**3b. Application energy**

This section describes the energy embodied in fertilizer and crop chemical applications (energy required to produce the products). The energy used to apply the material to the field (on farm equipment) also needs to be accounted for. This can be done either through the RUSLE2 Management Energy (ME) calculation, if the applications are included in the LMOD template. We provide both examples: 1) assuming application energy has already been included in ME, and 2) assuming application energy has not yet been accounted for.

* Note that many applications of fertilizers and crop chemicals to the field may occur with other operations (e.g. with the planting operation, with irrigation systems, etc).
* Application Energy will need to be calculated for all crops, according to the fertilizer and chemical application program specified by the user.
* Not all fertilizers or chemical types will be relevant for all crops.
* Alfalfa will require calculation of the application energy as well as the embodied energy (Example #2), unless the application timing is “at planting”.
* Lime applications (used in some regions to balance soil acidity) typically occur to accrue the benefit of the lime over several years of crop production, and therefore need to be amortized across the number of years in between applications.

Fertilizer and crop chemical energy are calculated separately as **AEf** and **AEc**, described below.

NOTE: This is a section that will need to be revisited depending on how field operation energy is adjusted in the new system (e.g. custom templates/rotation builder); if users specify all operations, including for applications of fertilizers and chemicals, then only the embodied energy needs to be calculated here.

**Revision History:** Updated 5.16.2018 to remove fuel type for application trips; assume diesel for v. 3.0 (Allison Thomson)

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| **User inputs:** |
| Crop Type |
| Yield (Y or Yi if irrigated) |
| Application timing |
| Fertilizer Type |
| Fertilizer amount (in lbs.) (per trip) |
| If fertilizer = lime, also enter number of years between lime applications (LY) |
| Crop protectant applications (by type, number of products and number of trips) |
|  |
| **Additional Info needed:** |
| Embodied fertilizer energies via Table 2 |
| Embodied crop protectant energy average, by type and crop via Table 3 |
| BTU/gallon fuel type via Table 1 |
| Gallons /acre for application = .1285 (FTM assumption) |

**Fertilizer energy calculation**

Step 1: Identify Fertilizer type and amount applied. If lime, identify number of years between lime applications.

Step 2: Look up “total Energy in lb./product” value for fertilizer type identified by grower in Table 2.

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| *Alternative Step 2: If the user selects a custom blended fertilizer instead of a product, first look at the common blend energy values in Table 2. If the blend is not included there, the energy can be calculated based on the N:P:K ratio:* |
| Calculate N P & K energies from Table 2. |
| For Nitrogen: Average N total energy (btu/lb. nutrient) value \* % N in blend |
| For Phosphorus (P): Average P total energy (btu/lb. nutrient) value \* % P in blend |
| For Potassium (K): Potassium chloride total energy (BTU/lb. nutrient) \* % K in blend |
| Sum N+P+K energy values to get the total energy for the custom blend |

Step 3: Calculate energy required for fertilizers (**AEf**)

**AEf** = (total energy/lb. product x amount of fertilizer applied per acre) = BTU/acre

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| *Alternative Step 3: If necessary, include in the calculation the energy for a separate fertilizer application field operation*: |
| **AEf** = (total energy/lb. product \* amount of fertilizer applied per acre) + (0.1285\*BTU/gal) = BTU/acre |

**Lime Energy Calculation**

Step 1: If fertilizer type is lime, identify amount applied and number of years between lime applications.

Step 2: Look up “total Energy in lb./product” value for fertilizer type identified by grower in Table 2.

Step 3: **AEl** = (total energy/lb. product x amount of fertilizer applied per acre)/LY = BTU/acre

**Crop Chemical energy calculations (AEc)**

For all crop chemical categories (herbicides, insecticides, fungicides, growth regulator, fumigants, harvest aids) Field to Market has developed standard values by category of chemical based on weighted averages of active ingredients, USDA application data and literature sources. For the metric therefore, what matters is the number of different chemicals applications (products + number of times applied) to a field.

Step 1: Identify number of crop chemical products and number of applications of each category.

For example, if grower requires 2 applications of one herbicide, and 4 applications of 2 different pesticides then the embodied energy in crop protectants will be = (2 \* herbicide embodied energy) + (4 \* pesticide embodied energy).

Step 2: Draw crop chemical energy values (BTU/acre/app) for crop type identified by grower from Table 3.

Step 3: Calculate individual crop chemical category energies and sum:

**AEc** = (Herbicide energy value (BTU/acre/app) \* number of applications)

+ (Insecticide energy value (BTU/acre/app) \* number of applications)

+ (Fumigant energy value (BTU/acre/app) \* number of applications)

+ (Fungicide energy value (BTU/acre/app) \* number of applications)

+ (Growth regulator energy value (BTU/acre/app) \* number of applications)

+ (Harvest aid energy value (BTU/acre/app) \* number of applications) = BTU/acre

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| *Alternative Step 3: If necessary, include in the calculation the energy for the number of separate field operations required for crop chemicals, if not accounted for in ME*: |
| **AEc** = [(crop chemical energy value \* number of applications)] + [(number of application passes)\*(0.1285\*BTU/gal)] = BTU/acre |

**Total Application Energy**

Once calculated, the energy embodied in fertilizer and the energy embodied in crop chemicals, plus energy required for field operations to apply the products, can be summed to provide total Application Energy (**AE**):

**AE** = (**AEf + AEc+ AEl**) = BTU / acre

**Example 1: At time of planting, with planter**

A grower applies 150 pounds of Ammonium Nitrate product and 1 herbicide product as he plants his corn. The grower ends up with a yield of 200 bu/acre. Since the application occurs with the planting operation, the fuel is accounted for in the LMOD template.

What is the grower’s total energy usage from this fertilizer and pesticide application?

Application energy (**AE**) = ((8,810 x 150) + (1 x 117091)

= 1,438,591 BTU/acre

**AEy**  = AE/Y = 7,193 BTU/bu

**Example 2: At planting, including a lime application**

A grower applies 150 pounds of Ammonium Nitrate product and 1 herbicide product as he plants his corn; the grower also applied 2 tons (4000 lbs) of lime once every four years. The grower ends up with a yield of 200 bu/acre. Since the application occurs with the planting operation, the fuel is accounted for in the LMOD template.

What is the grower’s total energy usage from this fertilizer and pesticide application?

Application energy (**AE**) = ((8,810 x 150) + (1 x 117091) + ((2144 x 4000)/4)

= 3,582,591 BTU/acre

**AEy**  = AE/Y = 17,912 BTU/bu

**Example 3: pre-planting (separate operation not accounted for in ME)**

A grower applies 75 pounds of Ammonium Nitrate product and 2 herbicide products in one pass before the corn is planted. The grower ends up with a yield of 200 bu/acre. What is the grower’s total energy usage from this fertilizer and pesticide application?

Application Energy = (8810 x 75) + (2 x 117091) + ((0.1285\*138490)\*100)

= 660,750 + 234,182 +1,779,596

= 2,675,096 BTU /acre

**AEy** = AE/Y = 13,375 BTU/bu