Estimating and Explaining the Greenhouse Gas Emissions

This chapter¹ starts with an overview of the national emission figures for Austria according to the latest climate protection report at the time of our survey (Klimaschutzbericht, 2020). Subsequently, the emissions of our respondents are presented in detail and also contrasted with the number of national emissions. With a view on improving survey research, a validity check is performed to select those variables that allow an estimation of the total emissions caused by a person. The goal is to select the smallest number of questions that allow for a good estimate of overall emissions. Finally, this chapter seeks to explain the caused emissions from a social science perspective by using socio-demographic variables and environmental attitudes and behaviors as explanatory variables in a linear regression model. It concludes with a brief discussion of possibilities to reduce emissions.

5.1 GREENHOUSE GAS EMISSIONS: THE CASE OF AUSTRIA

In Chap. 3, an overview of how to identify emission-relevant areas and how to calculate them was given. Following the distinction between a nation's greenhouse gas (GHG) inventory and emissions produced through supply chain activities, this chapter seeks to present the latest amount of emissions produced in Austria at the time of our survey.

¹Lead authors: Rebecca Wardana and Markus Schweighart.

According to the climate protection report (Umweltbundesamt, 2020), Austria emitted a total amount of 79 million tons of CO₂ equivalents in 2018, when air traffic is included. The figure, which does not consider the European Emissions Trading System (ETS), according to the Climate Protection Act, sums up to 50.5 million tons of CO₂ equivalents. Compared to the year 2017, in which 82.3 million tons of CO₂ equivalents (including ETS) were emitted,² emissions had decreased slightly. This results in per-capita GHG emissions of 9.4 tons³ (Statista, 2020a).

The climate protection report presents the share of individual sectors in total emissions for the year 2018 and therefore only refers to the national GHG inventory. The sectors with the highest share of emissions are energy and industry⁴ (43.4%), transport (30.3%), buildings (10%), and agriculture (10.3%). A total of 3.2% of emissions are from waste management and 2.9% from fluorinated gases (Umweltbundesamt, 2020).

How does the individual behaviors of Austrians weigh up to the millions of tons of GHG emissions produced? Considering ETS, the transport and building sectors are responsible for large shares of the emissions caused. The individual behavior of Austrians is particularly noticeable in these two sectors.

The transport sector includes road traffic (divided into passenger and cargo transport), rail, maritime, national air transport, and military vehicles. The main emitter is road traffic, which accounts for 97% of the total emissions of the transport sector. Within road traffic, 63% of the caused emissions are produced by passenger transport, which is 18.8% of the total national emissions. Passenger transport includes the individual use of motorized vehicles (cars, motorcycles, and mopeds), public transport (bus, train, and tram), national air transport, and non-motorized means of transport (walking and cycling). Most of the emissions from passenger transport are attributed to car use (Umweltbundesamt, 2020). The individual car use of Austrians is thus responsible for a considerable part of the emissions from the transport sector.

In the buildings sector, emissions from the burning of fossil fuels for heating and hot water in private households and public and private

² 51.7 million tons without ETS.

³ GHG emissions per capita according to the Climate Protection Act amount to 5.9 tons.

⁴ Including those companies that are part of the ETS. If these were not taken into account, the total share of the energy and industry sector would amount to only 11.6%; transport (47.3%) is the largest emitter, followed by agriculture (16.2%) and buildings (15.6%).

services are added. Electricity consumption within the household is also considered. At the national level, this represents a share of 10%. Here, too, the main sources of these emissions are private households. In full, 83.3% of the emissions in this sector come from private households, which is 8.3% of the total national emissions (Umweltbundesamt, 2020).

In addition to central questions on living and mobility behavior, our conducted survey also included detailed questions on the respondents' consumer behavior, with a focus on electronics, clothing and leisure behavior. It must be assumed that many daily consumer goods are not included in the national GHG inventory if they have a production chain that extends beyond the national area. This is where consumption-based approaches (CBAs) and life-cycle assessment (LCA) come into play (see more details in Chap. 3), which attempt to calculate the GHG emissions generated by the consumption of goods within a country using the international supply chain and various input-output (IO) models. The latest research from Windsperger et al. (2017, 2019) has calculated that the consumption of goods added an additional 40% to the national inventory, referring to data from 2013.

In summary, these Austria-wide emissions data show that Austrians contribute a significant share to the total emissions with their individual behavior in the transport and buildings sectors. If the shares are added up, just over a quarter (27.1%) of Austria's total emissions are caused by the use of cars and residential buildings. As the conducted survey has also shown, mobility behavior (especially car use), as well as key figures for buildings, heating, and electricity consumption, provide basic data for calculating individual CO₂ consumption. Therefore, it makes sense to implement climate policy measures in these two sectors that lead to a rethinking or a transformation of previous behavior. With regard to consumer behavior, it is difficult to assign precise values on an individual level. Nevertheless, the calculations of Windsperger et al. (2017, 2019) show that emission savings in the global supply chain should also not be forgotten. From the national level of emitted CO₂, we are now coming back to the emissions of our sample. First, an overview of the sample's emissions is given.

5.2 OVERVIEW OF THE SAMPLE'S GHG EMISSIONS

In total, an average of 7.36 tons of CO₂ equivalents are produced per person as a result of the behavior that was surveyed in our OeNB study (Hadler et al., 2021). As pointed out in Chap. 3, these calculations only

include the emissions of activities and decisions in which the influence of the individual is predominant. They are directly caused by the individual’s own behavior and do not include emissions from public infrastructure (e.g., roads), emissions from public services (e.g., administration and health care) and aliquot construction costs for residential buildings. These factors would result in an additional six tons of CO₂ per capita in Austria.

Table 5.1 presents the average distribution of the individual sectors in the composition of the total emissions based on our sample. The table shows that especially areas such as car use, meat consumption, flight, and heating behavior are responsible for 62% of the individually produced emissions. It also indicates that the average emission of the sample is lower than the Austrian average (9.4 tons). This may be caused by the sampling as the sample description shows that elderly people are overrepresented in

Table 5.1 Distribution of average GHG emissions by individual sectors

<i>Sectors</i>	<i>CO₂ equivalents in kg</i>	<i>Percentage of total CO₂-eq</i>
<i>Housing</i>		
Heating	750	10%
Warm water consumption	230	3%
<i>Mobility</i>		
Car use	1800	24%
Flights	1000	13.5%
<i>Diet</i>		
Meat consumption	1000	13.5%
Dairy products	640	9%
Other food ^a	580	8%
<i>Consumption</i>		
Car (purchase)	360	5%
Good consumption (clothing and electronic devices)	300	4%
Leisure activities	200	3%
Other ^b	500	7%
Total average	7360	100%

Source: OeNB sample (Hadler et al., 2021)

^a“Other food” refers to the selection of food categories that did not belong into the “meat” and “dairy” category. These were, for example, coffee, fruits, nuts, sweets, vegetables, and so on.

^b“Other” refers to other sectors included in the survey that contribute only little to the number of produced emissions and are therefore combined into one category, for example, the use of public transport, power consumption (household), or building information (household)

the survey. This will be further elaborated below, where the individual sectors and behaviors are described in detail.

*Housing—Buildings, Heating, Water, Electrical,
and Household Appliances*

Most of our respondents live in single-family homes (45.7%), 44% in an apartment block or a high-rise building, and 10.3% in a semi-detached or terraced house. The average living space is around 128.69 m² (1385 sqft). A total of 42.6% of respondents state that their place is completely thermally insulated, and 37.8% state that it is only partially insulated. When asked about an energy performance certificate, only 28 respondents were able to show one; 71.4% of these certificates indicate at least class B or higher, which represents low energy or passive houses. The most frequently used main heating system is central heating (31.7%), 26.3% have a district heating system, and 18.5% a gas convector heating system. The most frequently stated main energy source is gas (36.9%), followed by district heating (23.6%), oil (18.2%), and wood/pellets/wood chips (15.8%).

The average heating costs are €112/month. On average, the heating within the sample results in CO₂ emissions of 1277.1 kg/year. Most emissions are caused by oil heating systems. The average emission here is 2489 kg CO₂/year, which is twice the sample's average. The average emission values of gas, district heating, and electricity are between 1232 and 1374 kg CO₂/year. The lowest CO₂ emissions are emitted by wood heating systems (116 kg CO₂/year) and heat pump/solar thermal systems (63 kg CO₂/year).

As for heating behavior, more than half of our respondents indicate that their heating is lowered when they leave their home for more than one day. If leaving for only one day, 31.1% lower their heating. Around 30% also say that they lower their heating at night. During the heating period, 47.8% of the respondents believe that their room temperature corresponds to the Austrian average. The actual temperature measured in the households by the interviewer using a thermometer was on average 22 °C (72 °F). The actually measured temperature was also compared with the subjective temperature assessment of the respondents. For 68.8% of the respondents, the estimated room temperature corresponded with the actually measured temperature—or was within the range of ± 1 °C.

Regarding water consumption, the respondents stated that they shower on average six times per week, and the average showering time is between five and seven minutes. Thirty percent also say that they take baths, with an average number of four baths per month. The most frequently used technology to heat water is a storage heater (52.2%), 27.8% say that they use an instantaneous heater or a gas-fired heater, and around 12.4% a solar system.

The total electricity consumption of the respondents is on average 4534 kWh/year. This value was calculated on the basis of those respondents who provided their electricity bill. The average electricity cost per month is around €131. The most commonly used household appliances are an electric cooker in the form of a ceramic hob, oven, microwave, dishwasher and washing machine. All these appliances are usually used at least several times a week. A total of 70.8% say they eat a hot meal six to nine times a week, and 46.9% cook most often for two people. This usage behavior of household appliances causes an average CO₂ emission of 105.2 kg CO₂/year.

The electrical appliances most commonly found in the households of the respondents are a television (≤40 inch), a music or home cinema system, and a laptop. In full, 57.9% of the respondents say they do not own a large television set, 56.9% do not have a desktop computer in their household, and only 7.2% own an air conditioning system. Looking at the use of individual electronic devices, it can be seen that televisions are used on average between one and three hours per day. Desktops and laptops are used about two hours per day. Those with air conditioning indicate that they use it for one to two hours a day in the summer. In general, many of the respondents estimate their personal use of these electrical appliances as average (44%), and 30.6% think that their use is below average. This usage behavior causes an average CO₂ emission of 32.2 kg CO₂/year.

Mobility—Car Usage and Flight Behavior

On average, our respondents travel a distance of 5000–10,000 km per year in their most frequently used car. Data from the Verkehrsclub Österreich (VCO) show that the mobility behavior of our respondents is similar to that of the Austrian population. On average, Austrians travel around 9000 km per year by car (VCO, 2016), with commuting to work being a large share of these trips (see VCO, 2020a).

On average, our respondents estimate spending one and a half to two hours per week in the car. Around a quarter of the respondents stated that they spend more than 90% of the time alone in the car. Another quarter said they were “never or almost never” alone in the car. When they are not alone in the car, 70.2% say that there is one additional person besides the driver or passenger present. On average, car use causes CO₂ emissions of 1864 kg CO₂/year per person.

More than half of the respondents (57%) state that their most frequently used vehicle is a diesel car, 40.9% own a petrol-car and only two individuals (1%) an electric car. A total of 59.3% say that their car uses between 5 to 7 liters of fuel per 100 km and 26.6% estimate between 7 and 10 liters. On average, diesel vehicles emit 2319 kg CO₂/year, while petrol vehicles emit 1535 kg CO₂/year. This difference is mainly due to the fact that our respondents with diesel cars travel approximately 16,000 km per year, which is significantly above the average. For the two respondents who own electric cars, the average annual CO₂ emissions are 465 kg.

As for public transport, 37.7% of the respondents stated that they do not use public transport at all, 18.4% spend a maximum of 30 minutes on public transport per week, 18.9% between 30 minutes and two hours, and 14.9% more than five hours. Those who travel by public transport produce an average of 85.4 kg of CO₂/year as a result of this mobility. It should be noted that among those who use public transport, only 21.7% do not have a car.

When asked very generally about their flights, 43.3% of respondents said that they never fly abroad or only once every few years, 22.6% travel once a year, and 17.8% several times a year (both short- and long-haul flights). Asking about the preceding year specifically (which is referring to 2018–2019), 56.2% stated that they had not traveled by plane at all. In order to differentiate more precisely, a distinction was made between business and private flights and short- and long-haul trips. With regard to private flights, 64.1% did not take any short-haul flights in the previous 12 months, while 19.2% had taken two short-haul flights. The frequencies are even lower for private long-haul flights—89% report not having taken a private long-haul flight in the previous 12 months. When asked about business flights, it is also apparent that the majority did not take any short- (88.5%) or long-haul flights (95.7%). There are, however, a few respondents in the sample who took a large number of business flights.

Calculating the exact flight times, based on the requested information on the actual destinations of the mentioned flights, shows that most

individuals (32.2%) spent between two-and-a-half and five hours on a plane, 30.6% spent more than 20 hours, and 22.1% spent between five and ten hours traveling by plane. The rest of the sample had spent either less than two-and-a-half hours on a plane or were in the midfield, with 10–20 hours the preceding year. The average CO₂ output of those who had flown in the previous 12 months is 1040.4 kg CO₂/year. A comparison of our sample with the Austrian average, however, shows that infrequent flyers are overrepresented in our sample. Data from VCÖ (2017) show that about half of the population takes flights once a year, whereas around one-third of the population does not take any flights. Furthermore, the most frequent trips are short-haul flights, which are also considered to be particularly polluting.

Diet—Meat and Dairy Products

Questions on nutrition included detailed assessments of the frequency of the consumption of energy-intensive foods (mainly animal products). Respondents were asked how often they consume, for example, sausage products, beef, pork, lamb, poultry, dairy products, fish, and seafood. Meat is most often consumed in the form of sausage products. Dairy products and eggs are also among the most commonly consumed animal foods. In total, 70.3% of the respondents eat sausage products up to three times a week, and 93.4% eat cheese and eggs up to three times per week. Among the types of meat, poultry is the most frequently consumed; 49.5% eat it one to three times a week. For beef and veal, it is 39.7% and for pork 37.8%. Fish and seafood are eaten by 38% one to three times a week. In sum, the meat consumption of our respondents causes on average 1005.6 kg CO₂/year. Only 4.4% of the respondents stated that they are vegetarian or vegan. Most respondents (57.8%) eat meat “in some meals,” 18% “in most meals,” and 19.4% “very rarely.”

The reported diet of our respondents is somewhat lower than the official figures. Austria had an annual meat consumption of 62.6 kg per capita in 2019, which indicates that meat is consumed up to five times a week on average. In an EU comparison, Austria is in the middle in terms of consumption of various types of meat, but its consumption of pork is far above the European average (Statista, 2020b).

The questions on eating habits also included a query as to how often someone goes out to eat in restaurants and similar places. In all, 46.9% state that they eat out several times a month and 30.9% several times a year

or even less often. Finally, when asked about the percentage of food thrown away in their household, 26.3% say that they do not waste any food, 45.4% say that they throw away a maximum of 5%, and 19% around 5–10%.

Consumption—Goods, Leisure Activities, and Information

The questions on consumer behavior are divided into the consumption of electronic goods, leisure activities, and clothing. The respondents' own assessment of their purchasing behavior in all three areas shows that they see themselves as rather "frugal" and "considerate." With regard to electronic goods, 74.8% of those surveyed say that they pay attention to "long use" and "only replace items when they are broken." Even when dealing with major household investments, 72.8% pay attention to the "longevity of products" when making purchases. When asked about clothing, the answers are more widely distributed, with 47.8% particularly emphasizing "long use," 31% rating their purchasing of clothing as "average," and 12.3% describing it as "very modest."

When asked about consumption of electronic goods, respondents were also asked to indicate, from a list of different items, how often they buy them new. Of all the electronics items listed, the smartphone is most frequently bought new. On average, a new smartphone is bought every three to five years, whereas a laptop is bought new after five to seven years and a television after six to ten years. A new car is bought on average less frequently than every ten years.

In the assessment of their personal leisure time behavior, 56.3% state that they need little equipment and infrastructure. They were also asked how often they buy new sporting equipment (e.g., bicycle and ski/snowboard). Almost half of the respondents (49.3%) buy a new bicycle less often than every ten years. The situation is similar when buying new skis or a new snowboard. Those who practice this winter sport buy new equipment on average less often than every ten years.

In addition to purchasing behavior, the leisure activities of the respondents were also examined in more detail. They were asked how often they had visited various leisure facilities in the previous 12 months. On average, the respondents most frequently visited a cinema/theater, an opera, or a football stadium (each three to five days a year). A ski resort was visited on average for one or two days, with more than half of the respondents not having visited one at all in the previous 12 months. More than 60% also

say that they have never visited a theme park. Those who did were there for one or two days on average.

In addition, half of the sample (50.5%) had spent between 3 and 15 days in a hotel in the previous 12 months, 58% said they had not visited an apartment, bed and breakfast or youth hostel, and only 13% had spent six to ten days in one.

From a list of different items of clothing, the respondents indicated how often they had bought or received them as gifts in the previous 12 months. Of all the items given, a shirt was bought/gifted most often. On average, the majority of the respondents estimate that three to four shirts had been bought/gifted in the previous 12 months. The remaining items of clothing (shoes, trousers, skirts, sweaters, dresses, jackets, and coats) were most often bought/gifted one to two times a year. Converted to CO₂ consumption, this means, for example, an average of 93.6 kg CO₂/year for shirts and 106.7 kg CO₂/year for trousers and shoes.

5.3 ESTIMATING AND EXPLAINING AN INDIVIDUAL'S TOTAL EMISSION

The previous section discussed each emission area in detail. This section now uses a hierarchical linear regression model to identify sets of variables that allow for a good approximation of the respondents' total emission value. The goal is to explain as much variance as possible with the smallest number of variables. The identified small set of variables could then be used in future surveys that have only limited room for emission items.

Table 5.2 presents a model that is able to capture 77% of the emissions with five variables and an extended model that captures 88%. The first model includes variables that are associated with the largest quantities of GHGs in terms of content and can be surveyed validly, specifically the questions concerning the annual car-km, the consumption of beef and lamb products per week, the number of flights per year, the living space, and the number of people living in the household. The extended model includes additional variables, such as the amount of using a car alone, main heating source, long flights, consummation of pork and poultry per week, and number of shoes and phones per year as proxies for clothing and electronic devices. All the added variables in the second model have a significant influence on the explained emissions except for the main heating source.

Table 5.2 Estimating the total individual GHG emissions

<i>Predictors</i>	<i>Total CO₂ equivalents</i>			
	<i>Model 1</i>		<i>Model 2</i>	
	<i>Estimates</i>	<i>std. Beta</i>	<i>Estimates</i>	<i>std. Beta</i>
(intercept)	3591.93		1804.36	
Car kilometers	0.18	0.58***	0.16	0.51***
Beef and lamb per week	212.19	0.15***	189.46	0.13***
Number of flights per year	617.32	0.50***	295.19	0.24***
Living space in square meters	9.65	0.23***	9.39	0.22***
Number of household members	-636.63	-0.21***	-498.42	-0.16***
Percentage of using car alone			13.50	0.14***
Heating electricity			-73.44	-0.02
Heating gas			147.61	0.04
Heating oil			322.53	0.10
Heating solar			-599.39	-0.18
Heating wood			-936.98	-0.28***
Number of long flights			565.03	0.35***
Number of shoes per year			107.52	0.06**
Number of phones per year			2466.69	0.11***
Pork and poultry per week			183.53	0.10***
Observations	208		208	
R ² /R ² adjusted	0.772/0.766		0.888/0.879	

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. Linear regression. Source: OeNB sample (Hadler et al., 2021)

Factors that Shape the Total Emissions

Having shown how the emissions of an individual can be approximated with a few variables, we now want to provide some explanations for these emissions at the individual level. We start by adding the attitudinal and behavioral level in addition to relevant socio-demographic variables based on the theories and models discussed in Chap. 2. As noted earlier in the theoretical overview, explaining an individual's emission level requires not only the inclusion of individual social-structural factors but also the consideration of contextual factors such as geographical, political, or institutional settings. Including this contextual-level emission-oriented behavior has been well explained in past research (Kollmuss & Agyeman, 2002; Newton & Meyer, 2012; Stern, 2000; Tabi, 2013). This section, however, focuses on individual social-structural factors that have an impact on the emission-relevant behavior of individuals.

We will present the results of a regression that uses the total emissions as the dependent variable and a number of socio-demographic, attitudinal, and behavioral items as independent variables. We consider the following socio-demographics: income, age, education, gender, and place of residence⁵ (see, among others, Huddart Kennedy et al., 2013; Gatersleben et al., 2002). In addition to these socio-demographic variables, attitudinal and behavioral intentions are also included since their significance is highlighted in past research (see, among others, Maloney & Ward, 1973; Gifford & Sussman, 2012). The items we use are taken from the ISSP (www.issp.org) and will be presented in detail in the following sections.

Dimensions of Environmental Attitudes and Behaviors

When asked “In general, how concerned are you about the environment?”, 95.7% of the respondents say that they are “rather concerned” or “very concerned.” The distributions of the individual items show that the majority of the sample has a positive attitude toward the environment and environmental protection. Based on the 22 questions on environmental attitudes and behavioral intentions, a total of six scales were considered, as follows: environmental concern, economic influence on the environment, influence of modern lifestyles on the environment, micro fatalism, acceptance of personal restrictions and climate policy measurements, as well as behavioral intentions toward environmentally oriented actions. Factorial analysis (VARIMAX) was used to determine the different dimensions.⁶ The following sections summarize the composition of the scales and their distributions.

The scale “environmental concern” is intended to reflect the general concern about the environment and contains answers to the following questions: “How concerned are you about the environment?”; “There are more important things to do in life than protecting the environment”; “Many assertions about the threat to the environment are exaggerated”; and “We worry too much about the future of the environment these days and too little about prices and jobs.” A low value on this scale means that the individual has little concern for the environment. The mean value is

⁵The place of residence can also be considered at the contextual level. It, for example, determines the mobility behavior due to infrastructural differences.

⁶Reliability analyses show a Cronbach’s alpha between 0.547 and 0.639 within all six scales. All six scales have a range from 1 to 5.

4.2, and the mode is 4.75. This shows that a large part of the sample is highly concerned about the environment.

“Economic influences” is related to ecological modernization and reflects the attitude toward economic growth and its influence on the environment. It contains answers to the following questions: “Almost everything we do in our modern world harms the environment”; “In order to protect the environment, Austria needs economic growth”; and “Economic growth always harms the environment.” A low value means that one is of the opinion that economic growth is not harmful to the environment. The mean value and median are around 3.4, and the skew value is close to zero. There is no clear tendency in the response behavior in any direction.

The scale “influence of modern lifestyles” indicates how the influence of modern everyday life on the environment is perceived. It contains answers to the following questions: “I find it difficult to judge whether my lifestyle benefits or harms the environment” and “Modern science will solve our environmental problems with little change in our lifestyle.” A low value means that a respondent believes that a modern lifestyle has no negative impact on the environment. The mean value is 3.8, the median is 4, and there is a negative skew value. The majority of respondents therefore believe that modern lifestyles tend to have a negative impact on the environment.

The scale “micro fatalism” addresses subjective efficacy and contains answers to the following questions: “I do what is right for the environment even if it costs me more money or time” and “It is useless to do my part for the environment as long as others do not behave in the same way.” A low value means you believe that your own behavior has no influence on the environment. The mean value is 4.2, and the skew value indicates a left-skewed distribution. Thus, a majority of the respondents reject these statements, which means that they believe in a positive influence at the microsocial level on the environment.

The scale “willingness to sacrifice for the environment” is closer to environmental behavior and contains answers to the following three questions: “To what extent would you find it acceptable ... (a) ... to pay much higher prices to protect the environment?; (b) ... to pay much higher taxes to protect the environment?; and (c) ... to sacrifice your standard of living to protect the environment?” This scale is intended to show the individual’s willingness to accept personal restrictions and climate policy measurements to protect the environment. Therefore, it cannot be defined as

actual behavior but more as an intention. A low value on the scale means that the proposed measures would be denied on a high level. The mean value (3.4) and median (3.3) are close, and the distribution indicates that a larger part of the sample shows approval of these measures.

Finally, we also consider environmental private-sphere behavior, which includes the following six questions: “How often do you do the following things? (a) separate valuable materials from your waste, such as glass, metal, plastic, paper, etc. for reuse (recycling); (b) buy fruit and vegetables that have not been treated with pesticides or chemicals; (c) limit driving for the sake of the environment; (d) reduce energy and fuel consumption at home for the sake of the environment; (e) save or reuse water for the sake of the environment; and (f) for the sake of the environment, avoid buying certain products.” Since the respondent defines the answers to these questions as a mere self-declaration and thus the risk of socially desirable answers arises, they cannot be defined as actual environmental behavior. Rather, these answers are evaluated as behavioral intentions and are part of Stern’s (2000) private-sphere behavior that has a small impact on the environment. The scale thus represents the intention of an individual to perform the above environmentally oriented actions. A low value on the scale means that an individual has a low behavioral intention and does not indicate taking these actions often. The mean value and median are around 3; a large part of the sample thus shows a higher behavioral intention to take the above actions.

Factors that Shape the Total Emissions

Table 5.3 shows the results of a linear regression with the total emissions as the dependent variable and the above-mentioned socio-demographics and scales as independent variables. The model explains a quarter (25.9%) of the dispersion of the total produced emissions of an individual. It shows that the attitude variables have no significant influence on the individual emission consumption. This is somewhat expected since past studies have pointed out that attitudes are important regarding the intention to change behavior but have less influence on actual behaviors (Abrahamse & Steg, 2009). Only the willingness to make sacrifices for the environment was significant. The negative beta-coefficient of the willingness scale (-0.15) indicates that individuals who have a high willingness to accept these restrictions for the environment are also more likely to produce less emissions. This suggests that there are some individuals who already produce

Table 5.3 Linear regression model; dependent variable: total CO₂ equivalents

<i>Predictors</i>	<i>Total CO₂ equivalents</i>	
	<i>Estimates</i>	<i>Std. Beta</i>
Intercept	7299.26***	
<i>Residential area [ref. urban]^b</i>		
Countryside	1221.89	0.43*
Suburban	1489.28	0.53**
<i>Gender [ref. male]</i>		
Female	-708.17	-0.25
<i>Education [ref. university]</i>		
(no) compulsory school	-923.18	-0.33
Apprenticeship	57.02	0.02
Vocational school (BMS)	-654.44	-0.23
Upper secondary school (AHS/BHS)	-104.80	-0.04
Age	-54.58	-0.35***
Income	1.55	0.52***
Income not reported ^a	1844.67	0.28**
<i>Attitudes and intentions</i>		
Environmental concern	-169.96	-0.04
Economic influence	-98.77	0.03
Influence of modern lifestyles	82.32	-0.03
Micro fatalism	228.52	0.05
Willingness to sacrifice for the environment	-495.73	-0.15*
Environmental private-sphere behavior	-738.18	-0.13
Observations	194	
R ² /R ² adjusted	0.321/0.259	

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

^aA dummy variable was included for respondents who did not report their income and interacted with the main term. In our case, respondents who did not report their income consume 1844.67 CO₂ equivalents more than reported in the intercept. "Income" is the linear effect per unit income, which is per euro. Source: OeNB sample (Hadler et al., 2021)

^bAdditionally, further differentiations within the residential areas were made, that is, differences within the two largest cities in the sample (Vienna vs. Graz) and differences between federal states (Vienna and Lower Austria vs. Styria). There were no significant effects.

less emissions based on their behavior and are also willing to make more sacrifices for the environment.

The socio-demographic variables of age, income, and residential area have significant effects. Younger respondents, urban dwellers, and respondents with a higher income produce more emissions. Looking at the standardized beta-coefficients in the model, the socio-demographics have the

strongest influence on emissions (values over 0.3). These findings are thus in line with previous studies, which found a strong influence of these factors on an individual's consumption (Poortinga et al., 2004).

5.4 CONCLUSIONS AND OUTLOOK

This chapter started with a comparison and description of the emissions of Austrians and the study's respondents, which showed that our sample has somewhat lower CO₂ emissions than the average Austrian. The comparison of different areas of emissions made clear that most emissions are caused by car use, meat consumption, and flight behavior. The use of a regression model showed that five key variables are sufficient to estimate around three-quarters of the total CO₂ emissions caused by an individual. This finding suggests that asking about annual car kilometers, consumption of lamb and beef per week, number of flights, size of the living space, and number of household members allows for a quick assessment of an individual's CO₂ footprint.

As for factors shaping the CO₂ output, around a quarter of the dispersion can be explained by socio-demographics and willingness to act environmentally. Especially socio-demographic variables such as age, income, and residential area are strong and significant influences. Also, the willingness of someone to accept restrictions has a significant influence on emissions. The considered attitude scales had no significant effect.

What savings and guidelines for action can be derived from these results? Considering the areas that produce the most emissions, mobility, diet, and housing need to be addressed. As for buildings, Austria offers a number of subsidies, which vary from one federal state to other.⁷ However, subsidy guarantees for private homes and other forms of private housing have been declining every year since 2014. In 2018, subsidy expenditure was almost -18% below the average of the previous ten years. There were also returns of 40% in 2018 compared to 2010 for renovation subsidies, putting Austria in the bottom third of the European subsidy expenditure.

⁷For example, subsidies for private homes, multi-story residential buildings, ecological requirements ("Ökoförderungen"), residential building checks ("Wohnbauschek"), or residential building renovations. These subsidies are tied to a wide range of requirements, which, among other things, require the implementation of ecological measures by the developer (Land Steiermark, 2020).

At this level, a tripling of the renovation rate is necessary to meet the climate targets (IIBW/FV Steine-Keramik, 2019).

Another major contribution to national emissions is made by individual passenger transport. The VCÖ Mobility Survey (2020) shows that more than half of Austrians (57%) would prefer to cover some of the distances they have traveled by car by alternative means of transport (e.g., public transport, bicycle, and walking). At the same time, it is also apparent that, particularly in peripheral districts, the public infrastructure (e.g., cycle paths and railway stations) is considered to be insufficient (VCÖ, 2020b). The demand for alternative possibilities to the car is therefore given. Hence, transport policy measures should place a focus on the expansion of the cycle network and public transport in areas outside of large cities in order to offer those residents more alternatives to car use. Promotion of alternative mobility concepts such as car sharing⁸ or bike sharing⁹ can also contribute to reducing emissions, especially in peripheral areas.

As expected, the number of flights per year contributes to a high carbon footprint. According to the VCÖ (2020c), particularly short-haul flights are extremely harmful to the environment. In 2019 around five million passengers traveled by short-haul flights in Austria, each time covering distances less than 800 kilometers, which is equivalent to a flight duration of two hours or less. Therefore, the focus should be on reducing the number of these flights by either enforcing a higher tax or finding alternatives to reduce the necessity of these short flights, such as online meetings as alternatives to business trips or the use of alternative transportation such as railways or buses.

One last emission-intensive area would be the consumption of food, especially the consumption of animal products. It is a long and emission-intensive way until the meat lands on someone's plate. Looking at it from a consumer-based approach, it is important to raise awareness as to what sacrifices are made on different ecological levels when it comes to meat production and consumption. Generally, food, as a huge part of an individual's consumption, should be guided by environmentally conscious

⁸ This mobility concept refers to the rental of a car. A distinction is made between providers with fixed locations and free-floating systems (no fixed location, borrow and return within a defined zone) (Stadt Wien, 2020). An example would be the mobility concept called "tim" in Graz, which does include the concept of car sharing among other alternative mobilities.

⁹ This mobility concept refers to the rental of bicycles within a public space. There is also a distinction between stationary-based and free-floating systems. An example in Austria would be "city bike" in Vienna.

decisions to make up for the number of emissions that are caused through consumption.

The CO₂ quantities calculated in the study illustrate which areas of the household and personal behavior can be defined as emission-intensive. In addition to the already known “emission sinners,” such as meat consumption and car use, the calculations also showed where savings can be made on a smaller scale. An essential area in households is water treatment and water consumption. The average CO₂ emissions here are 228.3 kg CO₂/year. In comparison to electricity consumption, the CO₂ emissions caused by water consumption are higher. Thus, water-saving measures can make a small but important contribution to reducing CO₂ consumption within a household. The usage behavior of the electrical appliances surveyed (e.g., TV, computer, and laptop) causes an average CO₂ emission value of only 32.2 kg CO₂/year, which is only 0.4% of the total emissions caused. This is noteworthy since some of these behaviors are also interpreted as energy-saving behavior—for example, energy-saving recommendations regarding the standby consumption of electrical appliances. These figures indicate that the use of everyday electrical appliances produces fewer emissions than suggested by the energy-saving recommendations and that the focus needs to be shifted.

In sum, this chapter pointed out which areas of life are particularly CO₂ intensive and which individual factors influence total emission output. The following chapter will add to this perspective by identifying specific patterns of consumption. It will show that there are specific lifestyles that are characterized by high energy demands in only one of the six sectors of consumption.

REFERENCES

- Abrahamse, W., & Steg, L. (2009). How do socio-demographic and psychological factors relate to households' direct and indirect energy use and savings? *Journal of Economic Psychology*, 30, 711–720.
- Gatersleben, B., Steg, L., & Vlek, C. (2002). Measurement and determinants of environmentally significant consumer behavior. *Environment and Behavior*, 34(3), 335–362.
- Gifford, R., & Sussman, R. (2012). Environmental attitudes. In S. D. Clayton (Ed.), *Oxford library of psychology. The Oxford handbook of environmental and conservation psychology* (pp. 65–80). Oxford University Press.

- Hadler, M., Schweighart, M., & Wardana, R. (2021). *OeNB CO₂-relevant environmental behavior*. Data will be available for free at the Austrian Social Science Data Archive. www.aussda.at; <https://doi.org/10.11587/WQGMKY>
- Huddart Kennedy, E., Krahn, H., & Krogman, N. T. (2013). Are we counting what counts? A closer look at environmental concern, pro-environmental behavior, and carbon footprint. *Local Environment: The International Journal of Justice and Sustainability*, 20(2), 220–236.
- IIBW/Steine-Keramik. (2019). *Wohnbauförderung in Österreich 2018*. Novographik Druck GmbH.
- Kollmuss, A., & Agyeman, J. (2002). Mind the gap: Why do people act environmentally and what are the barriers to pro environmental behavior? *Environmental Education Research*, 8(3), 239–260.
- Land Steiermark—Amt der Steiermärkischen Landesregierung. (2020). *Förderungen*. <https://www.wohnbau.steiermark.at/cms/beitrag/12763938/155599590/>
- Maloney, M. P., & Ward, M. P. (1973). Ecology: Let's hear from the people: An objective scale for the measurement of ecological attitudes and knowledge. *American Psychologist*, 28(7), 583–586.
- Newton, P., & Meyer, D. (2012). The determinants of urban resource consumption. *Environment and Behavior*, 44(1), 107–135.
- Poortinga, W., Steg, L., & Vlek, C. (2004). Values, environmental concern, and environmental behavior. *Environment and Behavior*, 36(1), 70–93.
- Stadt Wien. (2020). *Was ist carsharing?* <https://www.wien.gv.at/verkehr/kfz/carsharing/wissenswertes.html>
- Statista. (2020a). *Treibhausgasemissionen in Österreich*. <https://de.statista.com/statistik/studie/id/59925/dokument/treibhausgasemissionen-in-oesterreich/>
- Statista. (2020b). *Konsum von Fleisch in Österreich*. <https://de.statista.com/statistik/studie/id/32545/dokument/konsum-von-fleisch-in-oesterreich-statista-dossier/>
- Stern, P. C. (2000). New environmental theories: Toward a coherent theory of environmentally significant behavior. *Journal of Social Issues*, 56(3), 407–424.
- Tabi, A. (2013). Does pro-environmental behavior affect carbon emissions? *Energy Policy*, 63, 972–981.
- Umweltbundesamt. (2020). *Klimaschutzbericht*. Wien. https://www.umweltbundesamt.at/studien-reports/publikationsdetail?pub_id=2340&cHash=04535flc207c6ac8814ee0edb3809750
- VCÖ. (2016). *VCÖ: Auto hat für Mobilität der Österreicher geringere Bedeutung als im EU-Schnitt*. <https://www.vcoe.at/presse/presseaussendungen/detail/vcoe-auto-hat-fuer-mobilitaet-der-oesterreicher-geringere-bedeutung-als-im-eu-schnitt>

- VCÖ. (2017). *VCÖ: Jeder dritte Österreicher fliegt nie—jeder sechste fliegt mehrmals im Jahr*. <https://www.vcoe.at/news/details/vcoe-jeder-dritte-oesterreicher-fliegt-nie-jeder-sechste-fliegt-mehrmals-im-jahr>
- VCÖ. (2020a). *Infographiken Mobilität allgemein*. <https://www.vcoe.at/publikationen/infografiken/infografiken-mobilitaet-allgemein>
- VCÖ. (2020b). *VCÖ-Factsheet 2020-04—Österreichs Bevölkerung ist sehr vielfältig mobil*. <https://www.vcoe.at/publikationen/vcoe-factsheets/detail/vcoe-factsheet-2020-04-oesterreichs-bevoelkerung-ist-sehr-vielfaeltig-mobil>
- VCÖ. (2020c). *VCÖ: Kurzstreckenflüge verstärkt durch Bahn und Videokonferenzen ersetzen*. <https://www.vcoe.at/presse/presseaussendungen/detail/vcoe-inlandflug-in-oesterreich-verursacht-50-mal-so-hohe-klimaschaedliche-treibhausgase-wie-bahnfahrt>
- Windsperger, A., Windsperger, B., Bird, D. N., Jungmeier, G., Schwaiger, H., Canella, L., Frischknecht, R., Nathani, C., Guhl, R., & Buchegger, A. (2017). *Life cycle based modelling of greenhouse gas emissions of Austrian consumption. Final report of the research project ClimAconsum to the Austrian Climate and Energy Fund, Vienna*. Institut für Industrielle Ökologie (IIÖ).
- Windsperger, B., Windsperger, A., Bird, D. N., Schwaiger, H., Jungmeier, G., Nathani, C., & Frischknecht, R. (2019). Greenhouse gas emissions of the production chain behind consumption of products in Austria. Development and application of a product- and technology-specific approach. *Journal of Industrial Ecology*, 1–12.

Open Access This chapter is licensed under the terms of the Creative Commons Attribution 4.0 International License (<http://creativecommons.org/licenses/by/4.0/>), which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence and indicate if changes were made.

The images or other third party material in this chapter are included in the chapter's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the chapter's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copy-right holder.