Table 1. Description of energy and GHG components of alfalfa life cycle

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| **Category** | **Description** | **Source** | **Notes** |
| Direct energy consumption (energy and GHG | | | |
| Use of tractor (or airplane) for field operations | Diesel fuel consumption is converted to energy consumed and GHG released. For alternative fuel source scenarios, this is converted to energy, and an alternative fuel consumption assuming standard work output efficiencies for each type of fuel. | NRCS database with field operations and estimated diesel fuel consumed (L/ha) | Estimates were developed in the 1980s |
| Irrigation | Energy required to move a given amount of water was calculated using standard engineering equations that include well depths, pump PSI, and irrigation method (different methods require different pump pressures). The required amount of fuel to achieve this work | NRCS energy estimator tool for average well depths in a given county, some input from stakeholders | Imperial is all gravity fed, and they actually ‘create’ energy from the movement of their irrigation water in some instances. This was ignored. G |
| Embedded energy (MJ) | | | |
| Fuel manufacturing | Diesel, gasoline and propane all require energy to manufacture. This includes drilling for raw materials, material processing, refining, and delivery to point of sale. Energy used to manufacture electricity depends on how it is manufactured (coal, natural gas, hydroelectric, solar). Each state has a unique portfolio of sources. | GREET national values for liquid fuels, CA-specific electricity value | Values were compared between sources, not large discrepancies (probably rounding errors)G |
| Pesticide manufacturing | Energy required to manufacture a given amount of active ingredient. The amount of active ingredient in a given product was extracted. This isn’t exactly correct, as the active ingredient then has to be manufactured into a product, but the amounts applied are so small that this number has very little impact anyways, so not really worth being picky about. | Audsely paper | If specific compound is not listed in the paper, the average for that group of pesticide (herbicide, fungicide, etc.) was used |
| Fertilizer manufacturing | Manufacturing of fertilizer requires energy. Estimates for manufacturing energy required per unit N, or per unit P, or per unit S, etc. are provided by GREET, and are used additively to create | GREET values for raw elements |  |
| Avoided fertilizer manufacturing | Subsequent crop requires less nitrogen fertilizer when grown after alfalfa, thus avoiding fertilizer application. This nitrogen credit is translated to an avoided energy consumption using the same calculations as the fertilizer manufacturing. | Various extension publications for wheat and tomato |  |
| Seed production | I need to double check this, but I believe Dan told me alfalfa seed for California is mainly produced in the Imperial Valley. I did a rough ‘seed production’ scenario (tractor passes are different for seed production) for the Imperial Valley and got the amount of energy consumed per unit seed produced. | Self-calculated. | At some point I compared this number to another estimate from somewhere, and it seemed reasonable. |
| Direct GHG release/avoidance/sequestering | | | |
| N2O emissions | All N sources are included, alfalfa root N is calculated | IPCC dry-area estimates (no nitrate leaching) | Tried including and excluding nitrate leaching, no idea which is more correct |
| Avoided N2O emissions | IPCC calculations, a function of the type of fertilizer application avoided. | IPCC |  |
| CO2C sequestration | Healthy Soils estimates for a given county, various assumptions on the intervention | Healthy Soils website |  |