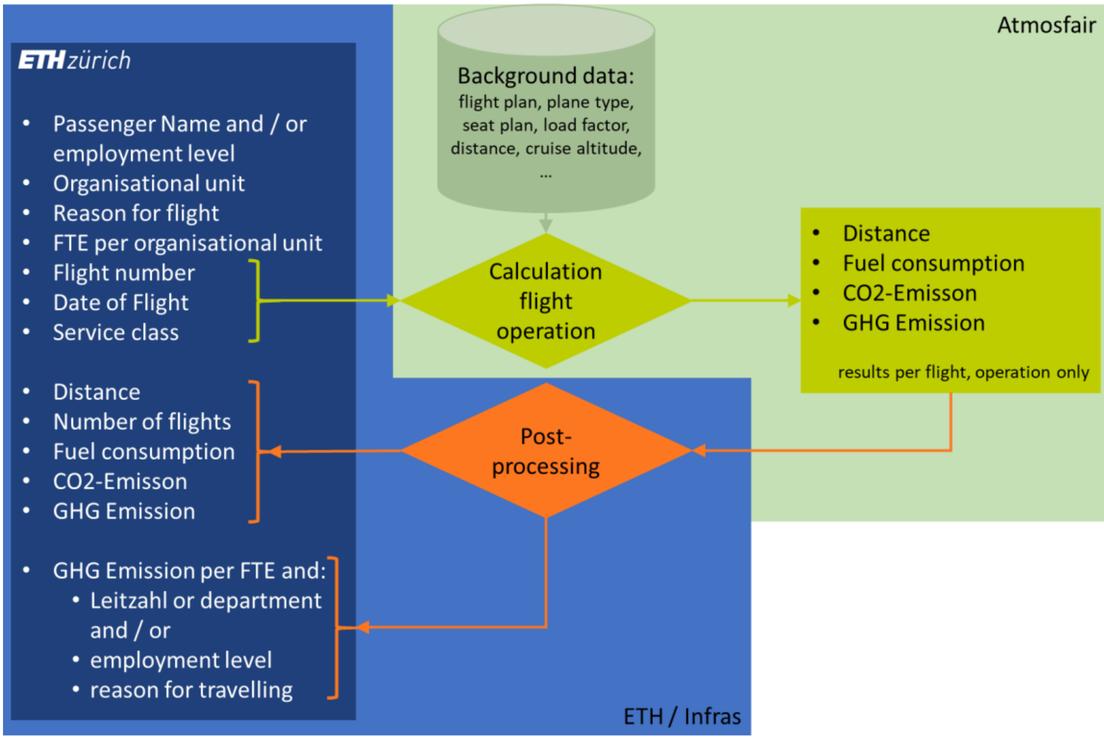
Content

Summary

ETH Zurich[1] committed to reducing greenhouse gas (GHG) emissions from air travel by 11% in the next few years. The reduction shall be in addition to reductions achieved by the aviation industry. Flights taken by ETH's employees and guests are included if they are paid for by ETH. Flights taken by ETH students are also considered, if they are part of their curriculum.

Strategies for reducing emissions include avoiding air travel by increased use of modern communication technologies or by preferring trains to flights and, if air travel can't be avoided or substituted, by choosing the most efficient flight available. The methodology used in previous years to estimate GHG emissions of air travel at ETH is not suitable for monitoring emissions in the accuracy required. Therefore, a new procedure for collecting flight information and calculating GHG emissions of flights was developed for ETH (Figure 1).

Figure 1: Overview of the data collection and calculation procedure.



Data collection by ETH and INFRAS (base period) and by ETH; calculation of emissions from operation by atmosfair, post processing by INFRAS (base period) and ETH (monitoring period)

Graphics INFRAS.

[1] From now on just referred to as ETH.

Data is collected, calculated and analysed for 2016 to 2018 (base period) and for 2019 to 2025 (monitoring period). Data for the base period is collected manually ex post to establish a baseline with system boundary and data quality comparable to the data from the monitoring period.
In the monitoring period, detailed information about all flights within the system boundary is collected. For flights paid for by ETH, data collection is included in the billing work flow where travellers are asked to provide flight number, date of the flight and service class for every leg of a journey. Information for flights which are not entering the electronic billing work flow (e.g. student flights which are not or not entirely paid for by ETH or flights related to the recruitment process) is collected manually using an Excel template. The same template is used to collect information for all flights in the financial database for the base period.

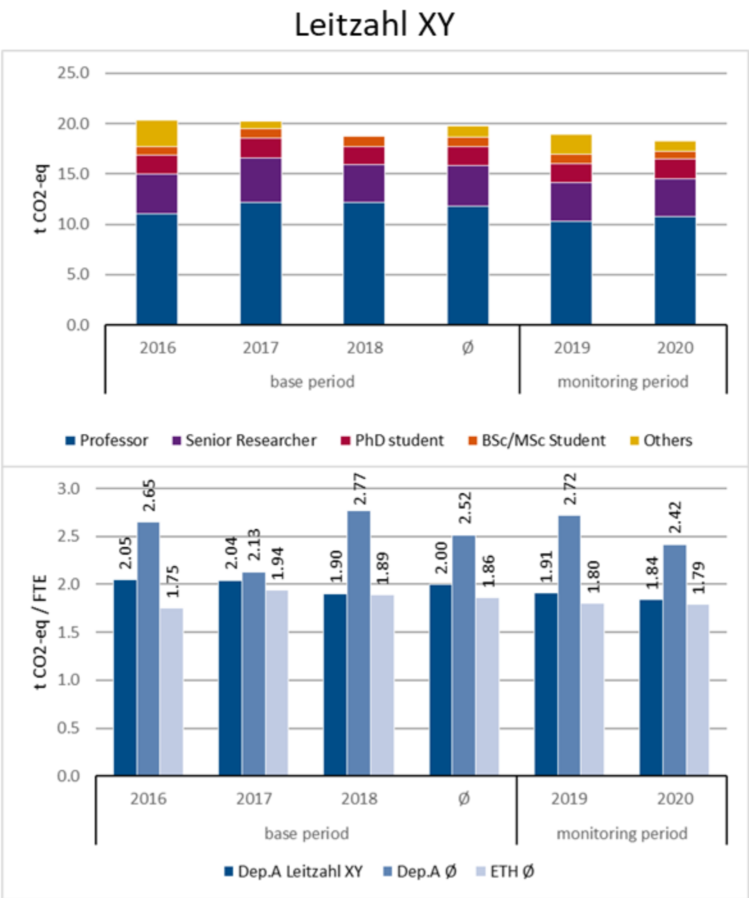
The calculation of GHG emissions is done by an external provider (atmosfair GmbH). The anonymized flight information collected in the first step is sent to atmosfair via web services or in Excel files. From the date and flight number and using an extensive background database, atmosfair determines the city-pair, carrier, aircraft type and configuration, seat plan of the aircraft and the load factor specific to the carrier and city-pair. Next, the greater circle distance between start and destination (plus default distance for holding patterns and detours) is calculated and the cruise altitude and fraction above 9000 meters above sea level (MAS) is determined based on the specific aircraft and flight distance (Piano-X flight profiles). All the information is used to calculate the fuel consumption of the flight per passenger based on the Piano-X model. From that, CO_2-emission and total GWP100 is calculated. An Emission Weighting Factor (EWF) of 2.0 is applied for CO_2 emissions above 9000 MAS (see Cox and Althaus 2019 for details). Results are fed back to ETH by web services or in Excel tables.

ETH (or, for the period between 2016 and 2018, INFRAS) adds the "well to tank" emissions (i.e. emissions from production and transport of the fuel) to produce results in line with the European standard for calculation and declaration of energy consumption and GHG emissions of transport services (EN 2013).

Detailed results will be made available for each "Leitzahl"[2] and Department[3] in a list. Results will also be aggregated on the levels of "Leitzahl", Department and for the entire ETH. Aggregated results are normalized with the number of full time equivalent (FTE) staff in the respective unit. Figure 2 shows an example how aggregated results could be presented. Aggregated results per department and for the entire ETH will be published every year in the business travel report.

[2] «Leitzahl» stands for a profit centre, e.g. a professorship
[3] Results are aggregated for each of the 16 scientific departments, for the administrative Departments (Abteilungen) and for the staff units and teaching and research facilities outside the academic departments (Rest).

Figure 2: Example of annual report per "Leitzahl" (dummy data).



			base period				monitoring period	
			2016	2017	2018	Ø	2019	2020
Dep.A	Leit-zahl XY	# Flights / FTE	12.1	12.0	11.4	11.8	11.2	11.5
		thereof in business/first	1.3	1.2	1.2	1.2	0.6	0.4
		thereof invalid input	0.14	0.12	0.13	0.13	0.10	0.11
		Ø distance (km)	1393	1309	1514	1405	1503	1744
Dep.A	Ø	# Flights / FTE	15.3	12.9	15.5	14.6	18.0	16.4
		thereof in business/first	1.0	1.1	1.0	1.0	1.0	1.1
		thereof invalid input	0.14	0.15	0.15	0.15	0.08	0.10
		Ø distance (km)	1100	1143	1130	1124	1288	1181
ETH	Ø	# Flights / FTE	10.5	11.5	10.8	10.9	10.5	10.3
		thereof in business/first	1.2	1.3	1.2	1.2	0.8	0.6
		thereof invalid input	0.12	0.11	0.12	0.12	0.08	0.09
		Ø distance (km)	1216	1145	1253	1205	1241	1265

Graphics INFRAS.

1. Introduction

More than half of the total greenhouse gas (GHG) emissions produced by ETH Zurich are due to business travel. Of these, over 90% are caused by flights (Althaus and Graf 2019). Therefore, in 2017, the executive board of ETH initiated a project for reducing GHG emissions from air travel based on a framework concept (Robledo Abad and Althaus 2016).

This project resulted in a commitment to an average per capita reduction of 11% between 2019 and 2025 compared to the average for 2016-2018 from the departments the, Executive Board and administrative units at ETH Zurich. All flights taken by staff as well as flights taken by students as part of their curriculum are included in the reduction targets and corresponding measures. This reduction shall be achieved without compensation of emissions, which are discussed and pursued by parts of ETH for (a part of) the remaining emissions.

ETH relies on cooperation and exchange with partners around the globe. Therefore, to embark on a real GHG reduction path that is compatible with the Paris Agreement (United Nations 2015), excellence in science, and the best possible career opportunities for researchers, it is indispensable for ETH to use all available options for reducing GHG emissions due to travelling: avoiding flights by increasing the use of modern communication technology, replacing (short) flights by trains, and using the most efficient flights available if they can't be avoided or replaced.

The methodology previously used to account for GHG emissions of air travel at ETH relies on start and final destination of roughly 25% of the flights and extrapolates from there using specific costs per person-kilometre and overall expenses for air travel. The result cannot be broken down to the group level where flight decisions are made, and the method is not capable of distinguishing between more and less efficient flights. Therefore, a new procedure to calculate the GHG emissions of flights had to be developed and was introduced in 2018 and 2019. The main principles and methods for collecting flight information and calculating the corresponding GHG emissions are briefly described in this report.

2. Scope and system boundary

The following flights are included in the GHG emission calculation for ETH in accordance with the control approach proposed by the GHG Protocol Corporate Standard[4]:

- Work related flights by ETH staff that are paid for by ETH
- Flights by invited guests of ETH
- Student flights that are part of the curriculum

GHG emissions are calculated for each year at the organizational level of "Leitzahl". This organizational unit of ETH can be translated as "profit centre" and includes professorships, institutes, departments and administrative units at different levels. Results are also aggregated to the level of departments and the entire ETH. Results are normalized by the number of full-time equivalent (FTE) staff in the respective units.

All Flights are accounted for in the year they occur. For comparing results of the old (Althaus and Graf 2019) and new method, annual emissions are additionally calculated for all flights that were booked into ETH's financial system in the base period (2016-2018).

Total GHG emissions are quantified as global warming potential using a time horizon of 100 years (GWP100). Effects of aircraft operation in the upper troposphere and lower stratosphere such as changes in the atmospheric concentration of greenhouse gases (ozone and methane), the formation of condensation trails (contrails) and the increase cirrus cloudiness (IPCC 1999) are accounted for using the concept of a CO_2 emissions weighting factor (EWF). ETH uses an EWF of 2 for CO_2 emitted above 9000 Meters Above Sea level (MAS). For details please refer to Cox and Althaus (2019).

Both emissions from aircraft operation and emissions from aircraft fuel production are included. Together, they are responsible for more than 97% of GHG emissions of air travel from a complete life cycle perspective (Cox et al. 2018). Emissions from producing the aircraft and the stationary infrastructure required are not relevant for the overall result and therefore excluded. Also excluded are emissions from surface transport of passengers to and from airports. In this respect, the assessment fully complies with the EN standard on calculation of energy consumption and GHG emission of transport services (EN 2013) and with the ISO standard on LCA (ISO 2006).

Airplanes often transport goods and passengers at the same time. This is accounted for using mass-based allocation using a weight of 100 kg per passenger including luggage. Allocation by cabin space used per seat is used to account for different service classes for passenger transport.

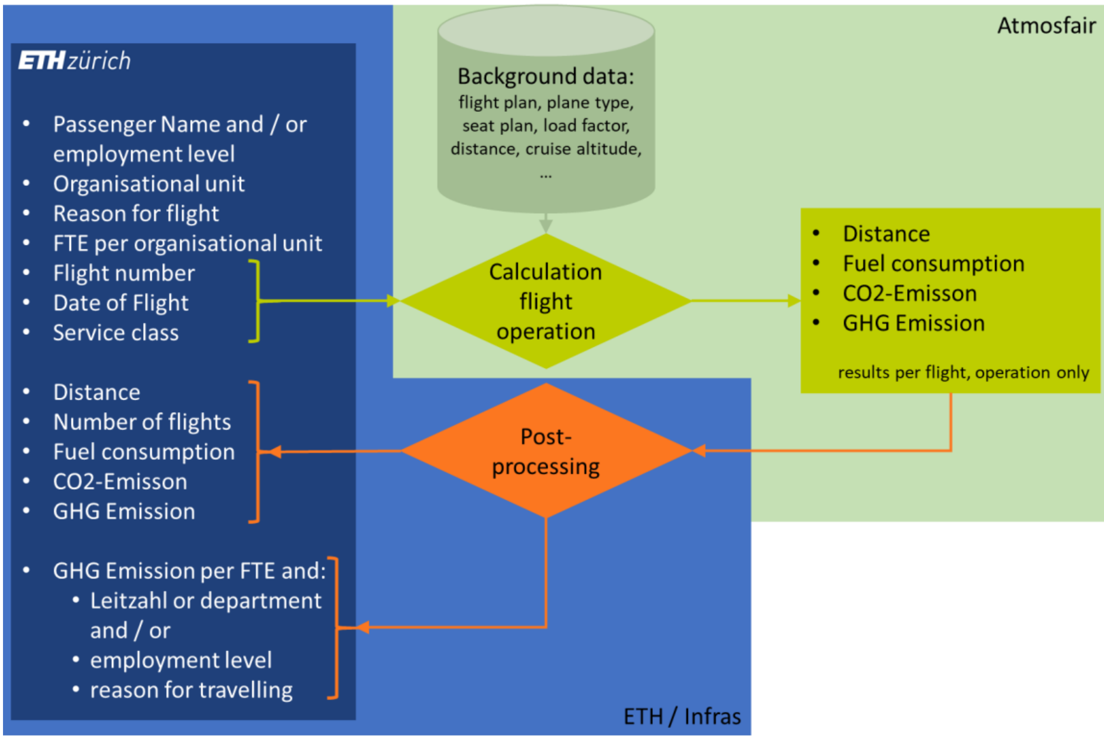
[4] https://ghgprotocol.org/sites/default/files/standards/ghg-protocol-revised.pdf

3. Overview of the calculation procedure

An overview of the calculation procedure is presented in Figure 3. The procedure includes three main steps:

1. the collection of flight information for the base period (2016 – 2018) and for the monitoring phase (2019 – 2024)
2. the calculation of flight-specific GHG emissions due to the flight itself
3. the post-processing of the results consisting of:
   - the inclusion of jet fuel production emissions
   - the normalisation of the emission per FTE
   - the compilation and analysis of annual results for roughly 500 organisational units of ETH

Figure 3: Overview of the data collection and calculation procedure.



Data collection by ETH and INFRAS (base period) and by ETH; calculation of emissions from operation by atmosfair, post processing by INFRAS (base period) and ETH (monitoring period)

Graphics INFRAS.

Chapter 4 shortly describes the data collection at ETH. Chapter 5 presents the key aspects of the methodology to calculate GHG emissions of the flight. Chapter 6 describes how the flight specific emissions are post-processed before communication with ETH units and the public. Chapter 7 finally describes the calculation of ETH's reference GHG emission level and how the achievement of the reduction target will be monitored.

4. Collection of flight information

Collection of the flight information is different for the base period and the monitoring period. For the base period, data was collected from ETH's financial database that contains receipts for all flights paid for by ETH[5]. This includes work-related flights for ETH staff and guests of ETH. Flights taken by ETH students related to activities for which ECTS points are awarded were collected in the departments and the Student Exchange Office. In the monitoring phase the information on flights paid for by ETH is collected in ETHIS. Information on student flights which are not entered in ETH's financial system are manually collected in the monitoring period. Data collection procedures for both the base and monitoring periods rely on the same principles and raw data; information is collected for every flight included in the system boundary (see chapter 2). Thus, completeness and data quality should be comparable over both periods.

Information is collected separately for each leg of a journey. For example, a return flight with one stop per direction would generate four flight entries. The following information is gathered for each flight entry:

- Passenger Name and / or employment level (Professor, Senior Researcher, PhD student, BSc/MSc Student, others)
- Organisational unit (Department, Institute…) responsible for the flight
- Reason for flight (Conference, Meeting, Field work, Excursion, Exhibition, PhD defence, Committee work, …)
- Year of booking into ETH's financial system[6]
- Flight number (if not known: carrier and city pair)
- Date of flight
- Service class (Economy, Economy Plus, Business, First)

[5] If flights are first payed by ETH and later refunded by another organisation or if flights are booked and paid by ETH and later cancelled, they should occur twice in the financial database: once with a positive and once with a negative sign and emissions should cancel each other out (if data is correctly entered)
[6] only for flights booked into ETH's financial system during the base period

Additionally, the number of FTE per “Leitzahl” is collected for every unit responsible for at least one flight.

Passenger names are only used to determine the employment level of the traveller. If no specific organisational unit is known, the unit on the lowest level known is used (e.g., if the professorship is not known, the department is used). Information on flight number (or at least city pair), date of flight, service class are necessary for the calculation. If both the flight number and the city pair is unknown for a flight in the base period, it is excluded. If the date of flight is unknown, the date of the booking is used. In case no information on service class is found, economy is assumed.

If the flight number of a flight in the monitoring period is not correct, the attempt to calculate a CO_2 emission will fail. In this case, the provider of the flight information is notified that an error occurred during calculation and is given the possibility to correct the flight information. In case, no correction is made (or the new data is also invalid), standard values for the calculation results are entered for the flight in question. These values correspond to the average value in the base period plus 20%.

5. Calculation of emissions from flight operation

For the calculation of flight emissions from the base period, anonymised flight data (Anonymized Flight ID, Flight Number, Date of Flight, and Service class) are sent to atmosfair in Excel files. Flight data for the monitoring period is automatically sent by web services from ETH’s IT system to atmosfair. CO_2 emissions for each flight are then calculated by atmosfair based on the VDR standard and the atmosfair airline index[7] (AAI) method. Results are either returned as Excel data (base period) or via web service (monitoring period). The calculation follows these steps:

1. determine operating airline, start and destination airport (city-pair), aircraft and its configuration (type of aircraft, engine type, use of winglets, passenger and cargo capacity and load factor) from flight number and date;
2. determine distance of city-pair (greater circle distance between start and destination plus default distance for holding patterns and detours);
3. determine cruise altitude and fraction above 9000 MAS based on specific aircraft and flight distance (Piano-X flight profiles);
4. determine load factors for passengers and freight;

[7] https://www.atmosfair.de/wp-content/uploads/aai-methode-2015-de.pdf

5. determine payload and the weight of the plane at start[8];
6. determine fuel consumption per passenger from information determined in points 2 to 4[9];
7. calculate CO_2 emissions per passenger from fuel consumption;
8. calculate total GWP100 from CO_2 emissions, considering the Emission Weighting Factor (EWF) of 2.0 for emissions above 9000 MAS (see Cox and Althaus 2019 for details).

The basis for the calculation of the CO_2 emissions for each flight is the VDR Standard for CO_2 business travel reporting[10]. This standard, initiated by the German Business Travel Association (VDR), covers the entire business travel sector (flight, hotel, rental car, train and conference). Flight related CO_2 emissions are calculated according to the VDR Standard using a set of standard flight profiles for different flight distances and aircraft types that determine absolute fuel consumption (and thus absolute CO_2 emissions). The flight distance ranges from 250 to 10000 km. These standard profiles thus establish the influence of factors such as flight distance, flight profile, flight altitude, type of aircraft, and taxiing.

In addition to the VDR standard, data and calculation methods of the AAI are used for ETH's flight emission calculations. The AAI was developed to compare (in hindsight) the efficiency of various airlines in three flight distance classes. The data behind the AAI is updated annually. Due to a lack of ex-post data for very recent and future flights, the calculation necessarily relies on planning data and assumptions based on information from the past year:

- information about type of aircraft is based on planning data in OAG flight plan;
- airplane related parameters (engines, winglets, capacity) are based on the average aircraft on the respective city pair and, if possible, carrier;
- load factors are estimated from load factors of similar flights in the past.

[8] Passenger and freight load factors are categorized in four accuracy levels, whereas Level 1 is the most accurate and Level 4 the least. Level 1 is specific to airline, city pair and plane type, level 2 is specific to airline and city pair, level 3 is specific to airline only but distinguishes national and international flights, level 4 is specific only to airlines.

[9] The absolute fuel consumption is modelled for many combinations of the parameters plane type, distance and payload. The absolute fuel consumption of the specific flight is approximated by linear interpolation between the two pairs of distance and payload closest to the specific pair. Additionally, a correction factor accounting for the specific engine has been applied according to Piano-X. Fuel consumption per passenger is calculated assuming a weight of 100 kg per passenger including baggage.

[10] Refer to: atmosfair CO_2 calculation business travel: VDR Standard Part 1 – Methods, https://www.atmosfair.de/wp-content/uploads/co2-calculation-business-travel-vdr-standard-part-1.pdf

6. Post processing

The following results are fed back for each flight from atmosfair in Excel files to Infras for the base period and to ETH via web service for the monitoring period:

- Airline
- City pair
- Distance of flight
- Fuel consumption per passenger (only in base period)
- CO_2-emissions per passenger
- cruise altitude
- cruise distance above 9000 MAM
- GWP100 per passenger (with EWF 2 for share of flight above 9000 MAM)

6.1. Post processing in SAP (monitoring period)

Once results from atmosfair are back in ETH's database, the following operations are automatically triggered:

- GWP100 of fuel production for each flight is calculated from total CO_2 emission. It is 15.2% of CO_2 emission from operation (Cox et al. 2018; Cox and Althaus 2019);
- Total GWP100 for each flight (including operation and fuel production) is calculated;

The results are presented in a table that can be viewed in ETHIS (the user-interface to ETH's SAP data). Restrictions for accessing financial data are also applied to flight data. This implies that every Professor sees the results for his/her "Leitzahl" and that the Controllers of a department see the results of all "Leitzahlen" that belong to the department.

ETHIS offers the user a selection window in which the time period and "Leitzahl" can be entered. If no "Leitzahl" is entered, results will be provided for all "Leitzahlen" the user has access to. In this window the user can also choose what flights shall be displayed. The following options are possible:

- Flights for which emissions were successfully calculated,
- Flights for which emissions could not be calculated,
- Flights for which emissions have not yet been calculated,
- all flights, using default values if emissions were not successfully calculated.

Results for each flight are presented together with cumulative results for the time period which was selected in ETHIS. The table reports flight information (flight number, city pair, date, service class, number of flights (always 1), distance and total GHG emission) for each flight for each “Leitzahl” and for the time period specified in ETHIS. The quantitative information (number of flights, distance and emissions) is cumulated per “Leitzahl” and for all “Leitzahlen” selected.

Options for a graphic representation of the results are being discussed but so far, no decision has been taken.

6.2. External post processing

The external post-processing for the base period (2016-2018) consists of the following steps performed by INFRAS in a PYTHON routine:

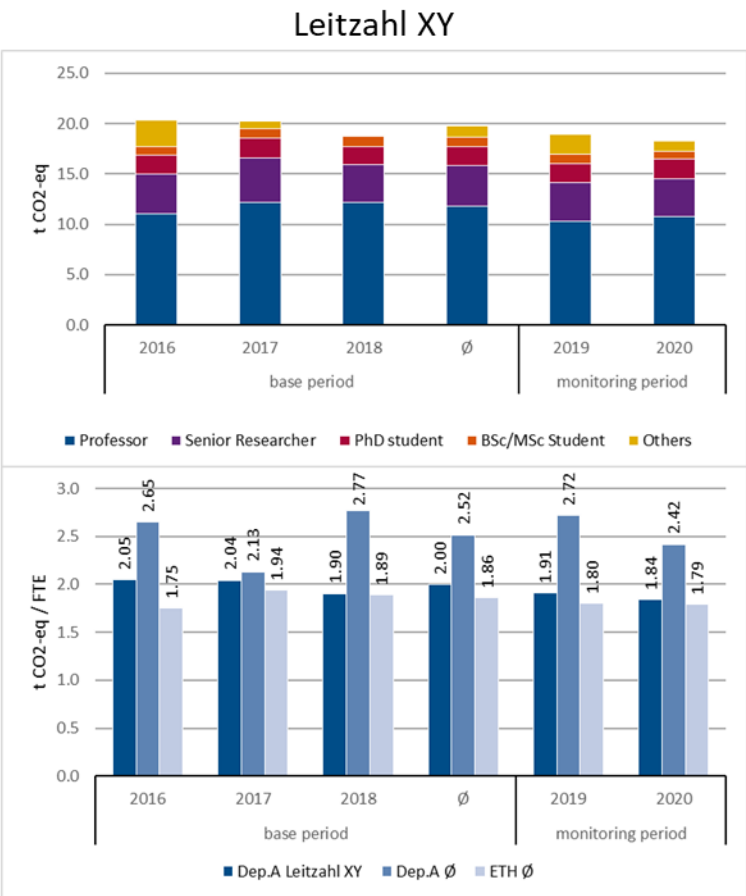
- GWP100 of fuel production for each flight is calculated from total CO_2 emission. It is 15.2% of CO_2 emission from operation (Cox et al. 2018; Cox and Althaus 2019);
- Total GWP100 for each flight (including operation and fuel production) is calculated;
- Total GWP100 for all flights are cumulated for each year and “Leitzahl”;
- Total GWP100 for all flights per year are cumulated for each academic department (16), for all administrative departments, and for all remaining units (executive board, staff units and teaching and research facilities outside the academic departments);
- Total GWP100 for all flights per year are cumulated for the entire ETH Zurich;
- Cumulated total GWP100 results are normalised by the number of FTE’s in the respective unit.

Normalised results for each «Leitzahl» are automatically compiled and graphically compared to the result of the higher levels to which the «Leitzahl» belongs (see Figure 4 and Figure 5). For each «Leitzahl» an individual result graph is provided. The results on the level of academic departments, cumulated administrative departments and cumulated remaining units are anonymised and published in an annual report.

If a graphic representation of the results can’t be done directly from SAP, the same (or a similar) post-processing could be done monthly or annually (ex-post) for the monitoring period, either by INFRAS[11] or internally at ETH[12].

[11] based on an export of all relevant data from ETH’s database. If a mailing address for each “Leitzahl” is available in a list, the graphs can be automatically sent by e-Mail.
[12] e.g. by Institutional Research, using Tableau software

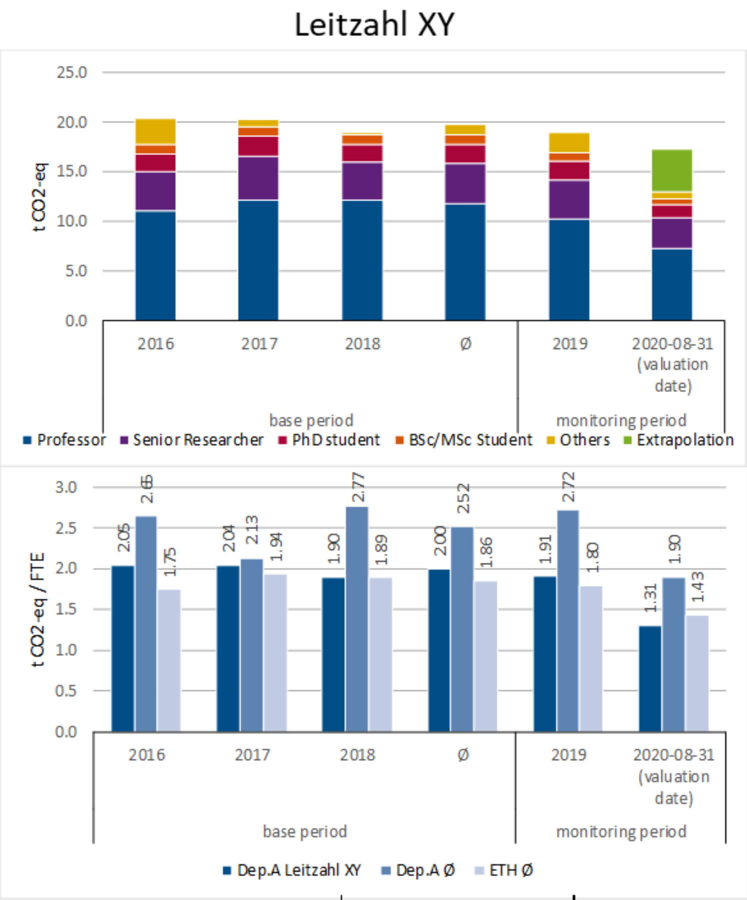
Figure 4: Example of annual report per "Leitzahl" (dummy data).



			base period				monitoring period	
			2016	2017	2018	Ø	2019	2020
Dep.A	Leit-zahl XY	# Flights / FTE	12.1	12.0	11.4	11.8	11.2	11.5
		thereof in business/first	1.3	1.2	1.2	1.2	0.6	0.4
		thereof invalid input	0.14	0.12	0.13	0.13	0.10	0.11
		Ø distance (km)	1393	1309	1514	1405	1503	1744
Dep.A	Ø	# Flights / FTE	15.3	12.9	15.5	14.6	18.0	16.4
		thereof in business/first	1.0	1.1	1.0	1.0	1.0	1.1
		thereof invalid input	0.14	0.15	0.15	0.15	0.08	0.10
		Ø distance (km)	1100	1143	1130	1124	1288	1181
ETH	Ø	# Flights / FTE	10.5	11.5	10.8	10.9	10.5	10.3
		thereof in business/first	1.2	1.3	1.2	1.2	0.8	0.6
		thereof invalid input	0.12	0.11	0.12	0.12	0.08	0.09
		Ø distance (km)	1216	1145	1253	1205	1241	1265

Graphics INFRAS.

Figure 5: Example of monthly or quarterly report per "Leitzahl" (dummy data).



			base period				monitoring period	
			2016	2017	2018	Ø	2019	2020-08-31 (valuation date)
Dep.A	Leit-zahl XY	# Flights / FTE	12.3	11.9	13.5	12.6	12.0	8.6
		thereof in business/first	1.8	1.8	1.4	1.6	0.8	1.2
		thereof invalid input	0.13	0.14	0.14	0.14	0.12	0.09
		Ø distance (km)	1272	1290	1399	1320	1238	1213
Dep.A	Ø	# Flights / FTE	13.6	12.1	13.0	12.9	14.8	10.2
		thereof in business/first	1.3	1.2	1.3	1.3	1.0	1.0
		thereof invalid input	0.10	0.11	0.09	0.10	0.11	0.08
		Ø distance (km)	1191	1383	1198	1257	1213	1390
ETH	Ø	# Flights / FTE	10.5	11.5	10.8	10.9	10.5	7.6
		thereof in business/first	1.2	1.3	1.2	1.2	0.8	0.9
		thereof invalid input	0.12	0.11	0.12	0.12	0.08	0.09
		Ø distance (km)	1216	1145	1253	1205	1241	1337

Emission for the rest of the year is estimated by linear extrapolation of emissions in the current year.

Graphics INFRAS.

7. Evaluation of reduction target achievement

This procedure will be used to calculate the GHG emissions for each year of the base-period (2016 – 2018) and of the monitoring period (2019 – 2025). In 2022 (mid-term) and in 2025 (final), the reduction target achievement will be evaluated.

The first step is straight forward: Emissions per FTE from 2016, 2017 and 2018 are averaged for the entire ETH, for each academic department, for the administrative departments and for the rest of ETH.

In a second step, emissions per FTE from the monitoring period are also averaged for the same units and levels. The difference between the two averages corresponds to the total reduction achieved.

However, only a part of this reduction can be attributed to ETH. Some of the improvement results from measures taken by the aviation industry and therefore needs to be attributed to this sector. If the goal of the International Civil Aviation Organization (ICAO) of 2% annual fuel efficiency gain per passenger kilometre (ICAO 2016) is achieved[13], an overall GHG emission reduction of almost 15% in 2025 compared to 2018 can be expected. In other words: if improvements in the aviation industry are not accounted for, ETH's reduction commitment of 11% is expected to be exceeded by the efforts of the aviation industry alone.

Therefore, in a third step, the emissions of all flights from the base period are calculated as if they took place in the monitoring period[14] and summed up. Thus, reductions achieved by improvements of airlines or in markets not relevant to ETH are neglected. The cumulated total GWP100 is then normalized with the number of FTE in the base period and results in "ETH's reference emission 2016 – 2018 in 20xx – 20yy" for the period from 20xx – 20yy (see Figure 6). This calculation is only performed for the entire ETH.

In step four, the "reference emissions 2016 – 2018 in 20xx – 20yy" for all departments and other units with a reduction target are calculated based on the departments (or units) average emission in the reference period and the relative reduction achieved by the aviation industry. The latter is calculated from ETH's average emission in the reference period and from "ETH's reference emission 2016 – 2018 in 20xx – 20yy".

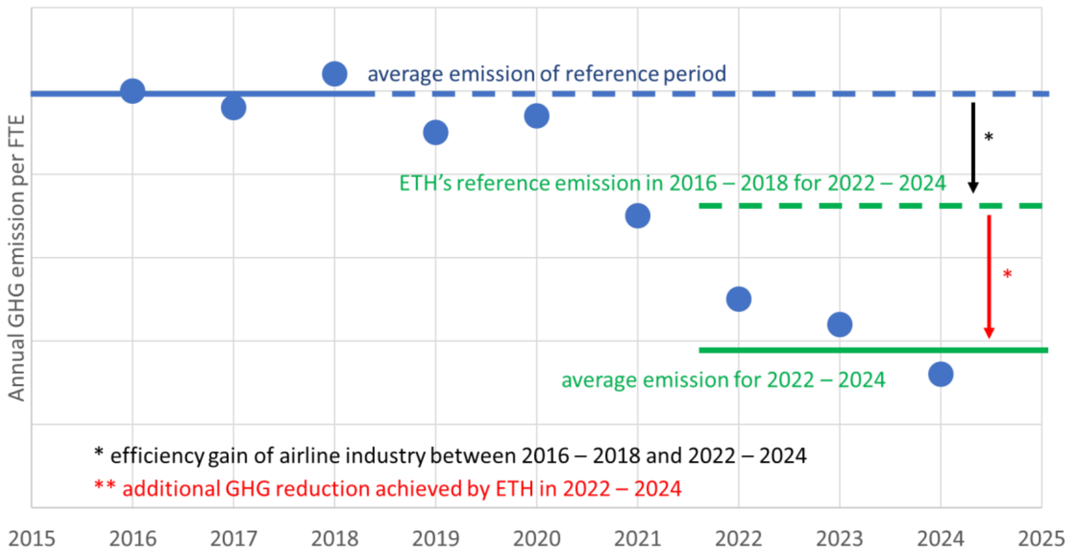
The reductions achieved by behavioural change within ETH (i.e. choice of more efficient carrier, choice of more efficient service class, reduction of flights) are finally calculated for the entire ETH and for each unit committed to reduction targets. As illustrated in Figure 6, this is

[13] Brandon and Rutherford (2018) showed, that aircraft fuel efficiency and seating density (i.e. capacity) were the most important drivers for airline efficiency on transatlantic flights in 2017, while in 2014, the passenger load factor was the most important driver. This suggests, that load factors of all airlines have increased to a high level in the past few years and that a further improvement is probably difficult to achieve.

[14] Each flight is virtually transferred to the corresponding flight several years later. For that, carrier, city pair, service class, time of year, day of week and time are considered.

done by comparing the “reference emission in 2016 – 2018 for 20xx – 20yy” to the average emission for 20xx – 20yy.

Figure 6: Calculation of ETH’s reference emission and of the emission reduction attributable to ETH.



Graphics INFRAS, based on Görlinger (2018)

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