Documentation Carbon Calculator & Priority Evaluator

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Version 1.0
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.[1] 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).

[1] 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

Table of Contents

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_2 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 looks like (2.2), how the answers to the survey items are translated into CO_2 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 (CO2), which is identified as a main cause of climate change.

Your answers to the following questions will be used to estimate how much CO2 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:

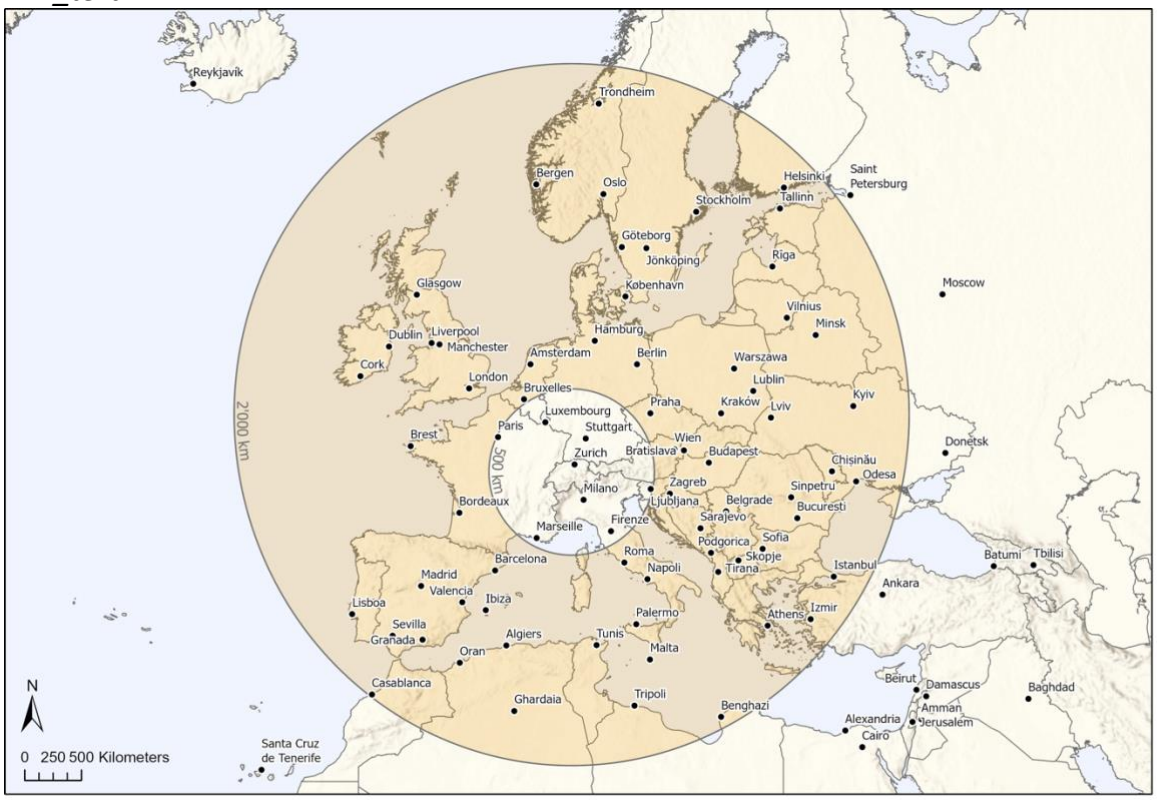
If answer to A10 is [1] "I have flown or plan to fly in 2022."

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:



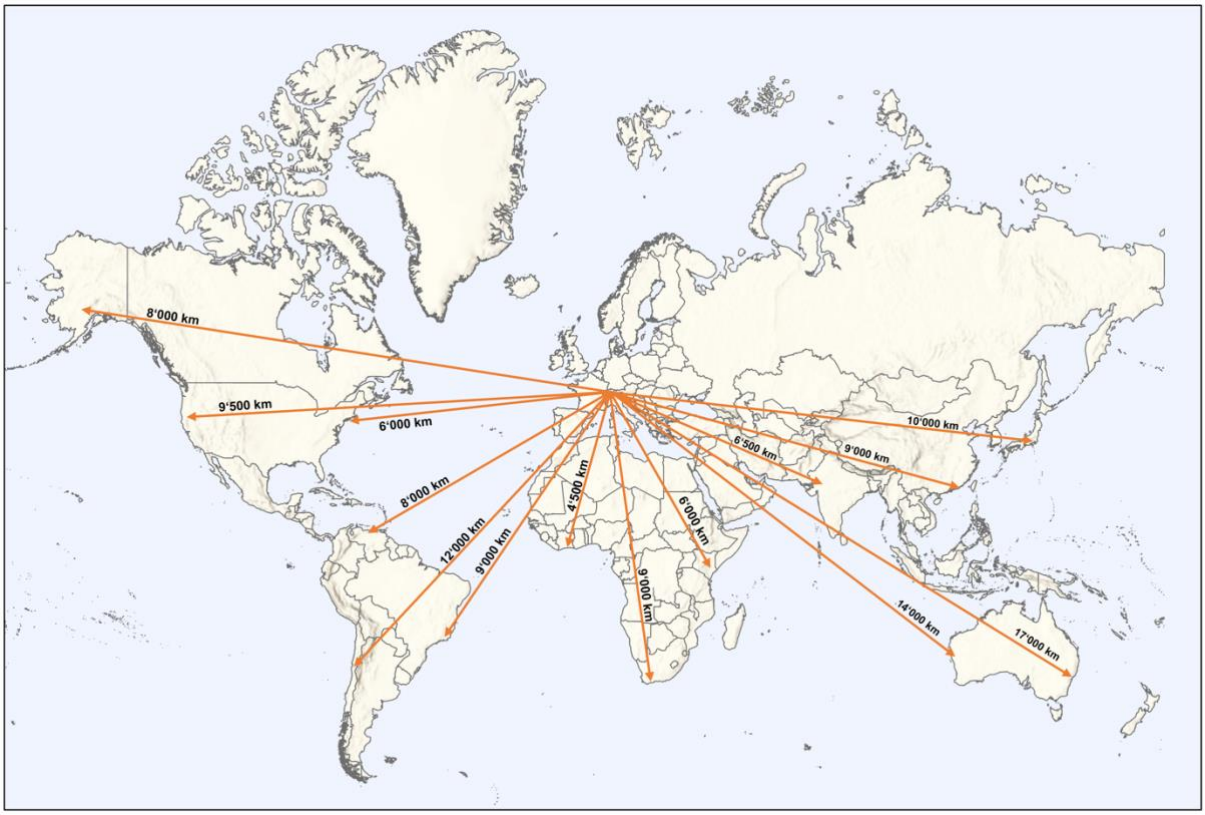
If answer to A10 is [1] "I have flown or plan to fly in 2022."

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^2), 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^2

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

3.1 Summary

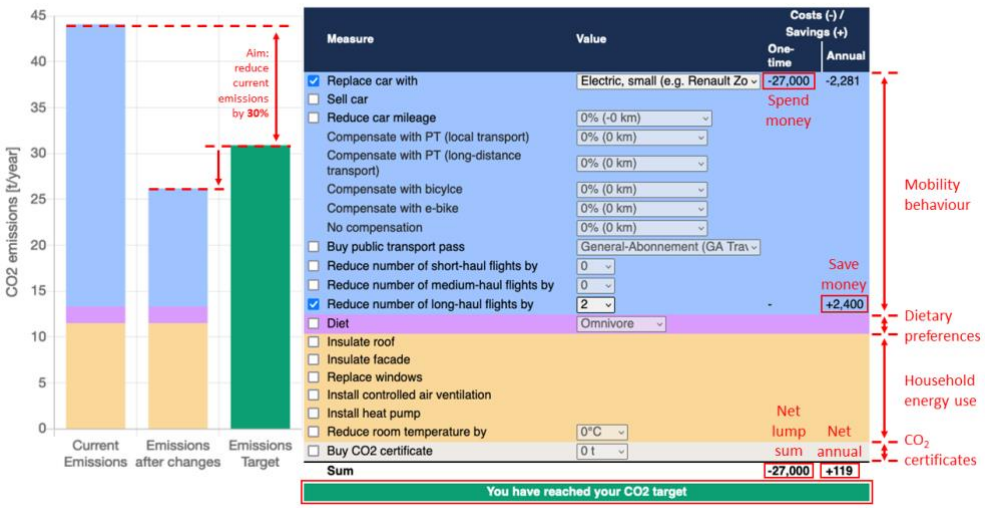
Using the answers to the first question block (Carbon Calculator, A1 – A25), each respondent's approximate annual CO2 emissions were calculated. The respondents were then shown an adapted, interactive javascript tool as shown in the image below. On the left-hand side, three bars were shown:

- 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'

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 gCO2 to tCO2 (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_2 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

Survey input			
		Demo 1	*Demo 2*
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

Calculated emissions and reduction target		
Sectoral emissions		
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