Table 1. Assumed energy amounts embedded in products

|  |  |  |  |
| --- | --- | --- | --- |
|  | Energy required, raw materials to shelf | Notes | Source |
| Fertility | MJ kg-1 |  |  |
| Mono-ammonium phosphate (11-52-0) | 22.0 |  | GREET |
| UAN-32 | 64.5 |  |  |
| Sulfur\* | 0.6 |  |  |
| Potash | 8.2 |  |  |
| Pesticides | MJ kg-1 active ingredient |  |  |
| *Insecticides* |  |  |  |
| Chlorantraniliprole | 214 | Mean insecticide value | Table 2 of Audsley et al. 2009 |
| Lambda-cyhalothrin | 214 |  |  |
| Indoxacarb | 214 |  |  |
| Zinc phosphide | 214 |  |  |
| *Herbicides* |  |  |  |
| Paraquat | 459 |  |  |
| Glyphosate | 454 |  |  |
| Imazamox | 265 | Mean herbicide value |  |
| Metribuzin | 265 |  |  |
| Flumioxazin | 265 |  |  |
| Pendimethalin | 265 |  |  |
| *Other* |  |  |  |
| Zinc phosphide (rodenticide) | 214 | Mean insecticide value, may be a bad assumption |  |
| Surfactant | 0 | Not included |  |

\*Assumed sulfuric acid manufacturing value

Table 2. Assumptions

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Table 3. Scenarios

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Scenario | Name | Locations | Description | Relative impact |
| 1 | Base | Unless otherwise noted, the scenario was run for all locations | Stand life, water requirements, number of harvests, field passes, and products applied are taken directly from the enterprise budget. 50% of water requirements are met using ground water from a 150 foot deep well, and 50% of requirements are met using surface water. All water, regardless of source, is distributed using a 25 psi pump. For Tulare the irrigation is flood, for Siskiyou it is sprinkler (it’s actually a pivot, but I assigned it as sprinkler bc I don’t have an ‘efficiency’ for pivots). Fuel used for all operations is diesel. Leaching is considered in nitrous oxide emission calculations. Subsequent crop for Tulare is tomatoes (170 lbs uan-32 N offset, for Siskiyou is wheat (80 lbs uan-32 N offset) |  |
| 2 | Ground water |  | All water requirements are assumed to be met using water pumped at 25 psi from 150 foot deep well |  |
| 3 | Surface water |  | All water requirements are assumed to be met using water pumped at 25 psi from a surface source |  |
| 4 | Deficit irrigation | Tulare | Water use is decreased from 64 ac-in per year to 51 ac-in per year (based on Ottman and PutnamDan, need to dig up), no July and August harvests of hay resulting in only 7 harvests instead of 9. Hay yields are reduced from 10 Mg ha-1 per year to 7 Mg ha-1 per year. All other field activities are assumed to remain the same. |  |
| 5 | Stand life extension |  | Stand life is increased by one-third (3 to 4 years in Tulare, 6 to 8 years in Siskiyou) |  |
| 6 | Double pump pressure |  | Pump pressure is doubled from 25 psi to 50 psi |  |
| 7 | Eliminate pesticides |  | Eliminate passes and embedded energy |  |
| 8 | Electrify irrigation |  | Change energy source for pumping irrigation water to electric (more efficient transfer of energy to mechanical work). | Table 19.1, Management of Farm Irrigation Systems ASAE Monograph 9 (you cannot find a digital copy of this, I had to have the library scan it). |
| 9 | Electrify harvest operations |  |  | Table 19.1, ASAE Monograph 9 |
| 10 | Electrify field operations |  |  | Table 19.1, ASAE Monograph 9 |
| 11 | Change from flood/sprinkler irrigation to drip irrigation |  | You have to apply more water than the crop actually needs due to water losses. Efficiencies are flood < sprinkler < drip (70%, 80%, 90%). | Table 19.2, ASAE Monograph 9 |
| 12 | Eliminate insecticides |  | Eliminate passes and products |  |
| 13 | Eliminate herbicides |  | Eliminate passes and products |  |
| 14 | Surface water, gravity fed irrigation (no pump) | Tulare |  |  |
| 15 | No leaching-derived N2O emissions |  | N2O from volatilization provides wet and dry climate values (used dry climate values). The fraction leached is set at 0.24 ‘in wet climates’, but the leaching/runoff derived N2O has only a static value (0.011 of the amount leached). May need to rerun everything eliminating this component (I don’t think California has a nitrogen leaching problem?) | Table 11.3, Chapter 11, IPCC 2019 refinement to the 2006 IPCC guidelines for national greenhouse gas inventories |
| 16 | Pasture carbon credit |  | From California Healthy Soils |  |
| 17 | No carbon credit |  | From California Healthy Soils |  |
| 18 | Eliminate fertilizer offset |  | The crop following alfalfa will require less nitrogen compared to if it followed another annual crop. Many studies don’t take this credit into account. |  |

Ottman and Putnam (??) deficit irrigation with alfalfa: What are the economics? <https://alfalfa.ucdavis.edu/+symposium/2017/PDFfiles/Ottman%20Mike.pdf>

IPCC 2019 refinement https://www.ipcc-nggip.iges.or.jp/public/2019rf/vol4.html