

# Documentation Carbon Calculator & Priority Evaluator

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Version 1.1

GitHub: <https://github.com/DeSciL/SmpPriorityEvaluator>

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The carbon calculator has been developed by the Swiss Mobility Panel team (ETH Zurich) and implemented in wave 3 of the Swiss Mobility Panel:

<https://istp.ethz.ch/research/swiss-mobility-panel.html>

Report with descriptive Results of wave 3 of the Swiss Mobility Panel:

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Data & Codebook of wave 3 of the Swiss Mobility Panel:

*tbd*

## 1. Summary

This documentation describes the implementation of an online, survey-based carbon calculator and an online, survey-based priority evaluator, using the software Qualtrics. The carbon calculator and priority evaluator have been developed by the Swiss Mobility Panel project team at ETH Zurich.<sup>1</sup> This documentation complements the publicly available code of the online tool. The documentation aims to show how the software can be implemented (chapter 1), spells out the underlying logic of the code as well as the sources used for the development of the software (chapter 2 and chapter 3).

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<sup>1</sup> The priority evaluator is based on the idea and software developed by Boris Jäggi and Christoph Dobler, see: Jäggi, Boris. "Decision Modelling on Household Level for Energy, Fleet Choice and Expenditure." ETH Zürich; Zürich, 2015. <https://doi.org/10.3929/ethz-a-010594497>

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## 1. Qualtrics implementation

### Files of the priority evaluator

#### **evaluator.js**

Main script of the evaluator. The same code was used for the carbon calculator and the priority evaluator.

#### **evaluator-settings.js**

Interface file which transforms the output-data from the Qualtrics survey into the input data of evaluator.js.

#### **evaluator.css**

Styling file of the PE.

#### **qualtrics.html**

The html code of the PE.

### Additional files

#### **README.md**

The README.md file provides the link to this document.

#### **test-PE.html**

Run this file to run the PE in its current form on the repository. Not used for Qualtrics implementation.

#### **qualtrics.min.html**

The html code of the PE in a reduced form to make it fit the Qualtrics requirements of maximum number of signs per question.

#### **qualtrics.js**

The code to be placed in the Qualtrics JavaScript field of the question.

### Implementation in Qualtrics

Steps to include the PE into Qualtrics:

- Add all questions for the Carbon Calculator. If you want to display the result of the Carbon Calculator to the respondent, create a 'Text/Graphic' question and use PART 1 of **qualtrics.js** in the JS field of the question to compute and display the result. Don't forget to adapt the QIDs.
- Add the imports of the evaluator files to the same Qualtrics question (see last lines of **qualtrics.html**). You need to host these files somewhere yourself.
- Now, to implement the PE: Create two new questions of type 'Text/Graphic' and 'Text entry' respectively. The second question will be invisible and just used for the

displayed prompt if the target is not yet met and the respondent wants to continue. The first question has no validation, the second question requests response (or forces response if you prefer) – adapt the request message accordingly.

- Copy **qualtrics.html** (or **qualtrics.min.html**) to the text field of the first question.
- Import **evaluator.css** for the entire survey.
- Copy Part 2 of **qualtrics.js** to the JavaScript field of the first question. Adapt the QID of the question to hide.
- You also must make sure to import Chart.js and jQuery.js somewhere. We use old versions of these packages – using newer ones might need changes in the code. Also, note that the jQuery command '\$' does not work on Qualtrics, you must use 'jQuery' instead.

## 2. Carbon calculator

### 2.1 Summary

The online, survey-based carbon calculator has the goal to approximately calculate an individuals' yearly carbon footprint (CO<sub>2</sub> equivalent greenhouse gas emissions) based on a list of survey items. The goal is to achieve a high level of accuracy with the least number of survey items in order to keep response burden to a minimum. The carbon calculator follows a consumption-based accounting method. This means that the calculated carbon footprints should represent all emissions regardless of whether they occur in the country of residence (i.e. Switzerland), or elsewhere (e.g. production of goods such as cars outside of Switzerland, emissions generated through international flights, etc.). We calculate per capita emissions for food and transport, while we calculate emissions for heating on the household level. The following subchapters describe how the survey items look like (2.2), how the answers to the survey items are translated into CO<sub>2</sub> equivalent greenhouse gas emissions (2.3), and what sources were used in order to assign carbon emissions (2.4).

## 2.2 Survey instrument

*A1\_text: In the first section, we will ask you questions about different behaviours and living conditions that use fossil fuels.*

*Fossil fuels are energy sources such as natural gas, coal, diesel and petrol (gasoline). Using fossil fuels emits carbon dioxide (CO<sub>2</sub>), which is identified as a main cause of climate change.*

*Your answers to the following questions will be used to estimate how much CO<sub>2</sub> emissions you produce per year.*

### **A1 Do you have access to a car?**

- ☐ [1] Yes
- ☐ [0] No

*If answer to A1 is [1] “Yes, I do have access to a car”:*

### **A2 Which of the following best describes the type of access to the car that you use the most?**

- ☐ [1] I own a car.
- ☐ [2] I have a company car.
- ☐ [3] Someone in my household owns a car that I can use when necessary.
- ☐ [4] Someone outside my household owns a car that I can use when necessary.
- ☐ [5] I am a member of a car-sharing organization (e.g. Mobility).
- ☐ [6] I rent a car several times a year.

*If answer to A1 is [1] “Yes, I do have access to a car”:*

### **A3 Which of the following best describes the type of car that you use the most?**

- ☐ [1] Petrol (gasoline) engine
- ☐ [2] Diesel engine
- ☐ [3] Electric motor (solely electric battery powered)
- ☐ [4] (Plug-In) Hybrid: Combination of electric motor and petrol (gasoline) or diesel engine

*If answer to A1 is [1] “Yes, I do have access to a car”:*

### **A4 What size classification best fits the car that you use the most?**

- ☐ [1] Compact: hatchback (e.g. VW Polo, Skoda Fabia, Renault Zoe)
- ☐ [2] Intermediate: Sedan, combi (e.g. Skoda Octavia, Mercedes-Benz A-Klasse, VW Golf)
- ☐ [3] Large: SUV, Van, Truck, Sports car (e.g. VW Tiguan, Seat Ateca, Porsche 911)

*If answer to A2 is [1] “I own a car”*

**A5 What is the current value of your car in CHF? The current value is the amount you would expect to receive if you were to sell your car today. Please estimate as best as you can.**

[1]; [1000]; [2000]; ... [78000]; [79000]; [80000+]

*If answer to A1 is [1] “Yes, I do have access to a car”:*

**A6 How many kilometres do you normally travel in total per year with the car you use most? Please estimate as best as you can.**

*[1]; [1000]; [2000]; ... [28000]; [29000]; [30000]*

**A7 In a typical week, outside the holiday season, how often do you normally use public transportation (i.e., train, bus, tram)?**

- ☐ *[0]* Never
- ☐ *[1]* 1 day per week
- ☐ *[2]* 2 days per week
- ☐ *[3]* 3 days per week
- ☐ *[4]* 4 days per week
- ☐ *[5]* 5 days per week
- ☐ *[6]* 6 days per week
- ☐ *[7]* 7 days per week

*If answer to A7 is [1] "1 day per week"*

*OR If answer to A7 is [2] "2 days per week"*

*OR If answer to A7 is [3] "3 days per week"*

*OR If answer to A7 is [4] "4 days per week"*

*OR If answer to A7 is [5] "5 days per week"*

*OR If answer to A7 is [6] "6 days per week"*

*OR If answer to A7 is [7] "7 days per week"*

**A8 In a typical week, outside the holiday season, how many kilometres do you normally ride on public transportation (i.e., train, bus, tram)? Please estimate as best as you can.**

\_\_\_\_\_ **km per week**

**A9\_X Do you currently hold any annual public transit passes/travel cards? Please select all of the following answers that apply (multiple responses are possible).**

**A9\_1**

- ☐ *[0]* Not selected.
- ☐ *[1]* General-Abonnement (GA Travelcard)

**A9\_2**

- ☐ *[0]* Not selected.
- ☐ *[1]* Halbtax Abonnement (Half Fare Travelcard)

**A9\_3**

- ☐ *[0]* Not selected.
- ☐ *[1]* Regional Transportation Pass (e.g. ZVV, Ostwind, etc.)

**A9\_4**

- ☐ *[0]* Not selected.
- ☐ *[1]* Seven25 (previously Gleis 7)



A9\_5

- [0] Not selected.
- [1] Point-to-point travelcard (not a stamp card)

A9\_7

- [0] Not selected.
- [1] No, I do not have any travel passes/cards

**A10 In this year, 2022, have you or do you expect to travel by airplane for private or business trips? Count outward and return flights to your destination as one flight.**

- [0] I have not flown and do not plan to fly in 2022.
- [1] I have flown or plan to fly in 2022.

*If answer to A10 is [1] "I have flown or plan to fly in 2022."*

A11\_text:



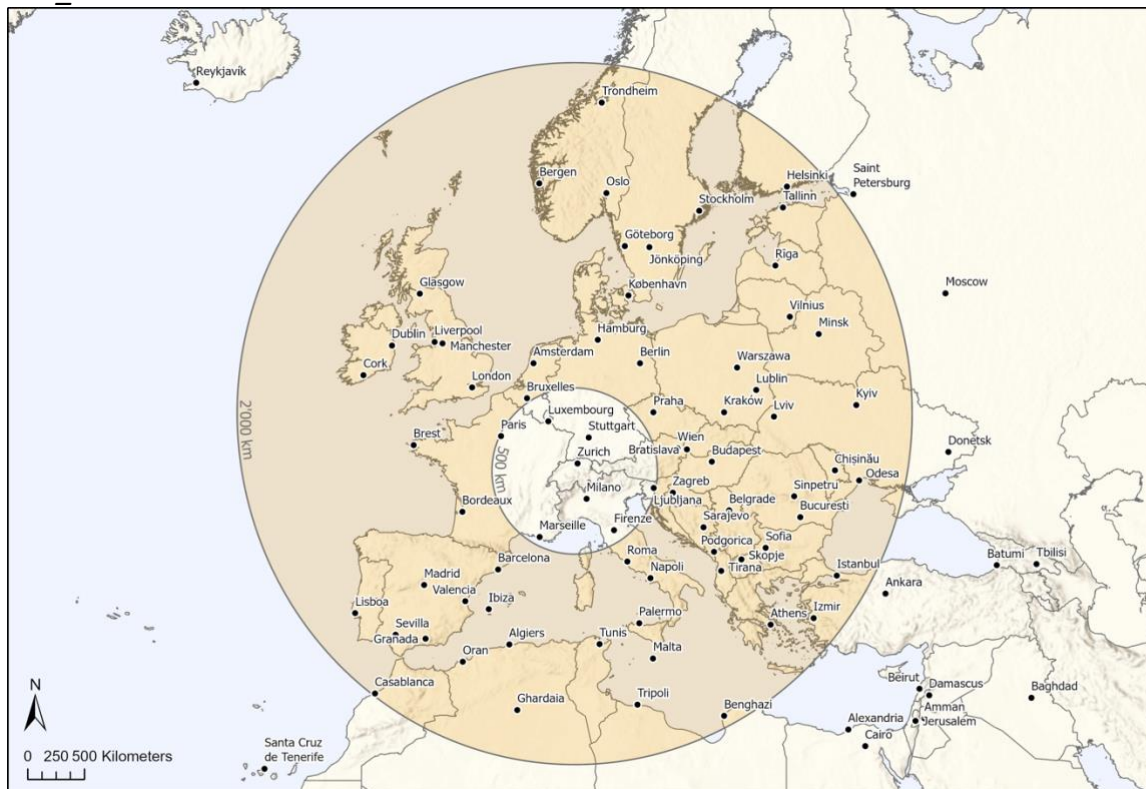
*If answer to A10 is [1] "I have flown or plan to fly in 2022."*

**A11 Short-haul flights are those where the destination is less than 500km away from your home (for example, Cologne, Paris, Brussels). In total, how many short-haul flights do you expect to take for either private or business travel in 2022? Please count outward and return flights to your destination as one flight.**

\_\_\_\_\_ short-haul flights

*If answer to A10 is [1] "I have flown or plan to fly in 2022."*

A12\_text:



*If answer to A10 is [1] "I have flown or plan to fly in 2022."*

**A12 Medium-haul flights are those where the destination is between 500km-2'000km away from your home (for example, Tel Aviv, London, Helsinki). In total, how many medium distance flights do you expect to take for either for private or business travel in 2022? Please count outward and return flights to your destination as one flight.**

\_\_\_\_\_ medium distance flights

*If answer to A10 is [1] "I have flown or plan to fly in 2022."*

A13\_text:



*If answer to A10 is [1] "I have flown or plan to fly in 2022."*

**A13 Long-haul flights are those where the destination is more than 2'000km away from your home (for example, New York, Hong Kong, Cape Town). How many long-distance flights do you expect to travel by airplane for private or business trips in total in 2022? Please count outward and return flights to your destination as one flight.**

\_\_\_\_\_ long-distance flights

**A14 How often do you ride a bicycle?**

- ☐ [1] Daily
- ☐ [2] Several times a week
- ☐ [3] Several times a month
- ☐ [4] At least once a month
- ☐ [5] Rarely
- ☐ [6] Never

*If answer to A14 is [1] "Daily"*

*OR If answer to A14 is [2] "Several times a week"*

*OR If answer to A14 is [3] "Several times a month"*

*OR If answer to A14 is [4] "At least once a month"*

*OR If answer to A14 is [5] "Rarely"*

**A15 In a typical week, outside the holiday season, how many kilometres do you normally ride on a bicycle without electric assistance (e.g. city bike, racing bike, mountain bike)? Please estimate as best as you can.**

\_\_\_\_\_ *km per week*

*If answer to A14 is [1] "Daily"*

*OR If answer to A14 is [2] "Several times a week"*

*OR If answer to A14 is [3] "Several times a month"*

*OR If answer to A14 is [4] "At least once a month"*

*OR If answer to A14 is [5] "Rarely"*

**A16** In a typical week, outside the holiday season, how many kilometres do you normally ride on an electric-assisted bicycle (e-Bike)? *Please estimate as best as you can.*

\_\_\_\_\_ *km per week*

*If answer to A16 is > 0*

**A17** Which of the following best describes the electric bicycle that you use most?

- [1] E-Bike (up to 500W engine and electric assistance up to 25km/h)
- [2] S-Pedelec (up to 1000W engine and electric assistance up to 45 km/h)

*A17\_text: The next question asks you about your dietary preferences:*

**A18** Which of the following best describes your current dietary preferences?

- [1] Omnivore (e.g. meat, cheese, eggs, fruits, vegetables, nuts, grains)
- [2] Flexitarian (e.g. limited meat, cheese, eggs, fruits, vegetables, nuts, grains)
- [3] Vegetarian (e.g. cheese, eggs, fruits, vegetables, nuts, grains)
- [4] Vegan (e.g. fruits, vegetables, nuts, grains)

**A19** Do you, or somebody else in your household, own your primary residence?

- [1] Yes
- [0] No

**A20** Which of the following best describes your primary residence?

- [1] Flat / apartment
- [2] Detached house
- [3] Semi-detached house / terraced house

**A21** How would you describe the building standard of your primary residence? *It does not matter whether it is an apartment or a detached house:*

- [1] Built/refurbished before 1980 (old)
- [2] Built/refurbished between 1980 and 2010
- [3] Newly built/refurbished since 2010

**A22** Including yourself, how many people (of all ages) live in your household?

[1] 1 ... [10] 10+

**A23 What is the total indoor living area, in square meters (m<sup>2</sup>), of your primary residence?**  
The total indoor living area is all of the heated room area in your residence including storage rooms. Balconies, terraces, garages, cellar rooms and attics are not included in the total indoor living area.

\_\_\_\_\_ m<sup>2</sup>

**A24 What is the main source of heating for your primary residence?**

- ☐ [1] Heating oil
- ☐ [2] Electricity (i.e., electric radiator)
- ☐ [3] Wood or wood pellets
- ☐ [4] Natural gas
- ☐ [5] Heating pump
- ☐ [6] District heating
- ☐ [9] Don't know / Other

**A25 Do you have photovoltaic solar panels (PV) for electricity production installed on your house?**

- ☐ [1] Yes
- ☐ [0] No

**A26\_text: Carbon calculation**

*Based upon the behaviours and living conditions that you stated in the survey, we estimate that the approximate amount of CO2 that you emit per year is.*

*[CO2 tons/year]*

## 2.3 Carbon calculator

The function in 'evaluator.js' to call is 'getStartingTotal()'. It is already callable when the PE is not initialized yet. The calculations are done in 'calculateActualValues()', split into four parts of calculations for mobility, diet, housing, and certificate. All input and output values are stored in the object 'evaluatorSettings'. It is initialized with 'buildEvaluatorSettings()'.

Detailed overview of carbon calculation and respective sources: Sheets 'PE carbon calculator' and 'PE carbon calculator sources' of the Excel workbook named 'Priority\_evaluator\_documentation.xlsx'

### 3. Priority evaluator

The following subchapters explain the functioning of the priority evaluator (3.1), describe how it is initialized in the online survey (3.2), how the underlying calculations work (3.3), and how the survey respondents were instructed to use the priority evaluator (3.4).

#### 3.1 Summary

Using the answers to the first question block (Carbon Calculator, A1 – A25), each respondent's approximate annual CO<sub>2</sub> emissions were calculated. The respondents were then shown an adapted, interactive javascript tool as shown in the image below. On the left-hand side, three bars were shown:

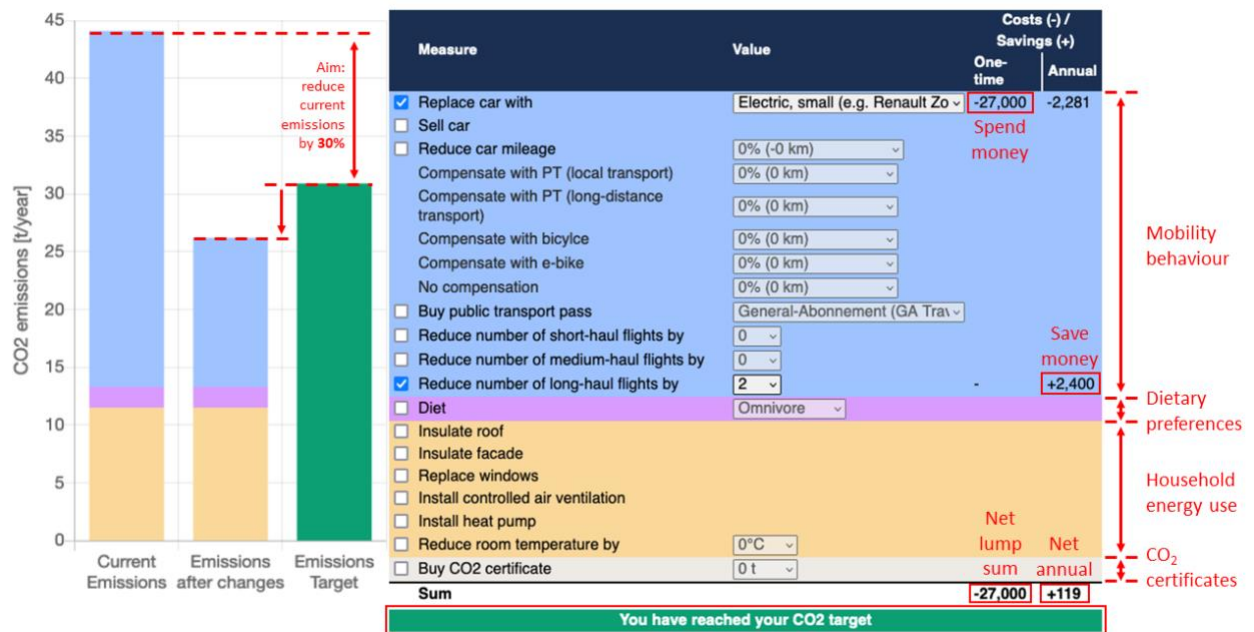
- The current emissions (fixed, computed in part “carbon calculator”)
- The interactive emissions (variable to the changes in the tool)
- The emission target (fixed to 30% of the current emissions)

On the right-hand side, a table with options to reduce the emissions is shown. These options are split into four categories:

- Blue: Mobility
- Purple: Diet
- Yellow: Housing
- Grey: Compensation

The image shows all options that were possible, but only those relevant to the respondent were displayed in the survey. For instance, someone not having access to a car did not get any option about cars. Furthermore, a cost calculation was done on the right-hand side of the table, considering both one-time and annual costs. Negative numbers represented costs; positive numbers represented savings. The respondents could check and uncheck any of the options, change the degree (e.g., the number of flights to reduce) and could observe the changes to their footprint in the second bar. If they wanted to continue the survey without having reached the target, they were shown a pop-up that asked whether they were sure to continue before having reached the target.







### 3.2 Priority evaluator calibration

The Priority Evaluator can be initialized using 'onload()' of the file 'evaluator.js'.

#### **Dynamic chart (left)**

The plot on the left-hand side contained three bars:

**Current emissions:** This bar is initialized to the result of the Carbon Calculator. It stays constant during the entire procedure.

**Emissions after changes:** This bar displays the emissions including the currently selected options in the Priority Evaluator (on the right hand side). In almost all cases, it is smaller than the current emissions.

**Emission target:** This bar shows the emission target as defined in the input parameters. It stays constant during the entire procedure.

#### **Behavioral adaptations (right)**

Detailed overview of priority evaluation calibration: Sheet 'PE calibration of the Excel workbook named 'Priority\_evaluator\_documentation.xlsx'

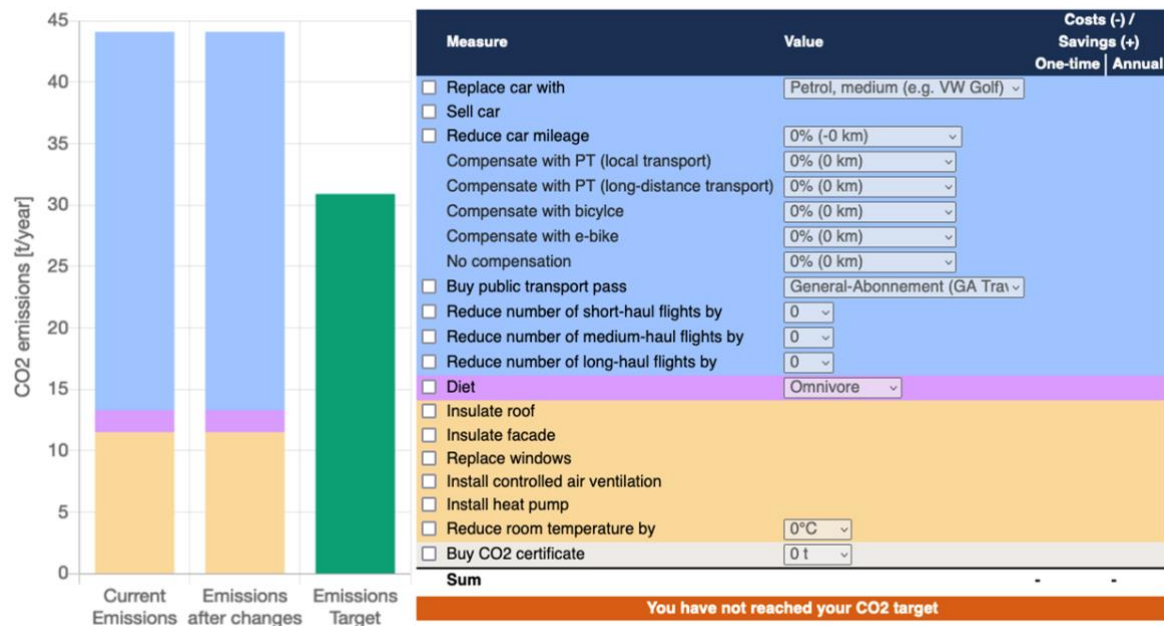
### 3.3 Priority evaluator adaptations calculation

Detailed overview of priority evaluation adaptations: Sheet 'PE adaptations calculation' and 'PE adaptation sources' of the Excel workbook named 'Priority\_evaluator\_documentation.xlsx'

### 3.4 Survey instrument (instructions to respondents)

On the following page we ask you to take part in an exercise on how individuals can reduce their CO<sub>2</sub> emissions.

In the exercise, you will be presented with a table that looks like this. In this table, you will be asked to choose which behaviours and living conditions you would like to change to meet your personalised CO<sub>2</sub> emission target.

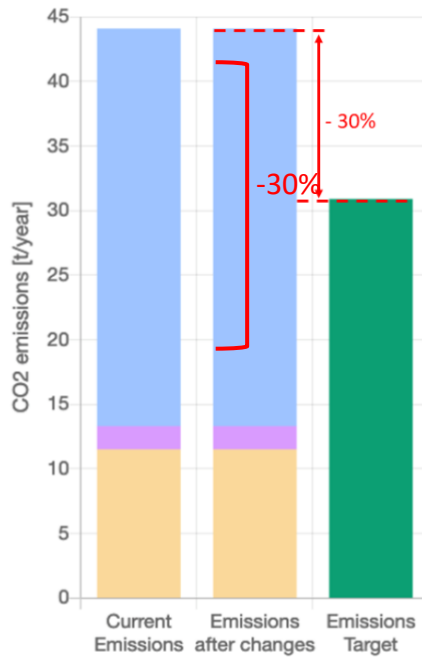


**[New page]**

Earlier in the survey, we estimated that your individual behaviours and living conditions lead to approximately XYt CO<sub>2</sub> emissions per year.

In order to limit climate change, people all across the world need to make changes that reduce their CO<sub>2</sub> emissions.

Based upon your individual behaviours and living conditions we have set a personalised CO<sub>2</sub> emission reduction target (i.e., a 30% reduction of your current emissions).



*[New page]*

You have the option to change:

- Your mobility related behaviour (i.e., kilometres driven, car type used, use of public transport and cycling, number of flights taken)
- Your dietary preferences (i.e., by becoming flexitarian, vegetarian, vegan)
- Your household energy use (i.e., through renovations, changing heat sources, installing solar panels, reducing room temperature)

*Example:*

Measure	Value	Costs (-) / Savings (+)	
		One-time	Annual
<input type="checkbox"/> Replace car with	Petrol, medium (e.g. VW Golf) ▾		
<input type="checkbox"/> Sell car			
<input type="checkbox"/> Reduce car mileage	0% (-0 km) ▾		
Compensate with PT (local transport)	0% (0 km) ▾		
Compensate with PT (long-distance transport)	0% (0 km) ▾		
Compensate with bicycle	0% (0 km) ▾		
Compensate with e-bike	0% (0 km) ▾		
No compensation	0% (0 km) ▾		
<input type="checkbox"/> Buy public transport pass	General-Abonnement (GA Tra) ▾		
<input type="checkbox"/> Reduce number of short-haul flights by	0 ▾		
<input type="checkbox"/> Reduce number of medium-haul flights by	0 ▾		
<input type="checkbox"/> Reduce number of long-haul flights by	0 ▾		
<input type="checkbox"/> Diet	Omnivore ▾		
<input type="checkbox"/> Insulate roof			
<input type="checkbox"/> Insulate facade			
<input type="checkbox"/> Replace windows			
<input type="checkbox"/> Install controlled air ventilation			
<input type="checkbox"/> Install heat pump			
<input type="checkbox"/> Reduce room temperature by	0°C ▾		
<input type="checkbox"/> Buy CO2 certificate	0 t ▾		
<b>Sum</b>		-	-

**You have not reached your CO2 target**

Mobility behaviour  
 Dietary preferences  
 Household energy use  
 CO<sub>2</sub> certificates

*[New page]*

Additionally, in order to meet your personalised CO2 emission target, you can also purchase CO2 offsets.

CO2 certificates offset your individual CO2 emissions by supporting projects that reduce CO2 emissions as well as initiatives that remove CO2 from the atmosphere.

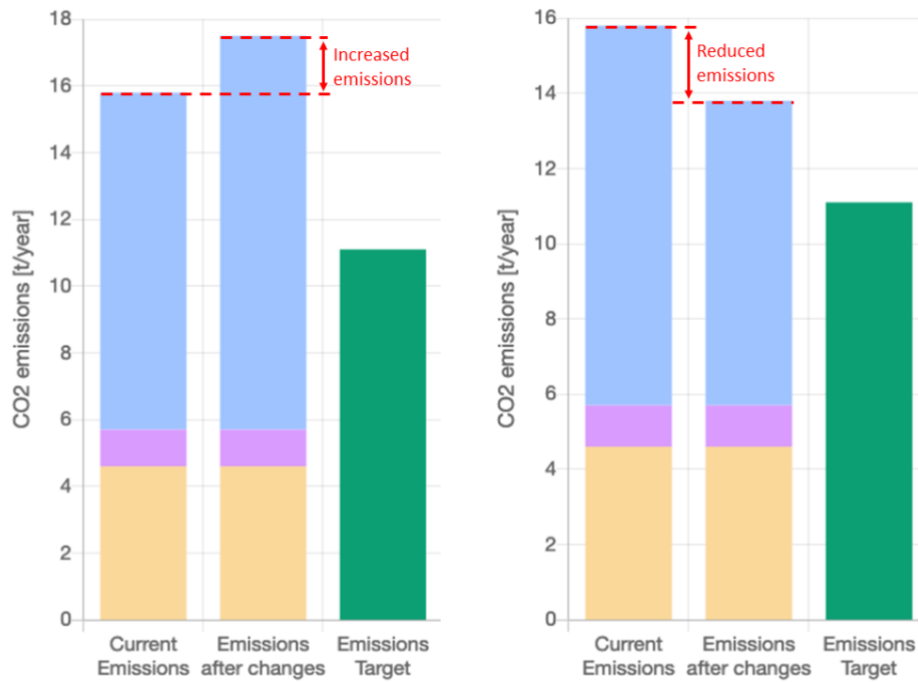
For example CO2 certificates support transitions from fossil fuels to renewable energy sources, give people new low-emission technologies and support natural solutions that remove CO2 from the atmosphere, such as planting trees and restoring forests.

CO2 certificates can be purchased by the tonne (e.g. 1t,2t,3t...) of CO2 emissions.

<input checked="" type="checkbox"/> Buy CO2 certificate	1 t ▾	-	-20
<b>Sum</b>		-	-20

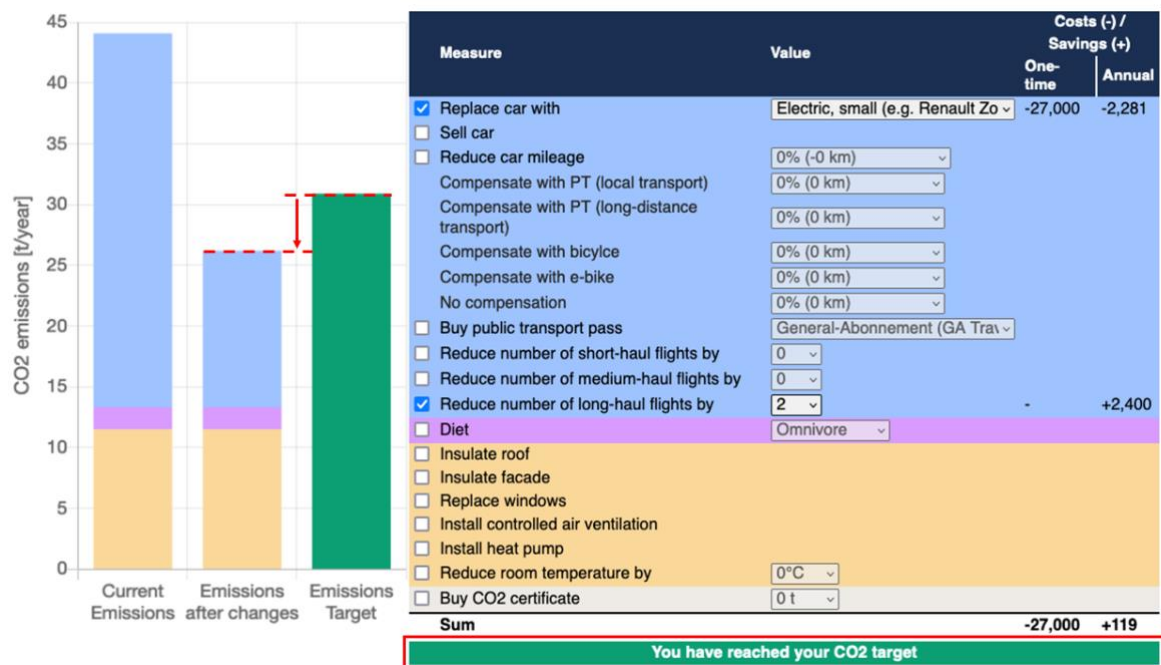
*[New page]*

When you select a change in your behaviour, living conditions or purchase a CO2 certificate, the “Emissions after changes” moves correspondingly up or down.



**[New page]**

When you have made changes to your behaviours, living conditions or have purchased CO2 certificates that reduce your CO2 emissions by at least 30%, the bar below the table will update and turn green to let you know you have met your CO2 reduction target.



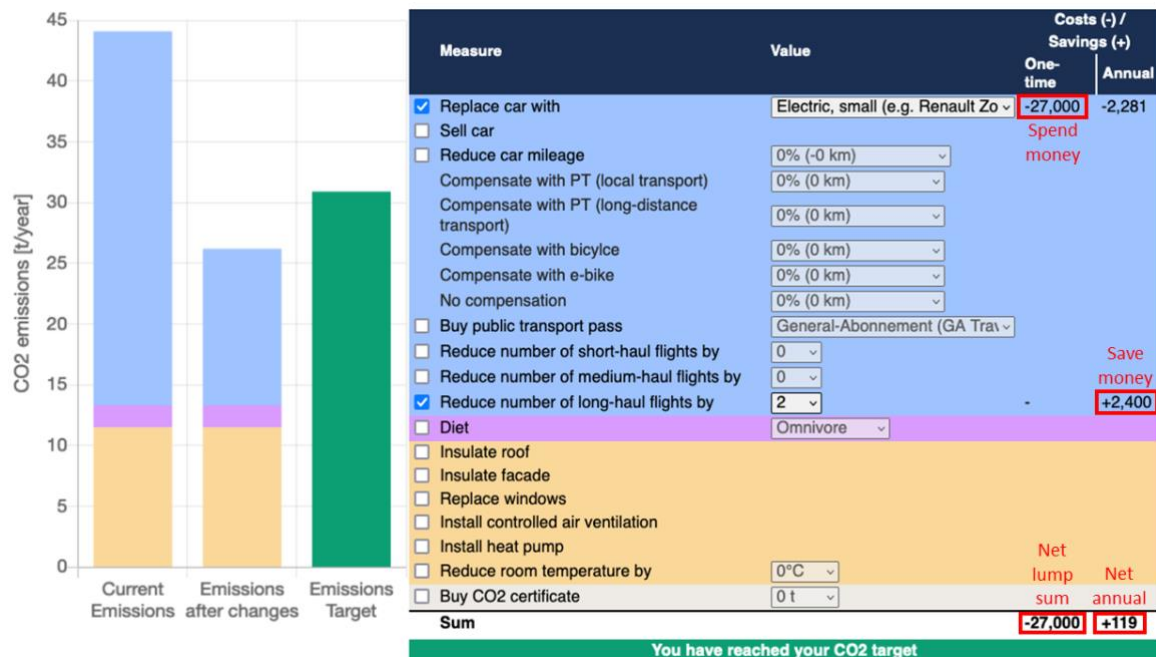
**[New page]**

For each change to your behaviour and living conditions, you will see the costs associated with making these changes.

Some changes to behaviours and living conditions will save you money, while some changes will cost you money.

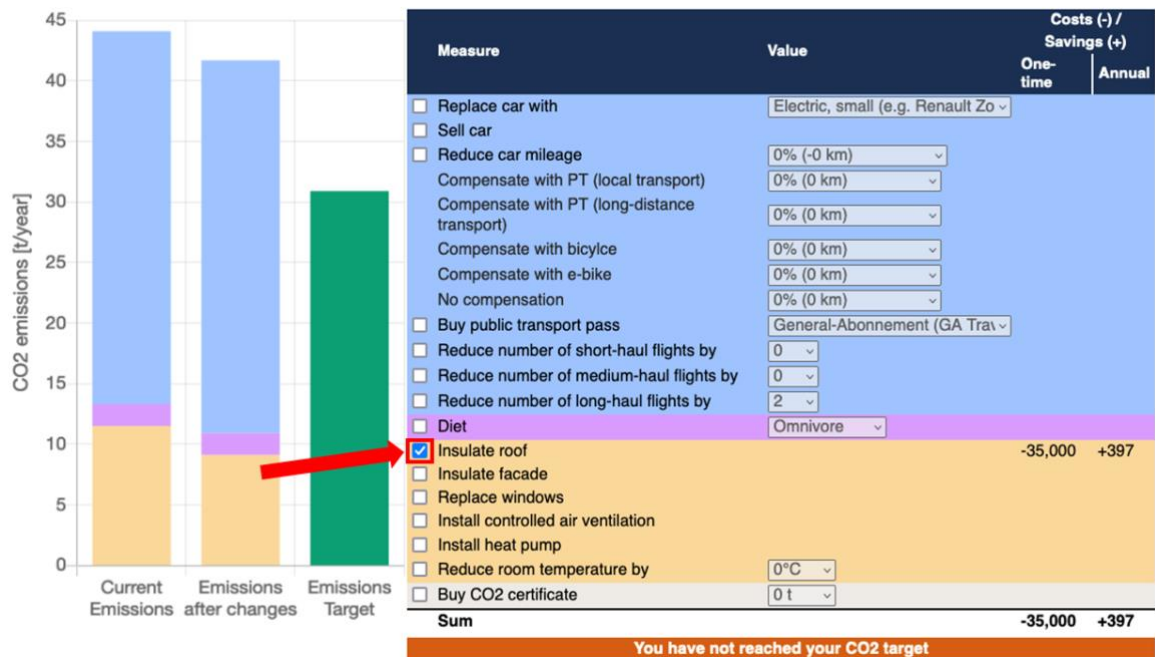
Positive values mean you save money (e.g.+500 CHF), while negative values mean you spend money (e.g. -500 CHF).

The savings and costs are presented in one-time lump sum and annual amounts.



[New page]

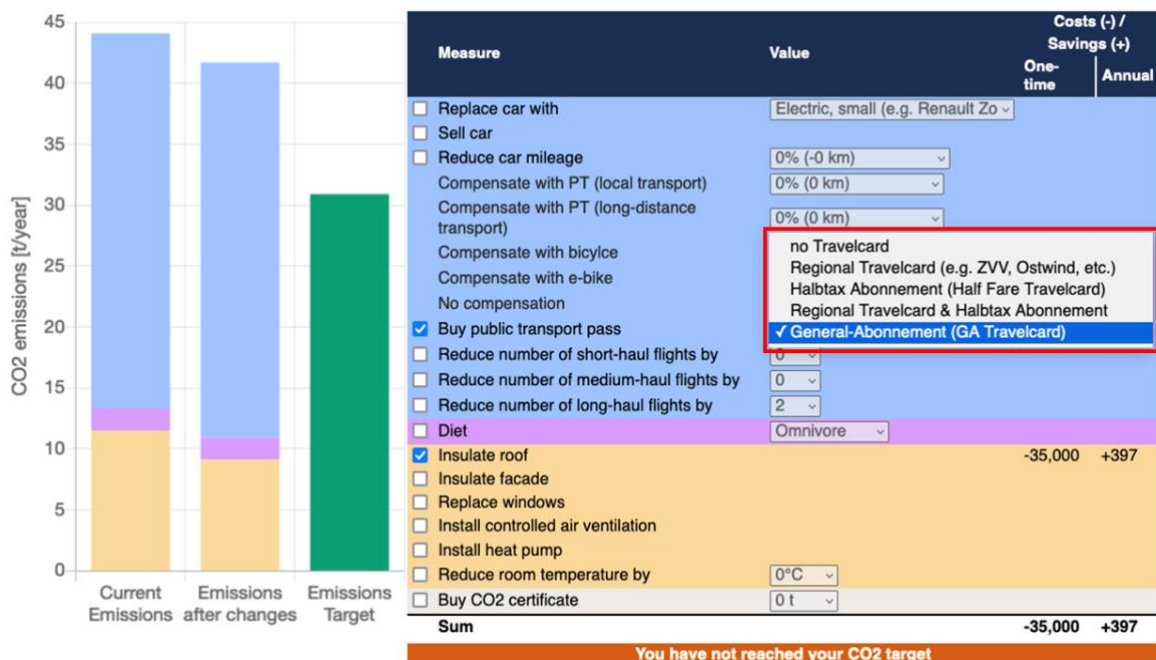
In order to change the calculated CO2 emissions, you need to first click the box on the left to select each desired change.



[New page]

For some changes, after you have clicked the box, you will select from different options in a dropdown menu.

Please make sure to unclick the box if you want to remove your changes!



[New page]

Please read all of the options carefully.

After you have made your preferred changes, you can complete the exercise by clicking on the 'Submit CO2 emissions target'-Button.

You are able to complete the exercise whether you have met your 30% CO2 reduction target or not.



[New page]

Priority evaluator is displayed

Follow-up-Question in case that target is not reached: You did not reach the target. Do you want to offset your remaining XXX tons of CO2 to meet your emissions reduction target by purchasing CO2 certificates for CHF XXX in total per year?



## 4. Coding errors

### Carbon calculator sources

- Heating efficiency of 'unknown': This has been coded as '1', however it should be 0.8 as we assume oil heating as default.

### Carbon calculator

- The emissions for e-bike and bike are underestimated by a factor of 10 due to a typo in the conversion from gCO<sub>2</sub> to tCO<sub>2</sub> (divided by 10'000'000 instead of 1'000'000)
- For calculating the emissions generated by housing, there is a mistake in the code/formula: the kg of CO<sub>2</sub> by heating type should be divided by 10 in order to harmonise its unit, which is kg/10kWh, whereas the specific heat energy demand of the building standard is given in **kWh** per square metre and year.
- The carbon calculator (evaluator.js) would allow for four levels of housing standard, however the survey only allows to differentiate three types (item A21 does not contain 'Minergie standard').
- Solar panels: The calculation of emissions generated by housing does not take into account, whether somebody already has photovoltaic solar panels (PV) for electricity production installed on their house (item A25).

### Priority evaluator

- Compensate car mileage reductions with bike - bike emissions: Here, there is a coding mistake which treats the compensated kilometer by bike not as annual but as weekly kilometers. This was partly counterbalanced by the typo regarding e-bike and bike in the carbon calculator. Therefore, this error overestimates the emissions produced by bike/ebike by factor 5.2.

## 5. Priority evaluator demo version

Two demo versions of the priority evaluator can be found using the following links, based on two stylized respondent profiles:

Demo 1 “Homeowner”

<https://github.com/DeSciL/SmpPriorityEvaluator/blob/main/PE-demo1.html>

Demo 2 “Student”

<https://github.com/DeSciL/SmpPriorityEvaluator/blob/main/PE-demo2.html>

<b>Survey input</b>			
		<i>Demo 1</i>	<i>Demo 2</i>
A1	Car access	Yes (1)	Yes (1)
A2	Car ownership	I own a car. (1)	Outside..(4)
A3	Car engine	Petrol (1)	Petrol (1)
A4	Car type	Intermediate (2)	Intermediate (2)
A5	Car value in CHF	30'000	30'000
A6	Km per year (car)	12'000	20
A7	Public transport use	Never (0)	5 days a week (5)
A8	Km per week (public transport)	0	300
A9	Public transport passes	Half fare (A9_2 =1)	GA (A9_1 = 1)
A10	Air travel in 2022	I have flown ... (1)	I have flown ... (1)
A11	Short return flights	0	0
A12	Middle return flights	0	1
A13	Long return flights	1	0
A14	Bicycle use	Several times a month (3)	Daily (1)
A15	Bicycle km / week	0	25
A16	E-bike km / week	40	0
A18	Diet	Omnivore (1)	Vegetarian (3)
A19	Home ownership	Yes (1)	No (0)
A20	Building type	Detached... (2)	Flat (1)
A21	Building standard	Built/ref. since 2010 (3)	Built/refurbished between 1980 and 2010. (2)
A22	Household size	4	4
A23	Home size in m2	180	140
A24	Heating type	Heating oil (1)	Heating oil (1)
A25	Solar PV	No (0)	No (0)
	Certificate baseline price	100 CHF	100 CHF

<b><i>Calculated emissions and reduction target</i></b>		
<i>Sectoral emissions</i>		
Mobility	9.9 t	3.3 t
Food	1.8 t	1.4 t
Housing	23.9 t	0.2 t
Annual emissions total	35.6 t	
Emissions reduction target	24.9 t	3.4 t