NATIONAL ENERGY TECHNOLOGY LABORATORY

NETL Upstream Dashboard Tool Documentation

June 18, 2012

DOE/NETL-2012/TBD

U.S. DEPARTMENT OF ENERGY

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Final Report

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Acronyms and Abbreviations

BTL	Biomass-to-liquid
CBTL	Coal- and biomass-to-liquid
CCS	Carbon capture and sequestration
CTL	Coal-to-liquid
EC	Energy Conversion
ECF	Energy Conversion Facility
FT	Fischer-Tropsch
GHG	Greenhouse gases
GWP	Global warming potential
IPCC	Intergovernmental Panel on Climate Change
LCA	Life cycle analysis
NMVOC	Non-methane volatile organic compound
NETL	National Energy Technology Laboratory
NREL	National Renewable Energy Laboratory
RMA	Raw Material Acquisition
RMT	Raw Material Transportation

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1 Introduction

In recent years, the National Energy Technology Laboratory (NETL) has been using life cycle analysis (LCA) as a new and innovative way to analyze and compare different power production and transportation fuel production pathways. By using LCA, NETL has integrated a holistic approach to comparing energy production pathways instead of solely considering combustion emissions at energy conversion facilities (i.e., power plant or fuels refinery).

To perform NETL's LCAs, the steps in energy production are broken down into stages (i.e., extraction, transportation, combustion) and even smaller pieces called unit processes (i.e., the operation or construction of each process within a stage). When possible, unit processes incorporate parameter variables that can be adjusted in order to render the unit process applicable to multiple scenarios or functions. For example, a train transport unit process would include adjustable parameters for transport distance, in order to ensure its suitability to a range of transport routes, locations, or products. NETL has built a library of over 250 of these unit processes. They are used as building blocks to create a comprehensive system in support of LCA modeling.

Each of NETL's unit processes functions as a discrete building block. Therefore, the unit processes can be grouped or utilized in different ways for different applications. For example, the group of unit processes needed to represent a coal mine can be connected and used as a group in many different applications: the coal could be routed into numerous different types of power production facilities or into a Fischer-Tropsch (FT) facility for the production of synthetic diesel. The Upstream Tool capitalizes on this flexibility, allowing the user to quickly evaluate a variety of feedstock supply systems or profiles. The goal of the Upstream Tool is to allow the user to customize key parameters specific to their case study or desired scenario, and generate customized results quickly and simply. The results calculated can be allocated, as upstream emissions, to a conversion facility or system of the user's choice. The combination of the upstream and combustion emissions provide a quick estimate of the overall emissions from an entire energy conversion system.

2 Model Use Instructions

The following sections guide the user in preparing and using the model, in either Excel 2007 or Excel 2010.

2.1 Macro Enabling

To use the model, Excel Macros must be enabled.

Excel 2007

- When opening Excel, a security warning message should appear just below the tool bars. The general instruction can be activated through clicking the "How to enable" link in the Input sheet, as shown in **Figure 1**.
- If no button appears in the security message, click on the Office button in the top left corner of the screen (**Figure 2**). Select the Excel Options button at the bottom of the menu (**Figure 3**). Within the Excel Options dialog, select the Trust Center on the left menu and then the Trust Center Settings button at the bottom right of the window (**Figure 4**). To enable the Macros, select the Macro Settings from the left menu and then the bottom option marked "Enable all macros" (**Figure 5**).

Figure 1: General Macro-Enabling Instructions

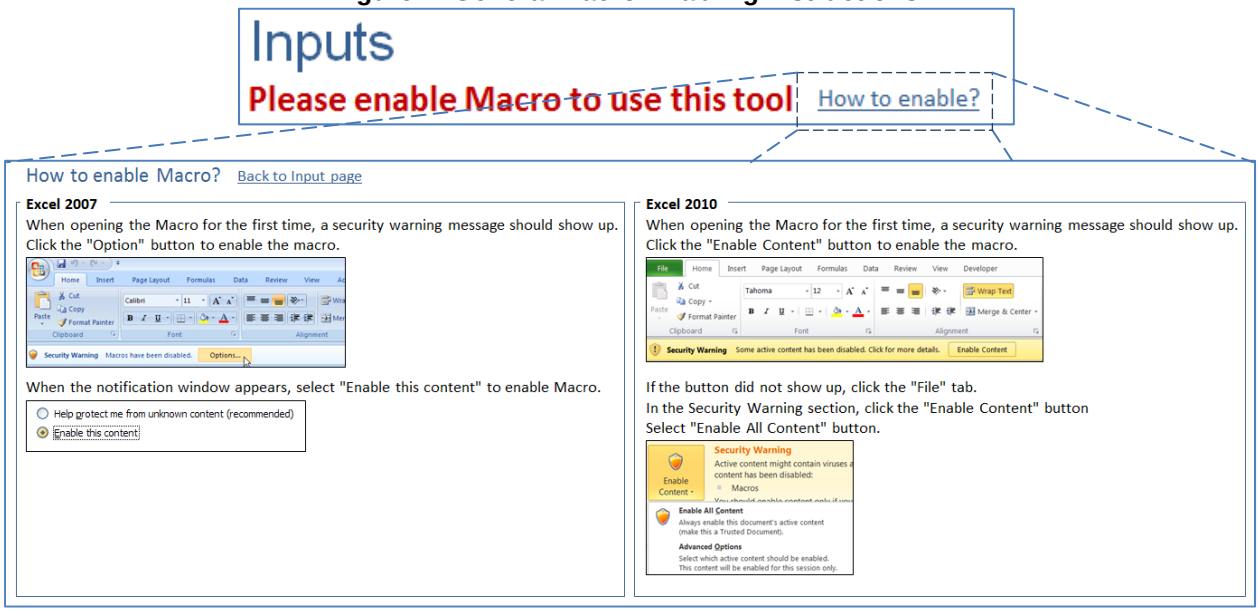


Figure 2: Office Button Location

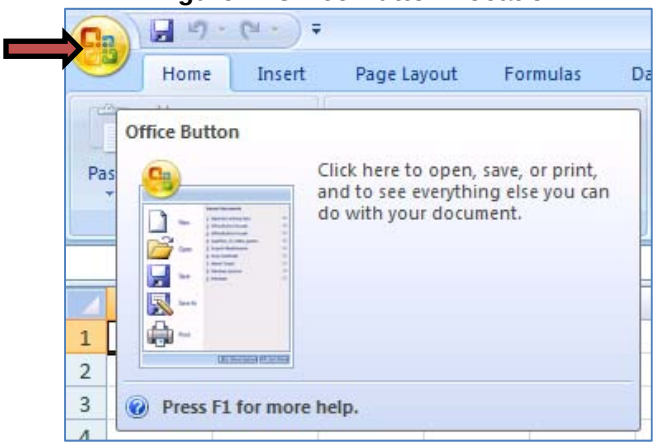


Figure 3: Excel Options Location

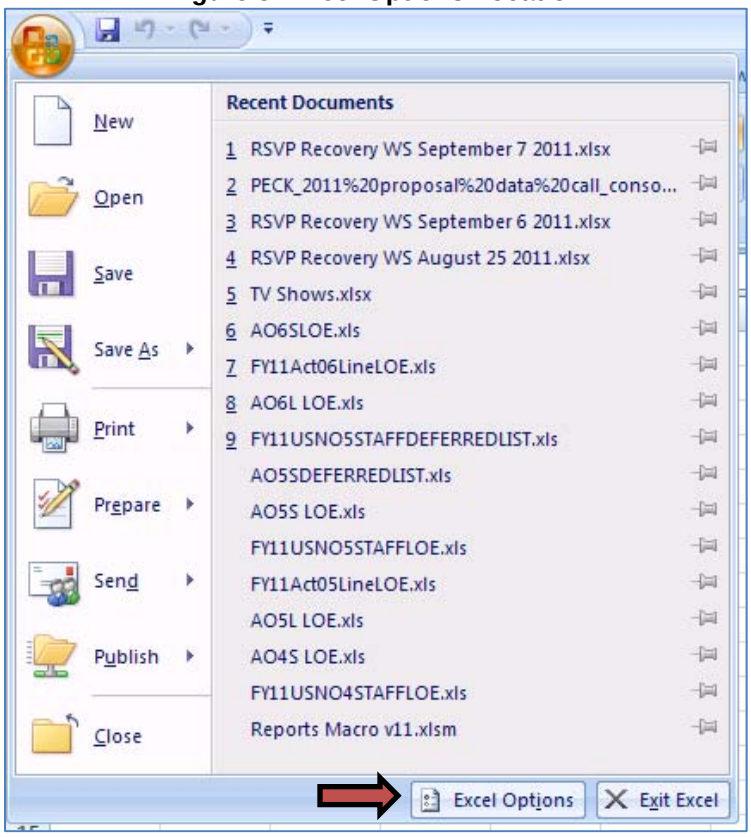


Figure 4: Opening the Trust Center

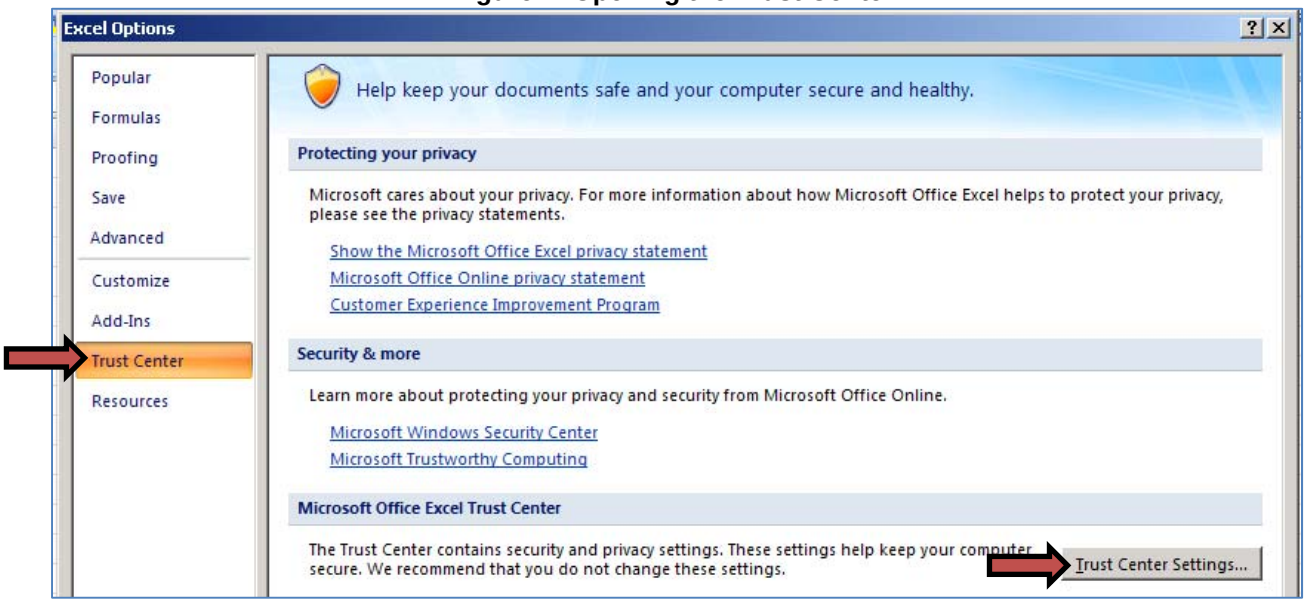
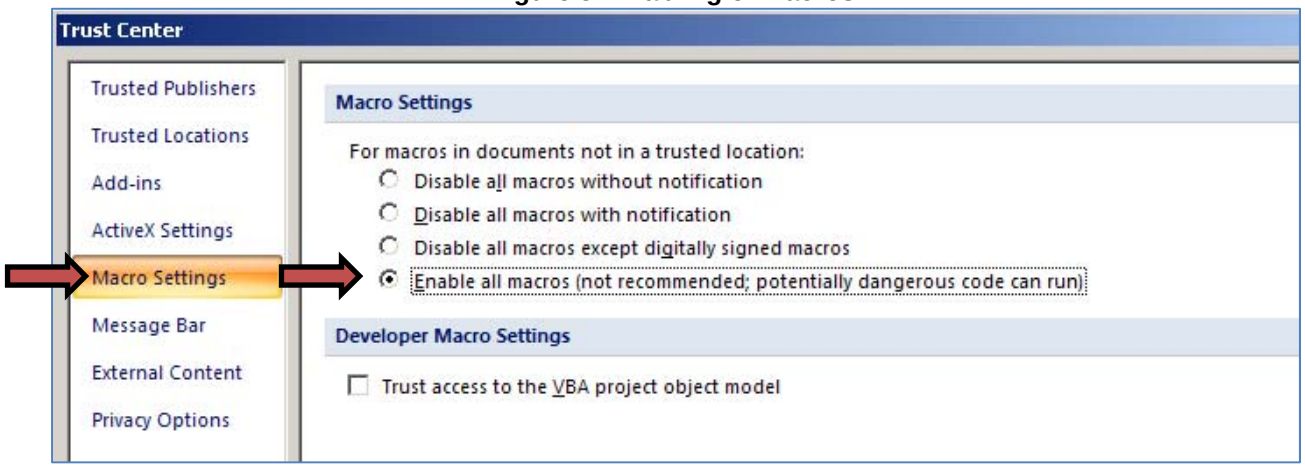


Figure 5: Enabling of Macros



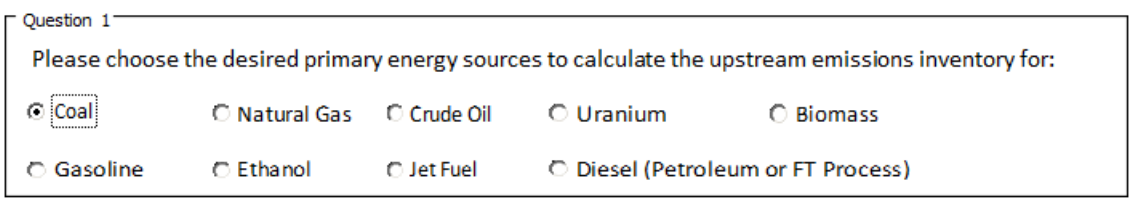
Excel 2010

- When opening Excel, a security warning message should appear just below the tool bars. The general instruction can be activated through clicking the "How to enable" link in the Input sheet, as shown in **Figure 1**.
- If there is no security warning message or the wrong option is selected, switch to the File tab. In the Security Warning section, clicking on the Enable Content button will open a drop-down menu. Select the option "Enable content for this session only."

2.2 Inputs

After enabling Macros and selecting to agree to the license usage prompt, switch to the "Inputs" tab. First, scroll to *Question 1* (**Figure 6**) and pick the desired primary energy source.

Figure 6: Feedstock Options



Question 2 determines how the results will be displayed (**Figure 7**). The top set of units (kg or lb) determines how the emissions should be measured and what the available units for the reference flow will be. The model will allow for any combination of units the user desires between the English and SI options. The denominator will, however, determine what the acreage changed and water quantity units are. Additionally, depending on the feedstock chosen in Question 1, the model will determine which of the reference flow units are available, based on the units and components used in the selected modeling sequence. For example, coal will not have a volume unit available because it is traditionally discussed or measured based on mass, not based on volume. The final option of *Question 2* is which set of carbon dioxide (CO_2) equivalents depending on the impact year from the International Panel on Climate Change (IPCC). The conversion factors can be found in **Table 1**

When the user has completed all selections, clicking on the "Show Results" button will switch the screen to the Dashboard tab.

Figure 7: Displayed Unit Options

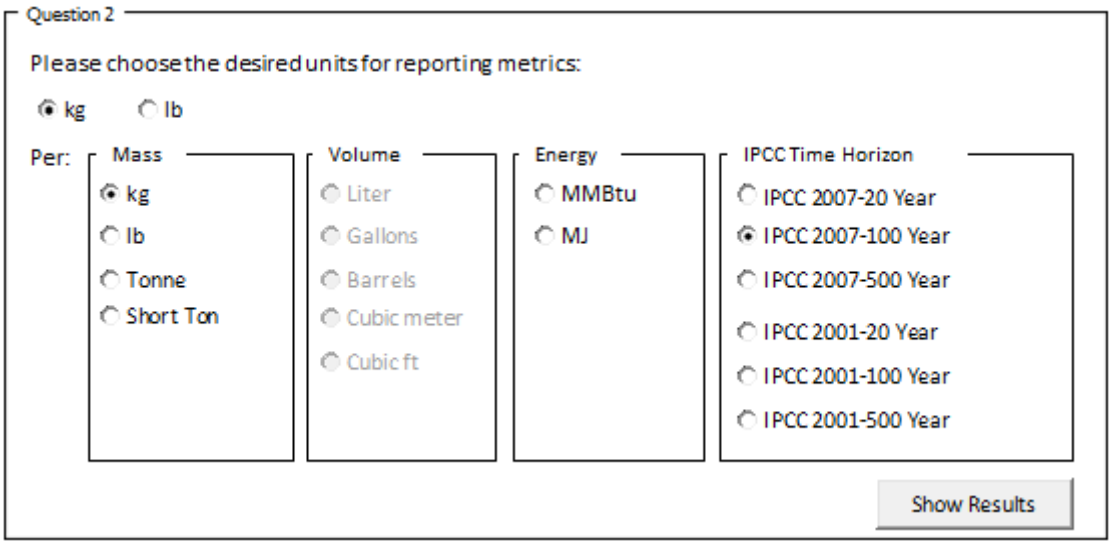
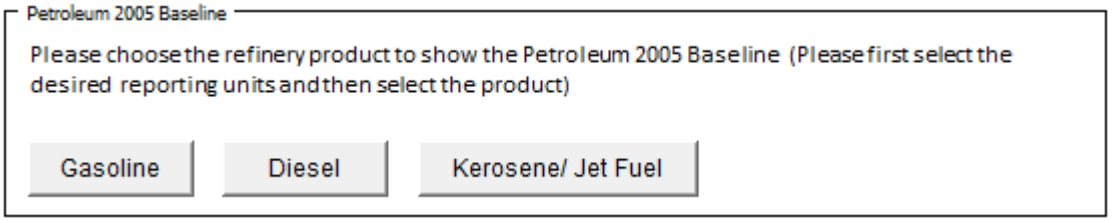


Table 1: IPCC Global Warming Potentials (Forester et al., 2007)

IPCC GWP Factor	Vintage	20 Year	100 Year	500 Year
CO_2	2007	1	1	1
CH_4	2007	72	25	7.6
N_2O	2007	289	298	153
SF_6	2007	16,300	22,800	32,600
CO_2	2001	1	1	1
CH_4	2001	62	23	7
N_2O	2001	275	296	156
SF_6	2001	15,100	22,200	32,400

In addition to the feedstock choices available in the *Question 1* box on the inputs tab, the user also has the ability to select one of three petroleum products from the NETL Petroleum Baseline, which is representative of year 2005 data (NETL, 2008). **Figure 8** indicates the fuel options available to the user: gasoline, diesel, and kerosene/jet fuel. Prior to selecting the desired petroleum product, the user should select the desired units for reporting metrics in the *Question 2* box. The Petroleum Baseline selection does not allow for any user customization of parameters on the dashboard of the tool since the results are recognized as published reference results. If the user desires additional customization for these petroleum products, the desired product should be selected in the *Question 1* box.

Figure 8: 2005 Petroleum Baseline Selections



2.3 Dashboard

After selecting desired units, proceed to the "Dashboard" tab. The "Dashboard" tab is set up in three sections: across the top are the stages of the life cycle (Raw Material Acquisition, Raw Material Transport, and Energy Conversion Facility), where the user can choose from and vary available parameters. On the lower left is a bar graph that shows global warming contributions from each of the emissions, separated by stage. On the lower right is a table showing all the emissions tracked by the NETL Guidelines document.[1]

2.3.1 Raw Material Acquisition

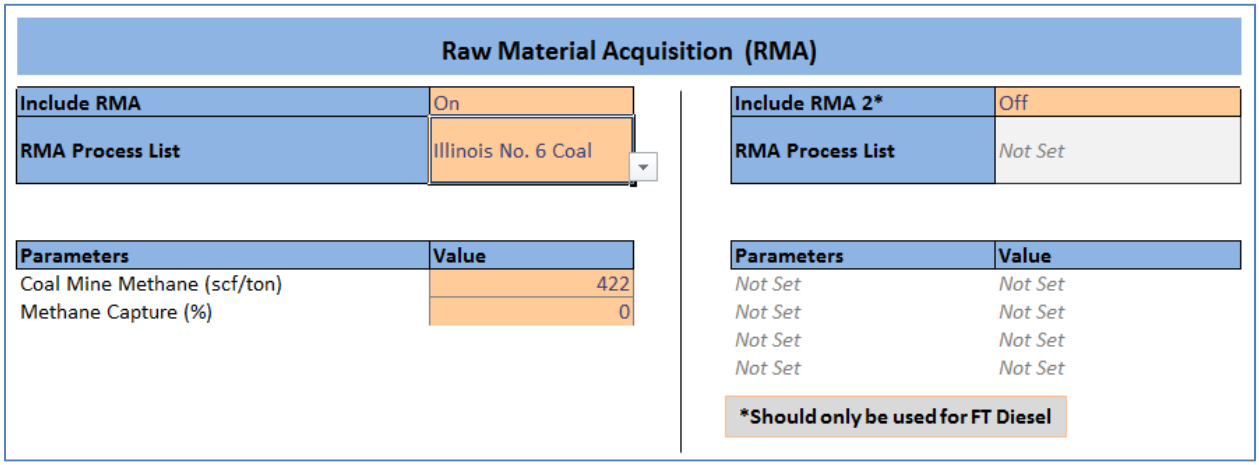
Raw Material Acquisition (RMA) boundaries are defined by the NETL Guidelines document as:

> [RMA] starts when material or energy has been drawn from the environment without previous human transformation. Includes the extraction of raw feedstocks from the earth and any partial processing of the raw materials that may occur before transport to the energy conversion facility (NETL, 2010).

RMA is broken into two subsections. Based on the answer to *Question 1* on the "Inputs" page, the RMA section will auto-populate with available selections. For all products other than diesel, there will only be one RMA section available; for diesel, the user may desire to model Fischer-Tropsch (FT) diesel with a combination of coal and biomass feedstocks, and therefore both RMA sections will be available. **Figure 9** shows both RMA sections when Coal is selected and therefore the second RMA is not being used.

[1] The NETL Guidelines is an internal document that describes life cycle analysis as whole and specifically discusses the scoping of a project. It is meant to assist in the creation and performance of an LCA. All stage descriptions are taken from it.

Figure 9: Raw Material Acquisition Selection



Raw Material Acquisition (RMA)

Include RMA	On
RMA Process List	Illinois No. 6 Coal

Parameters	Value
Coal Mine Methane (scf/ton)	422
Methane Capture (%)	0

Include RMA 2*	Off
RMA Process List	Not Set

Parameters	Value
Not Set	Not Set
Not Set	Not Set
Not Set	Not Set
Not Set	Not Set

*Should only be used for FT Diesel

If RMA is the only stage selected, the results will be normalized to the reference flow units determined in *Question 2*. If additional stages are selected, the quantity processed in RMA will be adjusted to produce the final product at the last stage per the reference units.

For all except the FT Diesel

Select the desired feedstock type from the drop-down in cell C3. After selection, the available parameters will appear starting in Row 7. The orange cells in Column C allow the user to enter values based a desired configuration. The table and graph will automatically update based on the changes.

For FT Diesel

To model FT diesel using combined coal and biomass feedstocks, turn “on” the second RMA portion in cell F2. The second RMA section will be activated and will operate the same as the first RMA section. Illinois No. 6 coal should be the chosen feedstock for the first RMA and the biomass type used should be selected in the second RMA.

Please note: for any case in which feedstocks may be mixed other than FT diesel (i.e., a co-fired power plant), complete upstreams for each feedstock separately and the ratio of the upstreams based on their feed rates into a facility.

2.3.2 Raw Material Transportation

Raw Material Transportation (RMT) boundaries are defined by the NETL Guidelines document as:

> [RMT] starts when raw material is ready for shipment to the energy conversion facility. Any intermediate storage required before entrance into the energy conversion system should be included (NETL, 2010).

Based on the answer to *Question 1*, the logical options for transportation modes will be available to be connected to the RMA of the feedstock. Up to four modes of transportation may be selected for

use in series as shown in **Figure 10**. The top mode in Row 7 is the first mode in the series; the increase in rows shows sequentially the order of transportation.

Figure 10: Raw Material Transport Selection

Raw Material Transport (RMT)

Include RMT	On
Num of Transp. Mode	1
RMA Suggested RMT	Coal Train

Transportation Mode**	Unit	Value
Coal Train	mi, one way	400

**Add sequential modes with the first at the top
**For FT Diesel, coal should be above the biomass transport

For FT Diesel

The FT Diesel calculations are set up differently than the rest of the calculations. For the FT Diesel calculations to be completed correctly, add the coal train in Row 7 and biomass transportation in Row 8.

2.3.3 Energy Conversion

Energy Conversion (EC) boundaries are defined by the NETL Guidelines document as:

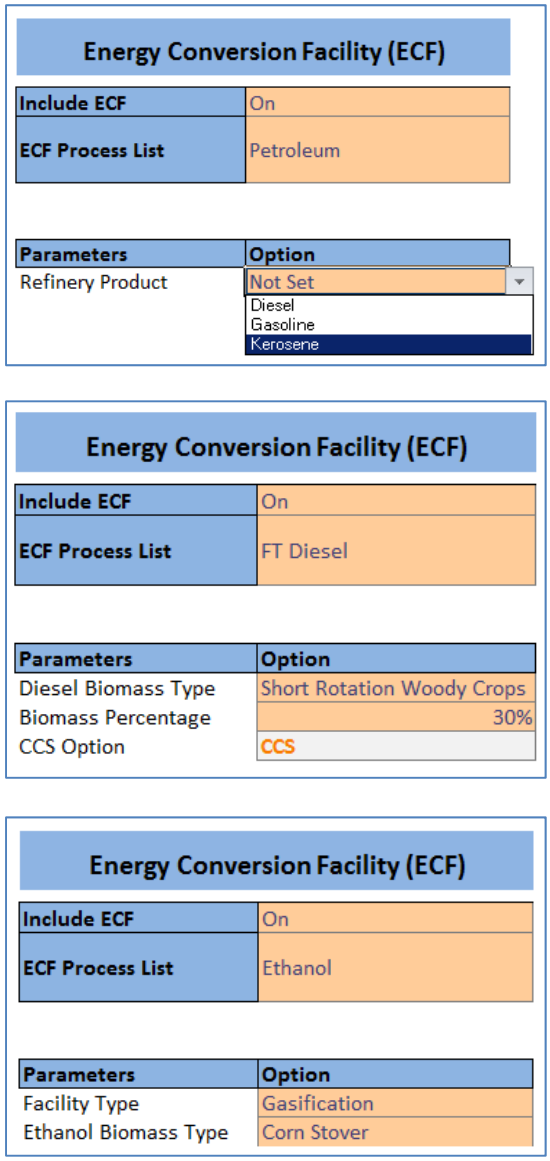
> [EC] starts with the primary transformation of a raw material into a product. Physical boundary is defined by the acceptance of ownership of the raw material by the transformation entity (NETL, 2010).

The EC stage is different from the other stages and always thought of in terms of the facility. It is often referred to as the Energy Conversion Facility (ECF) stage. Based on the way the facilities are modeled, no parameter variations are allowed. Instead, there is a predefined set of scenarios which the user may choose from. The type of facility selected determines how specific the model gets. For petroleum, the user may only choose the product. For an FT facility, the user can choose whether or not it is a combined input of coal and biomass, the concentration of the biomass input (0 percent,[1] 15 percent, 30 percent, or 100 percent), the type of biomass, and whether there is a carbon capture and sequestration unit (CCS).[2] Ethanol has the option of using corn grain into dry

[1] To have a coal-to-liquids facility, switch the "Diesel Biomass Type" to "None."
[2] For a coal and biomass-to-liquids facility, it is required to have CCS and the model will force the decision.

mill processes or advanced combustion and gasification processes based on switchgrass or corn stover.

Figure 11: Energy Conversion Options



Many of the fuel production facilities also produce co-products that have been modeled through system expansion. System expansion is performed by giving a credit to what the co-product replaces by its production. Each location where this is applicable is explained below:

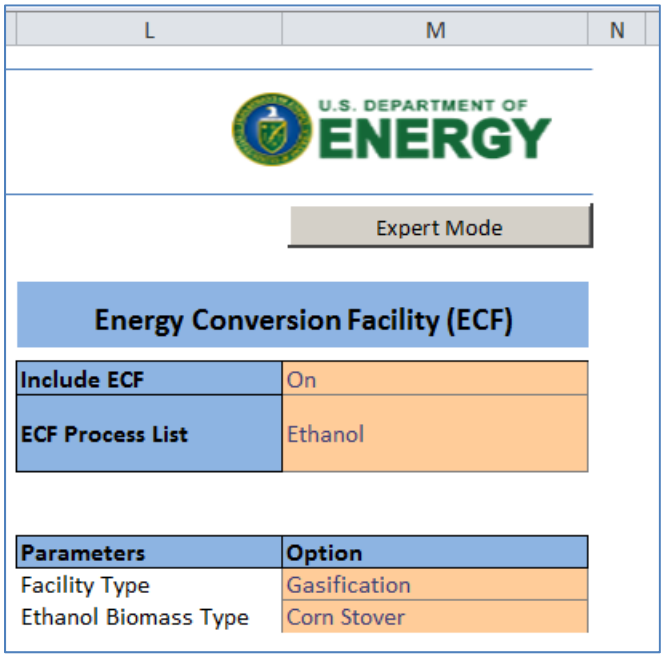
- Lignocellulosic Gasification: electricity production displacing power from the Midwest Reliability Organization West
- Lignocellulosic Combustion: electricity production displacing power from the Midwest Reliability Organization West
- Advanced Dry Mill, with and without CCS: corn oil produced displacing soybean oil

- Coal- and Biomass-/Biomass-to-Liquids: synthetic naphtha created displacing petroleum-based kerosene
- Coal-to-Liquids: electricity production displacing the North American average mix and synthetic naphtha to displace petroleum-based kerosene
- Petroleum Refinery: steam from hydrogen production displacing steam from natural gas

2.3.4 Expert Mode

As described above, the Dashboard is designed to guide the user through its use and make the options between stages simple and straightforward. The available options are programmed for logical connections between the stages. The Expert Mode button (as seen in **Figure 12**) clears all of these connections and shows all available options in RMA and ECF. The RMT modes are determined by the selected RMA mode. The Expert Mode will allow for two unrelated feedstocks to be produced and delivered; however, there is no way to see the differences from the production and transportation of each feedstock and both are delivered in the reference quantity. It is not recommended that this mode be used unless the user is strongly proficient in the use of the Dashboard.

Figure 12: Energy Conversion Options



2.4 Results

After the user has selected and adjusted the appropriate feedstocks and options, the model calculates the impacts of the created system. The model takes into account any losses during the transport stage, and the feedstock requirements for the energy conversion stage. **Table 2** shows the inventory table of the emissions from a sample model run. The values shown are direct emissions to the atmosphere or water, emissions of solid waste, land use change area, or energy return on investment (EROI), as shown. Each stage is broken out so that the user can see its relative contribution to the entire system.

Table 2: Inventory Results Table

Emission Inventory (Unit = kg / kg)

Life Cycle Inventory		Total	RMA	RMT	ECF
Air Emissions	Carbon Dioxide	6.330E-01	1.865E-01	5.340E-02	3.931E-01
	Methane	4.137E-03	3.629E-03	2.903E-05	4.785E-04
	Nitrous Oxide	1.243E-05	5.009E-06	1.078E-06	6.344E-06
	Nitrogen Oxides	8.068E-04	5.814E-04	1.113E-04	1.141E-04
	Sulfur Dioxide	1.620E-03	9.310E-04	1.444E-04	5.449E-04
	Carbon Monoxide	5.937E-04	4.034E-04	2.799E-05	1.624E-04
	Particulate Matter	1.425E-05	6.672E-06	2.532E-06	5.042E-06
	Lead	1.365E-08	7.652E-09	1.258E-09	4.736E-09
	Mercury	1.168E-09	2.793E-10	2.165E-10	6.722E-10
	Ammonia	6.958E-06	2.013E-06	1.010E-06	3.935E-06
	Radiation	4.612E-09	3.296E-10	1.426E-09	2.856E-09
	Non Methane VOC	1.723E-03	7.840E-04	7.628E-04	1.764E-04
Solid Waste	Heavy Metals to Soil	1.218E-05	1.104E-05	8.482E-07	2.922E-07
	Solid Waste	1.191E-04	1.191E-04	0.000E+00	0.000E+00
Water Emissions	Aluminum	3.724E-07	2.717E-08	1.148E-07	2.304E-07
	Ammonium/ammonia	1.357E-06	1.008E-06	1.478E-07	2.013E-07
	Heavy Metals	2.384E-03	3.444E-06	4.773E-06	2.376E-03
	Nitrate	2.105E-06	1.251E-07	6.391E-07	1.341E-06
	Nitrogen	1.881E-09	1.699E-09	2.531E-11	1.564E-10
	Phosphate	1.420E-08	8.540E-09	1.673E-09	3.986E-09
	Phosphorus	5.131E-04	1.090E-07	6.679E-09	5.130E-04
Water	Water Withdrawal (L)	5.803E-01	1.235E-01	1.522E-01	3.047E-01
	Water Consumption (L)	2.542E+00	2.341E-01	2.036E-01	2.104E+00
Land Use	Area Changes (Km^2)	1.099E+00	1.009E+00	3.797E-02	5.263E-02
EROI	Energy Input (MJ)	4.629E+01	4.256E+01	1.603E+00	2.120E+00

Below the Inventory Table, is a second table with the greenhouse gas (GHG) equivalents from each stage, shown in CO_2 equivalents. GHG values are calculated based on the selections made on the inputs tab for the IPCC vintage (2001 or 2007) and GWP time horizon (20-year, 100-year, or 500-year). The values from the Inventory Table are converted into CO_2e as shown in **Table 3**.

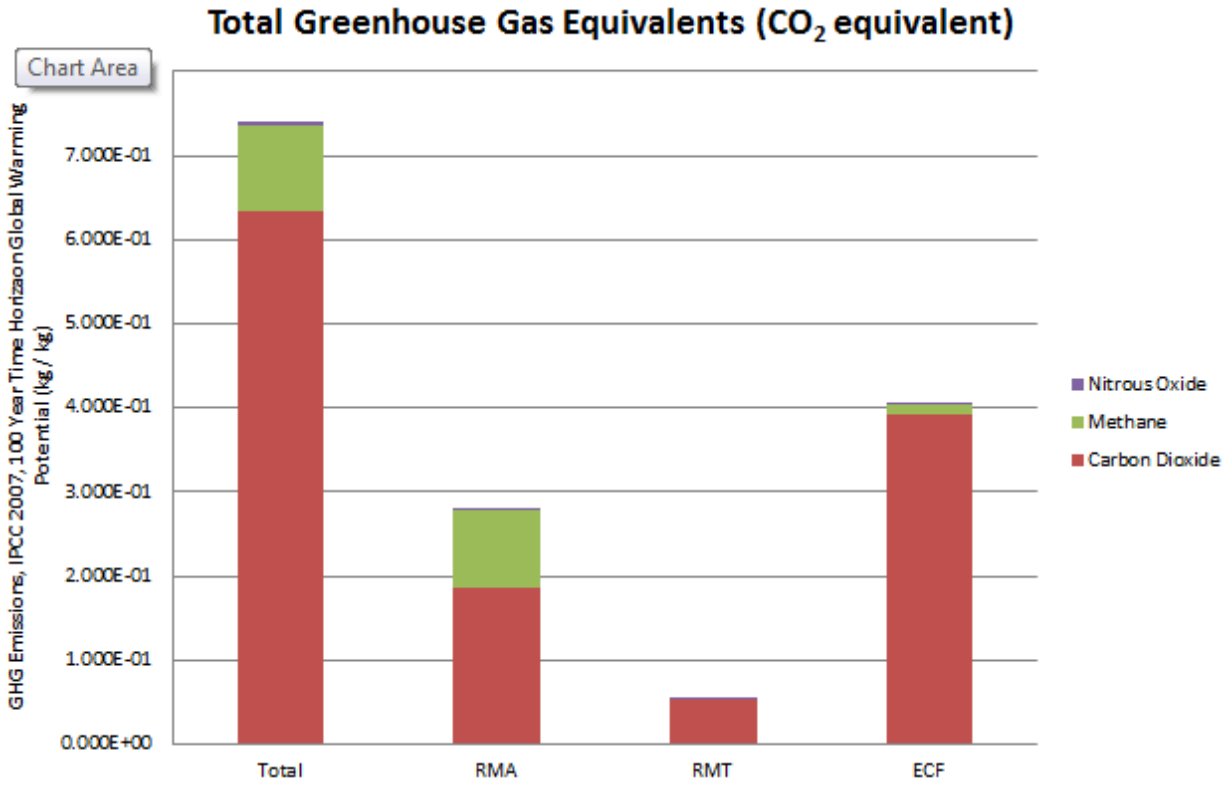
Table 3: Global Warming Potential Table

Greenhouse Gas Equivalents (Unit = kg CO_2 equivalent / kg) **Based on IPCC 2007, 100 Year**

GHG Inventory		Total	RMA	RMT	ECF
Air Emissions	Carbon Dioxide	6.330E-01	1.865E-01	5.340E-02	3.931E-01
	Methane	1.034E-01	9.073E-02	7.257E-04	1.196E-02
	Nitrous Oxide	3.704E-03	1.493E-03	3.213E-04	1.890E-03
	Total	7.401E-01	2.787E-01	5.445E-02	4.069E-01

For a visual representation of the GHG equivalents results, a graph with the stage results is also presented as shown in **Figure 13**. For the biomass feedstocks, carbon is sequestered during biomass growth, and thus a negative emission value is portrayed for the RMA.

Figure 13: Global Warming Potential Graph



3 Data Tables

The following pages contain the data sets as extracted from NETL models with default parameter values used for the dashboard.

Figure 14: Raw Material Acquisition Inventory

Life Cycle Inventory (kg/kg)		Coal			Uranium			Biomass		
		I6	PRB	U.S. Average Mix	100% US Enrichment	100% EU Enrichment	Corn Grain	Corn Stover	SRWC	Switch-grass
Air Emissions	Carbon Dioxide	2.55E-02	7.36E-03	6.07E+03	1.18E+04	8.13E+02	-1.91E-01	-1.25E-01	-8.46E-01	-1.22E+00
	Methane	8.96E-03	1.09E-03	1.80E+01	2.51E+01	1.14E+01	1.02E-04	1.78E-04	1.35E-04	1.34E-04
	Nitrous Oxide	4.49E-07	7.13E-06	9.93E-02	1.72E-01	3.35E-02	5.02E-04	7.02E-04	4.51E-04	6.90E-04
	Total GWP	2.50E-01	3.68E-02	6.55E+03	1.25E+04	1.11E+03	-3.88E-02	8.85E-02	-7.08E-01	-1.01E+00
	Nitrogen Oxides	4.24E-05	2.09E-05	1.47E+01	2.65E+01	4.06E+00	2.11E-04	3.90E-04	2.09E-04	2.81E-04
	Sulfur Dioxide	7.67E-05	6.40E-06	3.65E+01	7.45E+01	2.08E+00	1.33E-04	2.07E-04	1.43E-04	1.43E-04
	Carbon Monoxide	2.34E-05	3.80E-05	4.62E+00	7.04E+00	2.42E+00	8.33E-05	7.75E-05	2.35E-04	1.20E-04
	Particulate Matter	2.74E-06	9.47E-05	7.72E-01	1.50E+00	1.07E-01	2.04E-04	1.14E-03	6.69E-04	1.15E-04
	Lead	3.46E-09	1.93E-10	3.04E-04	5.55E-04	7.47E-05	4.23E-09	2.31E-09	1.53E-08	6.13E-09
	Mercury	6.15E-10	2.86E-11	6.54E-05	1.30E-04	6.78E-06	4.04E-10	4.00E-10	1.09E-09	5.42E-10
	Ammonia	5.31E-08	1.58E-06	3.62E-01	1.00E-01	6.01E-01	8.46E-05	1.57E-04	7.58E-05	1.16E-04
	Radiation	6.30E-12	3.54E-11	8.47E-05	6.67E-05	1.01E-04	5.89E-10	1.06E-09	5.62E-10	7.84E-10
	Non Methane VOC	6.35E-06	1.76E-06	1.71E+00	2.26E+00	1.21E+00	2.57E-02	1.08E-01	4.49E-02	1.76E-05
Solid Waste	Heavy Metals to Soil	1.49E-04	6.43E-06	1.05E+04	6.25E+03	1.43E+04	2.51E-05	4.70E-05	2.40E-05	2.34E-05
	Solid Waste	9.18E-07	1.56E-07	1.11E+00	1.33E+00	9.10E-01	6.40E-07	8.83E-07	2.40E-06	9.86E-07
Water Emissions	Aluminum	1.13E-08	8.11E-07	1.98E-02	1.97E-02	2.00E-02	1.33E-06	1.80E-06	5.22E-06	2.12E-06
	Ammonium/ammonia	3.73E-06	1.25E-05	2.56E+02	1.53E+02	3.50E+02	3.86E-05	6.43E-05	7.84E-05	5.60E-05
	Heavy Metals	3.56E-06	2.06E-05	4.43E+02	2.65E+02	6.05E+02	1.20E-05	1.85E-05	2.88E-05	1.65E-05
	Nitrate	2.89E-08	1.47E-06	8.89E-01	1.10E+00	6.95E-01	2.55E-07	4.61E-07	2.45E-07	3.40E-07
	Nitrogen	1.14E-07	2.95E-05	6.57E-01	9.12E-01	4.26E-01	4.30E-05	1.05E-05	8.17E-06	1.42E-05
	Phosphate	2.86E-10	2.09E-09	1.17E-03	1.59E-03	7.82E-04	3.99E-08	7.20E-08	3.55E-08	5.27E-08
	Phosphorus	1.46E-07	7.05E-07	1.65E-02	1.55E-02	1.74E-02	8.92E-05	1.04E-04	7.39E-05	5.65E-05
Water	Water Withdrawal (L)	1.14E+00	6.93E-02	7.44E+04	1.41E+05	1.34E+04	3.75E+02	9.03E+01	4.32E+02	7.72E+02
	Water Consumption (L)	-5.79E-01	1.99E-02	1.57E+04	3.08E+04	1.90E+03	3.74E+02	8.99E+01	4.32E+02	2.12E-01
Land Use	Area Changes (Km^2)	5.64E-08	2.42E-07	2.91E-03	2.91E-03	2.91E-03	1.83E-04	1.67E-04	2.65E-04	2.64E-04
EROI	Energy Input (MJ)	1.67E-01	6.86E-02	2.21E+05	2.88E+05	1.59E+05	1.34E+00	2.42E+00	1.71E+00	1.75E+00

Figure 14: Raw Material Acquisition Inventory (Continued)

Life Cycle Inventory (kg/kg)		Natural Gas								
		Onshore	Associated	Offshore	Barnett Shale	Coal Bed Methane	Imported LNG	Tight Gas	Marcellus Shale	2010 National Average
Air Emissions	Carbon Dioxide	1.66E-01	1.24E-01	1.32E-01	1.42E-01	1.34E-01	7.19E-01	1.34E-01	1.43E-01	1.42E-01
	Methane	1.64E-02	6.02E-03	2.21E-03	1.61E-02	6.10E-03	6.61E-03	1.62E-02	1.56E-02	1.29E-02
	Nitrous Oxide	4.90E-06	3.47E-06	6.24E-06	4.21E-06	3.80E-06	8.32E-06	3.80E-06	1.11E-05	4.58E-06
	Total GWP	5.78E-01	2.75E-01	1.89E-01	5.47E-01	2.87E-01	8.87E-01	5.40E-01	5.36E-01	4.66E-01
	Nitrogen Oxides	3.95E-03	3.91E-03	1.17E-04	3.00E-03	3.97E-03	1.58E-03	3.94E-03	3.94E-03	3.28E-03
	Sulfur Dioxide	2.54E-05	1.08E-05	3.90E-06	1.16E-04	3.18E-05	8.94E-05	1.93E-05	3.00E-05	4.00E-05
	Carbon Monoxide	3.63E-04	3.27E-04	2.88E-05	2.63E-04	3.79E-04	6.33E-04	3.48E-04	3.45E-04	2.96E-04
	Particulate Matter	9.83E-06	4.04E-06	3.13E-07	5.69E-06	1.24E-05	3.49E-06	7.42E-06	6.36E-06	6.93E-06
	Lead	1.93E-08	7.92E-09	6.12E-10	9.48E-09	2.42E-08	4.64E-09	1.45E-08	1.22E-08	1.32E-08
	Mercury	5.29E-10	2.17E-10	1.68E-11	8.52E-10	6.64E-10	2.95E-10	3.99E-10	4.07E-10	4.89E-10
	Ammonia	3.22E-09	1.34E-09	4.39E-10	2.60E-08	4.04E-09	6.59E-04	2.43E-09	6.57E-09	7.50E-09
	Radiation	2.99E-12	1.29E-12	5.18E-13	7.95E-12	3.73E-12	1.01E-10	2.28E-12	4.49E-12	3.54E-12
	Non Methane VOC	3.32E-03	1.00E-03	2.68E-04	3.31E-03	1.02E-03	3.23E-04	3.32E-03	3.17E-03	2.58E-03
Solid Waste	Heavy Metals to Soil	6.58E-06	2.71E-06	2.09E-07	2.16E-04	8.27E-06	3.14E-05	4.97E-06	2.94E-05	4.99E-05
	Solid Waste	1.51E-07	6.22E-08	2.25E-08	5.75E-07	1.90E-07	1.36E-05	1.14E-07	2.46E-07	2.15E-07
Water Emissions	Aluminum	7.21E-10	3.02E-10	5.78E-11	1.63E-08	9.04E-10	1.08E-08	5.46E-10	2.50E-09	3.90E-09
	Ammonium/ammonia	2.05E-07	8.48E-08	7.58E-09	5.35E-06	2.57E-07	8.40E-07	1.55E-07	9.21E-06	1.47E-06
	Heavy Metals	2.99E-06	0.00E+00	3.84E-07	1.34E-05	1.98E-04	3.70E-06	3.43E-06	4.71E-06	2.32E-05
	Nitrate	2.92E-09	0.00E+00	8.73E-10	3.61E-08	3.50E-09	8.02E-08	2.37E-09	6.98E-09	9.59E-09
	Nitrogen	5.03E-09	0.00E+00	1.60E-10	1.65E-07	6.32E-09	2.39E-08	3.79E-09	2.25E-08	3.81E-08
	Phosphate	1.54E-11	0.00E+00	2.36E-12	1.91E-10	1.92E-11	8.25E-09	1.19E-11	3.78E-11	5.03E-11
	Phosphorus	3.99E-07	0.00E+00	6.89E-07	2.26E-07	5.02E-07	9.09E-07	3.01E-07	6.47E-07	3.72E-07
Water	Water Withdrawal (L)	7.87E-01	0.00E+00	6.31E-03	2.64E+00	1.39E-01	3.82E-01	1.56E+00	9.64E-01	1.23E+00
	Water Consumption (L)	-5.15E-01	-5.59E-01	-7.26E-01	1.22E+00	-5.99E+00	-7.06E-01	1.16E+00	8.17E-01	-2.10E-01
Land Use	Area Changes (Km^2)	1.13E-06	1.13E-06	0.00E+00	2.32E-06	6.78E-08	2.20E-06	1.16E-05	4.81E-07	1.16E-05
EROI	Energy Input (MJ)	6.49E+01	0.00E+00	6.39E+01	6.44E+01	6.39E+01	7.50E+01	6.45E+01	6.46E+01	6.44E+01

Figure 14: Raw Material Acquisition Inventory (Continued)

Life Cycle Inventory (kg/kg)		Petroleum					
		Domestic	National Average	African	Middle Eastern	North American	South American
Air Emissions	Carbon Dioxide	1.36E-01	1.92E-01	3.47E-01	9.84E-02	1.95E-01	1.36E-01
	Methane	7.26E-04	3.85E-03	1.72E-02	5.32E-04	2.01E-03	1.61E-03
	Nitrous Oxide	4.09E-06	5.22E-06	8.99E-06	2.29E-06	5.59E-06	3.47E-06
	Total GWP	1.55E-01	2.90E-01	7.79E-01	1.12E-01	2.47E-01	1.77E-01
	Nitrogen Oxides	6.02E-04	6.13E-04	7.25E-04	3.24E-04	7.22E-04	4.09E-04
	Sulfur Dioxide	2.27E-04	9.86E-04	2.98E-03	1.27E-04	8.43E-04	5.75E-04
	Carbon Monoxide	3.63E-04	4.43E-04	8.80E-04	1.79E-04	4.46E-04	3.10E-04
	Particulate Matter	9.71E-06	6.81E-06	2.69E-06	3.10E-06	9.96E-06	2.82E-06
	Lead	1.41E-08	8.35E-09	1.05E-09	1.59E-09	1.35E-08	3.46E-09
	Mercury	4.05E-10	2.94E-10	3.21E-11	1.56E-11	4.97E-10	8.57E-11
	Ammonia	1.81E-07	2.26E-06	1.77E-08	1.27E-08	4.07E-06	2.39E-08
	Radiation	2.84E-10	2.27E-10	9.95E-12	5.09E-12	3.97E-10	3.39E-11
	Non Methane VOC	1.58E-04	8.68E-04	3.83E-03	9.65E-05	4.88E-04	3.07E-04
Solid Waste	Heavy Metals to Soil	6.52E-06	1.08E-05	6.81E-06	2.27E-05	1.06E-05	4.32E-07
	Solid Waste	0.00E+00	1.35E-04	0.00E+00	0.00E+00	2.42E-04	0.00E+00
Water Emissions	Aluminum	2.48E-08	1.94E-08	1.05E-09	9.02E-10	3.37E-08	3.19E-09
	Ammonium/ammonia	4.90E-07	1.01E-06	4.98E-07	1.59E-06	1.19E-06	6.19E-08
	Heavy Metals	3.96E-06	3.52E-06	1.96E-06	4.65E-07	5.42E-06	1.19E-06
	Nitrate	9.20E-08	1.19E-07	2.31E-07	3.18E-08	1.39E-07	2.66E-08
	Nitrogen	0.00E+00	1.95E-09	1.97E-10	3.25E-11	3.25E-09	8.09E-10
	Phosphate	1.16E-08	9.04E-09	5.30E-09	3.60E-09	1.26E-08	5.28E-09
	Phosphorus	5.10E-08	1.10E-07	5.50E-08	1.76E-07	1.28E-07	6.27E-09
Water	Water Withdrawal (L)	1.02E-01	2.31E-01	2.77E-01	1.37E-01	2.89E-01	6.09E-02
	Water Consumption (L)	5.36E-02	1.12E-01	2.35E-01	1.09E-01	9.63E-02	5.36E-02
Land Use	Area Changes (Km^2)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EROI	Energy Input (MJ)	3.83E+01	4.56E+01	4.99E+01	4.43E+01	4.51E+01	4.49E+01

Figure 15: Raw Material Transport Inventory

Life Cycle Inventory		Coal Train	Natural Gas Pipeline	Bale Truck	Container Truck	Petroleum Pipeline	Petroleum Tanker Truck	Petroleum Ocean Tanker	Petroleum Rail
Air Emissions	Carbon Dioxide	1.26E-02	2.61E-02	2.40E-03	1.91E-03	2.46E-02	6.19E-05	3.25E-02	3.26E-05
	Methane	6.88E-06	5.22E-03	7.01E-06	5.19E-06	2.86E-05	1.24E-09	2.39E-06	2.57E-09
	Nitrous Oxide	3.06E-07	3.98E-08	6.35E-08	4.85E-08	3.19E-07	1.59E-09	8.28E-07	8.36E-10
	Total GWP	1.29E-02	1.57E-01	2.60E-03	2.06E-03	2.54E-02	6.24E-05	3.28E-02	3.30E-05
	Nitrogen Oxides	3.13E-05	6.00E-06	1.93E-06	1.91E-06	4.55E-05	4.55E-09	6.10E-05	8.70E-08
	Sulfur Dioxide	7.81E-06	3.48E-06	3.61E-06	4.37E-06	1.33E-04	4.37E-10	0.00E+00	3.08E-10
	Carbon Monoxide	3.77E-05	4.32E-06	5.77E-06	6.87E-06	9.06E-06	1.42E-07	1.38E-05	1.00E-07
	Particulate Matter	4.11E-05	4.54E-07	1.80E-07	7.25E-07	2.49E-06	2.27E-10	0.00E+00	2.01E-09
	Lead	1.28E-10	1.13E-09	6.05E-10	5.20E-10	1.15E-09	0.00E+00	0.00E+00	0.00E+00
	Mercury	1.09E-11	4.29E-11	3.39E-11	2.96E-11	2.34E-10	0.00E+00	1.27E-19	1.61E-15
	Ammonia	4.45E-07	1.38E-08	1.91E-08	1.54E-08	1.22E-07	0.00E+00	1.03E-06	1.34E-09
	Radiation	3.85E-11	2.52E-13	1.23E-11	2.90E-11	1.57E-09	0.00E+00	0.00E+00	0.00E+00
	Non Methane VOC	2.51E-06	3.02E-05	2.65E-06	1.72E-06	2.60E-06	0.00E+00	0.00E+00	8.52E-04
Solid Waste	Heavy Metals to Soil	1.45E-08	4.65E-06	1.97E-08	1.54E-08	1.81E-08	0.00E+00	0.00E+00	0.00E+00
	Solid Waste	9.05E-07	1.66E-08	1.27E-07	1.27E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Water Emissions	Aluminum	3.04E-09	3.59E-10	6.50E-07	3.93E-07	1.26E-07	0.00E+00	0.00E+00	0.00E+00
	Ammonium/ammonia	4.35E-09	1.18E-07	7.05E-06	1.85E-08	9.79E-08	0.00E+00	0.00E+00	0.00E+00
	Heavy Metals	7.08E-06	1.87E-07	2.92E-06	1.85E-06	5.29E-06	0.00E+00	0.00E+00	0.00E+00
	Nitrate	1.20E-08	8.05E-10	1.94E-07	1.88E-07	7.23E-07	0.00E+00	0.00E+00	0.00E+00
	Nitrogen	7.94E-11	3.56E-09	9.04E-09	8.60E-09	1.44E-11	0.00E+00	0.00E+00	0.00E+00
	Phosphate	1.35E-10	4.39E-12	2.71E-10	3.20E-10	1.61E-09	0.00E+00	0.00E+00	0.00E+00
	Phosphorus	1.47E-06	1.71E-08	6.27E-07	3.80E-07	1.49E-10	0.00E+00	0.00E+00	0.00E+00
Water	Water Withdrawal (L)	1.13E-02	2.25E-02	7.56E-03	7.07E-03	2.18E-01	0.00E+00	0.00E+00	0.00E+00
	Water Consumption (L)	4.82E-03	5.34E-02	7.56E-03	5.11E-03	5.94E-02	0.00E+00	0.00E+00	0.00E+00
Land Use	Area Changes (Km^2)	0.00E+00	5.25E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EROI	Energy Input (MJ)	6.04E-02	1.35E-01	7.46E-02	5.28E-02	3.92E-01	0.00E+00	0.00E+00	0.00E+00

Figure 15: Raw Material Transport Inventory (Continued)

Life Cycle Inventory		Enclosed Train	Enclosed Truck	Ocean Freighter
Air Emissions	Carbon Dioxide	1.07E-02	1.42E-02	4.54E-03
	Methane	1.22E-05	5.84E-05	5.14E-06
	Nitrous Oxide	2.65E-07	3.11E-07	1.12E-07
	Total GWP	1.11E-02	1.58E-02	4.70E-03
	Nitrogen Oxides	2.62E-05	1.25E-05	1.11E-05
	Sulfur Dioxide	4.79E-06	2.40E-05	2.02E-06
	Carbon Monoxide	2.92E-05	2.04E-05	1.24E-05
	Particulate Matter	4.12E-08	2.10E-07	1.74E-08
	Lead	4.05E-11	2.06E-10	1.71E-11
	Mercury	3.36E-12	1.71E-11	1.42E-12
	Ammonia	3.90E-07	1.16E-07	1.65E-07
	Radiation	1.25E-11	6.36E-11	5.28E-12
	Non Methane VOC	5.03E-06	2.56E-05	2.12E-06
Solid Waste	Heavy Metals to Soil	2.88E-08	1.46E-07	1.22E-08
	Solid Waste	0.00E+00	0.00E+00	0.00E+00
Water Emissions	Aluminum	1.31E-06	6.65E-06	5.52E-07
	Ammonium/ammonia	1.42E-05	7.20E-05	5.98E-06
	Heavy Metals	5.81E-06	2.96E-05	2.46E-06
	Nitrate	5.87E-09	2.99E-08	2.48E-09
	Nitrogen	6.15E-12	3.13E-11	2.60E-12
	Phosphate	4.14E-11	2.11E-10	1.75E-11
	Phosphorus	1.25E-06	6.35E-06	5.28E-07
Water	Water Withdrawal (L)	6.62E-03	3.37E-02	2.80E-03
	Water Consumption (L)	1.61E-03	8.19E-03	6.81E-04
Land Use	Area Changes (Km^2)	0.00E+00	0.00E+00	0.00E+00
EROI	Energy Input (MJ)	1.29E-01	6.57E-01	5.46E-02

Figure 16: Energy Conversion Facility Inventory

Life Cycle Inventory (kg/kg)		Ethanol								
		Lignocellulosic Combustion		Lignocellulosic Gasification		Gasification		Dry Milling	Adv. Dry Milling	Adv. Dry Milling with CCS
		Corn Stover	Switch - grass	Corn Stover	Switch - grass	Corn Stover	Switch - grass	Corn Grain	Corn Grain	Corn Grain
Air Emissions	Carbon Dioxide	2.91E+00	2.91E+00	-1.31E-03	-1.31E-03	4.25E-02	4.25E-02	1.85E+00	1.60E+00	1.06E+00
	Methane	-4.92E-04	-4.92E-04	-1.28E-03	-1.28E-03	1.76E-04	1.76E-04	4.42E-03	2.36E-03	1.40E-03
	Nitrous Oxide	5.73E-05	5.73E-05	4.81E-05	4.81E-05	6.48E-05	6.48E-05	1.13E-05	6.54E-05	6.65E-05
	Total GWP	2.91E+00	2.91E+00	-1.90E-02	-1.90E-02	6.63E-02	6.63E-02	1.96E+00	1.68E+00	1.11E+00
	Nitrogen Oxides	-1.12E-03	-1.12E-03	-2.47E-03	-2.47E-03	9.40E-05	9.40E-05	1.48E-03	1.70E-04	3.21E-04
	Sulfur Dioxide	-1.88E-03	-1.88E-03	-6.68E-03	-6.68E-03	9.88E-04	9.88E-04	3.88E-03	5.48E-03	6.53E-03
	Carbon Monoxide	-1.88E-04	-1.88E-04	-1.92E-04	-1.92E-04	6.52E-05	6.52E-05	8.08E-04	1.55E-03	-2.48E-04
	Particulate Matter	-1.60E-05	-1.60E-05	-1.34E-04	-1.34E-04	2.32E-05	2.32E-05	7.34E-04	2.28E-03	7.73E-04
	Lead	-2.05E-08	-2.05E-08	-5.20E-08	-5.20E-08	2.95E-09	2.95E-09	1.57E-08	2.66E-08	3.03E-08
	Mercury	-6.32E-09	-6.32E-09	-1.37E-08	-1.37E-08	2.27E-10	2.27E-10	2.76E-09	4.17E-09	6.11E-09
	Ammonia	-2.86E-06	-2.86E-06	-6.63E-06	-6.63E-06	1.57E-05	1.57E-05	1.45E-06	-2.91E-04	-2.90E-04
	Radiation	-2.32E-08	-2.32E-08	-4.96E-08	-4.96E-08	2.08E-10	2.08E-10	9.49E-09	1.61E-08	2.19E-08
	Non Methane VOC	2.65E-05	2.65E-05	-1.28E-06	-1.28E-06	5.32E-06	5.32E-06	6.16E-04	3.86E-05	2.65E-05
Solid Waste	Heavy Metals to Soil	9.72E-07	9.72E-07	6.38E-07	6.38E-07	4.53E-07	4.53E-07	2.71E-07	3.87E-06	1.86E-06
	Solid Waste	4.43E-01	4.43E-01	4.43E-01	4.43E-01	3.15E-02	3.15E-02	8.80E-06	-1.59E-03	-1.48E-03
Water Emissions	Aluminum	-1.99E-06	-1.99E-06	-4.25E-06	-4.25E-06	1.78E-08	1.78E-08	8.10E-07	1.35E-06	1.86E-06
	Ammonium/ammonia	-4.65E-04	-4.65E-04	-1.28E-03	-1.28E-03	1.82E-04	1.82E-04	0.00E+00	0.00E+00	0.00E+00
	Heavy Metals	4.62E-05	4.62E-05	-9.92E-05	-9.92E-05	3.61E-06	3.61E-06	1.43E-04	9.08E-01	7.76E-05
	Nitrate	-1.35E-05	-1.35E-05	-3.71E-05	-3.71E-05	8.49E-06	8.49E-06	8.37E-06	1.24E-05	1.90E-05
	Nitrogen	2.45E-08	2.45E-08	2.40E-08	2.40E-08	9.26E-11	9.26E-11	4.84E-06	2.81E-06	4.84E-06
	Phosphate	9.44E-08	9.44E-08	6.37E-08	6.37E-08	4.57E-08	4.57E-08	1.12E-08	2.46E-08	2.80E-08
	Phosphorus	1.95E-05	1.95E-05	1.32E-07	1.32E-07	1.31E-07	1.31E-07	2.76E-05	9.50E-04	2.98E-06
Water	Water Withdrawal (L)	-9.34E-01	-9.34E-01	-2.31E+00	-2.31E+00	1.93E-01	1.93E-01	2.92E+00	-3.40E+02	-3.38E+02
	Water Consumption (L)	-9.35E-01	-9.35E-01	-2.31E+00	-2.31E+00	1.41E-01	1.41E-01	0.00E+00	0.00E+00	0.00E+00
Land Use	Area Changes (Km^2)	2.35E-07	2.35E-07	2.35E-07	2.35E-07	2.35E-07	2.35E-07	2.35E-07	2.35E-07	2.02E-06
EROI	Energy Input (MJ)	-6.20E+00	-1.89E-01	-1.60E+01	-1.60E+01	2.09E+00	2.09E+00	1.64E+01	2.44E+01	1.56E+01

Figure 16: Energy Conversion Facility Inventory (Continued)

Life Cycle Inventory (kg/kg)		Fischer - Tropsch Diesel						
		CBTL 15% Corn Stover with CCS	CBTL 15% Swithgrass with CCS	CBTL 15% SRWC with CCS	CBLT 30% Corn Stover with CCS	CBTL 30% Switchgrass with CCS	CBTL 30% SRWC with CCS	BTL Corn Stover
Air Emissions	Carbon Dioxide	2.27E-01	1.75E-01	5.26E-03	4.33E-03	1.75E-01	4.33E-03	1.21E-01
	Methane	-2.79E-04	-2.79E-04	-2.79E-04	-2.79E-04	-2.79E-04	-2.79E-04	-2.59E-04
	Nitrous Oxide	2.27E-06	2.26E-06	2.26E-06	2.26E-06	2.26E-06	2.26E-06	2.47E-06
	Total GWP	2.21E-01	1.69E-01	-1.03E-03	-1.97E-03	1.69E-01	-1.97E-03	1.15E-01
	Nitrogen Oxides	-2.33E-04	-2.33E-04	-2.33E-04	-2.33E-04	-2.33E-04	-2.33E-04	-2.12E-04
	Sulfur Dioxide	5.08E-04	4.55E-04	5.07E-04	5.07E-04	4.55E-04	5.07E-04	-1.64E-04
	Carbon Monoxide	-3.69E-05	-3.79E-05	-3.79E-05	-3.79E-05	-3.79E-05	-3.79E-05	-2.10E-05
	Particulate Matter	3.82E-04	3.82E-04	4.11E-04	4.11E-04	3.82E-04	4.11E-04	4.51E-04
	Lead	6.27E-09	5.88E-09	5.88E-09	5.88E-09	5.87E-09	5.88E-09	7.95E-09
	Mercury	3.31E-08	3.30E-08	5.52E-08	3.15E-08	3.30E-08	5.52E-08	-2.23E-10
	Ammonia	-1.02E-06	-1.02E-06	-1.02E-06	-1.02E-06	-1.02E-06	-1.02E-06	-9.44E-07
	Radiation	3.82E-04	3.82E-04	4.11E-04	4.11E-04	3.82E-04	4.11E-04	4.51E-04
	Non Methane VOC	-2.79E-04	-2.79E-04	-2.79E-04	-2.79E-04	-2.79E-04	-2.79E-04	-2.59E-04
Solid Waste	Heavy Metals to Soil	-5.64E-05	-5.64E-05	-5.64E-05	-5.64E-05	-5.64E-05	-5.64E-05	-4.83E-05
	Solid Waste	3.58E-01	3.58E-01	3.87E-01	3.87E-01	3.58E-01	3.87E-01	4.03E-01
Water Emissions	Aluminum	-2.79E-05	-2.79E-05	-1.77E-05	-1.83E-05	-2.79E-05	-1.77E-05	4.91E-06
	Ammonium/ammonia	-4.45E-08	-4.52E-08	-4.52E-08	-4.52E-08	-4.52E-08	-4.52E-08	-3.99E-08
	Heavy Metals	-7.25E-04	-7.25E-04	-7.14E-04	-7.15E-04	-7.25E-04	-7.14E-04	-6.43E-04
	Nitrate	1.24E-04	1.24E-04	1.35E-04	1.34E-04	1.24E-04	1.35E-04	1.47E-04
	Nitrogen	-6.60E-08	-6.60E-08	-6.60E-08	-6.60E-08	-6.60E-08	-6.60E-08	-5.66E-08
	Phosphate	-3.50E-08	-3.50E-08	-3.50E-08	-3.50E-08	-3.50E-08	-3.50E-08	-2.63E-08
	Phosphorus	2.03E-09	2.03E-09	2.03E-09	2.03E-09	2.03E-09	2.03E-09	3.24E-09
Water	Water Withdrawal (L)	-6.75E-01	-6.75E-01	-6.75E-01	-6.75E-01	-6.75E-01	-6.75E-01	-6.28E-01
	Water Consumption (L)	-6.80E-01	-6.81E-01	-6.81E-01	-6.81E-01	-6.81E-01	-6.81E-01	-6.31E-01
Land Use	Area Changes (Km^2)	5.84E-07	5.84E-07	5.84E-07	5.84E-07	5.84E-07	5.84E-07	5.84E-07
EROI	Energy Input (MJ)	-6.76E+00	-6.76E+00	-6.76E+00	-6.76E+00	-6.76E+00	-6.76E+00	-6.27E+00

Figure 16: Energy Conversion Facility Inventory (Continued)

Life Cycle Inventory (kg/kg)		Fischer - Tropsch Diesel						
		BTL Corn Stover with CCS	CTL I6 Coal with CCS	CTL I6	BTL Switchgrass	BTL Switchgrass with CCS	BTL SRWC	BTL SRWC with CCS
Air Emissions	Carbon Dioxide	1.11E-01	1.27E-01	4.56E+00	1.11E-01	1.11E-01	1.11E-01	1.85E-01
	Methane	-2.78E-04	-3.14E-04	-3.14E-04	-2.78E-04	-2.78E-04	-2.78E-04	-2.78E-04
	Nitrous Oxide	2.27E-06	3.69E-07	3.70E-07	2.28E-06	2.26E-06	2.28E-06	2.27E-06
	Total GWP	1.05E-01	1.19E-01	4.55E+00	1.05E-01	1.05E-01	1.04E-01	1.79E-01
	Nitrogen Oxides	-2.32E-04	-4.46E-04	-4.44E-04	-2.29E-04	-2.33E-04	-2.30E-04	-2.32E-04
	Sulfur Dioxide	-1.89E-04	8.66E-05	8.88E-05	-1.85E-04	-1.90E-04	-1.86E-04	-1.89E-04
	Carbon Monoxide	-3.48E-05	-6.30E-05	-5.62E-05	-2.65E-05	-3.72E-05	-2.94E-05	-3.60E-05
	Particulate Matter	4.42E-04	3.87E-04	3.97E-04	4.43E-04	4.41E-04	4.43E-04	4.42E-04
	Lead	6.33E-09	5.34E-09	6.35E-09	7.81E-09	5.90E-09	7.29E-09	6.40E-09
	Mercury	-2.58E-10	3.48E-08	3.57E-08	-2.45E-10	-2.59E-10	-2.50E-10	-2.46E-10
	Ammonia	-1.02E-06	-1.11E-06	-1.11E-06	-1.01E-06	-1.02E-06	-1.01E-06	-1.02E-06
	Radiation	4.42E-04	3.87E-04	3.97E-04	4.43E-04	4.41E-04	4.43E-04	4.42E-04
	Non Methane VOC	-2.78E-04	-3.14E-04	-3.14E-04	-2.78E-04	-2.78E-04	-2.78E-04	-2.78E-04
Solid Waste	Heavy Metals to Soil	-5.56E-05	-8.76E-04	-8.74E-04	-5.30E-05	-5.63E-05	-5.39E-05	-5.63E-05
	Solid Waste	4.33E-01	3.65E-01	3.73E-01	4.33E-01	4.33E-01	4.33E-01	4.33E-01
Water Emissions	Aluminum	-7.86E-06	-5.54E-05	-5.27E-05	-7.77E-06	-7.87E-06	-7.80E-06	-7.87E-06
	Ammonium/ammonia	-4.47E-08	-1.32E-07	-1.31E-07	-4.34E-08	-4.51E-08	-4.39E-08	-4.41E-08
	Heavy Metals	-7.03E-04	-7.70E-04	-7.68E-04	-7.02E-04	-7.03E-04	-7.02E-04	-7.03E-04
	Nitrate	1.44E-04	9.82E-05	1.01E-04	1.44E-04	1.44E-04	1.44E-04	1.44E-04
	Nitrogen	-6.50E-08	-1.99E-07	-1.97E-07	-6.21E-08	-6.59E-08	-6.31E-08	-6.59E-08
	Phosphate	-3.38E-08	-6.62E-07	-6.59E-07	-3.00E-08	-3.49E-08	-3.13E-08	-3.49E-08
	Phosphorus	2.27E-09	1.32E-09	2.08E-09	3.08E-09	2.04E-09	2.80E-09	2.04E-09
Water	Water Withdrawal (L)	-6.73E-01	-9.11E-01	-9.12E-01	-6.73E-01	-6.74E-01	-6.73E-01	-6.74E-01
	Water Consumption (L)	-6.79E-01	-1.00E+00	-1.01E+00	-6.78E-01	-6.80E-01	-6.78E-01	-6.78E-01
Land Use	Area Changes (Km^2)	5.84E-07	1.36E-07	1.36E-07	5.84E-07	5.84E-07	5.84E-07	5.84E-07
EROI	Energy Input (MJ)	-6.74E+00	-7.53E+00	-7.53E+00	-6.73E+00	-6.75E+00	-6.73E+00	-6.75E+00

Figure 16: Energy Conversion Facility Inventory (Continued)

Life Cycle Inventory (kg/kg)		Petroleum		
		Diesel	Gasoline	Kerosene/ Jet Fuel
Air Emissions	Carbon Dioxide	3.79E-01	3.93E-01	2.39E-01
	Methane	4.65E-04	4.79E-04	2.93E-04
	Nitrous Oxide	5.83E-06	6.34E-06	3.68E-06
	Total GWP	3.92E-01	4.07E-01	2.47E-01
	Nitrogen Oxides	1.08E-04	1.14E-04	6.84E-05
	Sulfur Dioxide	5.06E-04	5.45E-04	3.19E-04
	Carbon Monoxide	1.53E-04	1.62E-04	9.63E-05
	Particulate Matter	5.22E-06	5.04E-06	3.29E-06
	Lead	4.48E-09	4.74E-09	2.83E-09
	Mercury	6.29E-10	6.72E-10	3.97E-10
	Ammonia	3.57E-06	3.94E-06	2.26E-06
	Radiation	2.68E-09	2.86E-09	1.69E-09
	Non Methane VOC	1.64E-04	1.76E-04	1.03E-04
Solid Waste	Heavy Metals to Soil	3.18E-07	2.92E-07	1.99E-07
	Solid Waste	0.00E+00	0.00E+00	0.00E+00
Water Emissions	Aluminum	4.68E-04	2.30E-07	4.92E-04
	Ammonium/ammonia	1.91E-07	2.01E-07	1.21E-07
	Heavy Metals	2.07E-03	2.38E-03	2.17E-03
	Nitrate	1.26E-06	1.34E-06	7.94E-07
	Nitrogen	1.69E-10	1.56E-10	1.06E-10
	Phosphate	3.81E-09	3.99E-09	2.40E-09
	Phosphorus	4.47E-04	5.13E-04	4.70E-04
Water	Water Withdrawal (L)	2.87E-01	3.05E-01	1.81E-01
	Water Consumption (L)	1.87E+00	2.10E+00	1.79E+00
Land Use	Area Changes (Km^2)	5.54E-02	5.26E-02	3.47E-02
EROI	Energy Input (MJ)	2.23E+00	2.12E+00	1.40E+00

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