Table 1. Baseline assumptions for each region, represented by a single county’s enterprise budget

|  |  |  |  |
| --- | --- | --- | --- |
|  | Tulare County | Siskiyou County | Imperial County |
| Subsequent crop, fertilizer credit from alfalfa | Tomatoes, 170 | Wheat, 80 | Wheat, 80 |
| Planting rate | 25 lb/ac | 20 lb/ac | 20 lb/ac |
| Irrigation source, ground/surface water | 50/50 | 50/50 | 0/100 |
| Well depth (note: NRCS says CA state average is 236 feet) | 500 feet (Mike said 300-1,500 feet, gets deeper as you move west, he thought 500 feet might be a good estimate for Tulare) | 150 feet | NA |
| Amount of water applied | 8 ac-in establishment,  64 ac-in/year production | 4.5 ac-in establishment,  24 ac-in/year production | 18 ac-in establishment,  84 ac-in/year production |
| Establishment irrigation type, efficiency | Sprinkler, 80% | Pivot, 80% | Sprinkler, 80% |
| Production irrigation type, efficiency | Flood, 70% | Pivot, 80% | Flood, 70% |
| Role of pump (see pump table) | Before drip (filter and pressure reg), before sprinkler (probably contracted out) regardless of water source | Pump from river or ground for flood, add’l pump for drip (to go through filter and control pressure in lines), one pump for all other application types | Pump into sprinkler or drip system, no pumps for flood irrigation. |
| Irrigation pump energy source, work conversion efficiency | Diesel, 30% | Diesel, 30% | Diesel, 30% |
| Fertility | 200 lb/ac MAP at establishment | 300 lb/ac MAP at establishment, 25 gal 10-34-0 each production year | 200 lb/ac MAP and 250 lb/ac potash at establishment, 75 lb/ac MAP and 250 lb/ac potash each production year |
| Stand life | 3 years | 6 years | 3 years (Irrigation guy didn’t like this number, but it’s the enterprise budget value) |
| Number of harvests | 9 (2 haylage, 7 hay) | 3 | 12 (3 green chop, 9 hay) |
| Dry matter harvested | 8 dry Mg/ha | 3 dry Mg/ha Giuliano says 4.5-7.5, unsure if this dry or not | 8 dry Mg/ha (Ali didn’t like this number, but it is what is in the enterprise budget) |
| Pesticide application method | Tractor | Tractor, could do through irrigation system | Tractor/aerial |
| Average number of field passes per year | 11 | 6.8 | 16 |

Table 2. Scenarios – note all changes are individually made to the base scenario (i.e. no stacking of scenarios has been done).

|  |  |
| --- | --- |
| Name | Description |
| All ground water | All water requirements are assumed to be met using water pumped at 25 psi from 150 foot deep well |
| All surface water | All water requirements are assumed to be met using water pumped at 25 psi from a surface source |
| Deficit irrigation | (Tulare only)  Water use is decreased from 64 ac-in per year to 51 ac-in per year (based on Ottman and Putnam), 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. |
| Stand life extension | Stand life is increased by one-third (3 to 4 years in Tulare, 6 to 8 years in Siskiyou) |
| Double pump pressure | Pump pressure is doubled from 25 psi to 50 psi |
| Double well depth | Well depth is doubled from 150 to 300 feet, larger the range the more impactful this assumption |
| Eliminate pesticides | Eliminate passes and embedded energy |
| Electrify irrigation | Change energy source for pumping irrigation water to electric (90% work conversion efficiency). |
| Electrify harvest operations | Change harvest operations energy source to electric. |
| Electrify field operations | Change all operations except harvest to electric. |
| Change from flood/sprinkler irrigation to drip irrigation | Here we assume you have to apply more water than the crop actually needs due to water losses from the irrigation type. Efficiencies are flood < sprinkler < drip (70%, 80%, 90%). |
| Eliminate insecticides | Eliminate passes and products |
| Eliminate herbicides | Eliminate passes and products |
| Surface water, gravity fed irrigation (no irrigation energy used) | (Tulare only) |
| 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?) |
| Pasture carbon credit | From California Healthy Soils, specific to each county |
| No carbon credit | From California Healthy Soils, specific to each county |
| 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

# Energy and GHG components of alfalfa production (see separate table)

## Energy

Direct

1. Energy consumed by tractor for field operations
   1. Energy requirement is based on physics
   2. Energy actually used depends on fuel and how efficiently it transforms energy into work
      1. Diesel transforms 30% of its energy release into work
      2. Electricity transforms 90%
      3. FTM ignores these inefficiencies, NRCS tool does not
2. Energy consumed by pump for irrigation, depends on fuel used

Indirect

1. Energy consumed to manufacture fuel used by tractor/irrigation pump
   1. Fossil fuels require less energy to produce compared to electricity
      1. This is because often electricity is produced by burning fossil fuels
      2. Could find generation-specific values (a hydropower plant, a coal-fired plant) for scenario analysis (what if electricity all came from solar?)
      3. Currently estimates are based on a region’s electricity source profile
2. Energy used to manufacture applied pesticides
3. Energy used to manufacture applied fertilizer
   1. I think there must be a better source for this, GREET has a value for N, PO5, etc. and you just add those values up. So UAN-32 and ammonia have the same embedded N energy value. Everyone seems to use this.
4. Energy used to manufacture planted seed
5. Energy NOT consumed due to alfalfa-derived N credit for next crop

## GHG Emissions

Direct

1. CO2 released from combustion of fuel in tractor (none if electric)
2. CO2 released from combustion of fuel in irrigation pump (none if electric)
3. CO2 sequestered in soil
4. N2O formed and released from soil

Indirect

1. CO2 released during fuel/energy manufacturing
2. CO2 released during pesticide manufacturing
3. CO2 released during fertilizer manufacturing
4. CO2 released during seed production
5. N2O produced from downstream soil N leaching
6. N2O NOT produced due to reduced fertilizer needs of next crop

Pump table

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| county | water\_source | irr\_type | Surface source, pump psi | Ground source, pump psi |
| tulare | surface | flood | 0 | 50 |
|  |  | drip | 30 | 80 |
|  |  | sprinkler | 50 | 100 |
| siskiyou | surface | flood | 50 | 50 |
|  |  | drip | 80 | 80 |
|  |  | sprinkler | 50 | 50 |
|  |  | wheel line | 40 | 40 |
|  |  | pivot | 40 | 40 |
| imperial | surface | flood | 0 | - |
|  |  | sprinkler | 50 | - |
|  |  | drip | 30 | - |