Kandidatnummer: 10, 4, 1, 3, 23, 26

Fighting emissions with information

How our carbon app can help offset and reduce transport carbon emissions.

Motivation: the importance of carbon emissions their measurement

According to the NOAA the concentration of atmospheric carbon dioxide has continually risen since the start of the industrial revolution. This development is also closely correlated with a continuous increase in the carbon emissions that we humans emit (climate.gov). The effect of our heightened carbon emissions is clear: average global temperatures have risen one whole degree when compared with preindustrial levels (IPCC FAQ). If we don't keep temperatures under the 1,5-degree goal set by the Paris Agreement, the consequences will range from rising sea levels and floods to extreme heat and extinction of wildlife (WWF). It is therefore clear that today's level of carbon emissions is problematic and that it is necessary to reduce them.

To combat the negative effects of heightened emissions and the resulting global warming it is essential to measure the amount climate gases we currently emit. We would argue that there are mainly three reasons for this. To begin with it is useful to know the actual extent of our current carbon emissions so that we know how much we need to reduce them. Knowing this also gives us a benchmark, upon which we can calculate how many resources we need to designate towards developing new policies and technologies to reduce our emissions by the necessary amount. Finally measuring our carbon emissions enables us to identify what the main sources of our emissions are. This way we can identify potential opportunities to reduce carbon emissions more effectively by targeting their main sources.

For the app that we have developed we chose to focus on carbon dioxide emissions from personal transport. We are focusing on carbon dioxide because this is the primary greenhouse gas emitted through human activities. Carbon dioxide makes up about 79% of our total emissions (EPA). We also chose to focus on carbon emissions from personal transport because this is one of the largest drivers of global carbon emissions. Particularly in the EU, domestic transport is on the rise as the single largest cause of greenhouse gas emissions (EEA). As long as new alternative modes of transport haven't been developed and subsequently adopted, the points listed above show that there is a need to measure transport carbon dioxide emissions.

Our methodology for calculating transport CO_2 emissions

To calculate carbon emissions based on our users' use of different modes of transport we used the following formula:

$$CO_2 emissions\ per\ km = \frac{\frac{F \cdot C}{V} + \frac{L}{T}}{P} \cdot x$$

- F is the fuel consumption expressed in Quantity of Energy per km (Qe/km). Qe being the quantity of energy expressed in volume (e.g. litre), mass (e.g. kg) or energy unit (e.g. kwh)
- C is the mass of CO2 (kg) per Quantity of Energy (kg/Qe), Qe being expressed in the same unit as for F
- V is the vehicle efficiency factor
- L is the lifecycle carbon emission of the vehicle
- T is the average kilometer amount the vehicle has traveled
- P is the average amount of people present in the vehicle
- x is the kilometer amount

The only variable in the formula is kilometers traveled with the given mode of transportation x. This means that the user only has to input this one value to get a result. The other values are constants which are calculated individually for each mode of transport.

For our application for the formula the vehicle efficiency factor V will always be equal to one. This is because the vehicle efficiency factor is a number that describes one individual vehicle's efficiency, when compared to a reference vehicle's efficiency as a baseline. This only makes sense to incorporate in the formula when calculating the carbon emissions of a single vehicle and is irrelevant when using average numbers for all vehicles. If you choose a vehicle with perfectly average carbon emissions as the reference vehicle, then the average vehicle will have an efficiency factor of 1. In short terms we are multiplying the efficiency of an average vehicle with a factor of 1 to end up with the efficiency of an average vehicle. Because it is difficult to obtain average numbers for the efficiency and emissions of certain vehicle types, we could not find this for all vehicle types used in our app. For the sake of simplicity in these cases, we have used values from a generic vehicle of the given type and assumed that these represent an average value.

With a constant vehicle efficiency factor of 1 we end up with the following formula for carbon dioxide emissions per km:

$$CO_2\ emissions\ per\ km = \frac{F \cdot C + \frac{L}{T}}{P} \cdot x$$

Mode of transportation	Energy consumption per km (F)	Well to Wheels energy emissions (C)	vehicle effenciency factor (V)	carbon emmision of production of vehicle (L)	Average km amount the vehicle has traveled (T)	Average number of passengers per vehice (P)
Passenger train			1			
Diesel	4,25 [1]	3,24 [9]		1656700 [11]	7724851,2 [18]	350 [15]
Electric	0	0,371 [10]		1656700	7724851,2 [18]	350 [15]
Car						
Gasoline	0,0561 [2]	2,88 [9]		5600 [12]	160000 [19]	1,5 [26]
Diesel	0,053 [2]	3,24 [9]		5600 [13]	208000 [19]	1,5 [26]
Compressed natural gas	1,229 [3]	3,07 [9]		5600	184000	1,5 [26]
Electric	0	0,371 [9]		8800 [12]	321868 [20]	1,5 [26]
Bus			1			
Diesel	0,326 [4]	3,24 [9]		140000 [14]	450320 [21]	56 [27]
Compressed bio-diesel	0,41 [5]	1,92 [9]		140000	450320	56 [27]
Electric	0	0,371 [9]		150000 [14]	320000 [21]	56 [27]
Motorcycle			1			
Gasoline	0,041 [6]	2,88 [9]		2000 [15]	200000 [22]	1,5
Airplane			1			
Jet fuel	3,8 [7]	3,1 [9]		61000 [16]	84490560 [23]	121,55 [28 29]
Boat			1			
Diesel	0,784 [8]	3,24 [9]		553000 [17]	64373,76 [24 25]	5 [30]

Over is a table of the data we require to calculate the CO2 emissions per kilometer. The latter contains all the information we need for every chosen mode of transport and energy type. Under "mode of transportation", we can find the different vehicles and the different energy sources they use. If we for example go under Passenger train, we can see that we have the data for passenger trains running on diesel and electricity. The other columns give the values of the constants in the formula, which we need to compute the CO2 emissions. Let's imagine a scenario where a user wants to find the CO2 emissions emitted during a five-kilometer diesel passenger train ride.

We can then use the table, which gives us the following result:

$$\frac{4{,}25 \cdot 3{,}24 + \frac{1656700}{7724851{,}2}}{350} \cdot 5 \approx 0{,}2$$

The data is for the most part taken from scientific papers and trusted sources, with the exception of some information that we had major difficulties finding statistics on. In order to create the most realistic carbon app, we have tried our best to find accurate values when searching for data. Unfortunately, some statistics are hard to come across. For this reason, some of the data may differ from the actual global average. To simplify the CO2 emission computation, we have decided to convert each value fulfilling the same purpose to a standard measurement unit (we will for example use liters per kilometer instead of gallons per mile). For this reason, the data published in the papers we reference may not be given in the same measurement unit.Due to the fact that our table contains a lot of data from a wide variety of references, we will not explain each value. On the other hand, we will show how we came up with a value if we were unable to find the exact data, and therefore had to do our own computations to obtain it. The majority of the data is taken from sources that directly give us the values we are looking for. Every value is numbered, so if someone needs more information about specific data, they can go to the reference list at the end of the paper and find the article the value is based on.

The first column with values gives the energy consumption per kilometer for the different vehicle and energy types. These values replace the F variable in the formula. For vehicles running on diesel, gasoline, compressed bio-diesel, and jet fuel the data is in liters per kilometer, while it is in kilograms per kilometer for the vehicles running on compressed natural gas.
For the diesel passenger trains, the academic paper says that the average diesel consumption per kilometer ranges from 4 to 4,5 liters. For this reason, we used the average value of 4,25 l/km.
To find the jet fuel consumption per kilometer of a passenger airplane, we used a paper giving us the fuel consumption of six different aircrafts flying the same distance. To find the final value we had to divide the average jet fuel burn of the different planes by the mission length. This gives us a fuel consumption of 3,8 l/km.

The second column shows the well to wheels emissions of the different energy types. These values replace the C variable in the formula. For vehicles running on diesel, gasoline, compressed bio-diesel, and jet fuel the data is in CO_2 kilograms per liter, while it is in CO_2 kilograms per kilograms for vehicles running on compressed natural gas and in CO_2 kilograms per kilowatt-hour for electric vehicles.

The third column gives the vehicle efficiency factor for the different vehicle types. As explained above we have chosen an efficiency factor of 1 for each mode of transportation.

The fourth column gives us the carbon emission associated with the production of vehicle types. The values replace the L variable in the formula. For every transportation mode the data is in kilograms. Due to missing data, we have used the CO_2 emission associated with the production of a diesel passenger train to estimate the CO_2 emissions needed to produce an electric passenger train. When it comes to the carbon emission linked to the production of a car running on CNG, we didn’t manage to find any relevant data. For this reason, we estimated the carbon emission to be around 5600 kg, due to the fact that both the manufacturing of a diesel car and a gasoline car emits 5600 kg of CO_2 into the atmosphere. We couldn’t find any data on the CO_2 emissions caused by the production of a bus running on compressed bio-diesel, we therefore used the same value as for the diesel bus. Another piece of information we had a hard time obtaining was the carbon emission created by the production of a motorcycle. To solve the issue, we asked the AI chatbot ChatGPT for an estimate. The latter predicted that the average carbon emissions associated with the manufacturing of a motorcycle was around 120 kg CO_2. Since the chatbot has been trained using large amounts of data, the probability that his estimates are precise is pretty high. We therefore decided to stick with that value.

The fifth column shows the average kilometer amount the different vehicle types on average travel during their lifetime for each energy type. These values replace the T in the formula. For every transportation mode the data is in kilometers. To find the average distance travelled by a car running on compressed natural gas, we took the average of the distance travelled by a car running on gasoline and a car running on diesel. This gave us an average of 184000 km.
We couldn't find any data on the average kilometer amount a bus running on compressed bio-diesel has traveled during its lifetime, we therefore chose to use the value we found for the diesel bus. To find the average amount traveled by a diesel boat, we had to find the average amount of hours a boat is used during its lifetime (5000 hours), and multiply it by a boats average speed. With an average speed of 12.8 km/h, we ended up with an average kilometer amount of 64373,76 km.

The last column gives use the average amount of passengers per vehicle. These values replace the P in the formula. We didn't manage to find an average for trains, and therefore chose to ask ChatGPT for help. The latter estimated that a train most of the time holds between 200 and 500 passengers. We therefore concluded that a train on average holds 350 passengers. Another value we didn't obtain is the average amount of people present on a motorcycle. Since the majority of motorcycles have 1 to 2 seats, we concluded hat the average amount of passengers on a motorcycle was 1,5. We also had some difficulties finding the average number of passengers present on a commercial airplane. To compute the average, we first found that the average number of seats on an airplane is 143. The next step was to search up the average fullness of an airplane, which is 85%. By multiplying the average number of seats with the average fullness of a plane, we end up with an average number of passengers of 121,55.

Launching our app: a business strategy for maximizing emission offsets

Our mission

Our carbon offset platform primarily aims to maximize the amount of transport carbon emissions offset by corporate entities and private individuals. We want to build a large non-profit platform which enables our users to easily and quickly calculate their carbon emissions and purchase offsets based on those emissions.

Description of the market

According to Carbon Offset Guide, an initiative by GHG and SEI, there are two global carbon offset markets. These are the compliance and the voluntary offset markets. Compliance markets are created and regulated by mandatory national, regional, or international reduction regimes. Voluntary markets function outside of compliance markets and enable companies and individuals to purchase carbon offsets on a voluntary basis (Carbon Offset Guide). According to a 2023 report from Boston Consulting Group the voluntary carbon market had reached a size of 2 billion dollars – four times its value in 2020 (BCG). The same report shows that this growth will almost certainly continue, as the market is projected to reach a size of between $10 billion and $40 billion by 2030. Europe is the largest carbon market with a global share of about 50% (GlobeNewswire).

The large growth of the carbon offset market has brought with it quite a large selection of different companies who offer products within this space. Among them 5 major players make up about 45% of the global market (GlobeNewswire). These players are South Pole Group, 3Degrees, Aera Group, EcoAct and Terrapass. The remaining 45% are made up of about 20 different companies.

Description the product

Our carbon offset platform consists of two parts. The first part is the carbon calculator – a user friendly tool which is used to calculate transport carbon emissions of both corporate and individual users. The second part is an online storefront where our users can purchase carbon offsets based on their emissions which they calculated using our carbon calculator. We will not produce the carbon offsets ourselves, but rather purchase them from third parties and resell them in our store. Our store will be a an easy to use one-stop shop for a large variety of different carbon offsets. The users will be able to choose both which type of carbon offset they wish to purchase in addition to choosing who produced it.

Consumer insight and target group

In 2021 the UNDP and Oxford University published The Peoples' Climate Vote, a comprehensive report on people's views on climate change in 50 different countries. This report showed that more than two-thirds of the respondents believe that climate change is a global emergency. The respondents were also asked which climate policies they would support. Policies like "conservation of forests and land", "keeping the ocean and waterways healthy" and "build infrastructure and conserve nature to protect lives and livelihoods", which align with our mission statement, were popular in most regions, particularly in Western and Eastern Europe. The survey also showed an age-divide among the respondents where people over 60 had a slightly lower tendency to consider climate change an emergency than other age groups.

Although private individuals are highly motivated towards climate action most of the market for carbon offsets consists of corporate clientele. According to an article by the UN the demand for carbon credits is expected to increase exponentially, especially driven by the surge of corporate climate pledges that will boost activities in the voluntary market (UN). In late 2022 more than one-third of the world's largest publicly traded companies have announced net-zero targets. Many of these companies will utilize voluntary carbon offsets to reach their climate goals.

Pricing

Given that we are a non-profit our carbon offsets will be prices such that we just reach breakeven. When purchasing carbon offsets from us our customers will be paying the direct cost of the offset itself in addition to a small provision. The provision will mainly be used to cover salaries, loans, and other operational expenses. Any profits will be used to scale our operations. Running the organization as a non-profit will both align with our goal of maximizing the amount of carbon that we contribute to offsetting and make it easier to competitively price our carbon offsets.

Strategy and positioning

Our goal would be to become a visible player in the carbon offset market as quickly as possible and claim as much of the future potential market growth as possible. The large, growing corporate demand for carbon offsets suggests we should target large companies and organizations as our first clients to quickly scale our operations early on. Marketing our offsets to individuals would come later down the line.

When it comes to the positioning of our carbon offsets, we want to market them as an ethical, trustworthy, and easy to use alternative to competitors. In recent years a lot of carbon offset programs have been shown to not meet their promises (The Guardian). It is therefore paramount that our carbon offsets can be trusted to have their promised impact on GHG emissions.

Distribution

Sales to corporate clients would be completed through an online storefront where companies can both purchase and find detailed information about our range of available offsets. We believe sales to private individuals would work best through our carbon calculator in the form of an app, along with a directly integrated storefront.

Market communication

A report by Boston Consulting Group determined that reputable monitoring, reporting, and verification is a top criterion for buyers of carbon offsets (BCG Voluntary carbon market).

Therefore, it is important that we ensure both corporate clients and private individuals have easy access to all necessary information to assess the quality of the carbon offsets we offer. In the store our users will have access to information about each type of carbon offset and each producer that we have partnered with. This enables the user to make their own informed decision on what is the best way to offset their individual carbon emissions.

Discussion

What our methodology does in short: ease access to information about ones own and societies carbon emissions.

Through this essay we are getting a better grasp on the issues surrounding the lack of transparency in the voluntary carbon market. Thus, we will further discuss the policy implications that can be derived from our carbon calculator app.

The first policy implication we will discuss is the potential standardization of carbon emission reporting. Governments and different regulatory bodies could work together in creating standardized and transparent methodologies to compute the carbon emissions linked to transportation. The result of this policy would allow us to get accurate and relevant data which allow for an accurate and reliable app. Therefore, helping users make better-informed decisions when it comes to choice of transportation.

Secondly, encouraging transparency in the voluntary carbon market, is another very likely possibility for policy implication. Promoting the importance of transparency for our project could inspire governing bodies to introduce both incentives and penalties to promote transparency in the voluntary carbon market. Furthermore, another possible approach is to give tax breaks to enterprises that disclose accurate emissions data, with those who fail to do so receiving penalties.

A third policy implication could be to focus on higher public awareness, for instance through educational campaigns. Since our app helps reveal the current lack of transparency in the voluntary carbon market, this information can more easily be used in public information campaigns. The goal being to educate the public on the significant impact that transport carbon emissions have on the environment. This policy would help consumers make more informed decisions, allowing for social pressure to be held against these companies for more transparency.

Another policy implication could be a collaboration between public and private sector, with the aim of developing and maintaining carbon emissions databases for different modes of transportation. This association between public agencies and private companies could help keep the carbon emission data up-to-date, and easily accessible for the public. Hence making it accessible to individuals that actively use it, such as app developers or researchers.

The last policy implication we would want to propose, is the promotion and incentivization of low-carbon and environmentally friendly transportation options. Governments can use the carbon emissions data we obtain through apps like ours to encourage the usage of green transportation alternatives, such as public transport or electric vehicles, through subsidies and tax breaks.

To conclude, the creation of a carbon calculator app could have significant policy implications. We have seen that, addressing the lack of transparency in the voluntary carbon market can lead to more accurate data, better informed decision making, and in the long run, a more sustainable future.

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