Cheeseburger

PEAS 2022-2023

Sources

- Published papers
- Web resources
- If you are interested Just ask and I’ll give you the details.

Recipe

Ingredients	kg/hamburger
Bread	0,0740
Hamburger	0,0900
Dressing	0,0200
Lettuce	0,0280
Onions (freeze dried)	0,0017
Cucumber (pickled)	0,0074
Cheese	0,0145

Bread

Assume that the bread is frozen and put in storage for some time before preparation of the hamburger.

No estimation of mass flows for ingredients other than wheat flour.

Wheat flour and water are the main ingredients in bread while margarine, yeast, sugar and salt are minor inputs.

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Bread: mass flows

	kg/hamburger
kg bread	0.074
kg bread to restaurant	0.078
kg bread to storage facility	0.078
kg bread baked	0.097
kg flour needed	0.067
kg wheat milled	0.083
kg wheat cultivated	0.083

Bread: energy

	Low, MJ	High, MJ
Crop production incl. drying	0.17	0.24
Milling	0.03	0.39
Baking	0.45	1.0
Storage	0.31	1.6
Transportation	0.07	0.09
Total	**0.96**	**3.2**

Baking and storage are the most energy consuming stages and transportation the least energy consuming one.

Note: 1MJ = 239,006 KCal

Patty: mass flows

	kg/hamburger
kg meat	0.090
kg meat to frying table	0.093
kg meat to restaurant	0.11
kg meat to storage facility	0.11
kg meat to cutter	0.14
kg animal to slaughter house	0.23
kg of feed consumed	1.45

Patty: feed requirements

Feed composition	**kg/hamburger**
Cereals	0.68
Protein fodder	0.043
Coarse fodder, DM	0.72
Pasture on arable land, DM	0
Pasture, cutover, DM	0

Patty: feed requirements

Assumed that the meat came from a spring born calf that eats 2’728 kg of feed before attaining a carcass weight of 265 kg.

The feed consumption per kg live weight is 6.4 kg with a dressing yield of 62 %.

Feed is supposed to be composed of barley (cereals), fodder peas (protein fodder) and hey (coarse fodder).

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Patty: energy use

	Low, MJ	High, MJ
Crop production, drying, fodder production	3.5	5.0
Stable, slaughtering, cutting	0.23	1.4
Grinding, freezing	0.12	0.16
Storage	0.45	2.3
Frying	0.79	1.0
Transportation	0.44	0.59
Total	**5.6**	**10**

Patty: energy use

The energy use per kg of hamburger becomes 62-116 MJ per kg.

Crop production, drying and fodder production are the most energy demanding stages followed by storage and frying.

Assumed: patty is frozen after processing.

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Lettuce: mass flows

	kg/hamburger
kg lettuce	0.028
kg lettuce to restaurant	0.039
kg lettuce harvested	0.039

Lettuce: energy use

	Low, MJ	High, MJ
Crop production	0.04	4.27
Storage	0.02	0.05
Transportation	0.04	0.04
Total	**0.09**	**4.36**

Onions (freeze-dried): mass flows

	kg/hamburger
kg onions	0.0017
kg onions to restaurant	0.0021
kg onions to storage facility	0.0021
kg onions entering processing in freeze-dry plant	0.017
kg onions delivered to freeze-dry plant	0.020
kg onions entering long-term storage	0.021
kg onions harvested	0.021

Onions (freeze-dried): energy flows

	Low, MJ	**High, MJ**
crop production	0.012	0.015
freeze-drying	0.041	0.073
storage	0.0039	0.0093
transportation	0.0085	0.0109
Total	**0.057**	**0.12**

Cucumber

kg cucumber/Big Mac	0.0074
Kg cucumber to restaurant	0.010
kg cucumber to storage facility	0.010
kg cucumber entering processing in canning plant	0.016
kg cucumber delivered to canning plant	0.019
Kg cucumber harvested	0.019

Pickled cucumber

	Low, MJ	High, MJ
crop production	0.0074	0.0097
storage	0.0008	0.0074
pickling	0.02	0.032
transportation	0.014	0.0072
Total	0.046	0.056

Cheese

As with the hamburger, analysing mass flows for cheese includes accounting for fodder needs of dairy cows.

The mass flows for cheese shows that about 12 kg of milk are needed for 1 kg of cheese in a hamburger.

Assumed: milk came from a cow that eat 5’820 kg of feed while milking 7’300 kg of milk during one year.

The feed is supposed to be composed of barley (cereals), fodder peas (protein fodder) and hey (coarse fodder).

We assume that the amount of feed consumed is equal to the amount of barley, peas and hey produced not considering losses during feed preparation or farm losses.

No allocation was made to the meat of the cow’s calf.

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Cheese: mass flows

	kg/hamburger
kg cheese	0.015
kg cheese to restaurant	0.017
kg cheese to storage facility	0.017
kg milk to dairy plant	0.18
kg milk milked from cow	0.18
kg feed consumed	0.14

Cheese: feed requirements

feed composition	kg/hamburger
Cereals	0.037
Protein fodder	0.015
Coarse fodder	0.065
Pasture	0.022
Minerals	0.0005

Cheese: energy use

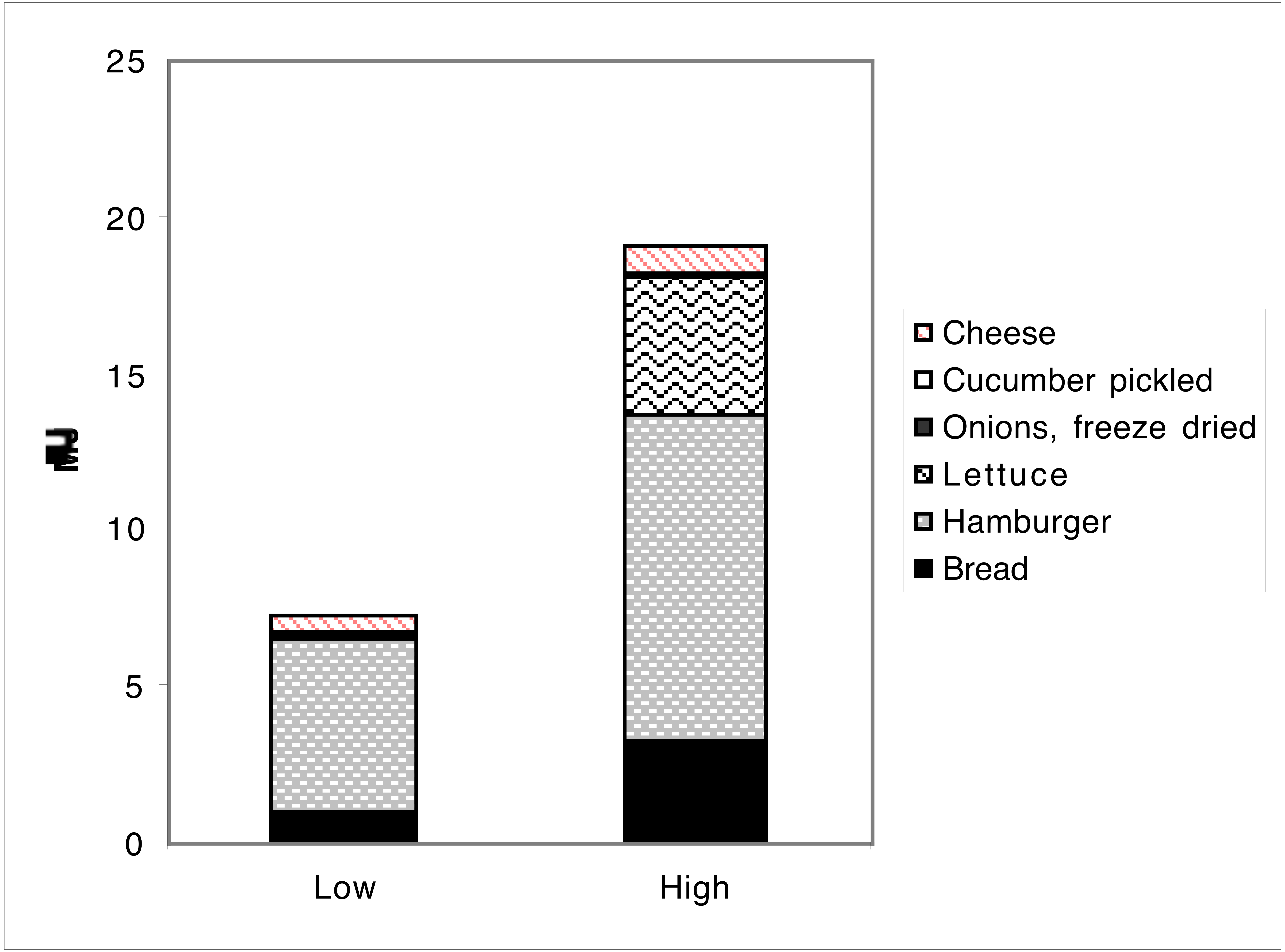
	Low, MJ	**High, MJ**
Crop production, drying, fodder production	0.26	0.37
Milking, making cheese	0.16	0.32
Storage	0.01	0.07
Transportation	0.11	0.15
Total	**0.54**	**0.90**

Total energy use for a hamburger

When we summarise the analyses for the various ingredients in a hamburger, the resulting energy use varies between 7.3-20 MJ.

It is the hamburger itself that requires the most energy followed by lettuce if this crop is cultivated in a greenhouse.

The energy use for the ingredients freeze-dried onions and pickled cucumber are minor when compared to the total; together they represent only about 1 %.



McDonald’s methane emissions

With a sprawling empire of 39,000 restaurants in 119 countries, McDonald’s Corp. serves more beef than any other restaurant chain on the planet — between one to two percent of the world’s total.

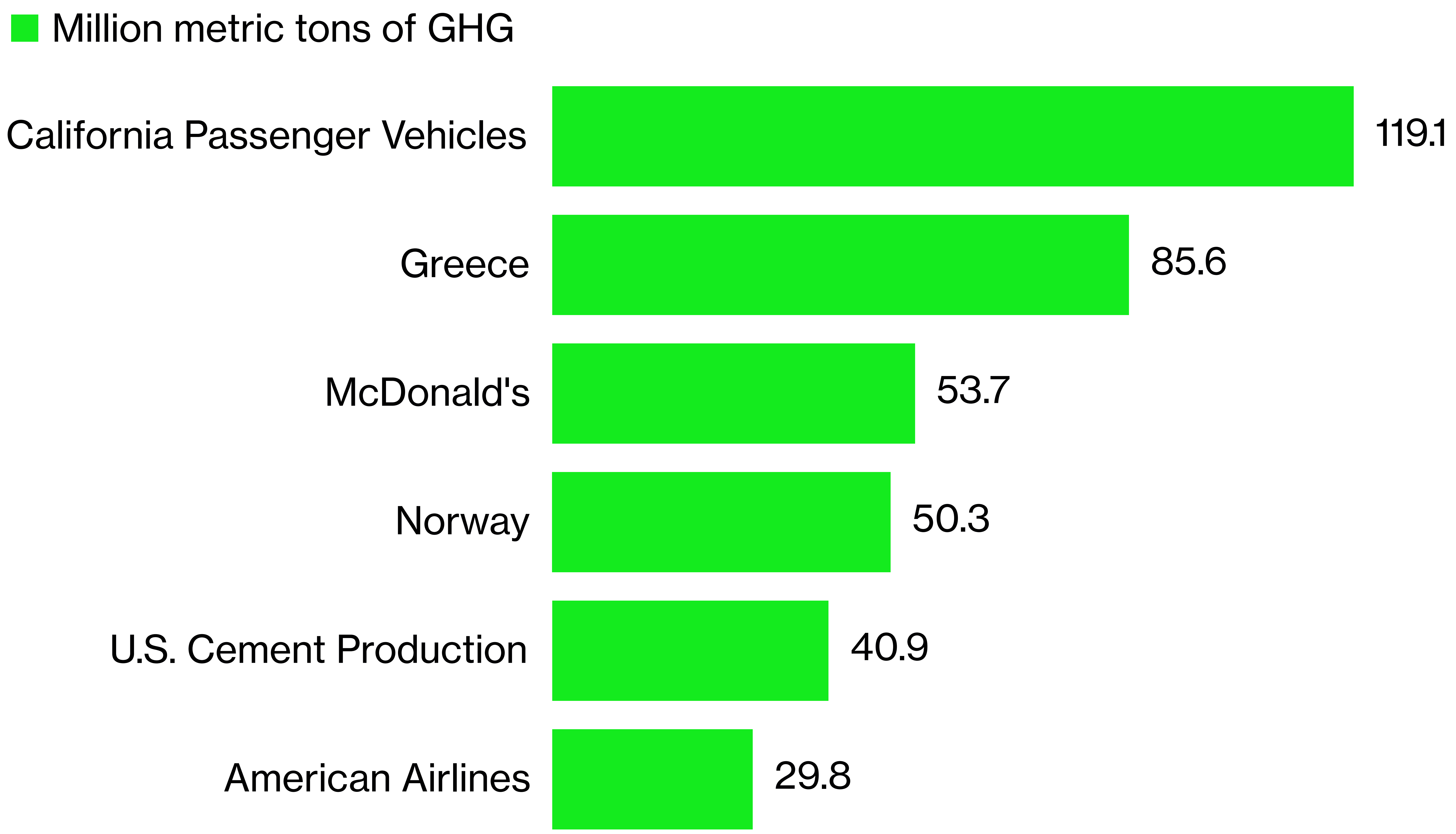
Selling hundreds of hamburgers every second has entrenched the fast-food giant as an outsized contributor to climate change.

Cattle belch out large quantities of heat-trapping methane, making beef the most harmful food for the climate, with at least five-times the warming of pork or chicken and more than 15-times the impact of nuts or lentils.

Beef is responsible for about a third of McDonald’s climate footprint. At more than 53 million metric tons of carbon per year, McDonald’s produces more emissions than Norway — and that number is still rising.

Supersized Footprint

How heat-trapping emissions at McDonald's stack up



The carbon footprint of foods: are differences explained by the impacts of methane?

How we treat the climate impacts of methane has a significant difference on the carbon footprint of foods.

But even if we exclude methane, meat and dairy products have the highest footprint.

Methane

It could be argued that red meat and dairy have a much higher footprint because its emissions are dominated by methane – a greenhouse gas that is much more potent but has a shorter lifetime in the atmosphere than carbon dioxide.

Methane emissions have so far driven a significant amount of warming – with estimates ranging from around 23% to 40% of the total – to date.

Methane

Since there are many different greenhouse gases researchers often aggregate them into a common unit of measurement when they want to make comparisons.[2]

The most common way to do this is to rely on a metric called ‘carbon dioxide-equivalents’.

This is the metric adopted by the Intergovernmental Panel on Climate Change (IPCC); and is used as the official reporting and target-setting metric within the Paris Agreement.

Methane

Carbon dioxide-equivalents' (CO_2eq) aggregate the impacts of all greenhouse gases into a single metric using 'global warming potential'.

More specifically, global warming potential over a 100-year timescale (GWP_{100}) – a timeframe which represents a mid-to-long term period for climate policy.

Methane

To calculate CO_2eq one needs to multiply the amount of each greenhouse gas emissions by its GWP_{100} value – a value which aims to represent the amount of warming that each specific gas generates relative to CO_2.

For example, the IPCC adopts a GWP_{100} value of 28 for methane based on the rationale that emitting one kilogram of methane will have 28 times the warming impact over 100 years as one kilogram of CO_2

Methane: problems with aggregation

Methane is short-lived, CO_2 is long lived: this makes aggregation difficult.

To understand why the conversion factor of 28 is criticised one needs to know that different greenhouse gases remain in the atmosphere for different lengths of time.

In contrast to CO_2, methane is a short-lived greenhouse gas. It has a very strong impact on warming in the short-term but decays fast.

This is in contrast to CO_2 which can persist in the atmosphere for many centuries.[5]

Methane therefore has a high impact on warming in the short term, but a low impact in the long run. This means there is often confusion as to how we should quantify the climate impacts of methane.

Methane and CO_2

Methane's shorter lifetime means that the usual CO_2-equivalence does not reflect how it affects global temperatures.

So CO_2eq footprints of foods which generate a high proportion of methane emissions – mainly beef and lamb – don't by definition reflect their short-term or long-term impact on temperature.

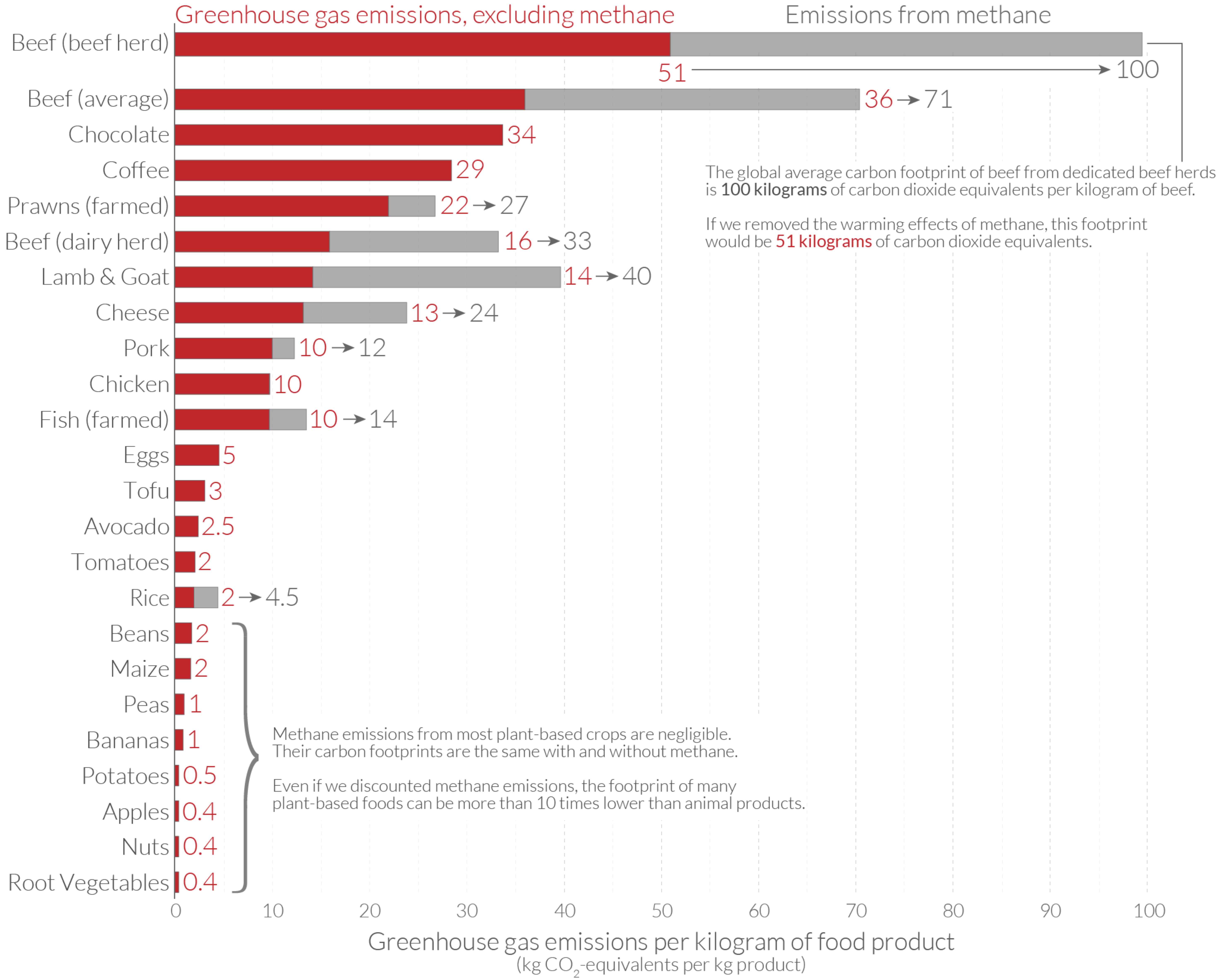
How big are the differences with or without methane?

The question then is:

1. Do these measurement issues matter for the carbon footprint of different foods?
2. Are the large differences only because of methane?

Greenhouse gas emissions from food, short vs. long-lived gases

Greenhouse gas emissions are measured in carbon dioxide-equivalents (CO_2eq) based on their 100-year global warming potential (GWP).
Global mean emissions for each food are shown with and without the inclusion of methane – a short-lived but potent greenhouse gas.

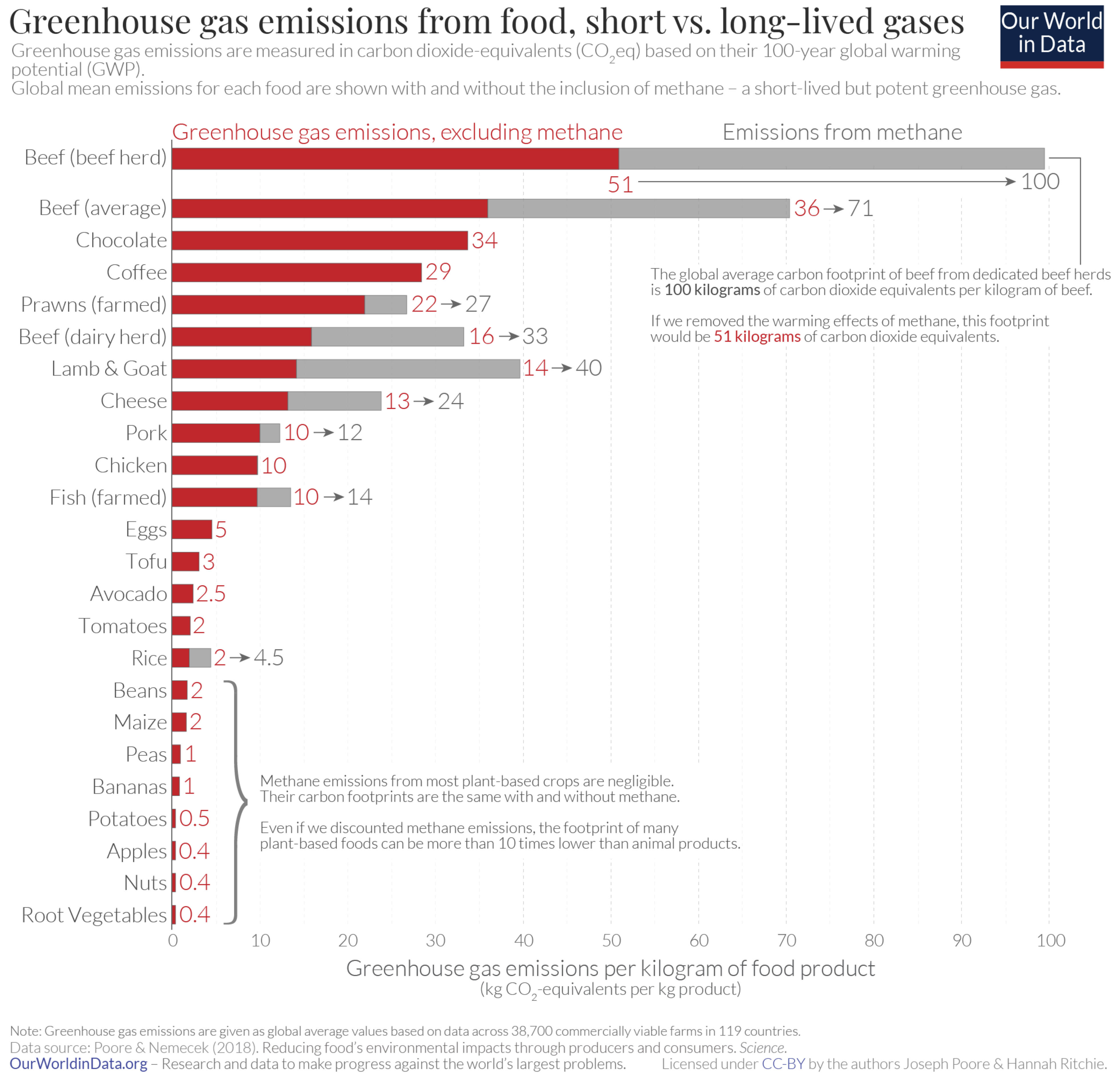


Note: Greenhouse gas emissions are given as global average values based on data across 38,700 commercially viable farms in 119 countries.
Data source: Poore & Nemecek (2018). Reducing food's environmental impacts through producers and consumers. *Science*.

With and without methane

The chart compares emissions in kilograms of CO_2eq produced *per kilogram* of food product.

The red bars show greenhouse emissions we would have if we removed methane completely; the grey bar shows the emissions from methane. The red and grey bar combined is therefore the total emissions including methane.



With and without methane

As an example: the global mean emissions for one kilogram of beef from non-dairy beef herds is 100 kilograms of CO_2eq. Methane accounts for 49% of its emissions. So, if we remove methane, the remaining footprint is 51 kgCO_2eq.

So is it true that red meat and dairy only has a large carbon footprint because of methane? As the red bars show it is not.

Although the magnitude of the differences change, the ranking of different food products does not.

With and without methane

The differences are still large.

The average footprint of beef, excluding methane, is 36 kilograms of CO_2eq per kilogram.

This is still nearly four times the mean footprint of chicken.

Or 10 to 100 times the footprint of most plant-based foods.

With and without

Where do the non-methane emissions from cattle and lamb come from?

For most producers the key emissions sources are due to:

land use changes;

the conversion of peat soils to agriculture;

the land required to grow animal feed;

the pasture management (including liming, fertilizing, and irrigation);

the emissions from slaughter waste.

Without converted land?

What about the impact of producers who are not raising livestock on converted land?

Do they have a low footprint?

When we exclude methane, the absolute lowest beef producer in this large global dataset of 38,000 farms in 119 countries had a footprint of 6 kilograms of CO_2eq per kilogram.

Emissions in this case were the result of nitrous oxide from manure; machinery and equipment; transport of cows to slaughter; emissions from slaughter; and food waste

6 kilograms of CO_2eq (excluding methane) is of course much lower than the average for beef, **but still several times higher than most plant-based foods.**

Comparing the footprints of protein-rich foods

Is it perhaps misleading to compare foods on the basis of mass?

After all one kilogram of beef does not have the same nutritional value as one kilogram of tofu.

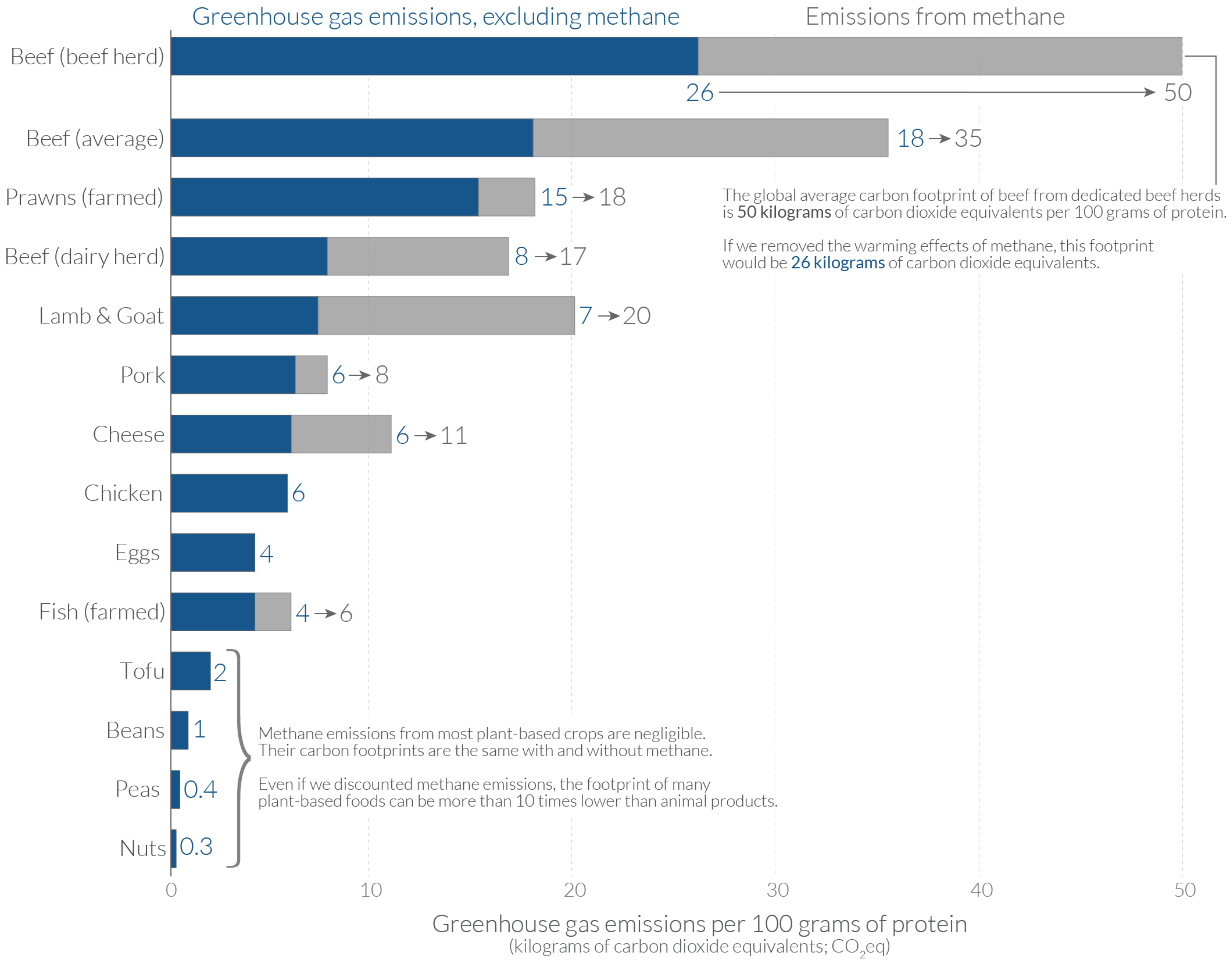
Comparing the footprints of protein-rich foods

Consider the carbon footprint per 100 grams of *protein*.

Again, emissions from methane are shown in grey; but this time, emissions excluding methane are shown in blue.

Greenhouse gas emissions from protein-rich foods, short vs. long-lived greenhouse gases

Greenhouse gas emissions are measured in carbon dioxide-equivalents (CO_2eq) based on their 100-year global warming potential (GWP).
Global mean emissions for each food are shown with and without the inclusion of methane – a short-lived but potent greenhouse gas.



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OurWorldinData.org – Research and data to make progress against the world's largest problems.

Comparing the footprints of protein-rich foods

The results are again similar: even if we excluded methane completely, the footprint of lamb or beef from dairy herds is:

- five times higher than tofu;
- ten times higher than beans;
- and more than twenty times higher than peas for the same amount of protein.

Lettuce: energy use

The energy use for lettuce show high variations due to the cultivation methods assumed: open ground or in greenhouse.

The energy use per kg of lettuce varies between 3.4- 160 MJ per kg.

For lettuce produced in greenhouse, it is the crop production stage that is the most energy demanding.

Assumptions about storage time and transportation distance are the same in both examples.

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