Energy Efficiency of Organic Farming
(summary of data from UK Government studies)

Introduction

Organic farming is generally a more energy efficient system of food production, mainly because it does not use inorganic nitrogen fertiliser, which is produced from petro-chemicals. Overall, UK organic farming is about 26% more energy efficient per tonne. It is more efficient in ten sectors, including green vegetables, wheat, milk, sheep and pigs, and less efficient in four sectors, such as chicken and eggs. This table summarises the findings of MAFF and Defra studies on organic farming energy use.

Sector	Organic energy use/t as % of non-organic	Non-organic energy use/t, GJ[5]	Organic energy use/t, GJ[5]	UK production t/yr, 2006[1]	Total UK energy use, GJx10[6]	Total UK energy use if all organic, GJx10[6]	Change in energy use if all organic, GJx10[6]
Milling wheat[2]	**84%**	2.40	2.02	6,115,000	14.67	12.35	-2.33
Oilseed rape	**103%**	4.85	4.99	1,870,000	9.07	9.33	0.26
Potatoes[6]	**114%**	1.49	1.71	5,684,000	8.49	9.70	0.21
Carrots	**75%**	0.60	0.45	718,500	0.43	0.32	-0.11
Cabbage	**28%**	0.90	0.25	262,700	0.24	0.66	-0.17
Onion	**84%**	1.25	1.05	404,500	0.51	0.42	-0.08
Broccoli	**51%**	3.70	1.90	86,900	0.32	0.17	-0.16
Leeks	**42%**	0.95	0.40	49,800	0.05	0.02	-0.03
Beef	**59%**	26.54	15.56	869,000	23.06	13.52	-9.54
Sheep	**43%**	24.99	10.79	333,000	8.32	3.59	-4.73
Pigmeat	**65%**	21.97	14.28	670,000	14.72	9.57	-5.15
Milk	**72%**	2.55	1.83	13,720,000 (unit = 1 m^3)	34.99	25.13	-9.86
Eggs	**110%**	13.66	15.00	443,000 (unit = 20,000eggs)	6.05	6.64	0.59
Poultry meat[3]	**111%**	15.17	16.89	1,500,000	23.40	26.04	2.57
Long season glasshouse tomatoes[4]	**130%**	122.00	159.00	82,684 (for all tomatoes)	10.09	13.15	3.06
Average excluding poultry, eggs & tomatoes	68%						-30.67
Average excluding tomatoes	**74%**						**-27.51**
Average energy use overall	**78%**						**-24.45**

Energy use in agriculture

- The level of energy use in industries is important as the carbon dioxide from fossil fuel energy use is the main cause of climate change, and also because society needs to reduce fossil fuel use to adapt to reducing global oil and gas supplies. In the UK, agriculture accounts for around 2.8% of the country's total fossil fuel energy use (including direct on-farm use and indirect energy use for the manufacture and transport of farm inputs). Overall, energy accounts for less than 9% of agriculture's total greenhouse gas emissions as, unlike in other industries, nitrous oxide and methane are more important greenhouse gases. However, energy use is the only source of greenhouse gases whose production has been analysed and compared between UK organic and non-organic farming. Additionally, energy use in agriculture is highly important due to the reliance of our current food supplies on fossil fuel energy and the expected worrying impacts of tightening global oil and gas supplies.

- In the UK, farming has been industrialised and most (72%) of the energy used in agriculture is used to manufacture and transport various farm inputs: agrochemicals (pesticides and veterinary drugs), farm machinary, and animal feed grain. The remainder of the energy is used by farmers on the farm for: tractor driving, combine harvesting machines, crop drying, milking, heating and ventilating glasshouses, and for heating and lighting factory farms that produce pigs and chicken.

- Defra has funded comparative 'life cycle' analyses for energy use in ten organic and non-organic sectors, which have been carried out by Cranfield University. The results of this study and an earlier MAFF comparative study into some vegetable energy use are presented in this briefing.

- Of the fifteen sectors analysed, **cabbages, leeks and carrots, are the least energy demanding foods** (ie. traditional British vegetables, around or less than 1GJ/t), arable crops and milk are next (a few GJ/t), then meat and eggs (10-30 GJ/t), while **heated glasshouse vegetables are highly energy intensive** (over 100 GJ/t), an order of magnitude greater than other foods. For example, non-organic 'long-season' glasshouse tomatoes requires 136 times as much energy as cabbages per tonne.

- Food may have a low energy use per tonne, but the total impact of a food can still be significant if it is produced and consumed in large quantities. Nationally, despite its relatively low energy use per tonne, the single largest user of energy in total among the food sectors is the milk sector because of its high production volume, followed by the beef and poultry sectors.

Organic farming energy use

- The comparative energy assessments for the fifteen sectors shows that (excluding tomatoes), **UK organic farming is overall about 26% more energy efficient**, if weighted according to the production levels of each sector. Organic farming is an average of 25% more energy efficient for vegetables and 23% for meat and dairy products (unweighted). We have excluded tomatoes from this average, as the data is only for long-season tomatoes which is little used in the UK organic sector. If tomatoes are included and it is assumed that all production is 'long season', then the overall energy efficiency of organic farming would be only 22% less than non-organic.

- **UK organic production is more energy efficient than non-organic production in ten sectors, similar in one, and less efficient in four sectors.** The average energy efficiency of the 10 sectors where organic farming is more energy efficient is 40% less than non-organic production. Organic farming makes the greatest national contribution to reducing national energy use in the milk and beef sectors. The energy use is similar for oilseed rape. The four sectors where it is less energy efficient are: potatoes (14% less efficient); poultry (11% less efficient); eggs (10% less efficient); and long season heated glasshouse tomatoes (30% less efficient).

- This analysis, however, omits data for several sectors such as arable feed crops (where we expect organic production to be around 30% more energy efficient), outdoor salad crops, and other heated glasshouse crops (where we expect organic production to be around 30% less energy efficient). In addition, the calculations are always being refined. Therefore, as further research proceeds, all these figures may change (though we do not expect them to change dramatically).

- **The main reason for the energy efficiency of organic farming is because it does not use inorganic nitrogen fertiliser**. Nitrogen fertiliser is the single main use of energy in farming, accounting for 37% of the total energy use. Nitrogen fertiliser is highly energy intensive, as the raw material is fossil fuels (usually natural gas) and the manufacturing process is also highly energy intensive. Each kg of nitrogen in fertiliser requires 41MJ of energy to produce. Farmers in the UK use about 1 million tonnes of nitrogen in fertiliser each year, applied to cropland and much grassland. More broadly, organic farming is more energy efficient, because it does not rely on industrial inputs but generally uses natural ecological and biological processes on the farm.

- The weakness of organic farming for energy efficiency in North West Europe is **the lower yields of organic farming** (not true for the rest of the world, where non-organic farming is generally less intensive and organic yields are similar or far higher than non-organic). In North West Europe, organic farming yields vary from being fairly similar to non-organic (say, 5% less for outdoor salad crops), to somewhat less (say, 15% less for dairy) to significantly less for a few important sectors (around 40% less for wheat, potatoes and tomatoes). For field crops, organic and non-organic field crops use the same amount of machinery, but the energy burden is distributed over the smaller yield in the organic system. Similarly, for 'long-season' glasshouse production, which involves heated glasshouses, organic and non-organic production require the same volume of glasshouse heating, but this energy burden is distributed over a smaller yield per glasshouse in the organic sector. Significant investment over a long period has maximised non-organic production of crops such as potatoes and wheat. As the development of organic production progresses, we expect yields to continue increasing thus improving energy efficiency.

- The main use of energy use in 'long season' **glasshouse vegetable production** is the heating of the glasshouse out-of-season. Organic heated glasshouses would require similar levels of heating but produce significantly lower yields. Hence the 30% lower energy efficiency of organic long-season tomato production, which we expect would also apply to any other long-season organic glasshouse crops such as courgettes and peppers. However, it should be noted that we believe only a small proportion of UK organic glasshouse vegetable production is long-season. Most UK organic tomato growers only have unheated glasshouse or polytunnel vegetable production, such as for supplying local box schemes which favours seasonal food production. Here the comparative energy efficiency of current UK organic tomato production would be much more favourable, although we do not have data. Non-organic vegetable growers make less use of local marketing (eg. there are almost no non-organic box schemes) and instead are generally geared to supplying the supermarkets during and out-of-season. In the supermarkets, however, organic tomatoes are available all year round, many imported, and many may be produced in heated glasshouses. A solution for UK tomato production would be a move away from heated UK glasshouse production, such as to mostly seasonal consumption of such vegetables or restricting the out-of-season supply to imports from Mediterranean countries where outdoor production is possible all year round (though there are concerns about water use for irrigation). Alternatively, UK long-season glasshouse production could be made more climate-friendly through a switch to renewable or low-carbon energy (eg. solar panels, wind turbines, Combined Heat and Power, or a green electricity supplier).

- Non-organic **poultry production** is very energy efficient because of the very fast growth of factory farmed chickens (modern breeds, artificial lighting etc.). This means high feed to meat conversion rates compared to organic production which is all free-range (genuine free-range

systems with smaller unit sizes, not pop-holes on large industrial sheds) and has slower growth rates. However, we do not believe that continued factory farming is a viable option due to its unacceptable standards of animal welfare. We therefore believe the solution is for consumers to enjoy fewer, but better quality, poultry products. Two factors in organic farming support a lower meat diet: the significantly higher price of organic meat products over non-organic (the price differential is more than for organic and non-organic crops) and the fact that organic livestock farming is more extensive (so the limited farmland area restricts total production).

Climate friendly food

Widespread organic farming would significantly reduce food energy use. A more seasonal diet and reduced consumption of meat would further reduce energy use. However, this data is only about energy use at the farm stage, and significant amounts of energy are used afterwards in the food transport, processing and cooking stages. Additionally, farming produces other greenhouse gases. Overall, for a climate-friendly diet we therefore recommend that people and businesses buy food that is predominantly all of: organic, seasonal, local, unprocessed, and with less (but better quality) meat.

References

1. Production data for field vegetable (except potatoes) from 'Basic Horticultural Statistics 2005', Defra. All other production data from 'Agriculture in the United Kingdom 2006', Defra.

2. This production figure for milling wheat is a Soil Association figure based on data from "Agriculture in the United Kingdom 2006", Defra. We have made the calculation for all UK milling wheat produced in the UK although the energy figure used was for breadwheat only. This is because there is no separate production figure for breadwheat, but only a figure for all wheat for flour milling (ie. including for bread and other milling uses). Milling wheat is 41.5% of the total wheat used domestically including net imports (51% is for animal feed; the rest is seed, other uses and waste). This 41.5% proportion was applied to the total wheat produced (14,735,000t) to give this figure for milling wheat (6,115,000t). This seems acceptable as UK imports and exports of wheat are very small (so the same proportion seems reasonable), and also because a proportion of non-bread milling wheat is produced with the intention of being breadwheat but does not reach the necessary quality (so we have effectively assumed that all non-bread milling has the GWP of breadwheat, although this will be an over-estimate).

3. Figure for total of chickenmeat, boiling fowl and turkeymeat, to match Cranfield University energy use figure which represents a composite of these sectors.

4. "Monthly Report on selected fruit and vegetable crops in England and Wales, position as at 30th November 2006" published by Defra. This figure reflects total volume of UK production leaving the farmgate in 2006.

5. Field vegetable energy use figures (except potatoes) from: 'Energy Use in Organic Farming Systems' (2000) Defra report OF0182. Note, the data for 'broccoli' is actually for calabrese (large green head), but the plant is commonly labelled as broccoli in shops. All other energy use figures from Cranfield University: Williams, A.G, Draft figures from 'Developing and delivering environmental Life-Cycle Assessment (LCA) of agricultural systems, Defra project (IS0222), an updated version of the life cycle assessment: Williams, A.G., Audsley, E. and Sandars, D.L. (2006) "Determining the environmental burdens and resource use in the production of agricultural and horticultural commodities. Main Report. Defra Research Project IS0205."

6. The figures for energy use in potato production is an aggregate of energy figures for first earlies, second earlies and maincrop, weighted to reflect the current conventional mix of the UK potato crop. According to Defra's "Agriculture in the United Kingdom 2006", maincrop potatoes make up 96.7% of the UK's potato harvest, with earlies making up the remaining 3.3%. We took a mean of the energy figures for the first and second earlies and gave this a 3.3% weighting, and the maincrop figure was given a 96.7% weighting in the final figure. Cranfield's finding were that organic potato production used 0%, 9% and 15% more energy than conventional for first earlies, second earlies and maincrop respectively.