Comparative analysis of carbon emission objective setting in a corporate context: Activity-Based Carbon Budgets vs. SBTi methods

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Abstract

Calculating greenhouse gas emission reduction targets is an essential element in the development of carbon strategies in companies. Existing methods for setting carbon reduction targets for companies either apply to certain sectors or have various drawbacks, such as the difficulty of taking into account the growth of the company or recognizing carbon reduction measures already implemented. While these issues may not be critical for large companies, they can prevent SMEs from setting meaningful reduction targets. This paper evaluates the alternative Activity-Based Carbon Budget (ACB) method and compares it to the well-established Science Based Targets Initiative (SBTi) methods in theory and practice. The ACB method is applicable to all sectors and regions and enables the integration of corporate growth as well as already implemented emission reduction measures, solving some of the problems inherent to the SBTi methods for calculating science-based emission targets. This thesis develops a database of average emission factors necessary for the application of the ACB method. The accuracy of the targets defined by the ACB method is dependent on the availability of national statistics and emission data. The ACB method is then applied to four SMEs within Switzerland. Results show that the application of the ACB method is feasible and provides emission targets that are different to SBTi targets, in particular for scope 1 and 2 emissions. Additionally, the comparison of company emissions to average emission factors proves useful as a benchmarking tool for each of the company's activities.

Please note: This document is dated 02.08.2024. It is possible that the method described has changed since then. In particular, it should be noted that the term "Expected Carbon Footprint (ECF)", which is used in this document, is referred to as "Benchmark Carbon Footprint (BCF)" in later versions of literature on the ACB method.

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Table 1 Abbreviations

ACB	Activity-Based Carbon Budgets	Acronym for the model applied in the present paper
ECB	Expected Carbon Budget	Extrapolated science-based carbon budget of a company, based on current activity data
ECF	Expected Carbon Footprint	Carbon footprint calculated using activity data and average emission factors
CCF	Corporate Carbon Footprint	Carbon footprint calculated using activity data and actual emission factors for the activity of the company
NCF	National Carbon Footprint	National emissions as reported to the UNFCCC
NCB	National Carbon Budget	Modelled emission budget to remain under 1.5°C of global warming
ACA	Absolute Contraction Approach	SBTi model calculation for the evolution of CO_2 emissions using linear reductions pathways
SDA	Sectoral Decarbonization Approach	SBTi model calculation for the evolution of CO_2 emissions using a sectoral decarbonation pathway
SBTi	Science-Based Targets initiative	Organization providing the most commonly used approaches to calculate science-based targets.
SME	Small and Medium-sized Enterprises	Businesses with revenues, assets or number of employees under a certain threshold. SBTi uses the thresholds <250 employees, <€50 million turnover, and <€25 million assets

1. Introduction

With the Paris Agreement of 2015, 195 nations committed to combat climate change by targeting to stay below 2°C of global warming above pre-industrial levels, with ambitions to stay beneath 1.5°C. This threshold was set based on scientific assessments of different scenarios. According to the Intergovernmental Panel on Climate Change (IPCC), in order to stay beneath the 1.5°C threshold, the world needs to reach net-zero emissions by 2050 (IPCC, 2018).

The move towards a net-zero economy requires structures to translate the global target into national, regional and ultimately company-specific targets. Such targets are called "science-based" if they are consistent with current climate science and compatible with the 1.5° ceiling, (Andersen *et al*., 2021).

With the ambitious goal of achieving net-zero emissions by 2050, the pressure to act is continuously increasing. Many companies are required to set climate targets by their clients, while others do so voluntarily. There are already several methods for setting company-specific emission reduction targets, each with different advantages and disadvantages. The pressure on companies to set targets has so far rarely come from a legal perspective but mainly through pressure from their own value chain. Companies require their suppliers to set targets in order to manage and reduce their own scope 3 emissions.

Among the existing models for emission target setting, those developed by the Science Based Targets initiative (SBTi) are by far the most well-known. The majority of companies with climate targets have set them according to the rules of the SBTi (WRI, 2024). SBTi applies two different target-setting methods. The Sectoral Decarbonization Approach (SDA), which works with sector-specific emission intensity targets, and the Absolute Contraction Approach (ACA), which specifies a linear reduction path. While SDA can only be applied to certain sectors, ACA can be used for all sectors. SBTi also distinguishes between large companies and SMEs. The latter can only use the ACA method.

Both SBTi methods have some disadvantages. While the SDA method accounts for company growth and even rewards reduction measures taken in the past, it is only available for a limited number of sectors, and it is designed for large companies. ACA, on the other hand, can be applied to all sectors, but does not take into account reduction measures that were already undertaken before the year in which the target was set. Furthermore, ACA does not consider the growth of a company.

Large companies are often able to overcome such difficulties. Most large companies do not have a particularly fast growth rate and rapidly changing emission levels. For smaller companies, however, these difficulties are more significant. As a result, SBTi does not offer a satisfactory solution for the target setting of small and medium sized companies. Yet SMEs account for more than half of Europe's GDP and their collective emissions represent 63% of all CO_2 emissions from businesses (European Commission, 2022). It is, therefore, of high importance to provide a target setting methodology that has been created with the needs of SMEs in mind and is easy to be applied by them.

This master’s thesis focuses on testing the applicability and advantages of an alternative method for emission target setting, namely the Activity-Based Carbon Budgets (ACB) method, which uses a new allocation mechanism to calculate a remaining CO_2 budget for companies. The ACB method makes it possible to set climate targets that are compatible with global and national legislation. It is applicable to all types of companies, considers reduction measures already implemented and allows adaptation to company growth. The ACB method thus solves most disadvantages inherent to the SBTi methods, and which are especially for SMEs.

The thesis will first provide an overview of the SBTi methods and other already existing methods for calculating emission reduction targets. Then, the theory of the ACB method, and the calculation model will be explained. After a theoretical comparison of SBTi methods with the ACB method, the practical part of the thesis presents and discusses the concrete results of applying the ACB method to real companies in Switzerland in direct comparison with the ACA method.

2. Research questions

This thesis explores the practical application of the Activity-Based Carbon Budgets (ACB) method for determining CO_2 reduction targets adjusted to companies' specific needs and for designing action plans that comply with these targets.

The ACB method itself was not developed in this master's thesis but is based on a paper by Halter *et al*. (no date) about the development of the method, which has not yet been published. This paper examines the practical application of the ACB method. The necessary steps for using the method in real cases are determined and undertaken.

The research will involve a critical comparison between the ACB method and the Science-Based Targets initiative (SBTi) approach. This comparative analysis will highlight the similarities and core differences between the methods. Specifically, the perspectives and requirements of the companies are considered in order to assess the suitability of the methods for setting carbon reduction targets. The strengths and limitations of each method will be explored.

Lastly, the ACB method will be applied to set emission objectives for existing companies. Parallel to the application of ACB, SBTi objectives will also be calculated to be able to compare the results of both approaches. This is done to test and emphasize the applicability and feasibility of the ACB approach in guiding companies towards effective carbon reduction strategies.

The aim of the thesis is to apply and evaluate the ACB model on real case studies, including the development of a database of emission factors needed and a comparison in theory and practice with the SBTi methodology.

The following research question will be answered:

1. *What are the differences between the ACB method and SBTi methods for setting emission reduction targets?*

2. *How can companies interpret and utilize the climate targets calculated using the ACB method?*

3. *How do the results obtained using the ACB method differ from those obtained using ACA method?*

3. Existing models

This section of the thesis provides an overview over already existing models and methods aiming to set emission reduction targets for companies.

3.1. Carbon accounting

Before emission reduction targets can be set for companies, a comprehensive carbon footprint must first be completed. The Greenhouse Gas (GHG) Protocol provides a framework for measuring and managing greenhouse gas emissions. It divides a company's emissions into three scopes, visualized in Figure 1 (WRI and WBCSD, 2013a):

Scope 1: Direct emissions from company-owned or controlled sources, such as company vehicles or on-site fuel combustion.

Scope 2: Indirect emissions from the generation of purchased electricity, steam, heating, and cooling.

Scope 3: All other indirect emissions that occur in a company's value chain, including upstream and downstream activities (WRI and WBCSD, 2013b). Scope 3 emissions are then further categorized into 15 subcategories. A more detailed list of the different emission scopes can be found in appendix A.

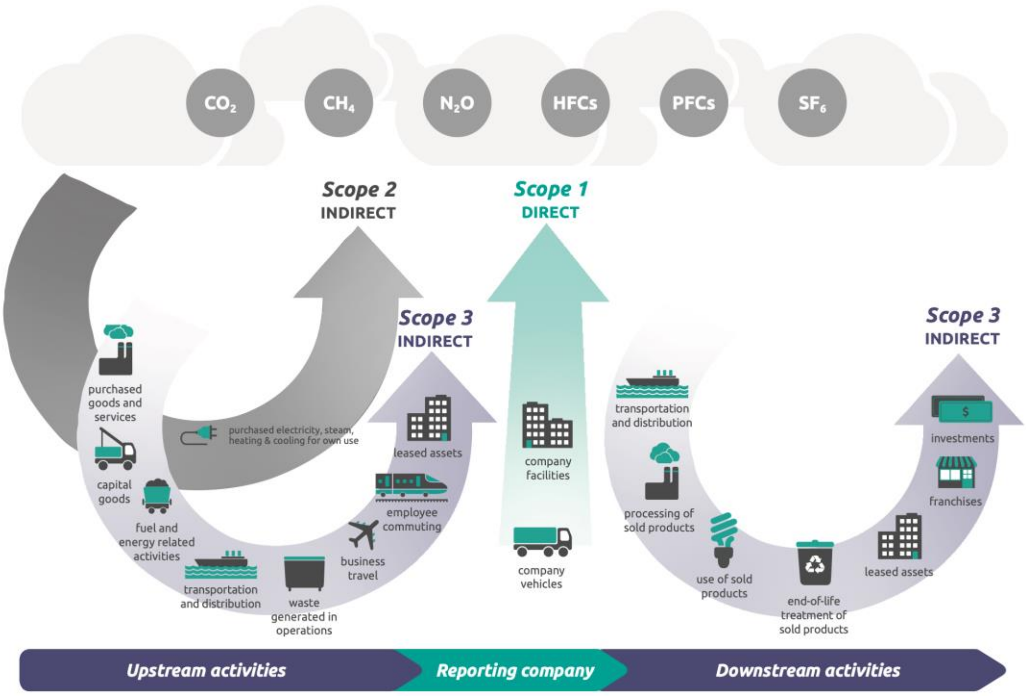

Figure 1 Overview of GHG Protocol scopes and emissions across the value chain

3.1. The Sectoral Decarbonization Approach (SDA) of the SBTi

The SDA method works with sectoral budgets and emission intensity targets specific to each sector. It calculates the relative contribution of a company to total emissions in its sector using a single indicator specific to the sector (e.g., tons of cement produced). This is then used to calculate the company's share of the emission reductions required in this sector to comply with the sectoral reduction pathway.

The SDA is available for the sectors power generation, industry, transport services and services/commercial buildings. These sectors are further divided into sub-sectors like e.g., cement and iron and steel. SDA works with intensity targets instead of total emission targets. An intensity target means a reduction of emissions per unit of activity like units produced, value added or building square meters (CDP, WRI and WWF, 2015).

Sectoral reduction goals are defined to reduce emissions at least by the same amount as if the cross-sector approach ACA would be used, so at least a total reduction of 90% between the years 2020 and 2050. Figure 2 shows the total reductions resulting from the sector-specific approaches for several different sectors and visualizes the defined reduction pathways (CDP, WRI and WWF, 2015).

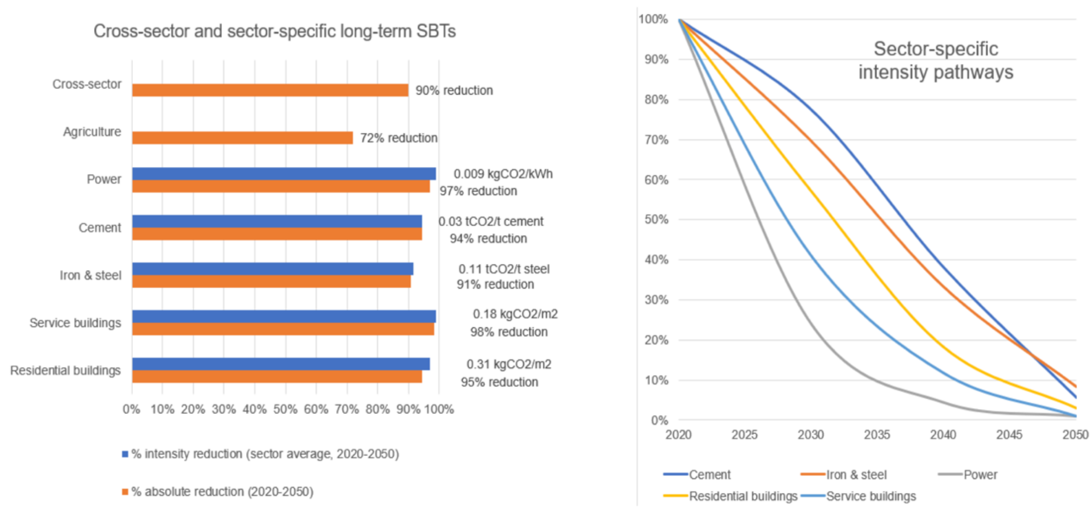

Figure 2 Emission reduction of different sectors with SDA

3.2. The Absolute Contraction Approach (ACA) of the SBTi

SBTi distinguishes between short-term and long-term targets. Short-term targets are emission reductions that are to be achieved by 2030. Long-term targets (or net-zero targets), on the other hand, are to be achieved at the latest by 2050.

Near-term targets are mitigation targets that need to be fulfilled within the next 5-10 years around 2030. If the target-setting year of the company setting an ACA target is 2020 or earlier, the near-term targets require a reduction of 4.2% (of the starting emissions) each year. If the target-setting year is later than 2020, the company must reduce emissions at a steeper rate to still achieve the same total reduction. A company setting targets in 2023 with the target year being 2030, would therefore still need to reduce the total of 42% over a seven-year period, amounting to 6% reduction each year. For ACA short-term targets, only emissions from scope 1 and 2 of the company must be taken into account.

Long-term targets, on the other hand, involve a total emission reduction of 90% by 2050 compared to the starting year. If a company sets long-term SBTi targets, it automatically also commits to a net-zero target, which, in addition to reducing emissions by 90%, also requires all remaining emissions to be compensated through sequestration. For large companies, the long-term and net-zero targets require the inclusion of all three emission scopes (CDP, WRI and WWF, 2024).

3.3. Other methodologies

In addition to the methods of SBTi, there are other, less well-known target setting methods. Bjørn, Lloyd, and Matthews (2021) provide a comprehensive overview of the methods available on the market and compares the different approaches. Next to the SBTi methods ACA and SDA, Bjørn, Lloyd, and Matthews (2021) compare the methods GEVA, BT-CSI, C-FACT, CSO and the 3% solution based on their theory and the application to fictitious companies.

GEVA is based on the economic contribution principle, meaning that a company's absolute decrease in emission should be smaller the more it is expected to increase its value added. The method accounts for growth and results in exponential emission pathways (Randers, 2012).

The method BT-CSI is similar to GEVA but additionally distinguishes between developed and developing countries to include climate change responsibility (Tupan, 2017).

The method C-FACT only exists for the 2°C emission scenario and includes that all companies in a region will reduce absolute emissions by the same degree. It also accounts for differences between developed and developing countries (Stewart and Deodhar, 2009).

CSO uses the same basic principles as BT-CSI and C-FACT but considers more detailed global emissions scenarios calculated for each year, rather than just the base and target year. It considers three different scenarios, including one that stays below the 1.5°C ceiling. CSO does not distinguish between regions. The method is currently no longer supported for use (McElroy, no date).

The 3% solution states that emission reductions should be distributed across sectors in such a way that costs are minimized. The method and its pathways are specific to the USA. It includes grandfathering, the responsibility principle and physical production as allocation factors (WWF and CDP, 2013). Grandfathering in emission target setting refers to the allocation of future emission allowances based on the organization's historical emission levels. Since the 3% solution is based on the United States decarbonization plan until the year 2020, this method is since outdated with no updated version.

In order to set a "science-based" target, companies need to set an emission reduction target that is consistent with the latest climate science, specifically achieving the goals of the Paris agreement of limiting global warming below 2° C above pre-industrial levels and striving to limit warming to 1.5°C (UNFCCC, 2015). A direct comparison between the method shows that none of the methods' targets add up exactly to the global allowable emissions. CSO proposes a stricter pathway than expected globally with the 1.5° emissions scenario, while most other methods are less strict and do not allocate more than the global emission budget to stay below the 1.5°C threshold. Bjørn, Lloyd and Matthews (2021) state that while none of the methods fulfills the global emission target exactly, the two methods CSO and SDA are closest. Additionally, none of the mentioned methods are applicable to all types of companies regardless of their sector, size and region.

This thesis focuses on the application of the ACB method (Halter *et al.,* no date), a new method that is not yet publicly available and has therefore never been compared with other methods. SBTi provides two of the most widely used target setting methods, therefore, this thesis focuses on comparing the ACB method with SBTi's SDA and ACA method. After an initial comparison of the theoretical background of all three methods, a practical comparison between the ACA and ACB method will be done. In contrast to Bjørn, Lloyd, and Matthews (2021), the practical comparison will not be based on fictitious but on real companies. The companies considered in the comparison are SMEs, as this is both the focus of the ACB method and the main customer base of Climate Services.

4. Method

The focus lies on testing the ACB method on real companies and interpreting the findings. Furthermore, the comparison with SBTi results is done to better understand the differences. Since the ACB method offers advantages especially for SMEs, the comparison with the SBTi methods is focused only on ACA, which is the SBTi method used for setting SME targets.

The ACB Method sets emission targets by allocating carbon budgets to the companies while the ACA approach gives a linear reduction path, so the two methods are not directly comparable. The calculation model used for the ACB Approach is detailed below as well as the calculation for transforming ACA linear reduction targets into budgets to be able to compare the results.

4.1. The Activity-Based Carbon Budgets (ACB) method

The Activity-Based Carbon Budgets (ACB) method allocates a CO_2 budget to each company as a fraction of a binding national CO_2 budget. The allocation is based on the operational needs of each company, in particular energy requirements, mobility and transportation needs as well as the necessary provision of goods and services. For each emission category, the CO_2 budget is determined by the national average emissions associated with it. The company's total budget is the sum of the budgets for each emissions category.

By relying on emission categories, the model can be applied to all sectors of the economy, regardless of their activities. The overall emissions budget is given to companies to ensure compatibility with national climate targets, but a specific reduction pathway is not imposed. This gives the companies the freedom to determine the most appropriate action plan according to their individual investment opportunities or technological constraints. Furthermore, allocating the emissions budget based on the company's needs ensures that companies with the same activities receive equal budgets, allowing for a fair inclusion of already completed emission reduction measures. Finally, a company's positive or negative growth is taken into account relative to the national GDP growth, reflecting an increase or decrease in market share, while ensuring compliance with the overall national reduction pathway.

4.1.1. Calculation of Corporate and Expected Carbon Footprint

The first step is to determine the Corporate Carbon Footprint (CCF). This quantification is done by multiplying the raw data r for the company's activity for a specific emission source with a suitable emission factor f. This emission factor should reflect the actual impact of the emission source in the company as accurately as possible - for example, it should take into account the energy mix or type of vehicle used, the types of waste produced or the class of a flight.

For each source i, the emissions e_i are obtained through

$$e_i = r_i * f_i$$

(1)

In the starting year (0), the corporate carbon footprint $CCF(0)$ is the sum of the emissions e_i from all emission sources

$$CCF(0) = \sum_{i=1}^{n} e_i$$

(2)

where n is the number of indicators used to establish the carbon footprint. Coverage of all sources should be complete and conform to the GHG Protocol. If no data is available, it must be estimated.

The calculated Corporate Carbon footprint is then set in relation to an Expected Carbon Footprint (ECF). Apart from the emission factors, the calculation of the ECF is identical to the CCF calculation. Instead of specific emission factors, average emission factors $f\emptyset$ are used, which represent the national average emissions for a specific emission category.

For each emission category c, the ACB model calculates an expected emission volume e_c for the company, which is determined by a specific activity level a_c.

$$e_c = a_c * f\emptyset_c$$

(3)

The activity level a_c represents the company's needs in the starting year, which is derived directly from the raw data used in the corporate carbon footprint and normalized to defined units.

Summing the emission quantities calculated for each category with the average emission factors results in the Expected Carbon Footprint for the starting year (0).

$$ECF(0) = \sum_{c=1}^{n} e_c(0)$$

(4)

In the given starting year, the ECF represents the emissions that the company would generate if it behaved like a perfectly average company at a given level of activity. The ACB model calculates the emission budget of a company based on the ECF and not the CCF. The actual CCF is higher than the ECF if the company has not taken any action to reduce its footprint and lower if it has already reduced its impact compared to the average. We define the "urgency" U as the ratio between the two footprints.

$$U = \frac{CCF}{ECF}$$

(5)

Values of U below 1 indicate that the company has below-average emissions in a particular category and values above 1 indicate that a company is lagging behind and needs to act quickly.

4.1.2. Calculation of the Expected Carbon Budget

The ECF in a given starting year (0) is a fraction of the national carbon footprint NCF. The Expected Carbon Budget ECB is assigned to the company as a fraction of the National Carbon Budget NCB using the following allocation equation.

$$ECB(0) = NCB(0) * \frac{ECF(0)}{NCF(0)}$$

(6)

The $ECB(0)$ represents the best estimate, calculated for the company's activities in the starting year, of the total amount of emissions that the company should not exceed if it is to comply with the national targets. If the NCB is set to be consistent with the 1.5°C target, the ECB calculated for direct emissions will also be consistent with this target, ensuring a science-based approach. The NCB can also be calculated based on mandatory legal reduction targets, thus ensuring compliance with national targets.

The ACB method can also be used for international companies with locations in several countries. However, necessary adjustments must be made to the budget calculation process. As the ACB model is based on national CO_2 budgets, international corporations must take into account the national budgets of each country in which they operate. Essentially, an expected carbon budget (ECB) is calculated per country for all sites located there, based on the activities and average emission factors that are relevant in each individual country. The total budget of a multinational company is then determined by summing up all the individual budgets for the sites in each country.

4.1.3. Accounting for growth of companies

The ACB model makes it possible to adjust company budgets depending on their growth in relation to GDP. This adjustment also guarantees a national science-based reduction path. Companies can evolve over time, making it is necessary to continuously adapt their allocated budget, while respecting the national carbon budget. A company's budget cannot simply be increased in relation to its turnover, as otherwise the national CO_2 target cannot be met. The ACB method therefore considers the growth of a company in relation to GDP growth. A company that grows faster than GDP should be allocated an increasing share of the national carbon budget. Growth below GDP growth would lead to a reduction in the ECB. The calculation model used to adapt the companies' ECB to company growth can be found in appendix B.

4.1.1. Covered emissions scopes

According to national legislation, only scope 1 and 2 emissions must be included in a company's carbon footprint. However, the ACB model can be applied to both direct and indirect emissions. The inclusion of scope 1 emissions is sufficient to remain "science-based". If the scope 1 emissions of all companies are covered, all emissions would be covered, as the scope 2 or 3 emissions of one company are the scope 1 emissions of another. However, it is recommended to always include all emissions including scope 3. This puts pressure on the entire value chain and motivates suppliers and customers to work together to find solutions. Figure 3 summarizes the concepts and calculation model of the ACB method graphically.

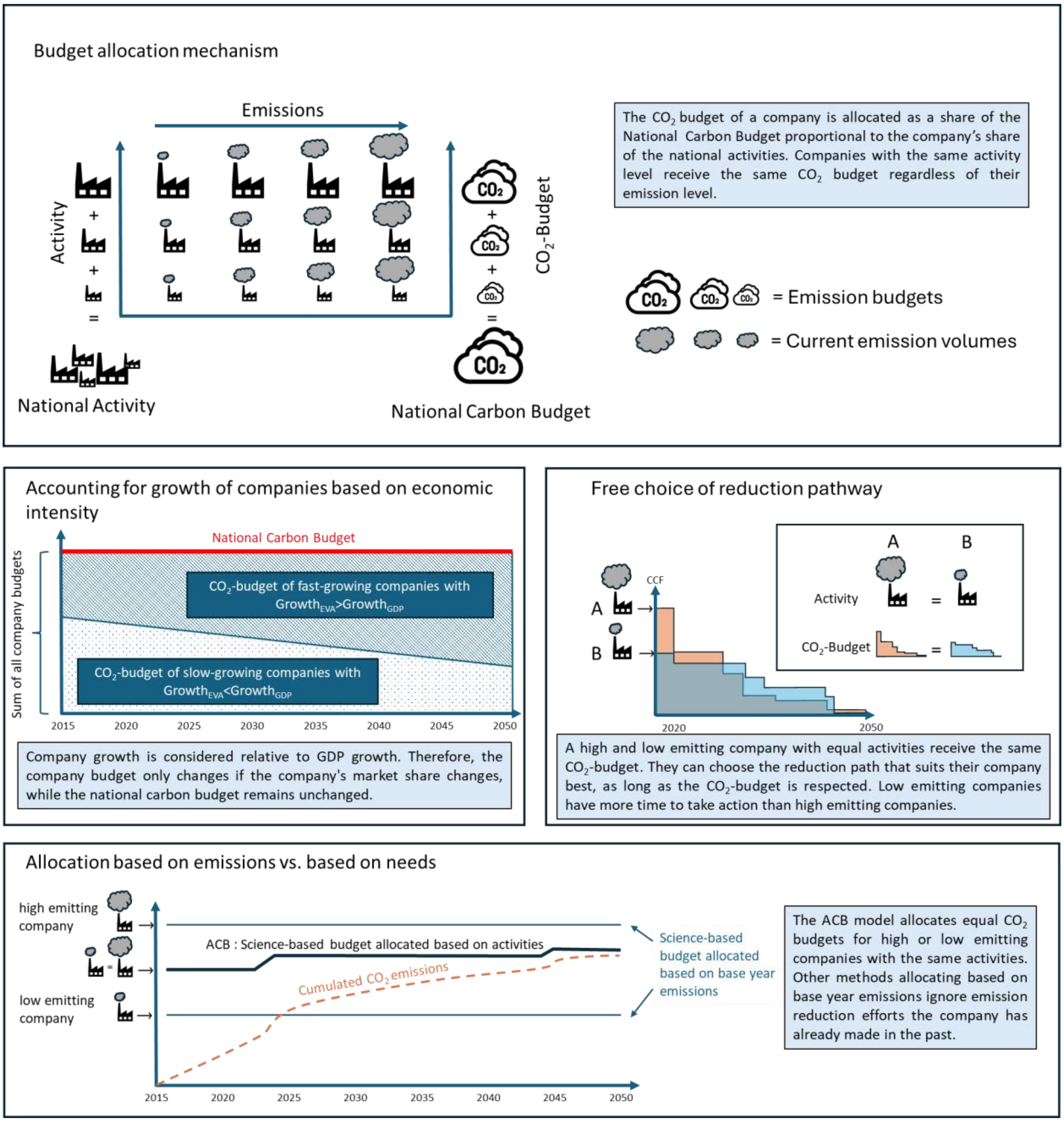

Figure 3 Graphic overview of the ACB method

4.1.2. Adaptability of the ACB method

The advantage of the ACB method is that it can be easily transferred to new sectors, regions, and countries due to its activity-based allocation. As long as average emission factors can be determined for the company activities within the new sector or region, there is no limit to the applicability of the model.

Furthermore, the calculation method can be adapted to national interim targets if necessary. In the case of a binding national target, e.g., to be achieved by 2030, the allocation of the company budget can be done by calculating the company's share of the national budget until 2030 instead of the total remaining national budget.

An adjustment to activity-specific regulations is also possible. If national targets are introduced for specific emission categories, such as transport, these could easily be included in the ACB model. The company's $ECB(0)$ would then not be calculated with the general national emissions budget, but with the specific national budgets for the respective emissions categories. The total budget for a company would then be the sum of all these category-specific budgets.

Over time, the set of average emission factors will need to be updated. As Switzerland is aiming for net-zero, the closer it gets to the target, the lower the average emission factors will become for the country. When net-zero is reached, all average emission factors will also have to be at zero. This means that a regular revision and adjustment of the average emission factor dataset is necessary to remain accurate.

4.2. Comparison between ACA, SDA and ACB

Table 2 shows a comparison between the two SBTi methodologies ACA and SDA and the new ACB method. There are some fundamental differences like the budget allocation mechanism, the integration of company growth and the sectors, to which the methods can be applied. An important advantage of ACB compared to the other two methods is its ability to be adapted to any regional or national targets. For better understanding, this thesis applies the ACB method in a national context for the country of Switzerland, but it can be just as easily applied to other regional entities like federal states or even the European Union.

Table 2 Comparison between ACA, SDA and ACB

	ACA	**SDA**	**ACB**
Budget allocation based on activity levels and average emission factors	✗	✓ Based on sector budgets; one average emission factor per sector	✓ Based on national budgets; one average emission factor per activity
Flexibility in the choice of the reduction path	✗ The company must follow a fixed linear reduction path	(✓) The company must achieve the final intensity target in 2050, the pathway in between can vary	✓ The company is free in its choice of reduction pathway as long as its CO_2 budget is respected

Company growth is taken into account	✗	✓ Growth is calculated in relation to the average growth of the sector	✓ Growth is calculated in relation to national nominal GDP
Integration of previous mitigation measures (before the year in which the targets are set)	✗	✓	✓
Integration of scope 3 emissions	✓ Calculation of scope 3 targets possible	(✓) Most scope 3 emissions are not included in SDA (Science Based Targets Initiative, 2015)	✓ Inclusion of all scopes possible and recommended
Compatible with Swiss Climate and Innovation Act	(✓) Could be compatible with Climate and Innovation Act, but this is not automatically given	(✓) Could be compatible with Climate and Innovation Act, but this is not automatically given	✓ Compatible with Climate and Innovation Act, as it is directly adaptable to its targets
Applicable for every sector	✓	✗	✓
Internationally recognized with many years of application	✓	✓	✗
Simplicity of the calculation model	✓ Very simple calculation model	(✓) Calculation models differ dependent on specific sector characteristics	(✓) Comprehensive model with relatively simple calculation

The comparison highlights the advantages of the ACB method. It is applicable to all sectors, takes already implemented measures and company growth into account and does not impose a fixed reduction path on companies. These arguments are especially important for SMEs. SMEs need a target calculation model that is adaptable to growth. Contrary to most larger companies, SMEs can easily have a growth rate of e.g., 50%. A climate target that cannot be adapted to this growth therefore does not make sense for these companies.

The reduction path of a company with very high emissions in its starting year can be much closer to a linear reduction path, since a multitude of measures will be implemented over time. On the contrary, a company with very low emissions will need only a few reduction measures, resulting in a reduction pathway with large steps. This further supports the point that while the ACB method is applicable to all types of companies, smaller companies in particular need an alternative method.

While the SDA method resolves some of the disadvantages of ACA, as can be seen in Table 2, a large disadvantage of it is that it is not meant to be applied to SMEs, only exists for certain sectors and makes it difficult to implement scope 3 emissions.

It is important to note that the ACB method does not allocate exactly the same budget to companies as the ACA or SDA method. This is due to the different basic approaches of the methods. The ACB method always calculates the company budget as a proportion of the national budget for Switzerland. The national budget was calculated to be compatible with the 1.5° target and the ACB allocation method ensures that it does not allocate more than the budget to which Switzerland is actually entitled. On the contrary, the SDA method is based on the allocation of sector-specific budgets, but this does not guarantee that national targets or the global remaining CO_2-budget will be complied with. The ACA method is not based on a remaining emission budget at all. The methodology always calculates its reduction pathway on the basis of a company's current emissions. It is not clear whether the sum of all emissions budgets distributed to companies using ACA would respect a national and ultimately a global budget enabling compliance with the 1.5°C-ceiling. It might therefore be misleading to describe the ACA method as "science-based", as compliance with the residual emission budget calculated by current climate science may be possible but is not guaranteed.

When using the ACA method, companies that have already implemented numerous emission reduction measures and therefore have below-average emissions must reduce their emissions with the same reduction rate as a company with above-average emissions. This not only penalizes the company by allocating a smaller CO_2 budget, but also makes compliance with the reduction path more difficult than for a high-emitting company. As a general rule, a company's first emission reduction measures are much easier and cheaper to implement than the reduction of the last remaining emissions. At the beginning of the emissions reduction process, the company can often reduce emissions relatively easy with simple measures such as switching to a better electricity mix or optimizing business travel. However, a company that has already taken all the “simple” measures must still reduce its remaining emissions by 42% by 2030. As these remaining emissions can often only be reduced through major investments or innovations, it is much more difficult for these companies to adhere to the strict reduction path in time. The ACB method, on the other hand, calculates a company's emissions targets based on its activities regardless of current emissions. This gives low-emitting companies significantly more leeway to reduce the remaining emissions, as their already implemented reductions give them an advantage.

4.3. Determination of average emission factors

For the calculation of the Expected Carbon Footprint ECF and in turn the emission budgets, the average emission factors are a central element. They are the base for the allocation of the national budget to the companies. The application of the ACB method therefore depends on the accurate determination of average emission factors for the specific region in which it is applied. In this thesis, the ACB method is applied to companies based in Switzerland, so the database of average emission factors is developed specific to this country. The creation of a database of average emission factors represents one of the major elements of this thesis work. The development of this database was done in two steps. First the activities had to be defined and then an appropriate emission factor for each activity had to be determined.

An activity is defined here as an action with a certain result. For each activity, an average emission factor is calculated. Each indicator used in the calculation of an organizations carbon footprint can be assigned to an activity. However, in some cases multiple indicators will be assigned to the same activity if they serve the same purpose. For example, commuting is an activity with the result of getting an employee to his workplace. Traveling to work by car, train or bicycle all serve the same purpose of commuting and are grouped into this one activity. An indicator included in the carbon footprint is therefore not necessarily the same as an activity. Other activities can be kWh electricity consumed, tons steel purchased or square meter building surface heated.

The first step of defining the activities is crucial. Many details need to be considered when making the decision. For example, the activity "transporting goods" is very general and the decision was made to further compartmentalize this activity. The average emission factor for transport depends on the distance and the available transportation means which can be reasonably considered. Different means of transportation are available for different distances. For example, overseas transport will either be done with container ships or air freight. The average emission factor should therefore reflect the average of the options which are currently used for transportation for the respective distance.

Purchased goods and services are difficult to group, since they usually represent a very distinct need of the company. Grouping can only be done here for goods and services that serve the same purpose, like recycled and virgin paper. In this case, the average emission factor represents the current mix between recycled and virgin paper.

An average emission factor $f\emptyset$ of a particular emission source can be based either on Life Cycle Analysis databases or on national emission intensities as given in National Inventory Reports. They represent the average impact of an emission source per unit of activity. These average emission factors evolve slowly with the development of technologies and behaviors. The values used for the budget calculation should come from data as close as possible to the chosen starting year. Ideally, national authorities should provide a comprehensive set of average emission factors that is updated annually.

The average emission factors are often based on data from national inventory reports, the publication of this data is often delayed by several years. To correct for this difference, it is recommended to extrapolate the development of these average emission factors to the starting year (0) on the basis of historical data.

The system boundaries of the company-specific and average emission factors must be identical. It is therefore necessary to document of the average emission factors clear and detailed enough so that the system boundaries can be easily understood and adopted by companies. The resolution of the calculated results is dependent on available data to determine average emission factors. However, the function and reliability of the method to meet the national budget and allocate it to companies is not dependent on the specific grouping and detailing of activities.

The following part describes how the database of average emission factors which was developed for the application of the ACB method. It will be discussed how the average emission factors were determined for the chosen activities. The complete list of average emission factors that was developed and used during this thesis can be found in appendix C.

4.3.1. Electricity

The activity of electricity consumption is necessary for almost every company. It is measured in kWh, and the average emission factor has been defined as the emissions per kWh of the Swiss electricity grid mix (Association des entreprises électriques suisses, 2023).

4.3.2. Heating of buildings

Heat generation was divided into heating of buildings and the generation of process heat. This separation was made because there are several options for heating buildings, e.g., heat pumps, district heating or pellets, which are not commonly used for the generation of process heat. For building heating, the activity is therefore defined as the heating of one square meter surface. The various heating systems that can be used are grouped into this activity, since they serve the same purpose and can be interchanged.

The average emission factor for building heating was calculated in two different ways in order to increase robustness. The first approach was based on data on heat consumption and its emissions in Switzerland (Narula *et al.*, 2019) and data on the energy reference area in 2023 (Swiss Federal Office for the Environment, 2024). As the emissions data is obtained for the year 2016, it was extrapolated to obtain values for 2023. To this end, the emissions were first increased in proportion to the increase in energy reference area in Switzerland (Swiss Federal Office for the Environment, 2024) and then adjusted with the information that Switzerland's building renovation program has resulted in an average annual reduction in emissions of 0.6 million tons of CO_2 (Swiss Federal Council, 2016). It was assumed that building refurbishments have brought about this reduction annually in the period 2016-2023. Based on the heated building area and the calculated emissions from building heating, an average emission factor of 0.0176 tCO_2/m^2 was calculated for the year 2023.

The second approach is based on data on emissions from building heating from the Swiss National Inventory Report for the year 2022 (Swiss Federal Office for the Environment, 2022) for commercial and institutional buildings and the FOEN values for the energy reference area of the same buildings in the same year (Swiss Federal Office for the Environment, 2024). The emission factor resulting from this calculation is 0.0175 tCO_2/m^2.

The average emission factors calculated from both approaches differ only slightly. Nevertheless, in order to obtain a more robust value, the average of the two values was chosen as the final emission factor for building heating.

4.3.3. Process heat

The average emission factor for the production of process heat was determined by assuming that two thirds fossil fuels (50% heating oil and 50% gas) and one third electricity are used. Since no exact data on this distribution could be found for Switzerland, this was estimated based on data for heat production in surrounding countries.

The emission factor used for the calculation is 0.00023 tCO_2/kWh for natural gas and 0.00033 tCO_2/kWh for heating oil (Federal Commission on Building and Construction KBOB, 2024). For the electricity share, the already determined average emission factor for electricity was used.

If reliable data becomes available, it would be interesting to divide the activity of generating process heat into more detailed activities based on the temperature range and the flexibility at which the heat is required. Different heating systems are possible for different heating needs, so the options for providing steady low temperature heat might be different than for providing high temperatures with temperature changes every few seconds.

Table 3 Average emission factors for electricity and heat production

Activity	fØ	Unit	Source
Electricity	0.00011	tCO2/kWh	Association des entreprises électriques suisses (2023)
Building heating	0.01756	tCO2/m2	Narula *et al.* (2019); Swiss Federal Office for the Environment (2024); Swiss Federal Council (2016); Swiss Federal Office for the Environment (2022)
Process heat	0.00019	tCO2/kWh	Federal Commission on Building and Construction KBOB (2024)

4.3.4. Mobility and transport

In the area of mobility and transport, the activities were grouped into three categories: commuting, business travel and freight transport.

The emission factor for the commuting activity is based on the assumption that the modal distribution of means of transportation for passenger transport in general is also a good approximation for the distribution in commuting. To determine the average emission factor for commuting, the emission factors of the individual means of transportation (Mobitool, 2023) were weighted with data on the distribution of means of transport per passenger kilometer travelled in Swiss passenger transport (Federal Statistical Office, 2023).

When more precise data become available, it would be interesting to break down the commuting activity even further into urban and rural regions. In urban regions there is much more public transport available, while in rural areas motorized private transport is often the only option. The means of transportation available influences the options available to commuters and therefore also the average emissions.

In the business travel category, a subdivision was made according to the distances traveled, as different means of transport can be considered for different distances. The distances selected are 0-500km, 500-1000km, 1000-4000km and >4000km. The following assumptions were made to calculate the average emission factors.

1. below 500km flights are excluded.

2. between 500km and 1000km the percentage of air traffic increases linearly,

3. from 1000-4000km only European air traffic is assumed

4. above 4000km only intercontinental flights are assumed.

For land transport, the same distribution of possible means of transport is assumed as for commuter traffic. The emission factors for the individual means of transport are average values determined for Switzerland (Mobitool, 2023). In the case of flights, the average distribution of business and economy class flights is considered. An emissions factor for hotel overnight stays on business trips was also defined in the business travel category. Due to a lack of data, the calculation was based on the assumption that 75% of overnight stays are booked in 2-3* hotels and 25% in 4-5* hotels.

In the freight transport category, a subdivision into different distances was done with the same argument, that different means of transport are possible for different distances. The following categories were chosen according to distances categorized by the Swiss platform on mobility management and environmental data Mobitool: 0-150km, 150-400km, 400-4000km and >4000km. All emission factors for the modes of transport stem from this database (Mobitool, 2023). Below 150km it is assumed that only trucks are used for transportation. The emission factor is therefore the average for the Swiss truck fleet. This value should decrease as electric trucks become available. For distances from 150km to 400km and 400-4000km, the distribution of means of transport was taken from European statistics (Eurostat, 2024). Maritime transport was excluded, as Switzerland has no seaports. For transport <4000km, it was assumed that only aircraft and container ship transport is possible. The distribution of the two modes of transport was determined based on the total transported volumes (Statista, 2024a; Statista, 2024b).

Assumptions are important for the definition of the activities and consequently for the interpretation of the results. It is important to note that although the exact definition of the boundaries of the individual activities can slightly change the budget allocated to individual companies, it will not change the total budget allocated. If all activities of all companies in Switzerland are summed with their respective average emission factors, we will always get the national budget for Switzerland, regardless of the choice of boundaries. This explains that while the exact boundary of each activity affects the company-specific results, the reliability of the method as a whole is not impacted.

Table 4 Average emission factors for mobility and transport

Activity	fØ	Unit	Source
Commuting	0.00015	tCO2/km	Mobitool (2023); Federal Statistical Office (2023)
Business travel <500km	0.00015	tCO2/pkm	Mobitool (2023)
Business travel 500-1000km	0.00023	tCO2/pkm	Mobitool (2023)
Business travel 1000-4000km	0.00030	tCO2/pkm	Mobitool (2023)
Business travel >4000km	0.00024	tCO2/pkm	Mobitool (2023)
Hotel night	0.01513	tCO2/night	Climate Services, 2024
Transport <150km	0.00020	tCO2/t.km	Mobitool (2023); Eurostat (2024)
Transport 150-400km	0.00011	tCO2/t.km	Mobitool (2023); Eurostat (2024)
Transport 400-4000km	0.00013	tCO2/t.km	Mobitool (2023); Eurostat (2024)
Transport >4000km	0.00002	tCO2/t.km	Mobitool (2023); Statista (2024a); Statista (2024b)

4.3.5. Water and waste

For waste, it was decided to group all waste into one activity and calculate a single emission factor for it. The company will receive its budget depending on the amount of waste produced, as the emission factor is calculated in tCO_2 per ton of waste. The average emission factor depends on how well the waste is separated and recycled on average in Switzerland. There is no emission factor available in literature, so it was determined by summing the individual emission factors for waste categories depending on their share in the total waste production. The categories taken into account are aluminum and sheet steel packaging, batteries and accumulators, PET bottles, old electrical appliances, glass packaging, iron and steel scrap, non-ferrous scrap metals, wastepaper, incinerated waste, green waste, waste from building construction and civil engineering (mainly asphalt and concrete). Data on quantities of each waste category was collected from Swiss Recycling (2023), VSMR (2019) and the Swiss Federal Office for the Environment (2021a). The respective emission factors were taken from Ecoinvent and KBOB (ecoinvent, 2024; Federal Commission on Building and Construction KBOB, 2024).

Water related activities were divided into wastewater production and freshwater consumption. The latter was divided into the two categories of spring water and purified water, as these are the most common sources of drinking water in Switzerland. It was not considered useful to group these categories, as they have different emission factors, and the company is dependent on the local drinking water supply and therefore cannot choose which of the two it uses. The emission factors used for water consumption stem from Climate Services' own emission database (Climate Services, 2024).

Table 5 Average emission factors for waste and water

Activity	fØ	Unit	Source
Waste	0.10548	tCO2/t	Swiss Recycling (2023); VSMR (2019); Swiss Federal Office for the Environment (2021); ecoinvent (2024)
Wastewater	0.00016	tCO2/m3	ecoinvent (2024)
Purified water	0.00075	tCO2/m3	Climate Services (2024)
Spring water	0.00043	tCO2/m3	Climate Services (2024)

4.3.6. Goods and services

The emission factors for purchased office supplies and purchased goods are taken mostly from the French database Base Empreinte, ecoinvent, the KBOB and from Climate Services' own database (ADEME, 2024a; ecoinvent, 2024; Federal Commission on Building and Construction KBOB, 2024; Climate Services, 2024). The purchase of office supplies was defined as a separate activity for most items. A grouping was only made for the cardboard and paper categories, so that the activity paper includes virgin and recycled paper, since both serve the same purpose. The same applies to cardboard. A recycling share of 90% was assumed for both paper and cardboard (Swiss Federal Office for the Environment, 2021b). The average emission factors for externally provided services are also taken from the Climate Services database (Climate Services, 2024). Since the list of activities in this category is extensive, Table 5 shows only a section of the determined average emission factors. The complete list of determined average emission factors can be found in in Table 14 in appendix C.

Table 6 Average emission factors for purchased goods and services

Activity	fØ	Unit	Source
Toner cartridge	0.00364	tCO2/p	Climate Services (2024)
Computer screen	0.26500	tCO2/p	Climate Services (2024)
Laptop	0.16900	tCO2/p	Climate Services (2024)
Desktop computer	0.18900	tCO2/p	Climate Services (2024)
Keyboard	0.07780	tCO2/p	Climate Services (2024)
Smartphone	0.03800	tCO2/p	Climate Services (2024)
Printer	0.19700	tCO2/p	Climate Services (2024)
Computer mouse	0.00351	tCO2/p	Climate Services (2024)
Cleaning service	0.00177	tCO2/h	Climate Services (2024)
Security service	0.00177	tCO2/h	Climate Services (2024)
Administrative service	0.00152	tCO2/h	Climate Services (2024)
Nitrogen	0.20060	tCO2/t	Climate Services (2024)
Oxygen	0.16264	tCO2/t	ecoinvent (2024)
Hydrogen	11.0230	tCO2/t	ecoinvent (2024)
Aluminium	5.65000	tCO2/t	Federal Commission on Building and Construction KBOB (2024)
Plastic	2.38300	tCO2/t	ADEME (2024a)
Textile	14.5000	tCO2/t	Climate Services (2024)
Cement	0.74496	tCO2/t	Climate Services (2024)

4.4. Calculation of ACA emission budgets

Since of the two SBTi methods only ACA is suitable for use with SMEs, the practical comparison concentrates on this method. The ACB results are compared to targets set using the ACA method for the several companies to test the reliability of the ACB method and explore the differences to conventional methods.

As explained in chapter 3.2, the ACA method can be used to calculate near-term targets that are based on a 42% total emission reduction between the years 2020 and 2030. The fictive company shown in Figure 4 sets targets in 2022, therefore the reduction of 42% has to happen faster with a 5.25% reduction each year until 2030. After 2030, the reduction pathway is defined so that the company reaches a total reduction of 90% in 2050. For better comparability to the ACB method, both near- and long-term targets have been calculated for all three scopes.

SBTi does not calculate an emission budget with the ACA method, so to be able to compare the reduction targets, an ACA budget was calculated for three of the example companies by calculating the linear reduction pathway and deducing the available budget from the surface below the pathway. For illustration, Figure 4 shows the ACA reduction pathway calculated for a fictional company with 1000 tCO_2 emissions in 2022. The CO_2-budget is determined to be the sum of all emissions until 2050, if the company were to follow this pathway, represented by the area of the graph.

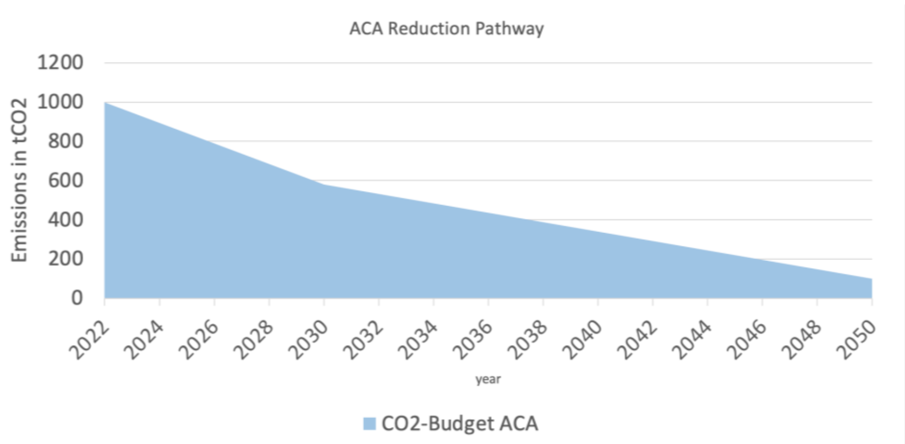

Figure 4 Linear reduction pathway determined with ACA

5. Results

The following part presents the results of applying both the ACB and the ACA method to real companies. It contains a detailed interpretation of the ACB results as well as a comparison of the CO_2-budgets calculated with the two methods. The first part will focus on detailed results for the application of the ACB method on a construction company while the second part compares the ACB results with the results of applying the ACA method for three additional companies from different sectors.

5.1. Detailed analysis of ACB results for company A

The first part will focus on the detailed results of applying the ACB method to company A, a Swiss company in the construction sector.

5.1.1. Company overview

Company A is a Swiss company operating in the construction sector. The company has approximately 300 employees and is therefore a medium-sized company. The carbon footprint for this company was calculated for the year 2023 in accordance with the GHG Protocol (WRI and WBCSD, 2013a). It includes all scope 1 and 2 emissions. For scope 3, the system boundaries were chosen to include relevant categories, namely scope 3.01 (production of purchased goods and services), 3.03 (activities related to oil and energy), 3.05 (waste generated), 3.06 (business travel) and 3.07 (employee commuting between home and work).

Table 7 summarizes the carbon footprint data for company A divided into categories. The category "heat consumption" includes both the heating of buildings and process heat generation. The category "consumables" includes the products and raw materials purchased by company A, namely cement, steel, and other construction materials which the company does not produce itself. The category "chemicals" includes chemical products purchased, for example chemicals necessary for the production and utilization of cement, bitumen, or concrete. The total emissions amount to 39908 tCO_2 for the year 2023.

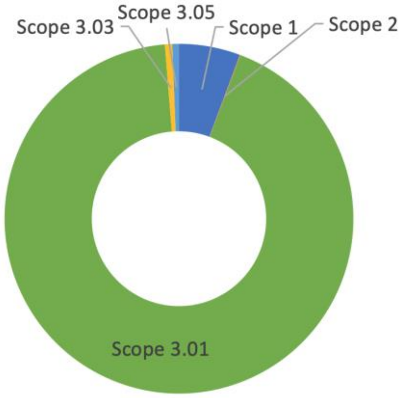

Figure 5 shows the same emission data for company A, divided into the respective scopes. For a detailed explanation of the emission scopes, refer to appendix A.

Table 7 Carbon footprint of company A divided into categories

Category	Data	Unit	tCO2	%
Consumables		diverse	22868	57.3%
Waste	989140	kg	243	0.6%
Office supplies		diverse	25	0.1%
Chemicals		diverse	14144	35.4%
Commuting	16160	km	0	0.0%
Electricity	1956468	kWh	25	0.1%
Business travel	622450	km	164	0.4%
Transport	95000	t.km	1238	3.1%
Food and drink		diverse	58	0.1%
Heat production		diverse	1136	2.8%
Water	12369000	l	6	0.0%
Total			39908	

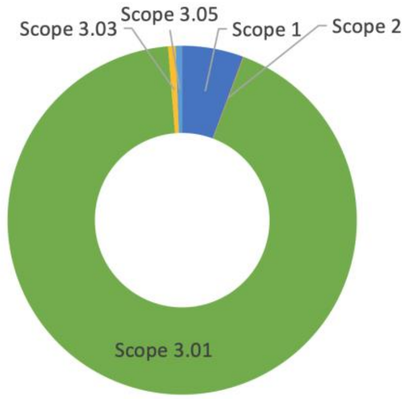

Figure 5 Carbon footprint of company A divided into emissions scopes

Most emissions caused by company A stem from purchased products and raw materials needed for construction. Within this category, the purchase of cement is responsible for more than half of the company's total emissions. Chemical products are also an important source of emissions. Compared to the large amount of scope 3 emissions, the company's scope 1 and 2 emissions appear relatively low.

5.1.2. Results using the ACB method

The application of the ACB method for company A yields an Expected Carbon Budget of 523450 tCO_2 from the starting year 2023. The detailed results structured by categories can be found in Table 8. The table shows the Expected Carbon Footprint calculated based on the average emission factors, the Corporate Carbon Footprint calculated based on the company's actual emission factors, the U-factor which represents how the company's emissions compare to the Swiss average and finally the calculated Expected Carbon Budget for each category. An even more detailed table which contains the results separated into each activity which was taken into account for the company, can be found in appendix D.

For the year 2023 the remaining National Carbon Budget (NCB) of Switzerland calculated with the Climate Analytics reduction path is 525.1 $MtCO_2$ and the National Carbon Footprint amounts to 41.2 $MtCO_2$ (Climate Analytics, 2021).

Table 8 ACB results for company A separated by categories

Category	ECF tCO2	CCF tCO2	U-Factor CCF/ECF	ECB tCO2
Consumables	22868	22868	1.00	291368
Waste	162	242	1.49	2069
Office supplies	25	25	0.99	319
Chemicals	14144	14144	1.00	180214
Commuting	4	0	0.08	53
Electricity	219	25	0.11	2792
Business travel	361	404	1.12	4595
Transport	2277	1018	0.45	29017
Food and drink	40	58	1.47	505
Heating	228	91	0.40	2909
Process heat	747	1024	1.37	9520
Water	7	7	1.00	89
Total	41083	39908	0.97	523450

Many companies are looking for an answer to the question of how they compare to other companies of a similar size. Unfortunately, this question is not easy to answer, as the total emissions of a company depend heavily on the selected system boundaries. A direct comparison is therefore not possible. However, the U-factors can be very helpful in making an assessment. The U-factor indicates how the company's emissions compare to a company with identical activities and average emission intensities for each activity.

As a reminder, a U-factor of 1 means that the companies emissions lie exactly at the average (in this case of Switzerland). A U-factor below 1 shows that the company emits less than average, and a U-factor above 1 means emissions higher than average in the respective category. For example, the U-factor of 0.11 for company A in the category electricity means that the company's emissions in this category are well below the Swiss average. The U-factor of 1.37 for process heat, on the other hand, shows that they are above the average emissions for the production of process heat.

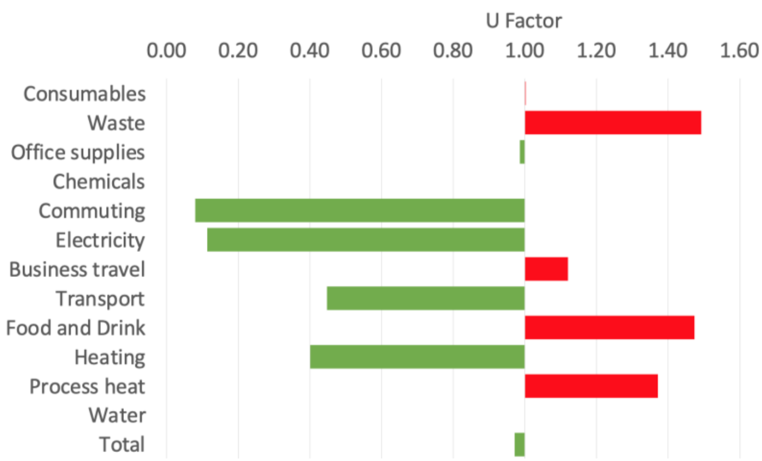

Figure 6 U-factors for each category of company A

For the special case of scope 3.01 (purchased goods and services), the U-factors do not provide much useful information. As no precise data is available on how much the specific suppliers of the company emit, average data are used to calculate both the CCF and the ECF. Therefore, the U-factor here is usually 1 due to a lack of detailed data.

Table 9 shows the aggregated data and U-factors broken down by scope, while first including and then excluding purchased goods and services (scope 3.01). Without purchased goods, only waste, business travel, commuting and transport are included in scope 3. This exclusion of scope 3.01 might provide a total U-factor which is more representative of the companies' emission reduction engagement, as it includes only the categories for which more exact data is available.

Table 9 ECB and U-factors for company A with and without considering scope 3.01

Scope	ECB	U-Factor	ECB (excl. Scope 3.01)	U-Factor (excl. Scope 3.01)
Scope 1	42293	0.68	42293	0.68
Scope 2	3032	0.10	3032	0.10
Scope 3	478125	1.00	5639	1.17
Total	523450	0.97	50964	0.70

5.1.3. Example calculation for electricity use

The following is an example calculation for the activity "electricity consumption" of company A to explain the calculation of the ECB using a real example.

First, the actual emissions of the company are calculated from the physical activity of the company and the company-specific emission factor, in this case the emission factor of the electricity mix purchased by company A according to equation (1).

$$CCF_{electricity} = 1956468\ kWh * 0.000013\ \frac{tCO_2}{kWh} = 24.79\ tCO_2$$

Next, the Expected Carbon Footprint is calculated. It represents the emissions that the company's electricity consumption would cause if they would purchase the average Swiss electricity grid mix (see equation (3)).

$$ECF_{electricity} = 1956468\ kWh * 0.000112\ \frac{tCO_2}{kWh} = 219.12\ tCO_2$$

The U-factor indicates the extent to which the company deviates from the Swiss average in the activity of electricity consumption. It is calculated by dividing the Company Carbon Footprint by the Expected Carbon Footprint (see equation (5)).

$$U_{electricity} = \frac{24.79\ tCO_2}{219.12\ tCO_2} = 0.11$$

Finally, the Expected Carbon Budget of company A for this activity is calculated by allocating the share of the National Carbon Budget corresponding to the share of the company's activity in the total national activity according to equation (6).

$$ECB_{electricity} = 525.1\ MtCO_2 * \frac{219.12\ tCO_2}{41.2\ MtCO_2} = 2791.90\ tCO_2$$

To calculate the total ECB, these calculation steps are completed for all activities of company A.

5.2. Comparative analysis for several companies

This second part will focus on the comparison of the emission targets calculated with ACB and the targets calculated with ACA. The targets calculated for three companies with activities in different sectors are compared.

The interpretation of the results for companies B, C and D focuses mainly on the results for scope 1 and 2 and the total emission budget. Similar to company A, the U-factor in scope 3 is also very close to 1 for companies B, C and D, as the purchased goods and services in scope 3.01 account for a large proportion of emissions for all example companies and no company-specific data is generally available for these so average values are used instead. In order to be able to interpret the U-factors for scope 3 for the companies in a meaningful way, the U-factors for the separate activities of the company in scope 3 would also have to be considered here in more detail. However, this subdivision has already been considered for company A and is not the focus of this comparison.

5.2.1. Company B

Company B operates in the material science and manufacturing sector. The system boundaries for their footprint include all scope 1 and 2 emissions as well as scope 3.01, scope 3.04, scope 3.05 and scope 3.07. The starting year for the target calculation is 2022. Company B does not have any scope 1 emissions, as they use the heat produced from their production processes to heat the buildings. Almost all emissions (97%) calculated in the starting year are in scope 3.01 (purchased goods and services). Table 10 shows the emission budgets calculated for company B using the ACB and the ACA method in coma

Table 10 Emission targets calculated for company B

Scope	U-Factor	Budget (ECB) ACB in tCO2	Budget ACA in tCO2
Scope 1	0.00	35	0
Scope 2	0.19	358	68
Scope 3	0.95	9643	9472
Total	0.92	10036	9540

The results for the ACA method were calculated as explained in chapter 4.4. The results shows that ACA and the ACB approach allocate different emission budgets. The ACA method will allocate a lower budget when emissions are already low, while the ACB method allocates the budget independent from current emission levels. In this way, the ACA method penalizes the company for already reducing its emissions.

Company B has no emissions in scope 1, therefore, the ACA method allocates no budget for scope 1, since it is based on emission levels. The company uses waste heat from the production processes for heating and thus replaces the need for additional heating with another heating source such as gas heating. The ACB method still allocates the company a scope 1 budget calculated based on the heated area of the company and the average emission factor of Swiss companies for heating one square meter. The fact that company B has opted for heating with an emission-free alternative is thus rewarded.

The relatively low U-factor of 0.19 in scope 2 indicates that the company has already decided to purchase a lower-emission electricity mix than the Swiss average. Company B therefore also receives a higher budget here with the ACB method compared to the ACA method.

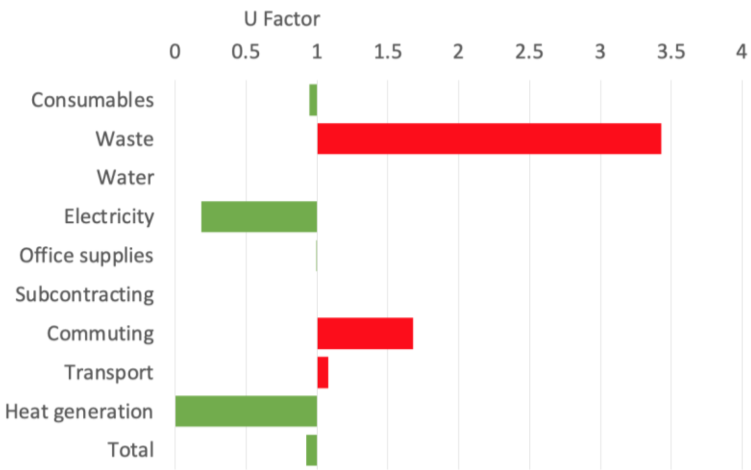

Figure 7 U-factors per category of company B

Figure 7 shows the U-factors for each category taken into account in company B's carbon footprint in the starting year. The figure shows that the company performs slightly better than average overall, which is largely due to its efforts to reduce emissions in heat and electricity consumption. On the contrary, the company emits more than the Swiss average in the waste and commuting categories and could benefit e.g., from the implementation of a mobility plan to reduce commuter emissions.

5.2.2. Company C

Company C operates in the sector industrial automation and robotics. The system boundaries for their footprint include all scope 1 and 2 emissions as well as scope 3.01, scope 3.03, scope 3.04, scope 3.05, scope 3.06, scope 3.07, scope 3.08. The starting year is 2023. Most of company C's total footprint stems from scope 3.01 emissions (purchased goods and services, 60%), with additionally 10% emissions from scope 3.07 (employee commuting) and 8% from scope 2 (in this case purchased electricity).

Table 11 Emission targets calculated for company C

Scope	U-Factor	Budget (ECB) ACB in tCO2	Budget ACA in tCO2
Scope 1	0.98	126	119
Scope 2	2.94	225	640
Scope 3	1.00	7400	7177
Total	1.06	7751	7936

In contrast to company B, company C uses a significantly more emission-intensive electricity mix, which even has higher emissions than the Swiss average. As the ACB method continues to allocate the budget that the company would need based on the kWh of electricity consumed with an average electricity mix. The ACB budget is significantly lower for this activity than the budget calculated with the ACA method. This means that the company is being rewarded with an increased budget by the ACA method for having implemented fewer emission reduction measures in scope 2 than the Swiss average.

In scope 1, the U-factor of company C is almost 1. Company C has rented its premises and is not the owner, which means that its emissions from heating were recorded in scope 3.08 instead of scope 1. The emissions from acope 1 here therefore only relate to the direct emissions from the operation of company-owned vehicles, where the company is roughly in line with the Swiss average.

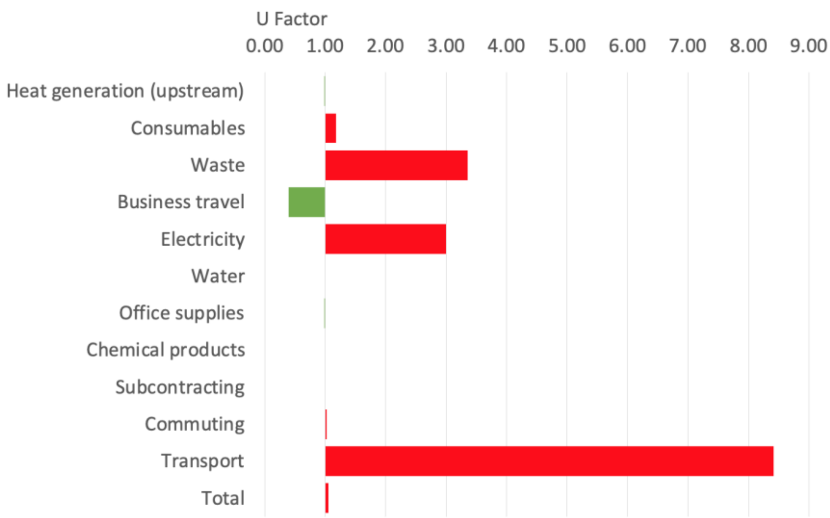

Figure 8 U-factors per category of company C

Figure 8 shows the U-factors of company C divided into more detailed categories than the three scopes. Here it can be seen, that next to waste and electricity, company C emits much more than average in the category transport with a U-factor of 8.42. The company uses mainly truck transport for all distances under 4000km, for which its emissions are close to average. However, all of company C's overseas transport uses air freight instead of the much more emission friendly option of container ship transport. This leads to the overall very high U-factor in the category transport.

5.2.3. Company D

Company D operates in the sector furniture and home decor. The system boundaries for their footprint include all scope 1 and 2 emissions as well as scope 3.01, 3.02, 3.03, 3.04, 3.05, 3.06, 3.07 and 3.12. The starting year is 2022. 46% of company D's emissions in the starting year are in scope 3.01 (purchased goods and services), 27% in scope 3.02 (capital investments) and 17% in scope 1 (direct emissions).

Table 12 Emission targets calculated for company D

Scope	U-Factor	Budget (ECB) ACB in tCO2	Budget ACA in tCO2
Scope 1	1.11	2933	3362
Scope 2	0.11	203	22
Scope 3	0.99	16266	16639
Total	1.00	19402	20023

Company D has an overall U-factor of 1.00. This means that the company's total emissions are very close to the Swiss average for these activities. However, if we consider the U-factors for the three scopes separately, we can see that even though the company's total emissions are close to average, it performs better or worse for its individual activities. For example, the U-factor for scope 1 is 1.11. The company uses company vehicles with a relatively high diesel consumption, causing higher emissions than average in this scope. In contrast, Company D has chosen a low-emission electricity mix, which offsets the higher emissions from scope 1 activities in the overall picture.

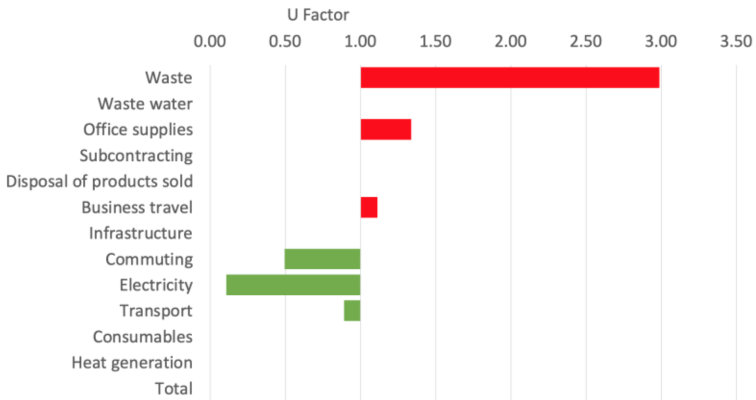

Figure 9 U-factors per category of company D

Figure 9 shows company D's U-factors for its considered categories. For many categories the U-factor is very close to 1.00. For consumables, subcontracting, wastewater and infrastructure, this is caused by the use of average data in the company's carbon footprint. For the category heat generation, the U-factor close to 1.00 shows that the company emissions are in line with the Swiss average. For transport, the company uses trucks for shorter distances. These transports are already optimized with little to no unloaded trips. Combined with overseas transport conducted solely by container ship with no air freight transport, the overall U-factor lies at 0.89 since the company's transport emissions are lower than the Swiss average.

The application to three companies shows that the ACA and ACB approach allocate different emission budgets for each company. The differences between the allocated budgets for the example companies is always a few percent. The largest difference exists for company B, where the budget allocated with ACB is 5.2% higher than that allocated with ACA. The more the company deviates from the Swiss average, the larger are the differences between the results of the two methods.

6. Conclusion

This master's thesis demonstration of the applicability of the ACB method for emission target setting. For this purpose, a data set with average emission factors was developed and the calculation model was successfully applied to four Swiss SMEs from different sectors. The calculation method is reliable in the calculation of science-based corporate goals.

The application of the ACB method shows that once a comprehensive database of average emission factors is available, the effort to calculate emission reduction targets is similar to the one using the methods proposed by the SBTi. In addition to the actual targets, the method also provides companies with important information on their current emission level, making it a useful and viable alternative to the ACA and SDA methods.

The comparison with the two SBTi methods ACA and SDA shows that the ACB method, with its applicability to all company types and sizes, adaptability to company growth and to specific national or regional targets, offers significant advantages over the currently widely used SBTi methods. A further advantage lies already in the fact that only a single method is required when applying the ACB method instead of having to use several methods to be able to include SMEs, large companies and different sectors or regions.

The comparison of the emissions targets of four Swiss SMEs using the ACB and ACA methods shows that the two methods calculate slightly different budgets, with the difference being larger for companies that deviate considerably from the Swiss average. The difference in budget between the two methods is particularly strong for scope 1 and 2.

A key advantage of an activity-based method such as ACB over an emissions-based method such as ACA is highlighted by the calculated emissions targets. While ACA allocates a high budget to companies with a high emission level, companies that have already reduced their emissions receive smaller budgets. The ACB targets are calculated based on average national emissions and emissions targets, so companies that have reduced their emissions early can meet their ACB budget with less effort, while CO_2-intensive companies are forced to act quickly in order to meet their CO_2 budget. Therefore, the ACA method rewards high emissions with a higher budget while ACB rewards the early implementation of reduction measures.

Another outcome of this thesis was to establish the use of the U-factors as a measure of the difference between the company's emissions and those of the Swiss average. One of the most common questions companies ask after completing a carbon footprint is how they compare to other companies. Until now, this question was difficult or even impossible to answer, as a comparison of the total emissions of one company with another depends heavily on the system boundaries chosen and therefore does not provide any meaningful information. The calculation of average emission factors and their use to calculate activity, category, or scope-specific U-factors makes it possible to answer this question for the first time. It is therefore possible to provide the company with a definite answer regarding areas in which it is already performing better than the average and areas in which it is performing worse and therefore has a heightened need for improvement. The usefulness of the U-factor is not directly linked to the ACB method as it is not part of the actual emission target calculation. It could therefore also be used as an independent tool for benchmarking companies.

Since the ACB method is largely based on the determination of the activities of a company and the calculation of the appropriate average emission factors, it would be useful to initiate a working group, including representatives from industry, to deal with the determination of activities so that accurate average emission factors can also be determined for more complex activities.

It would also be interesting to apply the method at cantonal level instead of federal level, so that the companies' emission targets are also compatible with the climate targets set at cantonal (Swiss member state) level. This would require, among other things, an adjustment of the average emission factors to be accurate for the canton. If the method were to be applied on other countries, a new set of average emission factors appropriate to the respective country would need to be determined.

The company Climate Services SA works frequently with SMEs and is therefore very interested in developing a method that is tailored to them, since currently available target setting methods do not provide a practical solution. After the success of this master's thesis in testing the ACB method, Climate Services is now in a position to broadly apply the ACB method. The calculation method, the database of average emission factors and the required calculation tool have been developed and tested as part of this master's thesis. The method has already been used to calculate emission reduction targets for several projects and the calculation has even been accepted as legitimate by the Swiss federal office for energy when it was submitted as part of a subsidy program.

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Appendices

A. Emission scopes defined in the GHG Protocol

The following emission scopes are defined in the GHG Protocol (WRI and WBCSD, 2013b).

Scope 1: Direct emissions from company-owned or controlled sources, such as company vehicles or on-site fuel combustion.

Scope 2: Indirect emissions from the generation of purchased electricity, steam, heating and cooling.

Scope 3: All other indirect emissions that occur in a company's value chain, including upstream and downstream activities.

Table 13 Scope 3 upstream and downstream emission categories

Upstream scope 3 emissions	Downstream scope 3 emissions
3.1 Purchased goods and services	3.9 Downstream transportation and distribution
3.2 Capital goods	3.10 Processing of sold products
3.3 Fuel- and energy-related activities (not included in scope 1 or 2)	3.11 Use of sold products
3.4 Upstream transportation and distribution	3.12 End-of-life treatment of sold products
3.5 Waste generated in operations	3.13 Downstream leased assets
3.6 Business travel	3.14 Franchises
3.7 Employee commuting	3.15 Investments
3.8 Upstream leased assets	

B. Calculation model for adapting the ECB to company growth

It is considered that for a company the activity $a_c(t)$ at the time t for a specific emission category c is proportional to the economic activity of that company, as expressed by its economic value added (EVA). Therefore, for the years following the starting year (0)

$$\frac{a_c(t)}{a_c(t-1)} = \frac{EVA(t)}{EVA(t-1)} \tag{7}$$

or

$$a_c(t) = a_c(t-1) * \frac{EVA(t)}{EVA(t-1)} \tag{8}$$

Since the GDP is equal to the economic values added by all companies in a country

$$GDP(t) = \sum_{j=1}^{J} EVA_j(t)$$

(9)

growth of a company is considered as an increase in the proportion of its market share.

Based on this principle the ACB method uses the approach described below to calculate the evolution of the ECB over time. This approach serves on the one hand to simulate the evolution of the budget for planning purposes and on the other hand, to periodically adapt it to real data.

As a first approximation, a linear relationship is considered between the Expected Carbon Footprint and the Economic Value Added on the one hand, and the National Carbon Footprint and the Gross Domestic Product on the other hand at a given point in time (Figure 10).

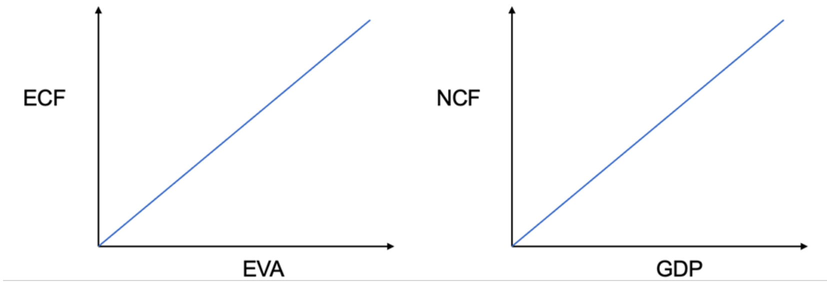

Figure 10: Variation of the ECF with EVA and of NCF with GDP

By making assumptions about company growth and GDP growth, this can be used to simulate the evolution of the Expected Carbon Budget by expressing the $ECB(t)$ as the previously calculated budget $ECB(t-1)$ adapted by the positive or negative growth depending on the current remaining National Carbon Budget. It is important to note that $ECB(t)$ represents the total cumulative emission budget of the company calculated in the year (t) while $NCB(t)$ always presents the remaining national budget in the year (t).

$$ECB(\text{t}) \;= ECB(t-1) + NCB\;(t) * \frac{ECF(0)}{NCF(0)} * \left(\frac{G_{EVA}}{G_{GDP}} - 1\right)$$

(10)

The parameter $G_{EVA}(t)$ represents the growth of EVA of the company between the year (t) and the year $(t-1)$ while $G_{GDP}(t)$ represents the growth of the GDP in the same time interval. Adaptation of the budget to growth is therefore fundamentally based on the economic growth.

Equation (10) can be used as a tool to predict the ECB of a company in case of growth. Figure 11 shows how the ECB of a company with a calculated $ECB(0)$ of 10000 tCO_2 develops over time depending on how the company grows in relation to the GDP.

For predictions, the national carbon budget $NCB(t)$ can be estimated by subtracting the expected National Carbon Footprint in the coming years as shown in Equation (11). Once there is real data for the remaining national Carbon Footprint in year (t), this value is used for calculating the budget adjustment of a company.

$$NCB(t) = NCB(0) - \sum_{i=0}^{t} NCF(i) \tag{11}$$

As mentioned above, we can use real growth data as they become available over time to continuously adapt the ECB (Figure 11). As real data becomes available, the $NCB(t)$ is calculated by deducting the real national carbon footprints instead of the expected national carbon footprint.

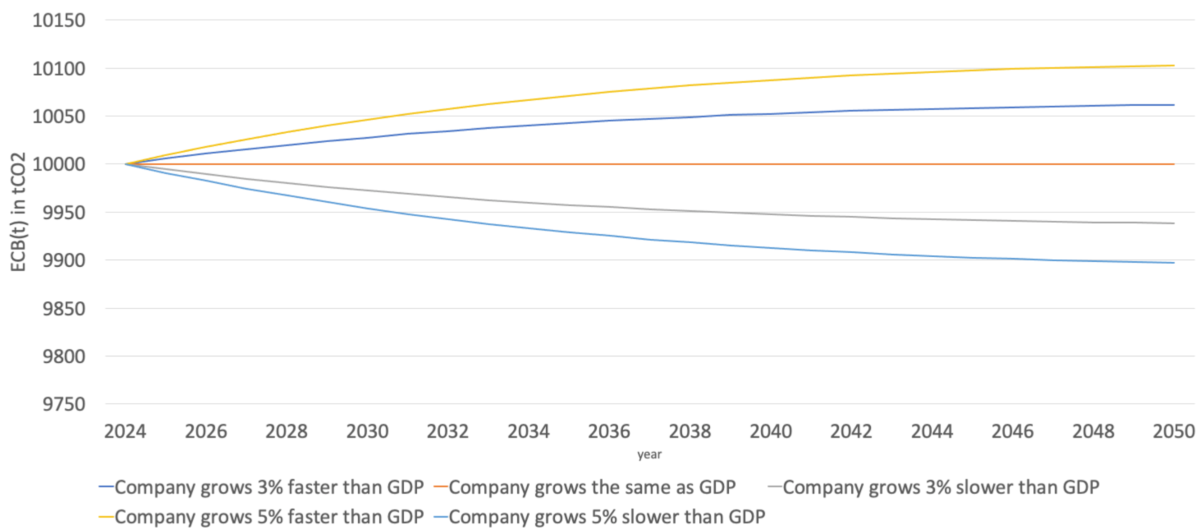

Figure 11 Development of Expected Carbon Budget depending on company growth in relation to GDP

The ACB method also facilitates the representation and allocation of emissions data for the processes of company mergers, acquisitions and divestitures. In the case of acquisition of a company, a separate $ECB(0)$ must be calculated for the purchased company, whereby the starting year (0) is the year of purchase. This separate budget is then added to the regular budget of the acquiring company. If the purchased company already calculated a ECB in the past, this can be added to the purchasing company's budget without recalculation.

In the event of the sale of a part of the company, we can calculate the $ECB(t)$ of the sold part of the company with year (t) being the year of the sale and the year (0) being the year (0) of the selling company. This budget is then deducted from the original budget of the selling company.

C. Complete list of average emission factors

Table 14 Average emission factors

Category	Average Emission Factor	Value	Unit	Source
Energy	AEF - Electricity	0.00011	tCO_2/kWh	Association des entreprises électriques suisses (2023)
	AEF - Building heat production	0.01756	tCO_2/m2	Narula *et al.* (2019); Swiss Federal Office for the Environment (2024); Swiss Federal Council (2016); Swiss Federal Office for the Environment (2022)
	AEF - Process heat	0.00019	tCO_2/kWh	Federal Commission on Building and Construction KBOB (2024)
Commuting	AEF - Commuting	0.00015	tCO_2/km	Mobitool (2023); Federal Statistical Office (2023)
Business trips	AEF - Business trips <500km	0.00015	tCO_2/pkm	Mobitool (2023)
	AEF - Business trips 500-1000km	0.00023	tCO_2/pkm	Mobitool (2023)
	AEF - Business trips 1000-4000km	0.00030	tCO_2/pkm	Mobitool (2023)
	AEF - Business trips >4000km	0.00024	tCO_2/pkm	Mobitool (2023)
	AEF - Service trip	0.00027	tCO_2/km	Mobitool (2023)
Hotel	AEF - Hotel	0.01513	tCO_2/night	Climate Services, 2024
Transport	AEF - Transportation <150km	0.00020	tCO_2/t.km	Mobitool (2023); Eurostat (2024)
	AEF - Transportation 150-400km	0.00011	tCO_2/t.km	Mobitool (2023); Eurostat (2024)
	AEF - Transportation 400-4000km	0.00013	tCO_2/t.km	Mobitool (2023); Eurostat (2024)
	AEF - Transportation >4000km	0.00002	tCO_2/t.km	Mobitool (2023); Statista (2024a); Statista (2024b)
Office supplies	AEF - Toner cartridges for printer	0.00364	tCO_2/p	Climate Services (2024)
	AEF - New screens	0.26500	tCO_2/p	Climate Services (2024)
	AEF - New laptops	0.16900	tCO_2/p	Climate Services (2024)
	AEF - New televisions	0.42200	tCO_2/p	Climate Services (2024)
	AEF - New desktop	0.18900	tCO_2/p	Climate Services (2024)
	AEF - New digital tablets	0.07780	tCO_2/p	Climate Services (2024)
	AEF - New smartphones	0.03800	tCO_2/p	Climate Services (2024)

	AEF - New printer	0.19700 tCO2/p	Climate Services (2024)
	AEF - New computer mouse	0.00351 tCO2/p	Climate Services (2024)
	AEF - New computer keyboards	0.00993 tCO2/p	Climate Services (2024)
	AEF - New docking station	0.03803 tCO2/p	Climate Services (2024)
	AEF - New cables	0.00038 tCO2/m	Climate Services (2024)
	AEF - New headphones	0.00577 tCO2/p	Climate Services (2024)
	AEF - Cardboard box	0.00064 tCO2/kg	Climate Services (2024)
	AEF - Envelope	0.00120 tCO2/kg	Climate Services (2024)
	AEF - Paper	0.00071 tCO2/kg	Climate Services (2024); Swiss Federal Office for the Environment (2021)
	AEF - Printer lease paper	0.00107 tCO2/kg	Climate Services (2024); Swiss Federal Office for the Environment (2021)
	AEF - National letter	0.00000 tCO2/p	Climate Services (2024)
	AEF - Letter Europe	0.00008 tCO2/p	Climate Services (2024)
	AEF - International letter	0.00016 tCO2/p	Climate Services (2024)
	AEF - National parcel	0.00002 tCO2/p	Climate Services (2024)
	AEF - International parcel	0.00243 tCO2/p	Climate Services (2024)
	AEF - International postal service	0.00200 tCO2/p	Climate Services (2024)
	AEF - National postal service	0.00100 tCO2/p	Climate Services (2024)
Water	AEF - Purified water	0.00075 tCO2/m3	Climate Services (2024)
	AEF - Waste water	0.00016 tCO2/m3	ecoinvent (2024)
	AEF - Spring water	0.00043 tCO2/m3	Climate Services (2024)
Waste	AEF - Waste	0.10548 tCO2/t	Swiss Recycling (2023); VSMR (2019); Swiss Federal Office for the Environment (2021); ecoinvent (2024)
Subcontracting	AEF - Cleaning service	0.00177 tCO2/h	Climate Services (2024)
	AEF - Security service	0.00177 tCO2/h	Climate Services (2024)
	AEF - Administration	0.00152 tCO2/h	Climate Services (2024)
	AEF - Outdoor maintenance service	0.00177 tCO2/h	Climate Services (2024)
	AEF - Textile cleaning service	0.00005 tCO2/kg	Climate Services (2024)
Consumables	AEF - Nitrogen	0.20060 tCO2/t	Climate Services (2024)
	AEF - Oxygen	0.47922 tCO2/t	ecoinvent (2024)
	AEF - Aluminum oxide casing	0.24800 tCO2/t	Climate Services (2024)
	AEF - Hydrogen	11.02300 tCO2/t	ecoinvent (2024)
	AEF - Aluminum	5.65000 tCO2/t	Federal Commission on Building and Construction KBOB (2024)
	AEF - Plastic	2.38300 tCO2/t	ADEME (2024a)
	AEF - Textiles	14.50000 tCO2/t	Climate Services (2024)
	AEF - Machinery (various)	5.50000 tCO2/t	ADEME (2024a)
	AEF - Passive electronic components	64.31900 tCO2/t	ecoinvent (2024)
	AEF - Copper	2.20000 tCO2/t	Federal Commission on Building and Construction KBOB (2024)
	AEF - Stainless steel	5.09820 tCO2/t	ecoinvent (2024)
	AEF - Metal	2.79000 tCO2/t	Federal Commission on Building and Construction KBOB (2024)
	AEF - PET	5.85000 tCO2/t	Climate Services (2024)
	AEF - Cement	0.74496 tCO2/t	Climate Services (2024)
	AEF - Pebble dust	0.06507 tCO2/t	ecoinvent (2024)
	AEF - Recycled asphalt stone	0.11620 tCO2/t	ecoinvent (2024)
	AEF - Concrete granulate (recycled gravel)	0.00133 tCO2/t	Federal Commission on Building and Construction KBOB (2024)
	AEF - Crushed gravel	0.00508 tCO2/t	Federal Commission on Building and Construction KBOB (2024)
	AEF - Hot bituminous mass	0.91100 tCO2/t	Climate Services (2024)
	AEF - Alkaline battery	3.80000 tCO2/t	Climate Services (2024)
	AEF - Reinforcing steel	1.52000 tCO2/t	Federal Commission on Building and Construction KBOB (2024)
	AEF - Bituminous sheeting	3.34000 tCO2/t	Climate Services (2024)
	AEF - Expanded polystyrene EPS (thermal insulatio	4.51000 tCO2/t	Federal Commission on Building and Construction KBOB (2024)

	AEF - Extruded polystyrene XPS (thermal insulatior	11.30000	tCO2/t	Federal Commission on Building and Construction KBOB (2024)
	AEF - Granite	0.47970	tCO2/t	Federal Commission on Building and Construction KBOB (2024)
	AEF - Internal electrical cable	0.00007	tCO2/m	Climate Services (2024)
	AEF - Lithium Li-ion battery	8.55170	tCO2/t	Climate Services (2024)
	AEF - Sand	0.00300	tCO2/t	Federal Commission on Building and Construction KBOB (2024)
	AEF - Non-alloy steel	1.92000	tCO2/t	ecoinvent (2024)
	AEF - Untreated gravel	0.01450	tCO2/t	ADEME (2024a)
	AEF - Cement based mortar	0.18816	tCO2/t	Federal Commission on Building and Construction KBOB (2024)
	AEF - Acetylene	2.53530	tCO2/t	ecoinvent (2024)
	AEF - Propane gas	1.11250	tCO2/t	ecoinvent (2024)
	AEF - Bottled natural gas	0.00020	t/kWh	Climate Services (2024)
	AEF - Chipboard	0.48500	tCO2/t	Climate Services (2024)
	AEF - Brass	5.97630	tCO2/t	ecoinvent (2024)
	AEF - Diesel	0.00026	t/kWh	Mobitool (2023)
Meals and drinks	AEF - Coffee beans	9.52000	tCO2/t	ADEME (2024b)
	AEF - Coffee	0.00091	tCO2/l	ADEME (2024b)
	AEF - Water, beverage	0.00027	tCO2/l	ADEME (2024b)
	AEF - Sweetened drinks	0.00051	tCO2/l	ADEME (2024b)
	AEF - Meal	0.00204	tCO2/p	ADEME (2024a)
	AEF - Tea	0.00020	tCO2/l	ADEME (2024b)
	AEF - Jus de fruit	0.00018	tCO2/p	ADEME (2024b)
	AEF - Barre chocolatée	0.00152	tCO2/kg	ADEME (2024b)
	AEF - Pain	0.00153	tCO2/l	ADEME (2024b)
Chemical products	AEF - Mineral oil	1.03870	tCO2/t	Climate Services (2024)
	AEF - Solvent	2.20000	tCO2/t	ecoinvent (2024)
	AEF - Acetonitrile	4.09530	tCO2/t	Climate Services (2024)
	AEF - Isopropyl alcohol	2.30450	tCO2/t	ecoinvent (2024)

	AEF - Cleaning agents	0.00249	tCO2/l	Climate Services (2024)
	AEF - Additives for concrete	4.00000	tCO2/t	Climate Services (2024)
	AEF - Agents to reduce hydraulic shrinkage	2.55000	tCO2/t	Climate Services (2024)
	AEF - Concrete plasticizer	1.86170	tCO2/t	ecoinvent (2024)
	AEF - Terra potassium pyrophosphate (concrete ac	2.16450	tCO2/t	Climate Services (2024)
	AEF - Bitumen doping agent	4.27220	tCO2/t	ecoinvent (2024)
	AEF - Cellulose fiber	0.27555	tCO2/t	ecoinvent (2024)
	AEF - Fiber (phonoabsorbent asphalt)	0.27555	tCO2/t	ecoinvent (2024)
	AEF - AdBlue	1.40390	tCO2/t	ecoinvent (2024)
	AEF - Flocculant	0.64800	tCO2/t	ADEME (2024a)
	AEF - Antifreeze	0.00077	tCO2/l	Climate Services (2024)
	AEF - Coolant	18.04800	tCO2/t	Climate Services (2024)
	AEF - Paint	5.48000	tCO2/t	ADEME (2024a)
	AEF - Windshield wiper fluid	0.00031	tCO2/l	Climate Services (2024)
	AEF - Cutting oil	0.20774	tCO2/t	Climate Services (2024)
	AEF - Release agent for concrete and bitumen	1.73850	tCO2/t	Climate Services (2024)
	AEF - Two-component adhesive	5.96000	tCO2/t	Climate Services (2024)
	AEF - Disinfectants for the food industry	0.99614	tCO2/t	ecoinvent (2024)
	AEF - Inorganic chemical products	1.86970	tCO2/t	ecoinvent (2024)
	AEF - Paint (water-based)	0.00136	tCO2/m2	Climate Services (2024)
	AEF - Paint (solvent-based)	0.00158	tCO2/m3	Climate Services (2024)
Infrastructure	AEF - Construction	0.08034	tCO2/m2	Climate Services (2024)
	AEF - Machinery	5.50000	tCO2/t	ADEME (2024a)
	AEF - Photovoltaic panels (production/20 years)	0.01250	tCO2/m2	ecoinvent (2024)
	AEF - Production of construction machinery	33.93400	tCO2/p	Climate Services (2024)
	AEF - Office chair	0.02800	tCO2/p	Climate Services (2024)
	AEF - New kitchen equipment	0.85000	tCO2/p	Climate Services (2024)
	AEF - Refrigerator	0.29467	tCO2/p	Climate Services (2024)
	AEF - Table	0.06010	tCO2/p	ADEME (2024a)
Disposal of products sold	AEF - Textiles, end of life (without recycling)	1.38000	tCO2/t	ADEME (2024a)

D. Detailed ACB calculation and results for company A

Table 15 Detailed ACB calculation of company A for each activity

Category	AEF	Total	Unit	CCF	Unit	f	fØ	Unit	ECF	Unit	U	ECB
Waste	AEF - Waste water	4504.0	m3	0.7	tCO2	0.00016	0.00016	tCO2/m3	0.7	tCO2	1.00	9.3
	AEF - Waste	1539.3	t	242.2	tCO2	0.15732	0.10548	tCO2/t	162.4	tCO2	1.49	2068.7
Office supplies	AEF - New screens	19.0	Einheit	5.0	tCO2	0.26500	0.26500	tCO2/p	5.0	tCO2	1.00	64.2
	AEF - New computer mice	19.0	Einheit	0.1	tCO2	0.00351	0.00351	tCO2/p	0.1	tCO2	1.00	0.8
	AEF - New computer keyboards	5.0	Einheit	0.0	tCO2	0.00993	0.00993	tCO2/p	0.0	tCO2	1.00	0.6
	AEF - New digital tablets	1.0	Einheit	0.1	tCO2	0.07780	0.07780	tCO2/p	0.1	tCO2	1.00	1.0
	AEF - New docking station	2.0	Einheit	0.1	tCO2	0.03803	0.03803	tCO2/p	0.1	tCO2	1.00	1.0
	AEF - New printers	9.0	Einheit	1.8	tCO2	0.19700	0.19700	tCO2/p	1.8	tCO2	1.00	22.6
	AEF - New televisions	20.0	Einheit	8.4	tCO2	0.42200	0.42200	tCO2/p	8.4	tCO2	1.00	107.5
	AEF - New cables	25.0	m	0.0	tCO2	0.00038	0.00038	tCO2/m	0.0	tCO2	1.00	0.1
	AEF - New headphones	1.0	Einheit	0.0	tCO2	0.00577	0.00577	tCO2/p	0.0	tCO2	1.00	0.1
	AEF - New laptops	19.0	Einheit	3.2	tCO2	0.16900	0.16900	tCO2/p	3.2	tCO2	1.00	40.9
	AEF - New desktop	7.0	Einheit	1.3	tCO2	0.18900	0.18900	tCO2/p	1.3	tCO2	1.00	16.9
	AEF - New smartphones	16.0	Einheit	0.6	tCO2	0.03800	0.03800	tCO2/p	0.6	tCO2	1.00	7.7
	AEF - Toner cartridges for printers	72.0	Einheit	0.3	tCO2	0.00364	0.00364	tCO2/p	0.3	tCO2	1.00	3.3
	AEF - Cardboard	40.0	kg	0.0	tCO2	0.00067	0.00064	tCO2/kg	0.0	tCO2	1.04	0.3
	AEF - Paper	3890.0	kg	2.5	tCO2	0.00065	0.00071	tCO2/kg	2.7	tCO2	0.92	34.9
	AEF - Envelope	1000.0	kg	1.1	tCO2	0.00105	0.00120	tCO2/kg	1.2	tCO2	0.88	15.3
	AEF - National letter	415.0	Einheit	0.0	tCO2	0.00000	0.00000	tCO2/p	0.0	tCO2	1.00	0.0
	AEF - National postal service	120.0	Einheit	0.1	tCO2	0.00100	0.00100	tCO2/p	0.1	tCO2	1.00	1.5
	AEF - National parcel	335.0	Einheit	0.0	tCO2	0.00002	0.00002	tCO2/p	0.0	tCO2	1.00	0.1
Chemical products	AEF - AdBlue	25.2	t	35.4	tCO2	1.40390	1.40390	tCO2/t	35.4	tCO2	1.00	451.5
	AEF - Concrete plasticizer	211.0	t	392.8	tCO2	1.86170	1.86170	tCO2/t	392.8	tCO2	1.00	5005.0
	AEF - Bitumen doping agent	2500.0	t	10680.5	tCO2	4.27220	4.27220	tCO2/t	10680.5	tCO2	1.00	136081.8
	AEF - Disinfectant for the food sector	0.0	t	0.0	tCO2	0.99614	0.99614	tCO2/t	0.0	tCO2	1.00	0.5
	AEF - Fiber (phonoabsorbent asphalt)	20.0	t	5.5	tCO2	0.27555	0.27555	tCO2/t	5.5	tCO2	1.00	70.2
	AEF - Flocculant	2.0	t	1.3	tCO2	0.64800	0.64800	tCO2/t	1.3	tCO2	1.00	16.5
	AEF - Antifreeze	400.0	l	0.3	tCO2	0.00077	0.00077	tCO2/l	0.3	tCO2	1.00	3.9
	AEF - Coolant	0.4	t	7.2	tCO2	18.04800	18.04800	tCO2/t	7.2	tCO2	1.00	92.0
	AEF - Paint	0.2	t	1.1	tCO2	5.48000	5.48000	tCO2/t	1.1	tCO2	1.00	14.0
	AEF - Solvent	0.4	t	0.9	tCO2	2.20000	2.20000	tCO2/t	0.9	tCO2	1.00	11.2
	AEF - Mineral oil	2.5	t	2.6	tCO2	1.03870	1.03870	tCO2/t	2.6	tCO2	1.00	33.1
	AEF - Cleaning agent	200.0	l	0.5	tCO2	0.00249	0.00249	tCO2/l	0.5	tCO2	1.00	6.3
	AEF - Windshield wiper fluid	200.0	l	0.1	tCO2	0.00031	0.00031	tCO2/l	0.1	tCO2	1.00	0.8
	AEF - Cutting oil	0.0	t	0.0	tCO2	0.20774	0.20774	tCO2/t	0.0	tCO2	1.00	0.0
	AEF - Release agent for concrete and bitumen	8.0	t	13.9	tCO2	1.73850	1.73850	tCO2/t	13.9	tCO2	1.00	177.2
	AEF - Cellulose fiber	5.0	t	1.4	tCO2	0.27555	0.27555	tCO2/t	1.4	tCO2	1.00	17.6
	AEF - Additives for concrete	750.0	t	3000.0	tCO2	4.00000	4.00000	tCO2/t	3000.0	tCO2	1.00	38223.4
	AEF - Two-component adhesive	0.1	t	0.7	tCO2	5.96000	5.96000	tCO2/t	0.7	tCO2	1.00	9.1
Business travel	AEF - Business travel <500km	582837.6	pkm	131.4	tCO2	0.00023	0.00015	tCO2/pkm	87.9	tCO2	1.49	1120.1
	AEF - Production of fossil fuels	272.8	tCO2	272.8	tCO2	1.00000	1.00000	tCO2/tCO2	272.8	tCO2	1.00	3475.2
Commuting	AEF - Commuting	27560.0	pkm	0.3	tCO2	0.00001	0.00015	tCO2/km	4.2	tCO2	0.08	53.0
Electricity	AEF - Electricity	1956468.0	kWh	24.8	tCO2	0.00001	0.00011	tCO2/kWh	219.1	tCO2	0.11	2791.9
Transport	AEF - Transportation <150km	11472984.0	t.km	1017.8	tCO2	0.00009	0.00020	tCO2/t.km	2277.4	tCO2	0.45	29017.2
Consumables	AEF - Alkaline battery	0.0	t	0.1	tCO2	3.80000	3.80000	tCO2/t	0.1	tCO2	1.00	0.6
	AEF - Reinforcing steel	2679.2	t	4072.4	tCO2	1.52000	1.52000	tCO2/t	4072.4	tCO2	1.00	51887.2
	AEF - Concrete granulate (recycled gravel)	5.0	t	0.0	tCO2	0.00133	0.00133	tCO2/t	0.0	tCO2	1.00	0.1
	AEF - Bituminous sheeting	0.2	t	0.8	tCO2	3.34000	3.34000	tCO2/t	0.8	tCO2	1.00	10.2
	AEF - Expanded polystyrene EPS (thermal insulat	0.3	t	1.6	tCO2	4.51000	4.51000	tCO2/t	1.6	tCO2	1.00	19.9
	AEF - Extruded polystyrene XPS (thermal insulati	4.0	t	44.9	tCO2	11.30000	11.30000	tCO2/t	44.9	tCO3	1.00	572.2
	AEF - Crushed gravel	79632.0	t	404.5	tCO2	0.00508	0.00508	tCO2/t	404.5	tCO4	1.00	5154.2
	AEF - Granite	600.0	t	287.8	tCO2	0.47970	0.47970	tCO2/t	287.8	tCO5	1.00	3667.2
	AEF - Hot bituminous mass	2329.9	t	2122.5	tCO2	0.91100	0.91100	tCO2/t	2122.5	tCO6	1.00	27043.6
	AEF - Internal electrical cable	7800.0	m	0.6	tCO2	0.00007	0.00007	tCO2/m	0.6	tCO7	1.00	7.4
	AEF - Lithium Li-ion battery	0.1	t	0.5	tCO2	8.55170	8.55170	tCO2/t	0.5	tCO8	1.00	6.9
	AEF - Recycled asphalt rock	8500.0	t	987.7	tCO2	0.11620	0.11620	tCO2/t	987.7	tCO9	1.00	12584.4
	AEF - Sand	56000.0	t	168.0	tCO2	0.00300	0.00300	tCO2/t	168.0	tCO10	1.00	2140.5
	AEF - Non-alloy steel	30.0	t	57.6	tCO2	1.92000	1.92000	tCO2/t	57.6	tCO11	1.00	733.9
	AEF - Untreated gravel	96332.0	t	1396.8	tCO2	0.01450	0.01450	tCO2/t	1396.8	tCO12	1.00	17797.0
	AEF - Cement	17675.0	t	13167.2	tCO2	0.74496	0.74496	tCO2/t	13167.2	tCO13	1.00	167764.8
	AEF - Cement based mortar	775.0	t	145.8	tCO2	0.18816	0.18816	tCO2/t	145.8	tCO14	1.00	1858.0
	AEF - Acetylene	2.1	t	5.2	tCO2	2.53530	2.53530	tCO2/t	5.2	tCO15	1.00	66.2
	AEF - Propane gas	3.7	t	4.1	tCO2	1.11250	1.11250	tCO2/t	4.1	tCO16	1.00	52.6
	AEF - Oxygen	0.4	t	0.2	tCO2	0.47922	0.16264	tCO2/t	0.1	tCO17	2.95	0.9
Food and Drink	AEF - Coffee beans	0.5	t	4.8	tCO2	9.52000	9.52000	tCO2/t	4.8	tCO18	1.00	60.8
	AEF - Water, beverage	66440.0	l	24.9	tCO2	0.00038	0.00027	tCO2/l	17.9	tCO19	1.39	228.6
	AEF - Sweet drinks	2791.0	l	1.4	tCO2	0.00051	0.00051	tCO2/l	1.4	tCO20	0.99	18.2
	AEF - Tea	415.0	l	0.1	tCO2	0.00020	0.00020	tCO2/l	0.1	tCO21	1.00	1.1
	AEF - Meal	7569.0	Einheit	27.2	tCO2	0.00359	0.00204	tCO2/p	15.4	tCO22	1.76	196.7
Heat production	AEF - Heat production	13000.0	m2	91.4	tCO2	0.00703	0.01756	tCO2/m2	228.3	tCO23	0.40	2908.6
	AEF - Process heat	3864690.0	kWh	1024.1	tCO2	0.00027	0.00019	tCO2/kWh	747.2	tCO24	1.37	9519.8
Water	AEF - Purified water	3000.0	m3	2.2	tCO2	0.00075	0.00075	tCO2/m3	2.2	tCO25	1.00	28.6
	AEF - spring water	9369.0	m3	4.0	tCO2	0.00043	0.00043	tCO2/m3	4.0	tCO26	1.00	51.3
Total				39907.6	tCO2				41083.4	tCO2	0.97	523449.9