Environment

Energy and greenhouse effect

The positive impact of arable crops

As biomass combusts, the CO2 released is the same gas as was temporarily fixed during plant growth, cancelling out the overall impact of this combustion on the greenhouse effect. This is the advantage of agricultural biomass over fossil resources.

In order to evaluate the energy efficiency of agricultural production, the whole farm's consumption must be taken into account, as well as the energy consumption required to manufacture inputs.

Reducing greenhouse gas emissions and developing renewable energy are ambitious objectives for France and the European Union. Those issues closely concern the agricultural sector, which produces and consumes energy, as it emits and "traps" greenhouse gases. Biomass production (1), truly capitalising on photosynthesis, offers environmental benefits. It offers energy benefits since it provides more renewable energy than it consumes by way of non-renewable energy. Its impact on the greenhouse effect can be analysed by calculating carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) emissions, as well as by comparing them to the amount of CO_2 temporarily fixed while the plant is growing. Calculating the long term fixing of carbon in the soil is also relevant, but more difficult to evaluate over a season.

The greenhouse gas "savings" achieved by using biomass instead of fossil resources is a good indicator of the positive climatic impact of that production.

To evaluate this impact, the energy resources consumption and greenhouse gas emissions are calculated at farm level, as well as upstream, manufacturing the inputs, fuel, electricity and equipment used. The aim is to take account of the whole life cycle (extraction, synthesis, construction, packaging, transport) of each of those elements, until their consumption.

Cereals: energy reserves with a neutral impact on the greenhouse effect

Through solar energy being captured and transformed into binding energy in plant tissue, plant production is the first link of our food chain. This is particularly true of the grain, cereals' stockpiling organ, as well as of straw. Those two components constitute an energy resource which can be stored and capitalised on. The potentially usable energy contained in biomass is evaluated using a bomb calorimeter, a device which allows complete combustion in a closed environment. For instance, one kilogramme of wheat grain (with a 15% moisture content), constitutes energy reserves of around 14.5 megajoules (2).

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The amount of energy actually restored depends on the efficiency of the valorisation sector. That kilo of wheat will help to produce around 7.5 megajoules of ethanol and 4.8 megajoules of draff that can be used as animal feed or for heat production.

During raw biomass or biofuel combustion, the carbon emitted into the atmosphere as CO_2 had been temporarily fixed while the plant was growing. Over a whole season, therefore, the global impact of this combustion on the greenhouse effect is neutral, unlike with fossil resources which when they combust, release into the atmosphere a "net" amount of the carbon trapped in the earth's crust.

Energy efficiency and greenhouse gas emissions of two rotations in the Beauce region (large arable production area south of Paris) and in the "bocage" (hedged farmland) of northwestern France *(fig. 1)*					
	Oilseed rape - Winter wheat – Spring barley rotation Beauce, clayey sil - 150 to 170 ha arable farm			Silage maize - Wheat rotation Northwestern "bocage", clayey silt Mixed crop - livestock farm with 80 ha of cereals/oilseeds/pulses	
	Oilseed rape	**Wheat**	**Spring barley**	**Silage maize**	**Wheat**
	Ploughing	Shallow cultivation	Ploughing	Ploughing (cover crop)	Ploughing
Fuel (/ha)	76 L	51 L	73 L	93 L	68 L
Nitrogen fertilisation (/ha)	190 kg of N (liquid urea ammonium nitrate)	130 kg of N (liquid urea ammonium nitrate) + 50 kg of N (ammonium nitrate)	110 kg of N (ammonium nitrate)	25 t of dairy cow manure + 50 kg of N (ammonium nitrate)	160 kg of N (ammonium nitrate)
Herbicide (/ha)	2210 g active ingr.	3210 g a. i.	990 g a. i.	60 g a. i.	740 g a. i.
Fungicide (/ha)	250 g a. i.	540 g a. i.	650 g a. i.	0 g a. i.	530 g a. i.
Insecticide (/ha)	60 g a. i.	6 g a. i.	0 g a. i.	0 g a. i.	0 g a. i.
Regulator (/ha)	0 g a. i.	1170 g a. i.	70 g a. i.	0 g a. i.	80 g a. i.
Yield (/ha)	4 t	8 t (removed straw)	6.5 t (removed straw)	11 t DM	

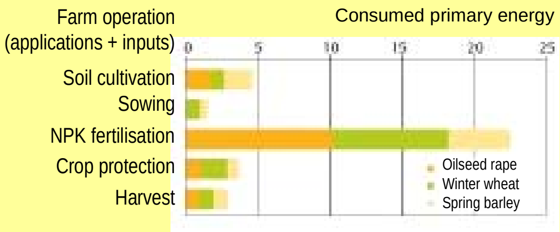
Beauce, clayey silt

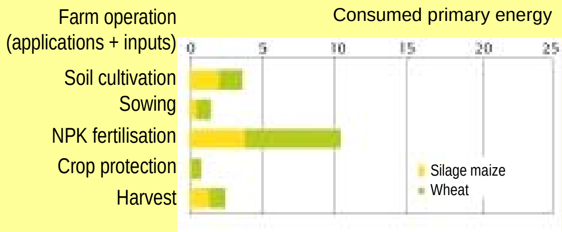
Energy produced/Energy consumed = 8.7

Northwestern "bocage", clayey silt

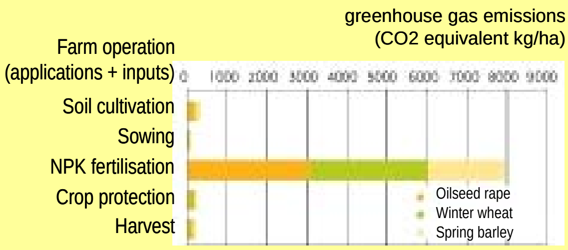
Energy produced/Energy consumed = 14.9

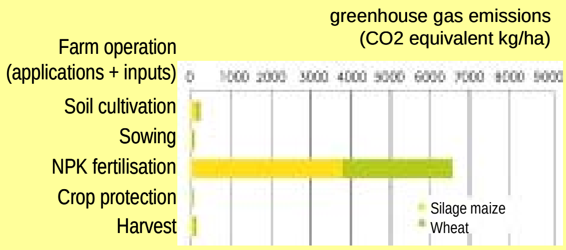
Distribution of energy used





Distribution of greenhouse gas emissions





Mobilised energy and greenhouse gas emissions vary greatly depending on crop management, including fertilisation system and rotation.

For wheat, ¾ of greenhouse gas emissions are linked to fertilisation.

Wheat: up to 15 times more energy produced than mobilised

Growing one hectare of soft wheat helps to produce around 123,000 megajoules from the grain (with an 8.5 t/ha yield) and up to 56,000 megajoules from the straw (for 4 t taken off the field), whereas it only mobilises 12,000 to 17,000 megajoules of non-renewable energy. The energy efficiency (energy produced/energy consumed) is between 10 and 15. Short term efficiency regarding the greenhouse effect (CO_2 equivalent fixed in the biomass taken off the field/ CO_2 equivalent emitted) (3) is between 2 and 8. This applies to conventional arable farms in the main cereal growing regions in France. Mobilised energy and greenhouse gas emissions can vary quite considerably depending on the type of crop management implemented: they are sensitive to the nature and quantity of each input, as well as to the size and use intensity of the equipment. For wheat, almost half the amount of energy consumed and over ¾ of greenhouse gas emissions are linked to fertiliser application. On a per hectare basis, mineral nitrogen is the input requiring the most energy to manufacture.

The significant impact of mineral and organic nitrogen on the greenhouse effect is explained by the release of N_2O during their application, a gas which has roughly a 300 times greater “warming” effect than CO_2.

The efficiency of the system in terms of energy and greenhouse effect, very much depends on the level of fertilisation and the yield. Reducing the mineral nitrogen rate by 15 kg/ha represents, depending on its form, a difference in consumption of between 600 and 920 megajoules/ha, and in emission of between 210 and 260 kg CO_2 eq./ha. Conversely, an increase in yield of 500 kg/ha represents a difference in the amount of energy produced of around 7200 megajoules/ha and in the amount of carbon fixed in the biomass of 608 kg CO_2 eq./ha. The input of farmyard manure, or the introduction of leguminous plants are both ways of improving the energy efficiency of the system, even if this does not prevent release of N_2O. Taking rotation into account to plan fertilisation and using management tools to adjust nitrogen rates help to limit energy consumption and greenhouse gas emission while maintaining an high yield level.

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Notes

(1) The term “biomass” here means harvested agricultural plant production.
(2) The international unit used to measure energy is the Joule (J).
1 calorie = 4.1868 J and 1 megajoule (MJ) = 10^6 J.
(3) The unit used to measure greenhouse gases is the CO_2 equivalent gram (CO_2 eq. g). This unit takes account of the respective contribution to global warming of each gas, through the use of weighting:
1 g CO_2 = 1 CO_2 eq. g, 1 g CH_4 = 21 CO_2 eq. g and 1 g N_2O = 310 CO_2 eq. g (IPCC weighting system).