Eating meat – a WinACC view

"Meat production and climate change are tightly linked".[1]

Introduction

Globally food production contributes a large proportion of all greenhouse gas emissions. It has been estimated that in 2009 the UK's embodied emissions in food were 27% of all direct emissions and 19% of the UK's total emissions when imported food is included as well.[2]

Meat and greenhouse gas emissions

Whether to eat meat, what meat to eat and how often are questions that WinACC is sometimes asked. Here meat is taken to include red meat (beef, veal, lamb etc.), white meat (mostly chicken but also other fowl) and fish. WinACC is also sometimes asked whether it encourages vegetarian or vegan diets.

This document provides guidance on this complex area with emphasis on the ecological and environmental impacts of meat eating. The health implications of eating meat are beyond the scope of the document, as are animal welfare considerations.

What are the benefits of eating meat?

Meat provides proteins and is a source of vitamin $B_{12.}$ It also contains saturated fat and lacks fibre. Fish provide oils, such as Omega 3 fatty acids, not readily obtained from other food.

Are some meats environmentally better than others?

The environmental impact of meat depends on many factors. We need to look at the impact on the global carbon and nitrogen cycles of an animal that is bred for food and at its overall contribution to greenhouse gas (GHG) emissions. It has been estimated that, globally, livestock production is the second biggest source (18%) of all GHG emissions after energy production, ahead of transportation,

[1] Kanaly, R. A., L. I. O. Manzanero, et al. (2010). Energy Flow, Environment and Ethical Implications for Meat Production. Bangkok, Thailand, Ethics and Climate Change in Asia and the Pacific (ECCAP) Project Working Group 13 Report**:** 76 pp.

[2] Berners-Lee, M., C. Hoolohan, H. Cammack, and C.N. Hewitt. "The Relative Greenhouse Gas Impacts of Realistic Dietary Choices." *Energy Policy* 43 (April 2012): 184–90.

fossil fuel retrieval and agriculture.[1,3] Fairlie has argued that the figure of 18% is based on erroneous assumptions and a more accurate estimate is about 10%.[4] The emissions from extensive production are estimated to be about 2.5 times those from intensive production[5] but this estimate is said to exclude indirect emissions associated with intensive production.[6]

The relative contributions to emissions from three common types of meat are shown in Table 1. Table 2 shows the amounts of fossil fuels involved in producing various meats and maize in the USA.

Table 1. Greenhouse gas emissions from the intensive production of different meats [7]

Meat	Chicken	Pork	Beef
Emissions (kg CO_2eq/kg of meat)	1.1	3.8	14.8

Table 2. Comparison of the amounts of fossil fuel energy required in the USA to produce 1 kcal of meat, using intensive methods, or grain protein[8]

Food	Maize	Broiler chicken	Turkey	Pigs	Eggs*	Beef	Lamb
Fossil fuel energy (kcals)	2.2	4	10	14	39	40	57

*The relatively high value for eggs can probably be explained by the intensive production methods considered by the authors.

Red and white meat

A cow that is industrially reared and fed maize, grain or soy that has been grown in a field, which required fertilisers and possibly extensive irrigation, contributes to global warming (for example, 75% of the total nitrous oxide emissions in Europe are caused by livestock farming).[9] An energy dense, human diet high in meat and animal products generally consumes more energy resources than a human diet based on plants. Even though grain feeding of animals to be killed and eaten by humans results in significant energy losses during conversion of grain calories to meat calories, it has been estimated that more than a third of the world's grain production is currently used as feed

[3] Goodland, R. and J. Anhang (2009). "Livestock and Climate Change: What if the key actors in climate change are cows, pigs, and chickens?" World Watch (November/December): 10-19. These authors have suggested that emissions may be as high as 51%.
[4] Fairlie, S. (2010). Meat - a benign extravagance, Permanent Publications.
[5] Steinfeld, H., P. Gerber, et al. (2006). Livestock's long shadow. Rome, UN, FAO: 26 pp.
[6] Anon. (2010). Briefing: Factory farming's hidden impacts. London, Friends of the Earth: 8 pp.
[7] http://www.scientificamerican.com/slideshow.cfm?id=the-greenhouse-hamburger. Scientific American, Feb 2009, p.75.
[8] Pimentel, D. and M. Pimentel (2003). "Sustainability of meat-based and plant-based diets and the environment." American Journal of Clinical Nutrition **78**: 660S-663S.
[9] Idel, A. (2011). "Cows are not climate killers!" Ecology & Farming(4): 16-19.

for animals.[1] Thus, it is said that about ten times more energy would be gained by humans eating the maize directly than by eating the cow that ate the maize, yet 40 per cent of the world's grain harvest is fed to livestock! Further, ruminants such as cows and sheep produce methane (at both ends of the animal). Both nitrous oxide and methane are powerful GHGs. Similar arguments apply to dairy cows so it is also better to consume less cheese, milk and similar products.

On the other hand a cow or sheep that has been raised on sustainable pasture contributes to a carbon-rich topsoil from its dung. Such pasture may be based on ground that is unfit for growing crops (too steep or inaccessible or initially the soil is too poor). The natural permanent grasses that feed the cow or sheep are said to be the largest terrestrial carbon sink on Earth[9]. Properly managed, pasture land is probably the most efficient natural means of capturing CO_2 in temperate latitudes.[10] In winter, such an animal requires much less sustenance from crops grown for the purpose. Sometimes sheep and/or cattle are used to graze grassland in order to encourage the growth of wild flowers and to maintain certain habitats.

Pigs and chickens used to be fed on catering and domestic food waste, which has a very low carbon footprint, but since 2001 this is contrary to EU regulations (although it is still legal to feed them some waste such as bread[11]). Pigs and chickens are more efficient at converting feed from intensive agriculture into meat for human beings than ruminant cattle and so are less carbon-intensive.[1]

Wild meat

Wild meat comes from animals (e.g. game) that live in the wild, and therefore form part of a sustainable natural cycle (sometimes with a human contribution), but have been shot or culled for human consumption. In the UK, examples include deer of all sorts, rabbit, hare, woodpigeon, pheasant, partridge and duck.[12] However the sustainable stocks are relatively small and such meat is usually more expensive than reared meat.

Exotic meat

Exotic, i.e. non-indigenous, animals bred for meat include water buffalo and boar, both of which are reared at Laverstoke Park in Hampshire, bison, elk, red deer and ostrich. These animals are especially bred in the open air and tend to be luxury products with unknown carbon footprints.

[10] Sudbury, G. (2010). Meat - To Eat or not to Eat.
[11] http://kerrymccarthy.wordpress.com/2012/03/14/feeding-pigs/
[12] http://en.wikipedia.org/wiki/Game_(food)#United_Kingdom

People in other cultures eat cold-blooded animals such as reptiles[13] and insects[14] which contain protein but fewer calories and fat. Being cold-blooded, insects convert plant matter into protein extremely efficiently; they don't spend energy on keeping warm.[15] It is said that 'farming insects emits ten times less greenhouse gas than farming livestock'.[14]

Fish

Fish are mostly either harvested at sea or grown in fish farms (a few come from rivers or inland breeding ponds). A distinction needs to be made between carnivorous and herbivorous species. A carnivorous fish lives higher up the food chain (trophic level), requires about ten times as much energy to sustain it and is more susceptible to being a stronger source of persistent pollutants such as heavy metals and some organic compounds. In the wild this distinction has less impact on the environment than in a fish farm, where energy has to be used to produce the herbivorous fish that are fed to the carnivorous fish. For example, it takes vast quantities of fish caught in the wild to provide sufficient fishmeal and fish oil to feed farmed salmon. One scientific study calculated that more than three pounds of wild fish - anchovies, herring, sardines, menhaden, mackerel and the like - are needed to produce one pound of marketable farmed salmon.[16] Other carnivorous fish include tuna, shark and swordfish.

It is better to eat herbivorous fish such as carp, tilapia, and barramundi which preferably have been caught in the wild. Grescoe[17] recommends eating Pacific halibut, herring, Atlantic mackerel, trout and blue whiting and not, under any circumstances, blue fin tuna, Chilean sea bass, Atlantic cod, grouper, Atlantic halibut, marlin, monkfish, orange roughy, shark, dogfish and skate whose populations have become endangered by overfishing. Overfishing leads to a waste of resources (fishing boats are underused, to meet quotas, and have to travel greater distances or stay longer at sea to find their catch).

It is good practice to buy only fish with a Marine Stewardship Council (MSC) or similar label. The MSC is a global organisation that allows suppliers to use its MSC ecolabel on fish that have been reared or harvested sustainably. The Global Aquaculture Alliance has similar objectives; look for suppliers with their Best Aquaculture Practices (BAP) certification. In the UK, among others, the Soil Association and the Organic Food Federation have developed aquaculture standards for organically farmed fish. This may also help to avoid fraudulent descriptions of the fish being bought.

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[13] http://www.fitday.com/fitness-articles/nutrition/healthy-eating/the-nutrition-of-snake.html; http://voices.yahoo.com/the-dangers-eating-reptiles-5455819.html
[14] http://travel.usnews.com/features/Countries_That_Eat_Bugs/
[15] http://www.worldchanging.com/archives/011453.html
[16] http://www.puresalmon.org/pdfs/feed.pdf
[17] Grescoe, T. (2009). Dead seas, Pan.

Processed meat

Processed meats include a variety of products usually derived from red meat, such as bacon, ham, sausages, meat balls and meat paste. Fast food such as frozen pizzas also contains processed meat. Many of these products use edible offal, edible fats, bone, blood, intestines, and gelatine from food processing plants (abattoirs) – in other words, parts of animals which would otherwise be thrown away. So they make meat production more efficient. However, producing processed meat also involves the use of extra electricity and gas not only for cooking but also for mechanical processing, canning, smoking and refrigeration[18]. The energy used for cooking is probably more efficient on an industrial scale than in our homes, but the other uses mean that in general processed meat is likely to have a larger carbon footprint than unprocessed meat.

The contributions of packaging and transport

Packaging, while important for protecting meat from contamination and *vice versa,* i.e. containing blood, contributes a small amount to the carbon footprint of meat. For example, carbon was reduced and shelf life extended, thereby reducing waste, by changing from plastic trays to shrink-wrapped and vacuum 'skin packs' for some meats[20]; other sorts of packaging, which allow customers to sub-divide the purchase into separate portions, have been proposed for chicken.[19] A lot of packaging is now diverted from landfill and is re-cycled. In 2008, the UK avoided sending 8.9 Mt CO_2 to landfill by recycling food packaging.[20]

The transport of feedstock and meat also involves GHG emissions. More than two-thirds of the protein-rich feed crops for livestock in the EU are imported, e.g. from South America. Meat is imported in refrigerated ships, e.g. mutton from New Zealand. Shipping currently accounts for around 1 billion tonnes of carbon dioxide and it has been suggested that this could triple by mid-century.[21] In 2007 maritime transport emitted 3.3% of the world's total CO_2 emissions.[22] The CO_2 emissions released by the shipping sector may already be a larger proportion of the global total than the CO_2 released by the aviation sector[23] however, because a ship can carry far more cargo than an

[18] http://www.fpeac.org/meat/EnergySavingsinMeatProcessing.pdf
[19] http://www.wrap.org.uk/sites/files/wrap/packaging_design_to_reduce.pdf
[20] http://www.meatinfo.co.uk/m/fullstory.php/aid/9476
[21] van_Renssen, S. (2012). "Stuck on shipping." Nature Climate Change **2**: 767-768.
[22] Lindstad, H., B. E. Asbjørnslett, et al. (2011). "Reductions in greenhouse gas emissions and cost by shipping at lower speeds." Energy Policy **39**(6): 3456-3464.
[23] Gilbert, P., A. Bows, et al. (2010). Shipping and climate change: Scope for unilateral action. Manchester, Tyndall Centre**:** pp.103.

aeroplane, the GHGs emitted per kg of meat brought by sea is much less than that brought by air.[24] Some sea-food is also air-freighted leading to an even higher carbon footprint than if it was locally sourced. Grescoe[17] quotes a worst-case scenario whereby a salmon farmed off Chile could be sent by container to China, to be filleted, and then by sea to Vancouver from where it could be trucked across Canada to Nova Scotia, to be processed and packaged, and then sent back to a supermarket in San Diego, California having covered 22,300 miles. He estimates that to bring a 5 kg farmed salmon to the American consumer causes the emission of 53 kg of CO_2. Therefore it is better to buy imported meat and sea-food which has been carried by sea instead of by air. It may also be better to buy meat and sea-food produced locally, or at least in the UK, depending on the circumstances under which it was reared. For example, free range animals reared abroad may have a lower carbon footprint at the sales counter than animals reared in UK under intensive conditions.

However, moving away from a diet of red meat and dairy will have an even greater impact on climate change (in the USA, and possibly elsewhere) than avoiding transport emissions. To quote ref.1 (underlining added) "Through life-cycle assessments, Weber and Matthews (2008)[25] demonstrated that dietary changes are an effective means for reducing GHG emissions. They explained that although food is transported long distances in general, the high GHG emissions associated with food consumption are dominated by the production processes and not transportation. In the U.S., 83% of the average household's GHG emissions from food consumption originated from the production process. Indeed, they concluded that modification of human diets by just shifting less than one day per week's worth of calories from red meat and dairy products to chicken, fish, eggs, or a vegetable-based diet achieved more GHG reduction than buying all locally sourced food."

How to reduce your carbon footprint from eating meat

Clearly we cannot survive without eating food but we can reduce the environmental impact of what we eat by altering our diet. A recent study for the European Commission[26] recommended changes in behaviour to reduce the carbon emissions from food including meat. The changes include: changing to a vegetarian diet, reducing the intake of animal protein, eating a larger share of local and seasonal food so as to reduce imported food, and reducing energy and fuel use from shopping,

[24] MacKay, D. J. C. (2008). Sustainable energy - without the hot air. Cambridge, UIT shows (Fig.15.8) that about 16 times as much energy is required per tonne for air freight than for sea freight. Weber, C. L. and H. S. Matthews (2008). "Food-miles and the relative climate impacts of food choices in the U.S." Environmental Science and Technology **42**: 3508-3513 suggest in their Table 1 that the ratio is at least 49.
[25] Weber, C. L. and H. S. Matthews (2008). "Food-miles and the relative climate impacts of food choices in the U.S." Environmental Science and Technology **42**: 3508-3513.
[26] Faber, J., A. Schroten, et al. (2012). Behavioural Climate Change Mitigation Options and Their Appropriate Inclusion in Quantitative Longer Term Policy Scenarios (Main report). Delft, Netherlands, CE Delft**:** 87 pp.

cooling (refrigeration) and cooking. Specifically for the UK it has been suggested that switching from a diet rich in meat and dairy to a nationally recommended diet with more fruit, vegetables and nuts could cause food-related emissions to fall by up to 17%.[27] Simply eating less meat or, at least, to move from eating red meat (beef, mutton and lamb) to white meat could entail a concurrent and advantageous reduction in the number of ruminants.[28]

Rejecting meat entirely (vegetarianism and veganism)

With the growing realisation of the environmental impact of most forms of meat production and the ever increasing threats posed by global warming many people are becoming vegetarians or vegans. In the UK, food-related greenhouse gas emissions of meat-eaters are approximately twice those of vegans.[29] Neither vegans nor vegetarians eat meat. However, while vegetarians tend to consume dairy products and eggs, a vegan avoids all edible animal products, including eggs and dairy.

But meat is a major source of essential-to-health protein. We need protein in our diet to help our body repair cells and make new ones. Without protein, the human body cannot function normally. So how can a vegetarian or vegan replace the lost protein? There are numerous non-meat sources of protein such as beans and lentils, low-fat or non-fat dairy products, fish and shellfish, tofu and other soy foods, nuts, nut butters and seeds, and eggs. There are also meat substitutes, such as a plant-based burger,[30] that can provide satisfying alternatives to the real thing. Generally speaking a milk and eggs vegetarian diet requires a 20% larger intake of protein that a meat diet, and for a fully vegan diet this is 30%. Even so, the modern western diet has been said to contain much more protein than needed.[31]

Many of the arguments for not eating meat have been presented already. In addition one can mention that feeding grain to livestock increases the global demand for grain and drives up grain

[27] Behrens, Paul, Jessica C. Kiefte-de Jong, Thijs Bosker, João F. D. Rodrigues, Arjan de Koning, and Arnold Tukker. "Evaluating the Environmental Impacts of Dietary Recommendations." *Proceedings of the National Academy of Sciences*, December 4, 2017, 201711889.
[28] Ripple, W.J., Smith, P., Habert, H., Montzka, S.A., McAlpine, C., and Boucher, D.H. "Ruminants, Climate Change and Climate Policy." *Nature Climate Change*, no. January (2014): pp.4.
[29] Scarborough, Peter, Paul N. Appleby, Anja Mizdrak, Adam D. M. Briggs, Ruth C. Travis, Kathryn E. Bradbury, and Timothy J. Key. "Dietary Greenhouse Gas Emissions of Meat-Eaters, Fish-Eaters, Vegetarians and Vegans in the UK." *Climatic Change* 125, no. 2 (July 2014): 179–92. https://doi.org/10.1007/s10584-014-1169-1.

[30] Curran, Tony. "The Burger Apocalypse: Low Carbon Eating and Avoiding Food Waste." *The Conversation* (blog), October 20, 2017. https://theconversation.com/the-burger-apocalypse-low-carbon-eating-and-avoiding-food-waste-85860.
[31] Westhoek, H., Rood, T., Van den Berg, M., Janse, J., Nijdam, D., Reudink, M., Stehfest,E., 2011. The Protein Puzzle. PBL Netherlands Environmental Assessment. Agency, Bilthoven/The Hague.

prices, making it harder for the world's poor to feed themselves. Grain and water could instead be used to feed people directly. Most meat, dairy and eggs are produced in ways that largely or completely ignore animal welfare. Lastly, meat eating may make us ill. Industrial livestock farming relies heavily on antibiotic use to accelerate weight gain and control infection – in the US, 80% of all antibiotics are consumed by the livestock industry. This contributes to the growing public health problem of antibiotic resistance.[32]

Finally, projections to 2050 of likely cropland and fertiliser needs to feed a growing population found that greenhouse gas emissions from agriculture are likely to increase by 30% over the next 35 years.[33] Something has to give.

For the above reasons we emphasise, more strongly than in the previous version of this document, the importance of cutting back on meat consumption.

Conclusions

1. We should always aim to eat food from lower down the food chain. Food and energy are wasted when animals, destined to be eaten by humans, eat plants such as maize; it would be better if humans ate the maize. A similar waste of potential food occurs when carnivorous animals eat herbivorous animals. This includes carnivorous and herbivorous fish.
2. Our carbon footprint is reduced if we eat less meat, particularly red meat, which has been produced intensively. In general, white meat is better than red meat and, when reared under similar conditions, locally reared meat is better than meat from abroad. Try to buy sustainably produced, local food. Factors to take into account when choosing low-carbon meat include whether the animal was allowed to range freely (extensive) or was industrially reared (intensive), whether the meat is red (beef, veal, mutton and lamb) or white (poultry and pigs) and where the meat has come from (locally, UK or abroad).
3. It is better to avoid carnivorous fish from higher up the food chain, such as tuna, salmon and swordfish and to eat herbivorous fish such as carp, tilapia, and barramundi. Species which have been overfished and whose populations are endangered should also be avoided. Wild fish, caught sustainably, are likely to contain less persistent pollutants than farmed fish although the relative greenhouse gas emissions involved remain to be demonstrated.

[32] Vergunst, Francis, and Savulescu, Julian. "Five Ways the Meat on Your Plate Is Killing the Planet." The Conversation, 2017. 26 April 2017

[33] Tubiello, F.N., Salvatore, M., Condor Golec, R.D., and and 6 others. "Agriculture, Forestry and Other Land Use Emissions by Sources and Removals by Sinks; 1990 – 2011 Analysis." FAO Statistics Division, March 2014.

4. Although simply eating less meat (and dairy products) can reduce your carbon footprint significantly the best way to cut your emissions is to become a vegetarian (no meat) or even a vegan (no meat or dairy products). Approximately, the carbon footprints of a medium meat eater, an occasional meat eater (4 times a week), a vegetarian and a vegan are 1705, 1566, 1391 and 1055 kg CO2e per year, respectively.[34] A vegan generates 650 kg less CO_2 per year or just over 60% of what a medium meat eater does.
5. Overall, to minimise your carbon emissions from food, it is better to move away from a diet based on meat to a diet based more on cereals, vegetables and fruit. These foods will also provide alternative sources of protein.

19 April 2018

[34] Scarborough, Peter, Paul N. Appleby, Anja Mizdrak, Adam D. M. Briggs, Ruth C. Travis, Kathryn E. Bradbury, and Timothy J. Key. "Dietary Greenhouse Gas Emissions of Meat-Eaters, Fish-Eaters, Vegetarians and Vegans in the UK." *Climatic Change* 125, no. 2 (July 2014): 179–92.