# Components of alfalfa production needing GHG estimates

1. Fuel combustion for field operations 1**0 kg co2e/gal; 30 kg co2e/ha-pass; 1.2 Mg co2e/ha**
2. Fuel manufacturing 1**0 kg co2e/gal; 1.2 Mg co2e/ha**
3. Insecticide manufacturing
4. Herbicide manufacturing
5. Fertilizer manufacturing **150 kg CO2e/ha**
6. Irrigation energy **100 kg CO2e/ha?**
7. Avoided emissions from reduced fertilizer needs in next crop **10 kg CO2e avoided per kg N avoided/ha**

# Fuel used in field operations

***~30 kg CO2eq/ha per pass (not including manufacturing of the fuel)***

For Tulare, there are 28 non-harvest passes over 3 years and 32x3 passes for harvests. This is an average of roughly 40 passes per year. There is roughly 10 kg co2e released per gallon of fuel, and say it takes 3 gallons of fuel per hectare. That means a pass releases ~ 30 kg

The USDA (I actually don’t know who developed these fuel estimates) has a dataset they use for running erosion models. The dataset includes different types of field operations, with each operation assigned a fuel consumption value (in liters of diesel consumed per acre). These estimates were created in the 1980s.

For non-soil disturbing operations, the range in fuel consumption is quite low, and general categories are as follows:

|  |  |  |
| --- | --- | --- |
| Operation | Erosion model fuel use (gallons of diesel per acre) | Gallons diesel per hectare |
| Sprayer | 0.133 | 0.33 |
| Planting, double disk opener | 0.655 | 1.62 |
| Plant material handling (chop, flail, shred) | 0.747 | 1.85 |
| Harvesting hay/silage | 1.61 | 4.06 |

*FTM assumes ~60 lbs CO2eq/acre for harvesting (Table 20). This equates to about 53 kg CO2eq/ha. If I use the 1.61 gal diesel per acre above and the 10.21 kg CO2eq per gallon of diesel, I get ~50 kg CO2eq/ha. This means the FTM estimates are only accounting for the actual baling component (and not all the operations that lead up to it, which is reasonable), and it doesn’t include the energy/GHG used/emitted in the manufacture of the fuel used.*

For tillage operations, there is some variability between similar operations.

Converting from fuel used to CO2 emissions should have two components: the CO2 released from the actual burning of the fuel, and the CO2 released during the manufacturing of the fuel. The following reference includes the amount released from combustion (which I confirmed in the Alfalfa notes R project – the 10.21 kg CO2 is literally just the amount of carbon contained in a gallon of diesel).

https://www.epa.gov/climateleadership/ghg-emission-factors-hub

Table

Description automatically generated

I don’t know where to get information on the GHG associated with the manufacture of fuels. Probably GREET?

# Fuel manufacturing

From a paper, it said ethanol’s carbon intensity is 50 gco2e per MJ ethanol. Conversions (45 MJ/kg ethanol) comes out to 6.6 kg co2e/gal. The paper says this is 40% lower than other fuels. So let’s say 10 kg co2e/gal. This is roughly equivalent to the amount released upon combustion.

# Pesticide manufacture

# Fertilizer manufacture

**~150 kg CO2e/ha**

From the FTM Table 2 (which I’m unsure how it was created, seems to be loosely taken from the Greet ag-chemicals info. Not sure how they converted BTUs to CO2e).

There are 3.35 lbs of CO2e released per lb of anhydrous ammonia-N, but there are 6.79 lbs released per lbs of ammonium nitrate N.

Back of the envelope let’s say 3 lbs Co2eq per lb nutrient applied. Or 3 kg CO2e per kg nutrient applied. So…say 50 kg of a given nutrient is applied.

# Irrigation energy

The NRCS energy estimator tool (<https://ipat.sc.egov.usda.gov/Default.aspx>) gives values but uses state-wide estimates.

Energy for irrigation may be used to pump ground water, or to move surface water. First you calculate the amount of energy required to move the defined amount of water. I’m working through this in the FTM document, currently.

The FTM document seems like it might be crap, and I can’t access the citations for the equations.

Another paper, Martindill et al. 2021, presents some options. They give an equation:

Energy = (V \* 27.23 \* H ) / mu

V = volume of water

27.23 is energy required to move a ha-m of water a meter? kw-h / (ha-m)m

H is head or something, related to well depth

Mu is pump efficiency

For well depth they refer me to some government sources. This one doesn’t have any information for Tulare county (says it is confidential).

https://www.casgem.water.ca.gov/OSS/(S(1jidhxlhp4gbwakgj0rghyay))/default.aspx

Once you know how much energy was used, the CO2 released will be a function of the energy source used. Irrigation energy can be derived from two major sources: fuel and electricity.

For liquid fuel, if you know the amount of energy required, and the fuel used, you can back-calculate the gallons needed (FTM uses this source, have not investigated: https://www.afdc.energy.gov/fuels/fuel\_comparison\_chart.pdf.

You know how much CO2 is released per gallon (but you don’t know how much CO2 is released during the manufacture of the fuel!!), so you can then get the CO2 released to do the irrigation.

For electricity…

# Avoided emissions

IPCC has direct and indirect emissions. Additionally, you could account for the reduced fertilizer manufacturing emissions.

Direct

Using IPCC dry-area estimates, the range in CO2eq from N2O emissions avoided per kg N applied is 0-0.005 Mg CO2eq/kgN avoided.

Indirect

Need to investigate. Not sure how big of a problem nitrate leaching is in dry areas?

Manufacturing

See fertilizer manufacture for details on that component. Assuming the farmer uses the most GHG-intensive N source of ammonium nitrate, for every kg N avoided they would get a credit of 0.007 Mg CO2eq/kgN.

Best case scenario: 0.012 Mg CO2eq avoided per kg N not applied. About 10 kg.