DE | EN | FR | LB

Towards
DECARBONISATION

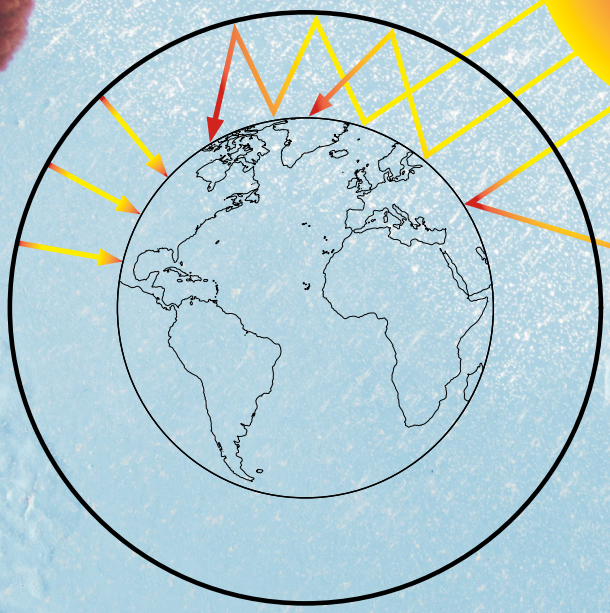
Understanding and reducing our carbon footprint in Luxembourg

LUXEMBOURG
INSTITUTE OF SCIENCE
AND TECHNOLOGY
LIST

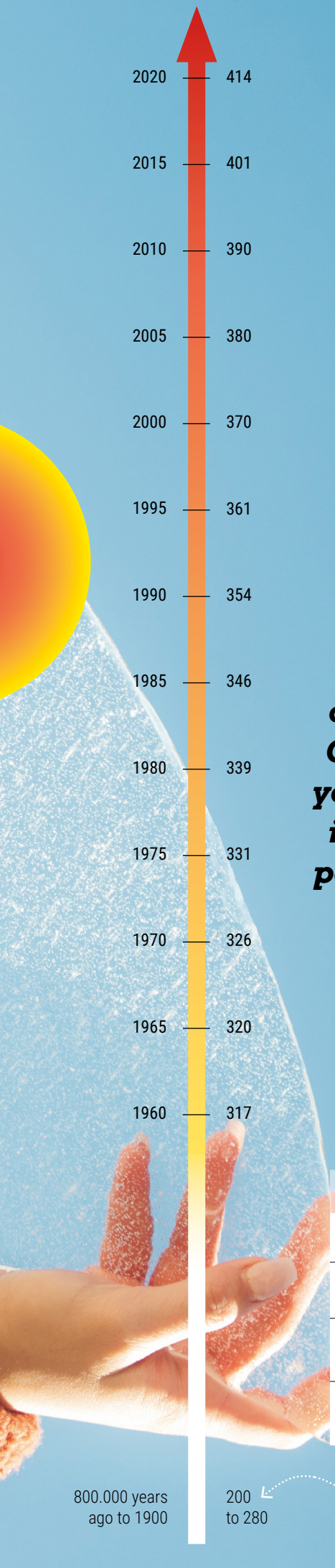
Why?

We seek to educate the public about climate change and decarbonisation. In this brochure, we explain the carbon footprint of the average Luxembourger and show how our consumption of food, mobility, and housing contributes to greenhouse gas emissions.
We believe that everyone needs to know, at least roughly, what their carbon footprint is and how impactful different decarbonisation measures are. With this knowledge, we can all do our part in mitigating climate change and putting Luxembourg on the path to net zero.

WHAT IS THE GREENHOUSE EFFECT?



During the day, sunlight passes through the atmosphere and heats up the Earth's surface. At night, this heat is radiated back into space, but some of the heat is trapped by greenhouse gases (GHGs). As greenhouse gases accumulate in the atmosphere, the Earth becomes hotter.



Climate Change & GREENHOUSE GASES

It will take hundreds of years for the concentration of GHGs in the atmosphere to fall back to pre-industrial levels if we were to suddenly stop emitting all GHGs.

For the past 800.000 years, the concentration of CO_2 in the atmosphere was around 200 to 280 parts per million (ppm), which is 200 to 280 molecules of CO_2 per million molecules of air. Since 1900, the **concentration of CO_2** has steadily increased to about 420 ppm today.

What was the concentration of GHGs in the year you were born and in the years your parents were born ?

The **global warming potential** (GWP) measures the amount of energy 1 ton of a GHG absorbs relative to 1 ton of CO_2 over a given period, usually 100 years. By definition, CO_2 has a GWP of 1, since it is the reference gas. Thus, 1t of CH4 is equivalent to 34 t CO_2 and is generally expressed as in CO_2-equivalent or CO_2eq.

The livestock sector in Luxembourg is responsible for about 19 kilo-tons (kt) methane, 15 kt carbon dioxide and 0.79 kt nitrous oxide emissions.

Q1 **Can you calculate total livestock sector emissions in units of CO_2-equivalent?**

HUMAN ACTIVITY (EXAMPLES)	GREENHOUSE GAS	GLOBAL WARMING POTENTIAL (GWP)
Burning of fossil fuels	Carbon dioxide (CO_2)	1
Cow burps, natural gas pipeline leaks	Methane (CH_4)	34
Emissions from over-fertilisation in agriculture	Nitrous oxide (N_2O)	298
Leaks from refrigerators, air conditioners	Hydrofluorocarbons (HFC)	1.000 to 22.000

GLOBAL CARBON Budget

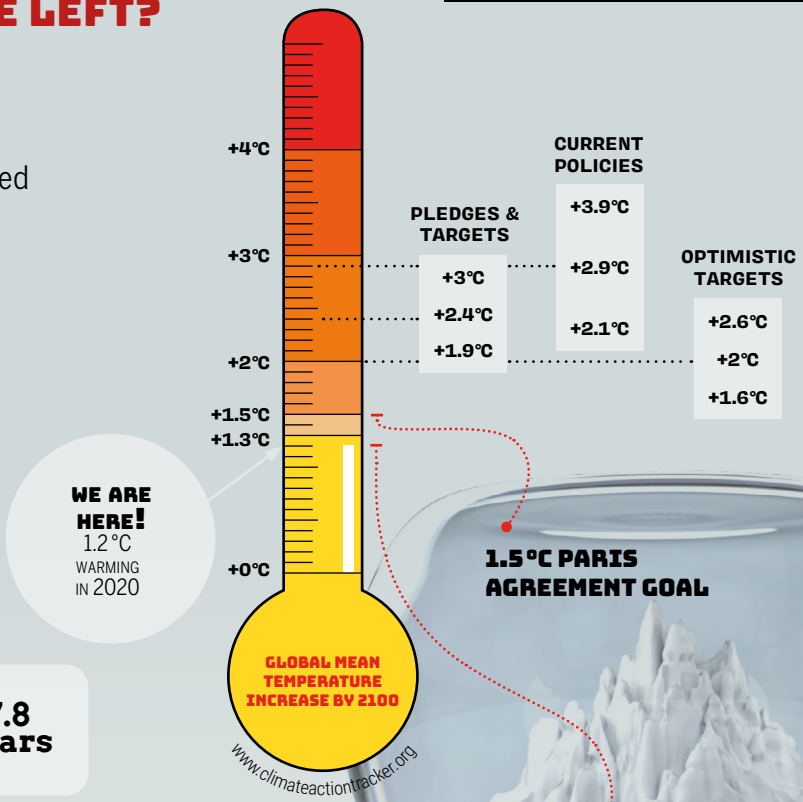
Q2 **How many years do we have left, if we want to be more sure and limit global warming to 1.5 °C with 83% probability? How old will you be then?**

HOW MUCH TIME DO WE HAVE LEFT?

Our Target Paris Agreement of 2015

In 2015, almost all countries in the world signed the Paris Agreement to limit global warming to well below 2 °C, preferably to 1.5 °C.

How many years do we have left at current CO_2 emission levels of 38.6 Giga-ton (Gt) CO_2eq, if we want to limit global warming to 1.5 °C with 67% probability?



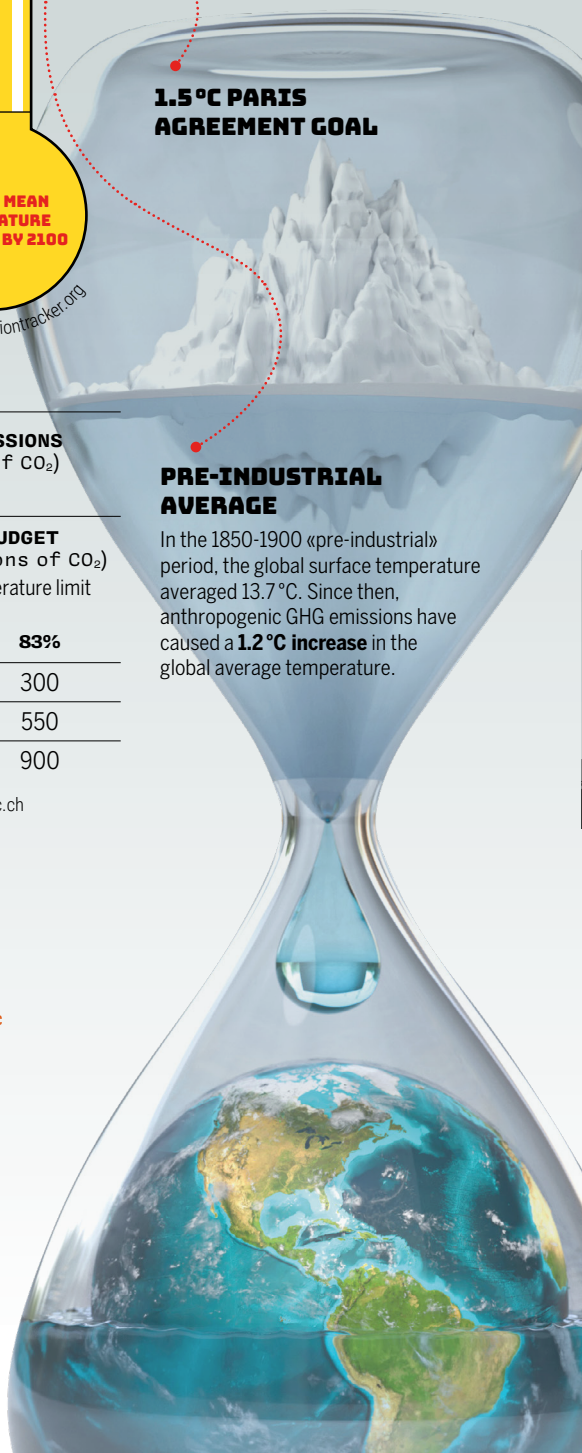
We will use up the estimated remaining carbon budget of 300 Gt CO_2 at current emission levels of 38.6 Gt CO_2 in:

$$\frac{300 \text{ Gt } CO_2}{38.6 \text{ Gt } CO_2/\text{year}} = \textbf{7.8 years}$$

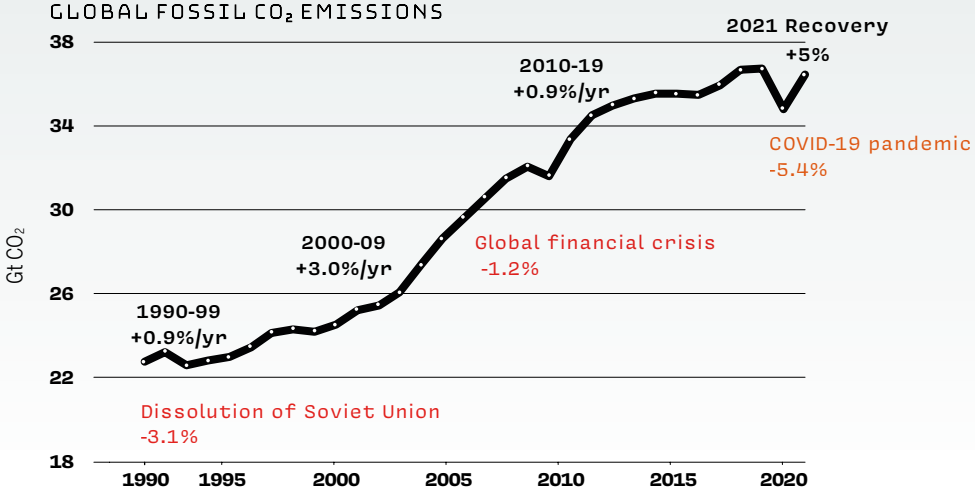
GLOBAL CARBON BUDGET

HISTORY	**GLOBAL WARMING BETWEEN** between 1850-1900 and 2010-2019	**HISTORICAL CUMULATIVE CO_2 EMISSIONS** from 1850 to 2019 (Giga-tons of CO_2)		
	1.07°C	2390		
FUTURE	**TEMPERATURE LIMIT**	**ESTIMATED REMAINING CARBON BUDGET** from the beginning of 2020 (Giga-tons of CO_2) Probability of limiting global warming to temperature limit		
		50%	**67%**	**83%**
	1.5°C	500	400	300
	1.7°C	850	700	550
	2.0°C	1350	1150	900

www.ipcc.ch



GLOBAL FOSSIL CO_2 EMISSIONS



Source: Slide 12 https://robbieandrew.github.io/GCB2021/index.html

Climate Change: **THE CONSEQUENCES**

Q3 **Have you or someone you know been affected by climate change? What are the effects in other parts of the world?**

What will happen in Luxembourg?

The **catastrophic effects** of climate change in Luxembourg include extended periods with no rain or cloud cover, causing extensive dry spells during the spring and summer, followed by warmer winters with greater risk of flooding.

Climate change mitigation: preventing or reducing GHG emissions, such as investing in renewable energy.

Climate change adaptation: adapting to climate change that is or will occur, such as flood protection.

WHY IS 1.5 °C IMPORTANT ?

HUNDREDS OF YEARS FROM NOW

IMPACTS FOR 2100

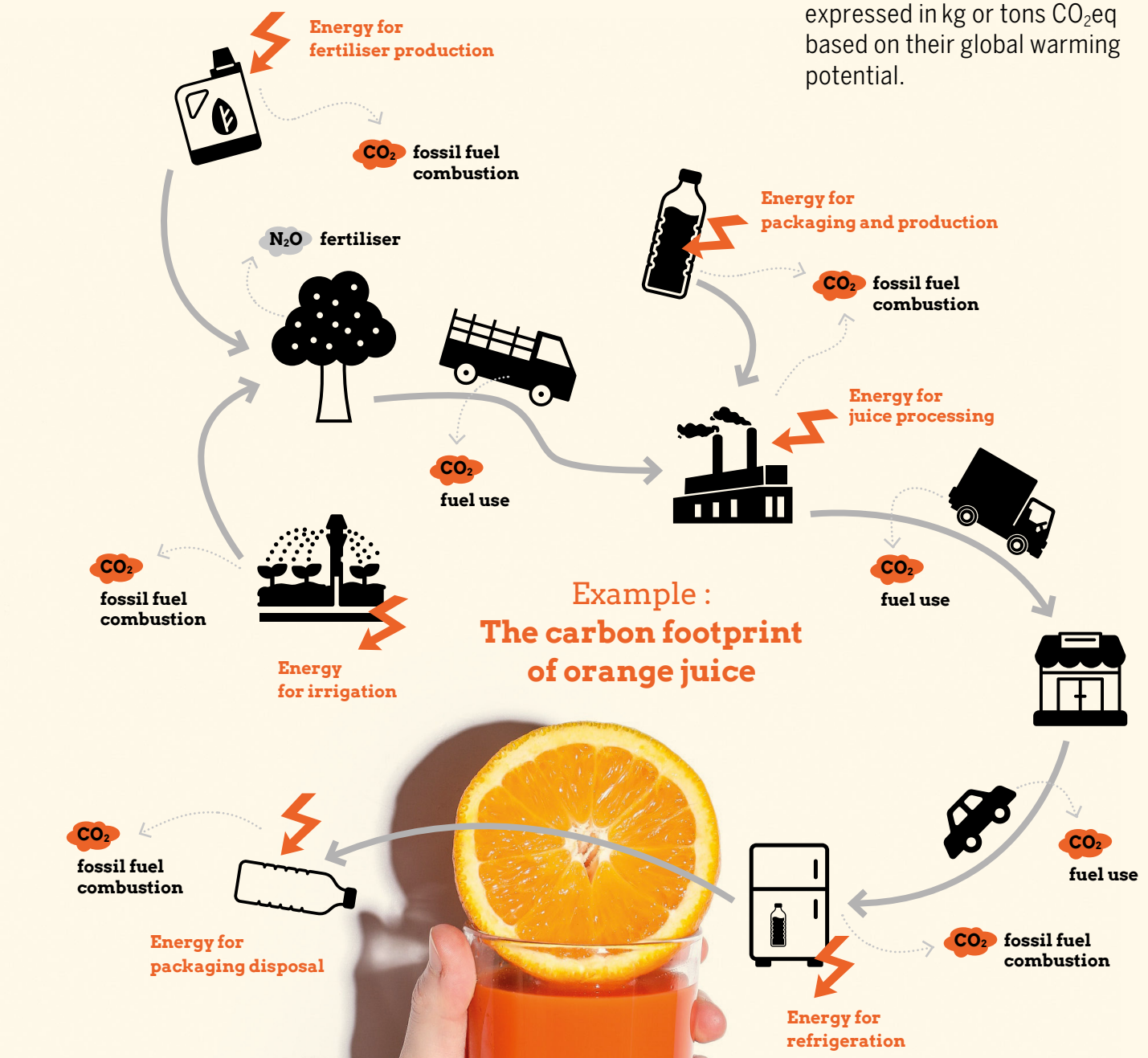
4 °C	3 °C	2 °C	1.5 °C	
More frequent and extreme draughts	10 months average drought, 97% more burned area in wildfires	4 months average drought, 62% more burned area in wildfires	2 months average drought, 41% more burned area in wildfires	IMPACTS ON DROUGHT AND WILDFIRES
High levels of food insecurity, development path reversed	Local fish species go extinct	Agriculture yields fall rapidly	Wheat, rice, maize and soybean production suffers	IMPACTS ON FOOD
470-760 million people at risk; sea level rise of nearly 9 meters	Near-complete melting of the Greenland ice sheet; sea level rise of 7+ meters	Fewer opportunities for infrastructure adaptation; sea level rise of 56cm	Rising sea levels displace 46 million people; sea level rise of 48cm	IMPACTS ON COASTS
Half of all plant and animal species face local extinction	Marine ecosystems may collapse	Virtually all coral reef lost	Coral reefs would decline by 70-90 percent	IMPACTS ON NATURE

Source : https://wedocs.unep.org/bitstream/handle/20.500.11822/37341/LCCA_EGI.pdf

Carbon Footprint: **What is it?**

WHAT IS THE CARBON FOOTPRINT?

It's the sum of direct and indirect GHG emissions of a product or process over its life cycle, expressed in kg or tons CO_2eq based on their global warming potential.



Example : **The carbon footprint of orange juice**

www.climateactiontracker.org

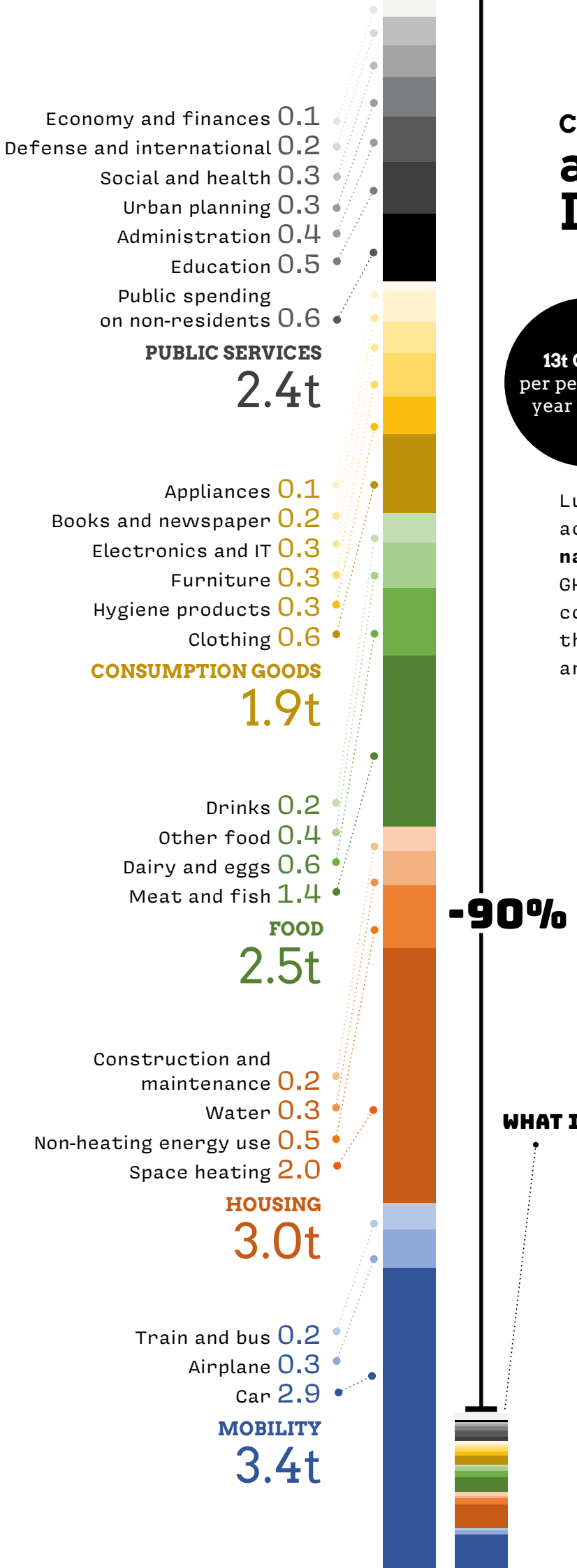
CARBON FOOTPRINT OF PRODUCTS

Take a look at the life-cycle GHG emissions from the production of a bottle of orange juice.

HOW DOES IT RELATE TO ME?

Calculating one's own carbon footprint helps us understand the impacts of our consumption choices, such as whether to take the car or bus or what type of food to buy. Even if industry and the public sector do their part to decarbonise, we need to change our consumption choices, in order to fully decarbonise to reach the Paris Agreement target.

Q4 **Can you describe the GHG emissions related to the production, use, and disposal of a car, a t-shirt, or a mobile phone?**



CARBON FOOTPRINT OF THE

average Luxembourger

13t CO_2eq per person per year in 2019

The **consumption-based carbon footprint** (shown here) adds up GHG emissions occurring anywhere in the world due to consumption in Luxembourg. Another kind of accounting is the **production-based national inventory**, which includes GHG emissions occurring within the country, irrespective of whether the goods produced in Luxembourg are also exported.

WHY IS A LUXEMBOURGER'S CARBON FOOTPRINT SO HIGH?

At 13 t CO_2eq per person per year, Luxembourg's carbon footprint is higher than those of our neighbors, currently at 11 t in Germany and 8.6 t in France and Belgium. It is so high mainly because Luxembourg is a rich country and residents are more likely to own larger houses, several cars, and fly at least once per year. Luxembourgers are also less likely to take public transportation.

WHAT IS OUR TARGET FOR 2050?

To be aligned with the 1.5 °C target, each person would need to have an annual carbon footprint of 1 to 2 tons CO_2eq in 2050 (allocating GHG emissions equally to the world population).

WHY ISN'T OUR TARGET ZERO?

Some sectors will still produce GHG emissions in 2050, and these need **to be countered with carbon uptake** or sequestration **to achieve net zero emissions**.

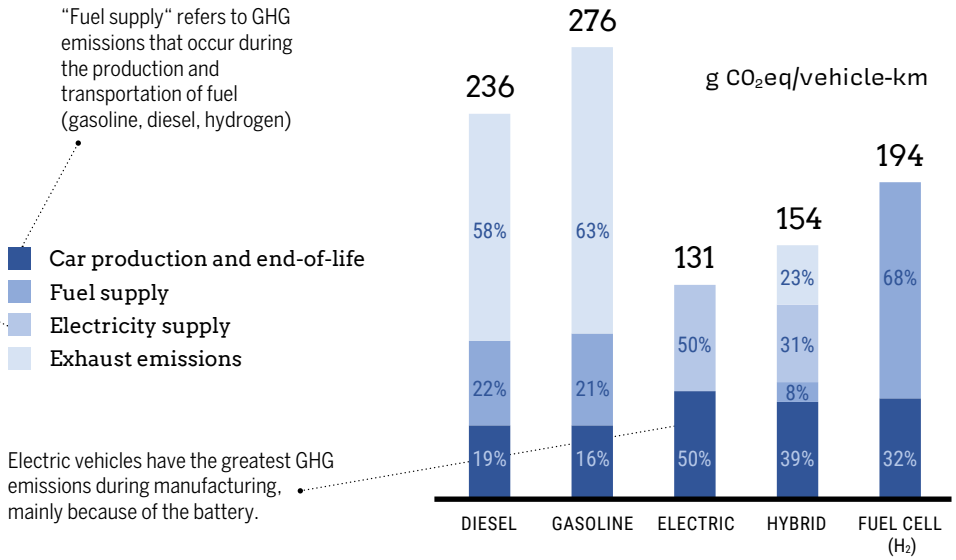
LIFE-CYCLE GHG EMISSIONS FOR CARS

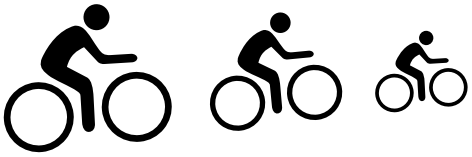
"Fuel supply" refers to GHG emissions that occur during the production and transportation of fuel (gasoline, diesel, hydrogen)

Emissions from "electricity supply" will decline as the electricity grid decarbonises.

- Car production and end-of-life
- Fuel supply
- Electricity supply
- Exhaust emissions

Electric vehicles have the greatest GHG emissions during manufacturing, mainly because of the battery.





When we compare different modes of transport, we use "passenger-km" (1 passenger transported 1 km) to account for differences in the average number of people transported per vehicle. **For example,** an average car emits 256 g CO_2eq/vehicle-km, assuming 50% diesel and 50% gasoline cars. Since a car is occupied by 1.15 people on average, we get (256 g CO_2eq/vehicle-km)/(1.15 passenger/vehicle)= 222 g CO_2eq/passenger-km.

GHG EMISSIONS FROM TRAVEL

(g CO_2eq/passenger-km)

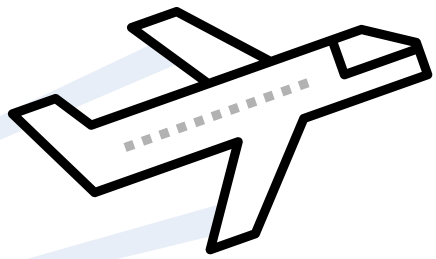
	2021	2050
CAR	222	53
BUS	80	40
TRAM	21	15
RAIL	59	40
AVIATION	206	150
BIKE	12	19
WALK	0	0

Switching to electric vehicles and decarbonisation of the electricity grid will reduce GHG emissions from cars and buses

Biking is the only mode of transportation with an increase in GHG emissions, because of the increasing share of electric bikes.

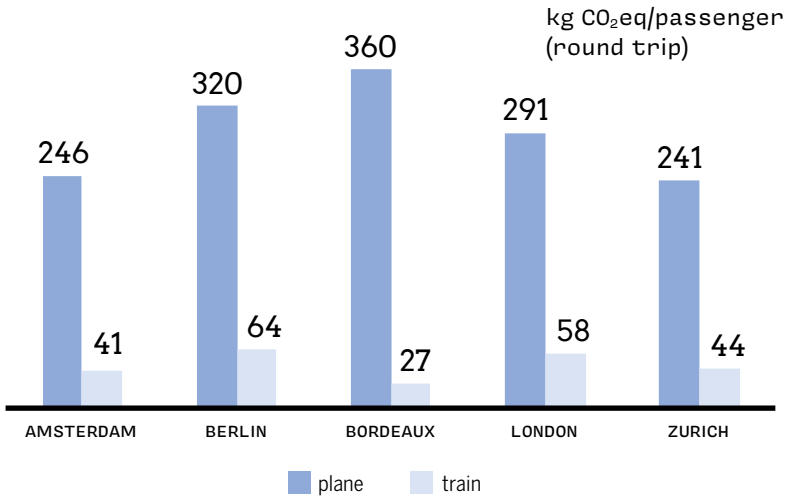
MOBILITY 26%

Q5 How many kg of CO_2eq would you save per day in 2022, if you took the bus instead of the car to your school or your work that is 10 km away from home?



PLANE

The total global warming effect of air travel is at least **double the impact of CO_2 emissions from fuel combustion** due mainly to the warming effect of condensation trails (contrails) - the white cloudy trails that airplanes paint in the sky.

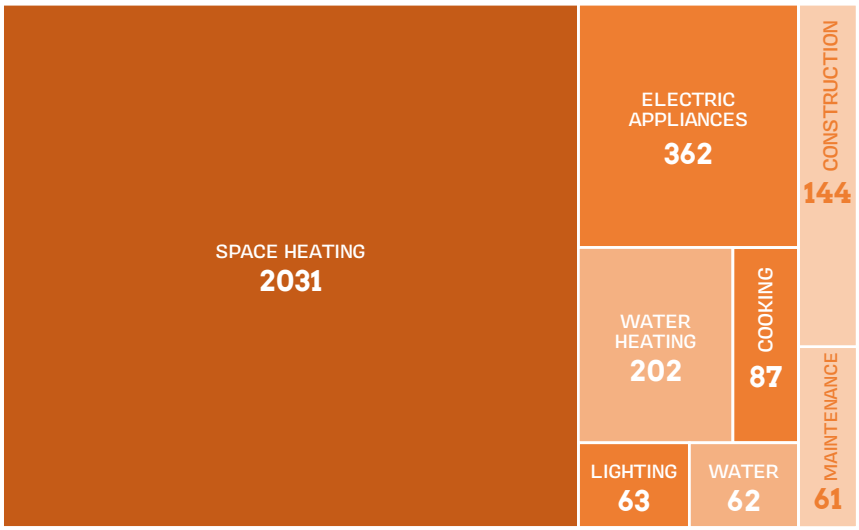


HOUSING 23%

Space heating represents 67% of housing emissions

In Luxembourg, 88% of residents use fossil fuels to heat their home (55% natural gas and 35% oil)

Most of the impacts of our home are due to heating and electricity consumption, while the impacts for its construction, maintenance and end-of-life are less significant.



LIFE-CYCLE GHG EMISSIONS FROM HOUSING

(kg CO_2eq/person/year)

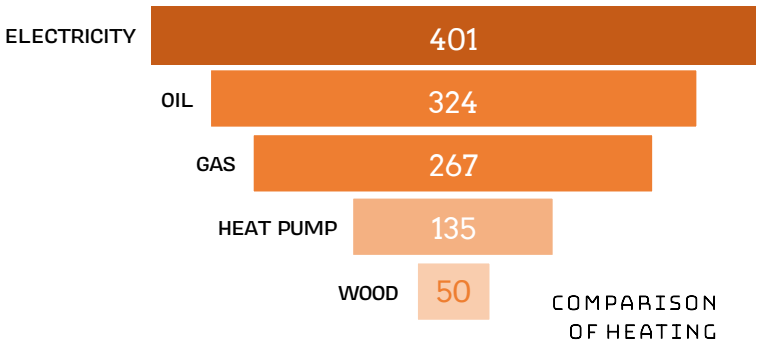
- Space heating
- Non-heating energy use
- Water
- Construction & Maintenance

How can we reduce GHG emissions from space heating?

Improving energy efficiency (i.e. the energy consumed per m²): energetic renovations and insulation help reduce heat loss. Luxembourg single-family homes have an average energy class rating of F, consuming 220 kWh/m² per year compared to 101 kWh/m² for single-family homes in France.

Reducing the housing size: the larger our home, the higher our heating needs. Luxembourg has one of the highest average housing sizes in Europe (144 m² compared to the European average of 105 m²).

Switching to a low-carbon energy source: the current average in Luxembourg is 280 g CO_2eq/kWh of heat. Heat pumps and wood can reduce the carbon footprint of heating, with 135 and 50 g CO_2eq/kWh respectively (and heat pump impacts keep decreasing with a cleaner electricity!).



COMPARISON OF HEATING SOURCES

(g CO_2eq/kWh)

Zero energy buildings: zero energy buildings are designed to consume very little energy, while also supplying that energy on-site from renewable sources, such as solar panels.

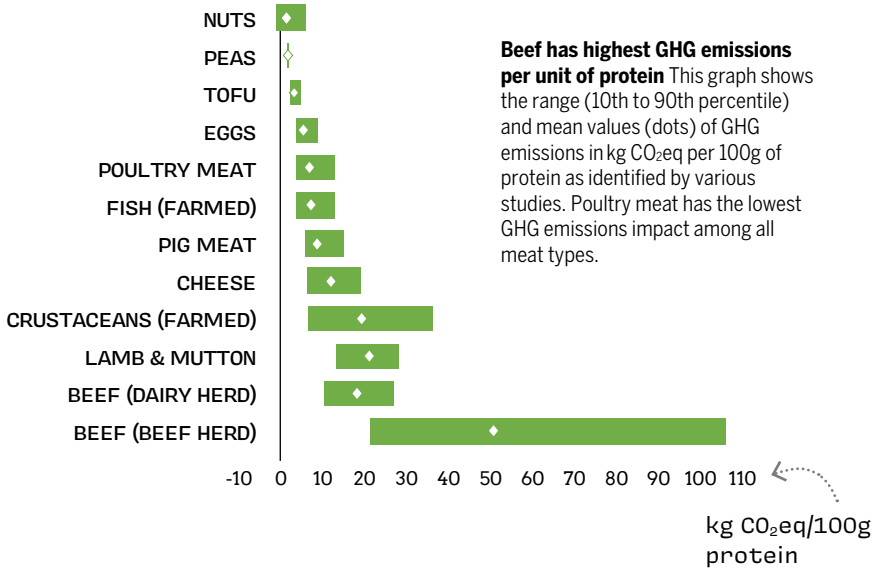
Q6 **Do you know with which energy source your home is heated?**

19%
FOOD

75%

of our food-related carbon footprint of 2.5 t CO_2eq per person per year is due to meat and dairy consumption.

The majority of emissions (82%) occur at the farm stage because of direct GHG emissions from soil and livestock explained below.

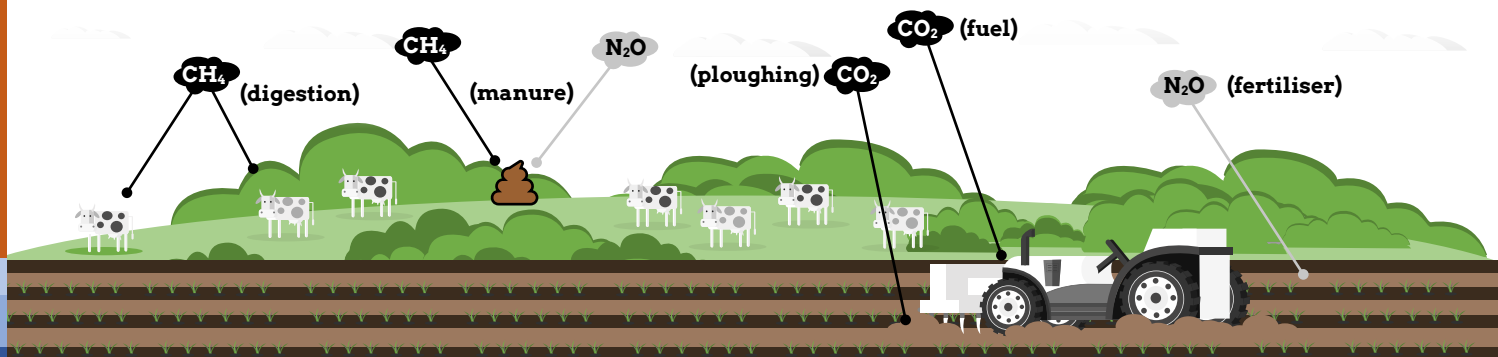


Beef has highest GHG emissions per unit of protein This graph shows the range (10th to 90th percentile) and mean values (dots) of GHG emissions in kg CO_2eq per 100g of protein as identified by various studies. Poultry meat has the lowest GHG emissions impact among all meat types.

What can I do?

Eat less meat

We consume more than double the recommended amount of meat per day. Adjusting our diet to meet the dietary guidelines would reduce food-related GHG emissions by 30%. Switching to a vegetarian or vegan diet would reduce our food carbon footprint by 47% and 51%, respectively.

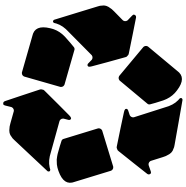


Cattle and sheep release methane (through burps and farts) when they digest food in a process called **enteric fermentation. Manure** from all livestock produce nitrous oxide and methane emissions.

Q7 One cow burps out 2.5 t CO_2eq of methane per year. **The carbon footprint of 1 person living in Luxembourg (13 t CO_2eq/year) is equivalent to the annual enteric fermentation emissions of how many cows?**

Soil management emissions occur when a field is ploughed. Over-fertilisation also contributes to nitrous oxide emissions.

14%
CONSUMPTION GOODS



1. RETHINK YOUR NEEDS

Do I need this good?

Refusing consumption is the greenest action.

For occasional use, rent instead of buying.

Broken device? Repair it

Impacts of reparation lower than if producing new.

Do it yourself, repair cafe or ask a specialist.

Rethink functionalities

Devices with high capacities (e.g. large and high-resolution screens, high volume washing machine) generally have higher impacts.

2. PREFER SECOND-HAND

Rethink your consumption

Impacts of reuse (conditioning and transport) lower than the ones of producing a new item

Q8 What are good places to look for second-hand items?

3. LOOK FOR GREENER OPTIONS

Energy-efficient products

Impacts of electronics and electric appliances are dominated by the consumption of electricity, so energy efficiency is particularly important.

Durable and reparable products

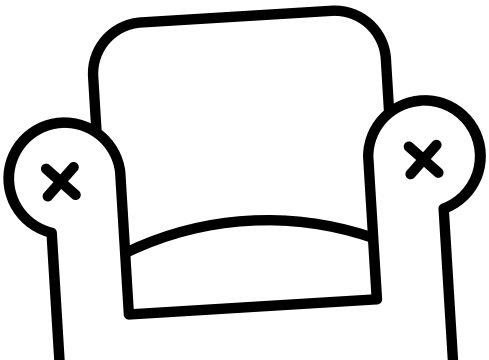
Prefer high quality products, with better warranty, to extend the lifetime of products.

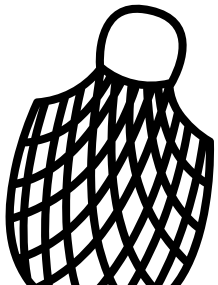
Ecolabeled products

Lower impacts compared to the average of the product category.

Shopping online?

Environmental benefits if it avoids a trip to a physical shop with your car.

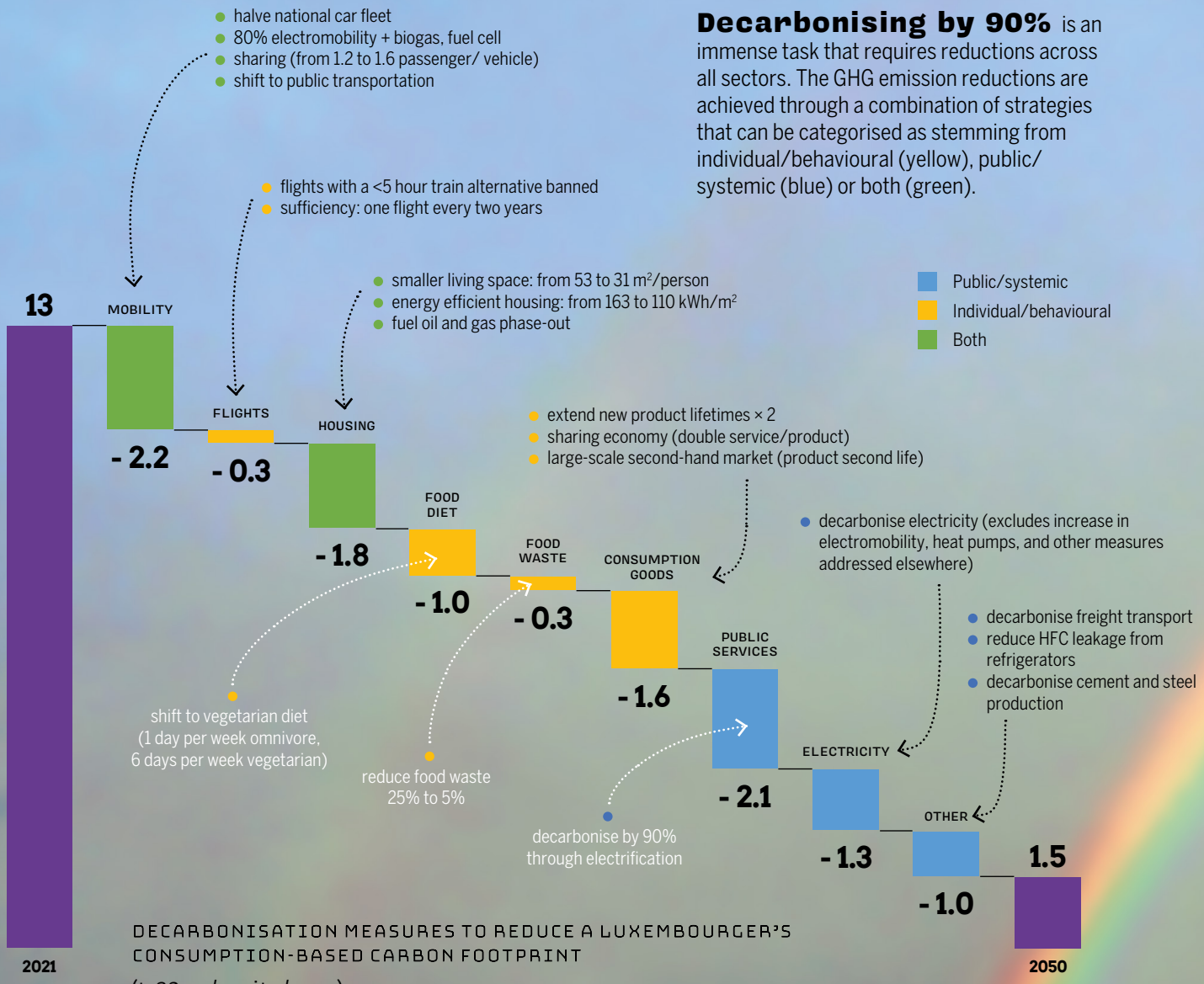




Decarbonisation

Q9 What can the government do and what can individuals do to reduce GHG emissions?

Decarbonising by 90% is an immense task that requires reductions across all sectors. The GHG emission reductions are achieved through a combination of strategies that can be categorised as stemming from individual/behavioural (yellow), public/systemic (blue) or both (green).



DECARBONISATION MEASURES TO REDUCE A LUXEMBOURGER'S CONSUMPTION-BASED CARBON FOOTPRINT

(t CO_2eq/capita/year)

If we rely solely on individual/behavioural change, we fall short of our target and continue emitting 5.9 t CO_2eq/capita/year.

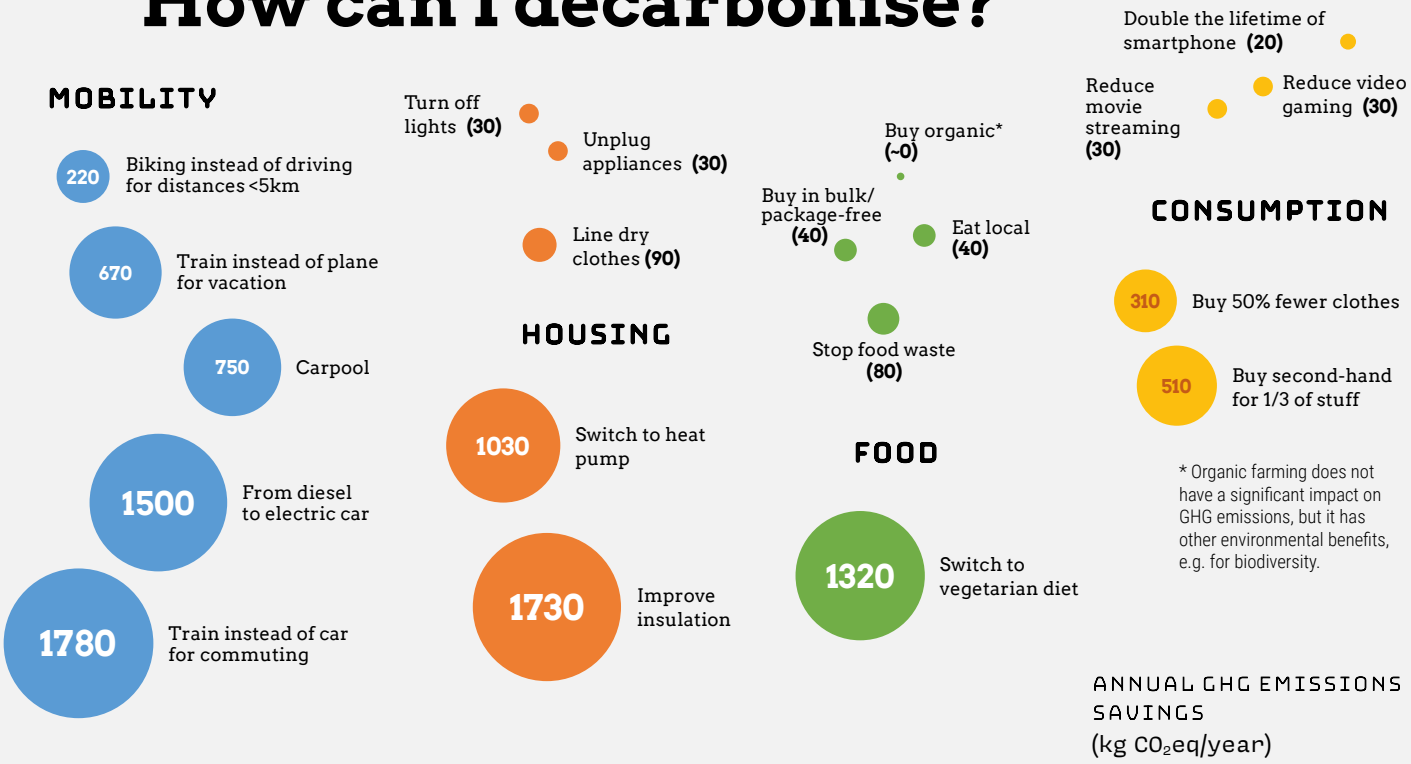
Similarly, if we implement only systemic changes, we are also left with emissions of 4.7 t CO_2eq/capita/year in 2050.

The two drivers of change—individuals and government—are thus equally called to action.

WHAT ABOUT CARBON UPTAKE OR SEQUESTRATION?

What do we do with the remaining emissions of 1.5 t CO_2eq/capita/year in 2050? We need to significantly improve our carbon sequestration efforts, such as through re-forestation and improved management of agricultural soils. Two other technologies may help us get to **net zero** emissions. **Carbon capture and storage** refers to capturing CO_2 emitted from industrial sources and storing it. **Direct air capture,** which remains very expensive, refers to capturing CO_2 from the air and storing it.

How can I decarbonise?



[redacted]

- 110 kg CO_2eq/an

Martin makes sure to always turn off lights when he leaves a room (-30kg CO_2eq), and he also tries to buy shampoo and detergent in bottles with recycled content or reduced packaging (-40 kg CO_2eq). Half of the time, he buys organic or local fruit and vegetables (-40 kg CO_2eq), because he knows that's good for the environment.

[redacted]

- 1920 kg CO_2eq/an

Carla recently started taking public transportation instead of the car to school (-1780 kg CO_2eq). She does not spend a lot of time on her smartphone (-60 kg CO_2eq). She is also very careful with food to avoid waste (-80 kg CO_2eq).

[redacted]

- 3830 kg CO_2eq/an

Naima does not have a car, so she always takes public transportation (-1780 kg CO_2eq) or her bike (-220 kg CO_2eq). As soon as she wants to purchase new clothes, books or furniture, she looks for second-hand stores and platforms to avoid the purchase of new goods (-510 kg CO_2eq). Because of animal welfare and to help the planet, she stopped eating meat (-1320 kg CO_2eq).

IT'S IMPORTANT that we know at least approximately how impactful different actions are. This kind of knowledge is called carbon numeracy. Without it, we might allocate our effort inefficiently and end up doing too little of actions that are very impactful, such as using public transportation, improving home insulation and switching to heat pumps, and eating less meat. Consider that Martin, in our example above, may believe he is doing a lot more in fighting climate change and protecting the environment than he actually is.

Q10 Every little bit helps when it comes to reducing GHG emissions. **Are you already doing any of the actions listed above? How many kg of CO_2eq in emissions are you avoided per year? Did any of the numbers surprise you?**

PROTEST, RALLY, AND VOTE AS SOON AS YOU'RE OLD ENOUGH!

Make your voice heard, go to climate rallies, and speak to your local, national, and EU politicians. Without changes to government regulations, we won't be able to decarbonise. Governments create the right incentives for industry decarbonisation, expansion of public transportation, energy efficiency improvements in buildings, and reduction of GHG emissions from agriculture.

You can seek inspiration from Greta Thunberg, who inspired the global Fridays for Future movement through her weekly school strikes in front of the Swedish Parliament. Make your voice heard!

What else can I do?

Make your voice heard!

EDUCATE YOURSELF AND YOUR FRIENDS ABOUT CLIMATE CHANGE AND WHAT YOU CAN DO TO DECARBONISE.

It's important that you know your carbon footprint and the reduction in GHG emissions that different actions can achieve. Without this knowledge, you may put too much effort into a low-impact action while putting too little effort into a high-impact action. Keep this brochure handy and check out our website for updates, so you can keep yourself and your friends informed. And speak up when you see wasteful behaviour, and inspire others to do their part to mitigate climate change.

RESOURCES TO CHECK OUT

LIST CarbonNerd website	list.lu/en/research/project/carbonnerd
Youth for Climate LU	youthforclimate.lu
Scienteens Lab	https://wwwen.uni.lu/lcsb/scienteens_lab
Science.lu	science.lu
Energy Charts	energy-charts.info
EU Decarbonisation Tool	tool.european-calculator.eu
The shift project	theshiftproject.org
La fresque du climat	fresqueduclimat.org
IPCC Reports	ipcc.ch
Open GHG Map	openghgmap.net

Sources

The carbon footprint of an average Luxembourgish resident was calculated by LIST based on these main sources:

National statistics (yearly transport data per mode, car ownership, household energy consumption, house size, heating sources, electricity mix, purchasing power) from Eurostat, STATEC, Odysee-MURE and ENTSOE.

European data for consumption goods and food from Sala & Castellani (2019) *(https://doi.org/10.1016/j.jclepro.2019.118050).*

Carbon footprint of processes and products from ecoinvent database.

Carbon footprint of public services from EXIOBASE database.

The carbon footprint estimates of DE, FR, and BE come from the consumption footprint platform of the European Commission's Joint Research Center, *(https://eplca.jrc.ec.europa.eu/ConsumptionFootprintPlatform.html).* According to their estimates the LU footprint is 11 t CO_2eq per capita per year, compared to our estimate of 13 t CO_2eq per capita per year.

Additional sources were used for each chapter of this booklet:

Mobility: the comparison of vehicles is based on Ricardo Energy & Environment (2017) study for the European Commission *(https://ec.europa.eu/clima/system/files/2020-09/2020_study_main_report_en.pdf).*

Housing: statistics on housing size in Luxembourg and Europe come from STATEC (2014) (*https://statistiques.public.lu/catalogue-publications/regards/2014/PDF-27-2014.pdf).*

Food: the impacts of single ingredients come from the meta-analysis of Poore & Nemecek (2017) *(DOI: 10.1126/science.aaq0216)*

Decarbonisation potential of line drying clothes, eating local, organic or bulk food from the French Energy & Environment Agency ADEME tool «Nos gestes climat» *(https://nosgestesclimat.fr/documentation).*

Decarbonisation potential of food waste reduction was calculated from European Parliament data *(https://www.europarl.europa.eu/news/en/headlines/society/20170505STO73528/food-waste-the-problem-in-the-eu-in-numbers-infographic).*

Decarbonisation potential of digital actions were derived from the report of Gröger (2020) of the Öko-Institut *(https://www.oeko.de/fileadmin/oekodoc/Digitaler-CO_2-Fussabdruck.pdf).*

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