WHAT'S IMPORTANT IN WTW ANALYSES?

By Robert Edwards, JRC Ispra

GHG BALANCE	COSTS
IMPORTANT	
• change in land use ✓	• treatment of by-products ✓
• treatment of by-products ✓	• subsidies and taxes
• N_2O estimates ✓	• transport distances
• mixing up processes ✓	• profitability assumptions
• figure of merit used ✓	• fuel distribution infrastructure
• fuel cell vehicles	• assumptions on farm income
NOT IMPORTANT	
• exact data on processes	• precise data
• transport distances	
• fuel distribution	

consensus emerging on energy input-data for EU

Figures of merit for biofuels (1)

	WTT	WTW
Energy balance =	$\frac{\text{fossil energy used to make fuel}}{\text{energy content of fuel}}$ …or	$\frac{\text{MJ (fossil)}}{\text{km}}$

1. does not include N_2O, CH_4 emissions
2. ignores cost
3. ignores how efficiently the renewable resources are used
4. easy to distort

	WTT	WTW
GHG balance =	$\frac{\text{kg } CO_2 \text{ eq.}}{\text{MJ fuel}}$. …or	$\frac{\text{kg } CO_2 \text{ eq.}}{\text{km}}$

1. Includes N_2O etc.
   ….otherwise no better.

Figures of merit for biofuels (2)

Think: what will limit our GHG reduction?

Short term: Money

➡ **(GHG saved) /**

- can compare with other GHG mitigation:
  - biomass to electricity
  - C sequestration
  - energy saving
- less easy to distort
- more work!

Long term: Land

(GHG saved) / hectare

- **which** hectare?
- number of possible ha depends on the crop (soil, climate, rotation).

IMPORTANCE of a pathway is given by the **availability**:

max. GHG saved per year

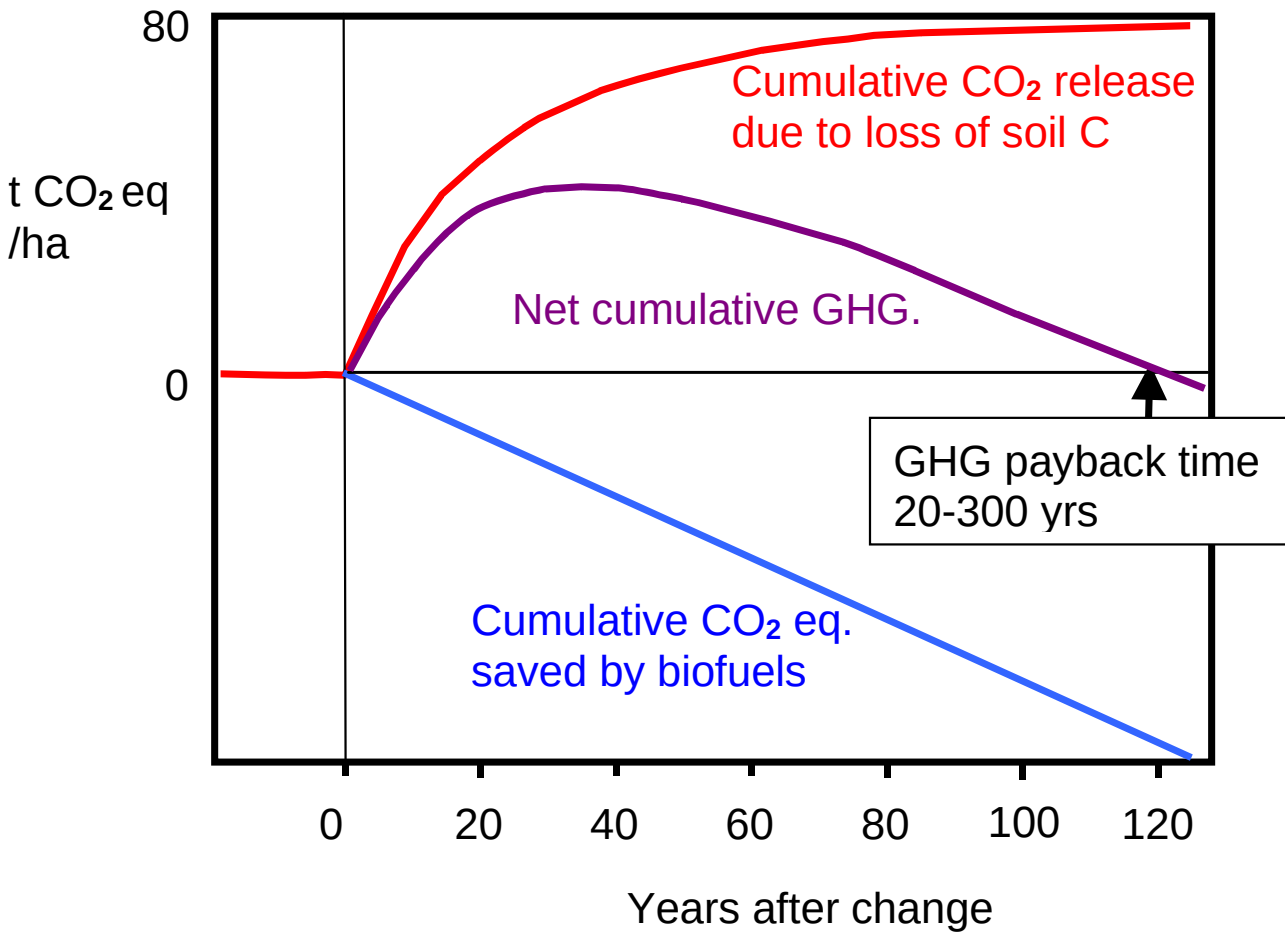
CHANGE IN LAND USE IS THE BIGGEST EFFECT OF ALL

- e.g. change from grassland to arable biofuel crops:

  - one-off, but **large**, release of soil C
- (woodland is between grassland and arable land)

- Huge uncertainty
- USUALLY IGNORED in WTW studies!

- **Conclusion: don't increase arable area!**



Why do energy- (or GHG-) balances differ, although input data is about the same? - **ALLOCATION** to by-products:

e.g. esterification process:

rapeseed oil + energy → bio-diesel + glycerine

ALLOCATING input energy by mass, energy content, cost, etc.
HAS NO RATIONAL BASIS.

In REALITY the GHG credit for glycerine depends on what it **substitutes**:-

? synthetic glycerine (needs18x its energy content in fossil fuel) — Tiny production
? **a process chemical** (e.g. solvent or antifreeze: needs 2x the energy content))
? fuel for process heat (1x the energy content)
? **animal feed** (e.g. 0.12x energy content fossil fuel) — Worth more as animal feed than fuel

- CHOICE DEPENDS ON **ECONOMICS**, NOT ENERGY BALANCE
Economics says most by-products are used for animal feed

Mixing processes distorts energy/GHG ratios 1

e.g. many studies propose using straw to heat ethanol production process

- Straw is NOT an intrinsic by-product of wheat (like glycerol from biodiesel), because

  the use of straw is not tied to the use of the wheat

- **Any** energy-use of straw saves GHG (although collecting it usually causes soil damage)
- Don't say that "if we don't make ethanol, we can't use straw"
- If you insist on mixing processes: e.g. wheat ⟶ ethanol
  + straw ⟶ heat + electricity

  ...you should compare a reference scenario where straw is used in a comparable way: e.g. CHP.

YOU MUST HAVE REALISTIC BIOFUELS + REFERENCE SCENARIOS!

Mixing processes distorts energy+GHG ratios 2

For simplicity, take 2 energetically self-sufficent processes:

			A	B
			2MJ wood ⇩ 1 MJ methanol	4MJ wood ⇩ 2 MJ electricity
Energy ratio	$\frac{\text{MJ fossil energy*}}{\text{MJ product}}$	=	**0.05**	**0.05**

Now combine as a methanol process with electricity export:

A+B:
6MJ wood
⇩
1MJ methanol
+2 MJ electricity

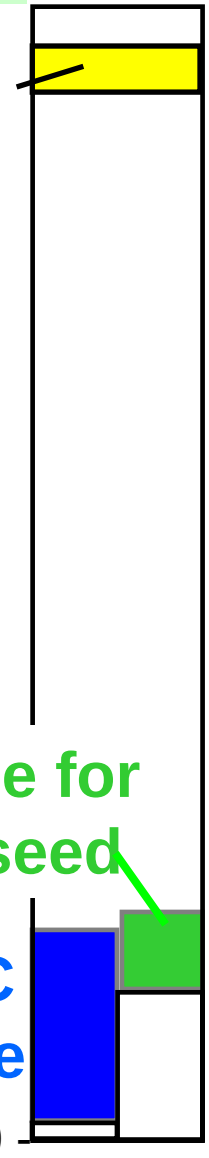
energy for wood* 6 x 0.025 = 0.15 MJ
credit for electricity export*2/3 = - 0.67 MJ
energy ratio **- 0.52! MJ/MJ methanol**

Some thing happens if we look at B+A as as a electricity process with methanol export

- WHY?: we have a silly reference scenario: we assumed all the wood disappears if we do not make methanol. Then we assign all the GHG benefit of substituting 2MJ fossil electricity, to making 1MJ of methanol
- The lower the methanol yield the better the energy ratio!
- If your methanol process looks like A+B, subtract B as a ref. scenario.
- Doesn't happen if you use GHG/ !

N_2O emissions from agriculture

- biggest source of error-bars in WTW studies
- > 100x variation from one field to another
- depends strongly on organic content of soil
- best you can do usually is **IPCC guidelines**: error range >9x



JRC-IES soils database/model

- Average **N_2O↑ per MJ for each crop in EU15**
- Uses well-validated **DNDC soils chemistry model**
  - + JRC-IES's EU soils database (5 parameters)
  - + Daily weather data including nitrogen content of rain
  - + EUROSTAT crop area and yields
  - + Fertilizer use per crop per country from IFA
- calculated for 1070 regions, daily for 2 yrs
- error **+/-30%** (limited by fertilizer data)

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