

January 27, 2025

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# Demo for R&D GREET<sup>®</sup> 1: Fuel Cycle Analysis

3:00-4:00 p.m. CT

## **Instructors**

*Gabrielle Olson, Great Plains Institute*

*Branden Leonhardt, Department of Energy*

**Argonne National Laboratory Subject Matter Experts**

*Longwen Ou, Uisung Lee*



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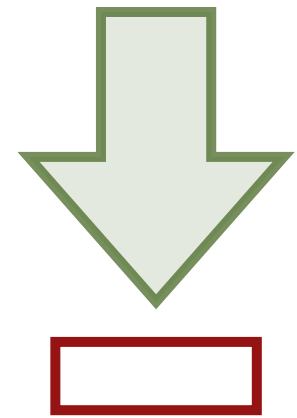


# Table of contents

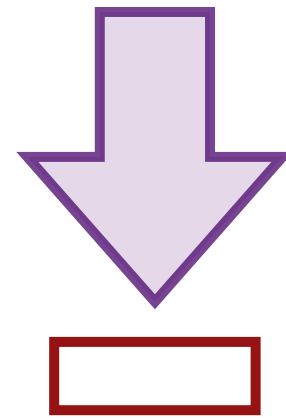
1. Navigate in R&D GREET
2. Steps to Model a Scenario in R&D GREET 1
3. Similarities Across Tabs
4. Example Scenarios
  - a. Model an SI-ICE Vehicle
  - b. Model an SI-ICE Vehicle Used in 2017
  - c. Model an SI-ICE Vehicle in the Midwest
5. Fuel Efficiency in R&D GREET
6. Greenhouse Gase Modeling in R&D GREET
7. Transportation and Distribution in R&D GREET



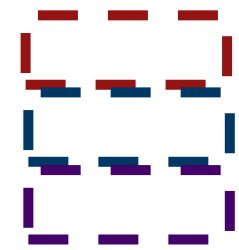
# Demo session symbol key



Select



Right click



Look here

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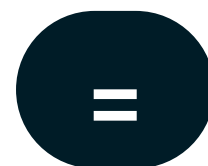
Step 1



Scroll

Note:

Instructions  
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Equation

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Type the  
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# Review the Overview Tab



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**Inputs** **Results**

Petroleum Ethanol Natural Gas MeOH & RNG

Electric Hydrogen BioOil Pyrolysis & IDL Integrated Biorefiner

Fuel Production Time Series Emission Factors Time Series Agricultural and Mining Machinery Emission Factors Time Series

Water Consumption Factors Passenger Car Time Series Light Duty Truck 1 Time Series Light D Tim

Fuel Specifications Vehicles Ag Inputs

Overview **Inputs** **Results** Petroleum Co\_processing NG MeOH\_FTD EtOH Electric Generation\_mixes Bio ... +

**Open R&D GREET Excel**

# What Do the Different Color Cells in R&D GREET 1 Indicate?



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46 **Color Scheme for Cells in the GREET Model**

47 Clear cells are primarily for calculations and secondary assumptions

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50 Yellow cells are key input assumptions that users can change for their own simulations

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53 Peach cells are key options that users can select for their own simulations from drop-down menu

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55

56 Green cells are key input assumptions with probability distribution functions built in

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59 Blue cells are GREET forecast cells for running stochastic simulations

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62 Gray cells are placeholder pathways. Even though simulations of these pathways are completed in GREET, no thorough research was conducted to examine key input assumptions for the pathways.

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65 Cells with red triangle in the upper right corner contain comments. Users are advised to read the comments

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Overview Inputs Results Petroleum Co\_processing NG MeOH\_FTD EtOH Electric Generation\_mixes Bio ... +



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**Color Scheme for Cells in the GREET Model**

- Clear cells are primarily for calculations and secondary assumptions
- Yellow cells are key input assumptions that users can change for their own simulations
- Peach cells are key options that users can select for their own simulations from drop-down menu
- Green cells are key input assumptions with probability distribution functions built in
- Blue cells are GREET forecast cells for running stochastic simulations
- Gray cells are placeholder pathways. Even though simulations of these pathways are completed in GREET, no thorough research was conducted to examine key input assumptions for the pathways.
- Cells with red triangle in the upper right corner contain comments. Users are advised to read the comments

Overview Inputs Results Petroleum Co\_processing NG MeOH\_FTD EtOH Electric Generation\_mixes Bio ... +

**Note:** beginners will change the highlighted cells

# What Do the Different Color Tabs in R&D GREET 1 Indicate?



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	A	B	C	D	E	F	G	H	I	J	K	L	M
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Green cells are key input assumptions with probability distribution functions built in

Blue cells are GREET forecast cells for running stochastic simulations

Gray cells are placeholder pathways. Even though simulations of these pathways are completed in GREET, no thorough research was conducted to examine key input assumptions for the pathways.

Cells with red triangle in the upper right corner contain comments. Users are advised to read the comments

**Color Scheme for Tabs in the GREET Model**

- Clear tab is for GREET overview
- Yellow tabs indicate worksheets for input assumptions
- Peach tabs indicate worksheets for fuel production
- Green tabs indicate worksheets for well-to-wheels and well-to-wake results
- Gray tabs indicate supporting worksheets
- Blue tabs indicate worksheets for stochastic simulations

Overview Inputs Results Petroleum Co\_processing NG MeOH\_FTD EtOH Electric Generation\_mixes Bio



# Describe the Electric R&D GREET 1 Tab



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Sheet	Description
<b>Inputs</b>	Key input parameters that users can specify for GREET simulations.
<b>Results</b>	Well-to-pump and well-to-wheels energy use, emissions, and water consumption results for vehicle/fuel technology combinations
<b>Petroleum</b>	Calculations of well-to-pump energy use and emissions for petroleum-based fuels (including production of additives)
<b>Co_processing</b>	Calculations of well-to-pump energy use and emissions for co-processed bio-fuels in petroleum refineries
<b>NG</b>	Calculations of well-to-pump energy use, emissions, and water consumption for NG-based fuels
<b>MeOH&amp;FTD</b>	Calculations of well-to-pump energy use, emissions, and water consumption for methanol (MeOH), dimethyl ether (DME), Fischer-Tropsch diesel (FTD), and Fischer-Tropsch (FT) naphtha
<b>EtOH</b>	Calculations of well-to-pump energy use, emissions, and water consumption for producing ethanol from corn, sugarcane, and cellulosic biomass and producing butanol from corn
<b>Electric</b>	Calculations of energy use, emissions, and water consumption for electricity generation
<b>Bio_electricity</b>	Calculations of energy use, emissions, and water consumption for electricity generation from biomass
<b>Hydrogen</b>	Calculations of well-to-pump energy use, emissions, and water consumption for hydrogen production pathways
<b>BioOil</b>	Calculations of well-to-pump energy use, emissions, and water consumption for biodiesel, renewable diesel, and renewable gasoline from soybeans, palm, canola, jatropha and camelina
<b>Algae</b>	Calculations of well-to-pump energy use, emissions, and water consumption for biodiesel, renewable diesel, and renewable gasoline from algae
<b>Macroalgae</b>	Calculations of well-to-pump energy use, emissions, and water consumption for biofuels from macroalgae
<b>Waste</b>	Calculations of well-to-pump energy use, emissions, and water consumption for conventional waste management practices
<b>RNG</b>	Calculations of well-to-pump energy use, emissions, and water consumption for renewable natural gas from landfill gas, manure anaerobic digestion and wastewater sludge anaerobic digestion
<b>Pyrolysis_IDL</b>	Calculations of well-to-pump energy use, emissions, and water consumption for pyrolysis-based renewable gasoline and diesel and for high-octane gasoline production via indirect liquefaction
<b>IBR</b>	Calculations of well-to-pump energy use, emissions, and water consumption for liquid fuels and chemicals from integrated biorefinery (IBR)
<b>E_fuel</b>	Calculations of well-to-pump energy use, emissions, and water consumption for electro-fuel (CO2 utilization) pathways
<b>Fuel_Prod_TS</b>	Time-series tables for key parametric assumptions for well-to-pump fuel production processes. This sheet interacts with other fuel production sheets
<b>EF_TS</b>	Time-series tables for emission factors of combustion technologies applied to stationary sources
<b>AgMining_EF_TS</b>	Time-series tables for emission factors of agricultural and mining machineries
<b>EF</b>	Emission factors of combustion technologies by fuel type. This sheet interacts with EF_TS sheet.
<b>WCF</b>	Water Consumption Factors (WCF) of feedstock and fuel production
<b>Fuel_Specs</b>	Specifications of individual fuels and global warming potentials of GHGs
<b>Car_TS</b>	Time-series tables of fuel economy and emission rates/changes associated with vehicle operations for passenger cars
<b>LDT1_TS</b>	Time-series tables of fuel economy and emission rates/changes associated with vehicle operations for light duty truck 1
<b>LDT2_TS</b>	Time-series tables of fuel economy and emission rates/changes associated with vehicle operations for light duty truck 2
<b>Vehicles</b>	Calculations of energy use, emissions, and water consumption for vehicle operations

Overview Inputs Results Petroleum Co\_processing NG MeOH\_FTD EtOH Electric Generation\_mixes Bio ... +



# Navigate in R&D GREET



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Inputs	Results			
Petroleum	Ethanol	Natural Gas	MeOH &	RNG
Electric	Hydrogen	BioOil	Pyrolysis & IDL	Integrated Biorefinery
Fuel Production Time Series	Emission Factors Time Series	Agricultural and Mining Machinery Emission Factors Time Series		
Water Consumption Factors	Passenger Car Time Series	Light Duty Truck 1 Time Series	Light Duty Truck 2 Time Series	
Fuel Specifications	Vehicles	Ag Inputs		

Overview Inputs Results Petroleum Co\_processing NG MeOH\_FTD EtOH Electric Generation\_mixes Bio...

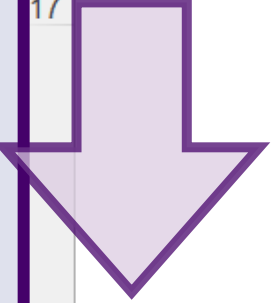
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		Inputs		Results								
		Petroleum		Ethanol		Natural Gas		MeOH &		RNG		
		Electric		Hydrogen		BioOil		Pyrolysis & IDL		Integrated Biorefinery		
Fuel Production Time Series			Emission Factors Time Series			Agricultural and Mining Machinery Emission Factors Time Series						
Water Consumption Factors			Passenger Car Time Series			Light Duty Truck 1 Time Series			Light Duty Truck 2 Time Series			
Fuel Specifications			Vehicles			Ag Inputs						

Overview Inputs Results Petroleum Co\_processing NG MeOH\_FTD EtOH Electric Generation\_mixes Bio ... +



**Right click**

Microsoft Excel ribbon showing tabs: Clipboard, Font, Alignment, Number, Styles, Conditional Formatting, Format as Table, Cell Styles, Insert, Delete, Format, Cells, Editing, Sensitivity, Add-ins, Analyze Data.

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Buttons in spreadsheet:

- Inputs (Yellow)
- Results (Green)
- Petroleum (Orange)
- Ethanol (Orange)
- Natural Gas (Orange)
- MeOH & FTD (Orange)
- RNG (Orange)
- Algae (Orange)
- Electric (Orange)
- Hydrogen (Orange)
- BioOil (Orange)
- Pyrolysis & IDL (Orange)
- Integrated Biorefinery (Orange)
- Plastic Fuel (Orange)
- Fuel Production Time Series (Yellow)
- Emission Factors Time Series (Yellow)
- Agricultural and Mining Machineries Emission Factors Time Series (Yellow)
- Water Consumption Factors (Yellow)
- Passenger Car Time Series (Yellow)
- Light Duty Truck 1 Time Series (Yellow)
- Light Duty Truck 2 Time Series (Yellow)
- Fuel Specifications (Yellow)
- Vehicles (Yellow)
- Ag Inputs (Yellow)

Activate dialog box:

Activate: ? X

- Overview (Selected)
- Inputs
- Results
- Petroleum
- Co\_processing
- NG
- MeOH\_FTD
- EtOH
- Electric
- Generation\_mixes
- Bio\_electricity
- Hydrogen
- BioOil
- Algae
- Macroalgae
- Waste
- RNG
- Pyrolysis\_IDL
- IBR
- E\_fuel

OK Cancel

Excel status bar showing active cells: Petroleum, Co\_processing, NG, MeOH\_FTD, EtOH, Electric, Generation\_mixes, Bio, ... +

# Results Tab Navigation



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Inputs Results

Petroleum Ethanol Natural Gas MeOH & RNG

Electric Hydrogen BioOil Pyrolysis & IDL Integrated Biorefiner

Fuel Production Time Series Emission Factors Time Series Agricultural and Mining Machinery Emission Factors Time Series

Water Consumption Factors Passenger Car Time Series Light Duty Truck 1 Time Series Light D Tim

Fuel Specifications Vehicles Ag Inputs

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Row 15: \*\*\*\*\*

Buttons: Inputs (yellow), Results (green)

Buttons: Petroleum, Ethanol, Natural Gas, MeOH & FTD, RNG, Algae

Buttons: Electric, Hydrogen, BioOil, Pyrolysis & IDL, Integrated Biorefinery, Plastic Fuel

Buttons: Fuel Production Time Series, Emission Factors Time Series, Agricultural and Mining Machineries Emission Factors Time Series, Emission Factors Time Series

Buttons: Water Consumption Factors, Passenger Car Time Series, Light Duty Truck 1 Time Series, Light Duty Truck 2 Time Series

Buttons: Fuel Specifications, Vehicles, Ag Inputs

Bottom bar: Petroleum, Co\_processing, NG, MeOH\_FTD, EtOH, Electric, Generation\_mixes, Bio, ... +

Dialog Box: Activate (1), Overview, Inputs, Results (2), OK, Cancel

Callout: Press F9 to ensure the results of R&D GREET are up to date (3)



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# Ag Inputs Tab Navigation



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*****												

**Inputs** **Results**

Petroleum Ethanol Natural Gas MeOH & RNG

Electric Hydrogen BioOil Pyrolysis & IDL Integrated Biorefiner

Fuel Production Time Series Emission Factors Time Series Agricultural and Mining Machinery Emission Factors Time Series

Water Consumption Factors Passenger Car Time Series Light Duty Truck 1 Time Series Light D Tim

Fuel Specifications **Vehicles** **Ag Inputs**

Overview **Inputs** Results Petroleum Co\_processing NG MeOH\_FTD EtOH Electric Generation\_mixes Bio ... +

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		Petroleum		Ethanol		Natural Gas		MeOH & FTD		RNG		Alga												
		Electric		Hydrogen		BioOil		Pyrolysis & IDL		Integrated Biorefinery		Plastic Fuel												
		Fuel Production Time Series		Emission Factors Time Series		Agricultural and Mining Machineries Emission Factors Time Series				Emis														
		Water Consumption Factors		Passenger Car Time Series		Light Duty Truck 1 Time Series		Light Duty Truck 2 Time Series																
		Fuel Specifications		Vehicles		Ag Inputs																		

\*\*\*\*\*

LDT2\_TS Vehicles Urban\_Shares Compression Coal T&D\_Flowcharts T&D Uranium ASU **Ag\_Inputs** Enzyr ... +



Microsoft Excel ribbon: Clipboard, Font (Arial, 10), Alignment, Number, Styles (Conditional Formatting, Format as Table, Cell Styles), Cells (Insert, Delete, Format), Editing, Sensitivity, Add-ins, Analyze Data.

Formula bar: T13

Worksheet grid: Columns A-M, Rows 1-6.

Worksheet content:

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Worksheet navigation: Inputs (yellow), Results (green), Petroleum, Ethanol, Natural Gas, MeOH & FTD, RNG, Algae, Electric, Hydrogen, BioOil, Pyrolysis & IDL, Integrated Biorefinery, Plastic Fuel, Fuel Production Time Series, Emission Factors Time Series, Agricultural and Mining Machineries Emission Factors Time Series, Water Consumption Factors, Passenger Car Time Series, Light Duty Truck 1 Time Series, Light Duty Truck 2 Time Series, Fuel Specifications, Vehicles, Ag Inputs.

Bottom navigation: Petroleum, Co\_processing, NG, MeOH\_FTD, EtOH, Electric, Generation\_mixes, Bio, +, : (80%)

Activate dialog box (left):

Activate: [? X]

- Car\_TS
- LDT1\_TS
- LDT2\_TS
- Vehicles
- Urban\_Shares
- Compression
- Coal
- T&D\_Flowcharts
- T&D
- Uranium
- ASU
- Ag\_Inputs** (highlighted with red box)
- Enzymes\_Yeast
- Pretreatment
- Catalyst
- PUP\_conversion
- Steam\_Cracking
- Chemicals
- Plastics
- CESA

Annotations:

- 1: Purple circle pointing to the scroll bar in the dialog box.
- 2: Purple circle pointing to the list items in the dialog box.
- 3: Purple circle pointing to the OK button in the dialog box.

Green arrows indicate the flow of activation: from the dialog box to the 'Ag\_Inputs' cell in the worksheet, and from the 'OK' button to the 'Ag\_Inputs' cell.

# Steps to Model a Scenario in R&D GREET 1



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# Steps to model a scenario in R&D GREET 1



## Go to the “Results” Tab

*Are the results for your scenario generated by default?*

## Go to the “Inputs” Tab

*Are the changes I want to make altered on this tab?*

### **If Yes,**

*Make your changes and go to the “Results” tab to see your results*

### **If No,**

*Go to the fuel-specific/vehicle-specific tabs for the fuel/vehicle you want to model*

## Dive into the formulas on the “Results” tab

### **Vehicle Operation Inputs**

*Go to the “Vehicles” tab*

### **Fuel and Feedstock**

*Go to the “Fuel-specific” tab*



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# Light-Duty Vehicle Outputs



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Inputs Results

Petroleum Ethanol Natural Gas MeOH & RNG

Electric Hydrogen BioOil Pyrolysis & IDL Integrated Biorefiner

Fuel Production Time Series Emission Factors Time Series Agricultural and Mining Machinery Emission Factors Time Series

Water Consumption Factors Passenger Car Time Series Light Duty Truck 1 Time Series Light D Tim

Fuel Specifications Vehicles Ag Inputs

Overview Inputs Results Petroleum Co\_processing NG MeOH\_FTD EtOH Electric Generation\_mixes Bio



# Adjust General Simulation Settings



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Water Consumption Factors Passenger Car Time Series Light Duty Truck 1 Time Series Light D Tim

Fuel Specifications Vehicles Ag Inputs

Overview Inputs Results Petroleum Co\_processing NG MeOH\_FTD EtOH Electric Generation\_mixes Bio



# Adjust More-specified Simulation Settings



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Home Results Petroleum MeOH & Ethanol Electric Vehicles Car\_TS Tab LDV1\_TS Tab LDV2\_TS Tab  
 Natural Gas Hydrogen Bio Oil Pyrolysis WTP Vehicles Tab HDV\_TS Tab HDV\_WTW Tab  
 Fuel Economy

### Scenario Control Variables and Input Assumptions

#### 1. Key Options for Simulation

1.1) Target Year for Simulation: 2022

1.2) Point-Estimation or Probability-Estimation Option: Load Stochastic Toolkit

Link with GREET2: Reactivate GREET2 Links, Deactivate GREET2 Links

Load Stochastic Toolkit ... To load the stochastic toolkit  
 Unload Stochastic Toolkit ... To unload the stochastic toolkit

#### 2. Vehicle Types for Simulation

1 -- Passenger Cars; 2 -- Light-Duty Trucks 1 (LDT1) (Sports utility vehicles [SUV]); 3 -- Light-Duty Trucks 2 (LDT2) (Pickup Truck [PUT])

#### 3. Petroleum-Based Fuels

##### 3.1) Petroleum Recovery Options

##### 3.1.a) Share of crude oil sources

1 -- Basis of share of crude oil sources: 1 -- EIA projection, 2 -- User defined

	U.S. Domestic	Canada (Oil Sands)	Canada (Conv. Crude)	Mexico	Middle East	Latin America
EIA projection	80.8%	6.6%	5.0%	1.9%	2.3%	
User defined	0.0%	100.0%	0.0%	0.0%	2.3%	
Used in calculation	80.8%	6.6%	5.0%	1.9%	2.3%	
API gravity	34.0	18.1	26.5	26.5	31.8	
S Content (wt %)	1.4	2.9	1.9	2.2	2.3	
Average transportation distances (mi)	See T&D_Flowcharts tab	1,708	1,708	797	14,596	

U.S. Domestic crude	Shale Oil (Bakken)	Shale Oil (Eagle Ford)	Rest of U.S. domestic crude
API gravity	42	48	32.0
Vol. Share (%)	8.7%	8.0%	83.3%

Petroleum Worksheet Results Back to Top

Overview Inputs Results Petroleum Co-processing NG MeOH FTD EtOH Electric Generation mixes Bio



# Similarities Across Tabs



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	A	B	C	D	E	F	G	H	I
1	<b>Natural Gas to Compressed Natural Gas (CNG), Liquefied Natural Gas (LNG) and Liquefied Petroleum Gas (LPG)</b>								
2	<b>1) Scenario Control and Key Input Parameters (from the <i>Inputs</i> sheet)</b>								
3	Transportation Fuel Application								
4	LPG Production	Natural Gas	Crude Oil	Renewable NG					
5		86.6%	13.4%	0.0%					
6	LNG Production	Natural Gas	Flared Gas	Renewable NG					
7		100.0%	0.0%	0.0%					

Home
Inputs
Results

	A	B	C	D	E	F	G	H	I
1	<b>Natural Gas to Compressed Natural Gas (CNG), Liquefied Natural Gas (LNG) and Liquefied Petroleum Gas (LPG)</b>								
9	<b>2) Shares of Combustion Processes for Each Stage</b>								
10		NG Recovery	NG Processing	NG Compression	NG Liquefaction	LPG Production	Canadian NG Recovery	Canadian NG Processing	LNG Regasification
11	Resi. oil industrial or commercial	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	0.0%
12	Diesel commercial Boiler	25.0%	33.0%		33.0%	33.0%	25.0%	33.0%	0.0%
13	Diesel stationary engine	50.0%	33.0%	50.0%	33.0%	33.0%	50.0%	33.0%	0.0%

	A	B	C	D	E	F	G	H	I
1	<b>Natural Gas to Compressed Natural Gas (CNG), Liquefied Natural Gas (LNG) and Liquefied Petroleum Gas (LPG)</b>								
20	<b>3) Calculations of Energy Consumption, Water Consumption, and Emissions for Each Stage</b>								
21	Natural Gas as a Processing Fuel (produced in North America)								

	A	B	C	D	E	F	G	H	I
1	<b>Natural Gas to Compressed Natural Gas (CNG), Liquefied Natural Gas (LNG) and Liquefied Petroleum Gas (LPG)</b>								
80	<b>4) Summary of Energy Consumption, Water Consumption, and Emissions: Btu or Gallons or Grams per mmBtu of Fuel Throughput at Each Stage</b>								
81	<b>4.1) Energy Use, Water Consumption, and Total Emissions</b>								
82		Natural Gas as Stationary Fuels	Natural Gas for Electricity generation	NGL to Oil Sands	NGL (based on Shale Gas) to Steam Crackers	Natural Gas to Liquefied Natural Gas (as an intermediate fuel)		Flare gas to Liquefied Natural Gas (as an intermediate fuel)	
83						Feedstock	Fuel	Feedstock	Fuel
84	Loss factor						1.017		1.019
85	Total energy	112,491	96,953	87,461	78,172	83,867	122,871	79,182	125,549





# Example Scenarios



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# Default Gasoline

Model a Spark-Ignition Internal Combustion Engine  
(SI-ICE) Vehicle Fueled by Gasoline



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# Review the Results Tab



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Fuel Production Time Series Emission Factors Time Series Agricultural and Mining Machinery Emission Factors Time Series

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Fuel Specifications Vehicles Ag Inputs

Overview Inputs Results Petroleum Co\_processing NG MeOH\_FTD EtOH Electric Generation\_mixes Bio ... +

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Comments Share

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RSELSIICEV Select Fuels

Home Inputs Back to Top WTP Results WTW Changes

**WTW Results Menu** Select a vehicle type from a pink drop down menu, then press "Go"

SI ICE Vehicles Select Fuels Go

SIDI ICE Vehicles Select Fuels Go

CIDI ICE Vehicles Select Fuels Go

**Unit Selection** Select units from a pink drop down menu for the Results

Per Vehicle Distance Travelled Energy Unit: Btu Emission Unit: g Service Functional Unit: mile

Per Energy in Fuels Energy Unit: Btu Emission Unit: g Energy Functional Unit: mmBtu

SI Hybrid Vehicles (HEV) Select Fuels Go

CIDI Hybrid Vehicles (HEV) Select Fuels Go

BEV and FCV Select Fuels Go

SI Plug-in Hybrids (PHEV) Select Fuels Go

CIDI Plug-in Hybrids (PHEV) Select Fuels Go

GCI ICE Vehicles Select Fuels Go

Performance-enhancing Fuels Select Fuels

Gasoline Vehicle: Gasoline

Item	Btu/mile or Gallon/mile or g/mile				Btu/mmBtu or Gallon/mmBtu or g/mmBtu			
	Feedstock	Fuel	Vehicle Operation	Total	Feedstock	Fuel	Vehicle Operation	Total
Total Energy	217	944	4,289	5,450	50,498	220,096	1,000,000	1,270,595
Fossil Fuels	203	837	4,003	5,042	47,218	195,069	933,326	1,175,613
Coal	19	30	0	49	4,492	6,898	0	11,391
Natural Gas	147	538	0	685	34,251	125,536	0	159,788
Petroleum	36	269	4,003	4,308	8,474	62,635	933,326	1,004,435
Water Consumption	0.1	0.2	0	0	15	38	0	53
CO2 (w/ C in VOC & CO)	-4	63	329	388	-839	14,592	76,702	90,455
CH4	0.315	0.173	0.015	0.503	73.544	40.320	3.414	117.279
N2O	0.000	0.012	0.004	0.016	0.066	2.787	0.911	3.764
GHGs	6	71	330	407	1,371	16,554	77,053	94,977
VOC: Total	0.013	0.114	0.230	0.356	2.988	26.524	53.597	83.110
CO: Total	0.026	0.043	2.741	2.810	6.071	10.068	639.104	655.243
NOx: Total	0.039	0.071	0.082	0.193	9.137	16.540	19.209	44.886
PM10: Total	0.002	0.010	0.035	0.047	0.443	2.360	8.044	10.847
PM2.5: Total	0.002	0.006	0.007	0.015	0.372	1.502	1.729	3.602

Overview Inputs Results Petroleum Co\_processing NG MeOH\_FTD EtOH Electric Generation\_mixes Bio

Ready Calculate Accessibility: Investigate 85%



# Well-to-Pump (WTP) GHG Emissions



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# General formulas in R&D GREET



Well-to-pump (WTP) = [feedstock + fuel]

Well-to-wheels (WTW) = [feedstock + fuel +  
vehicle operation]

$WTW = WTP + \text{vehicle operations}$

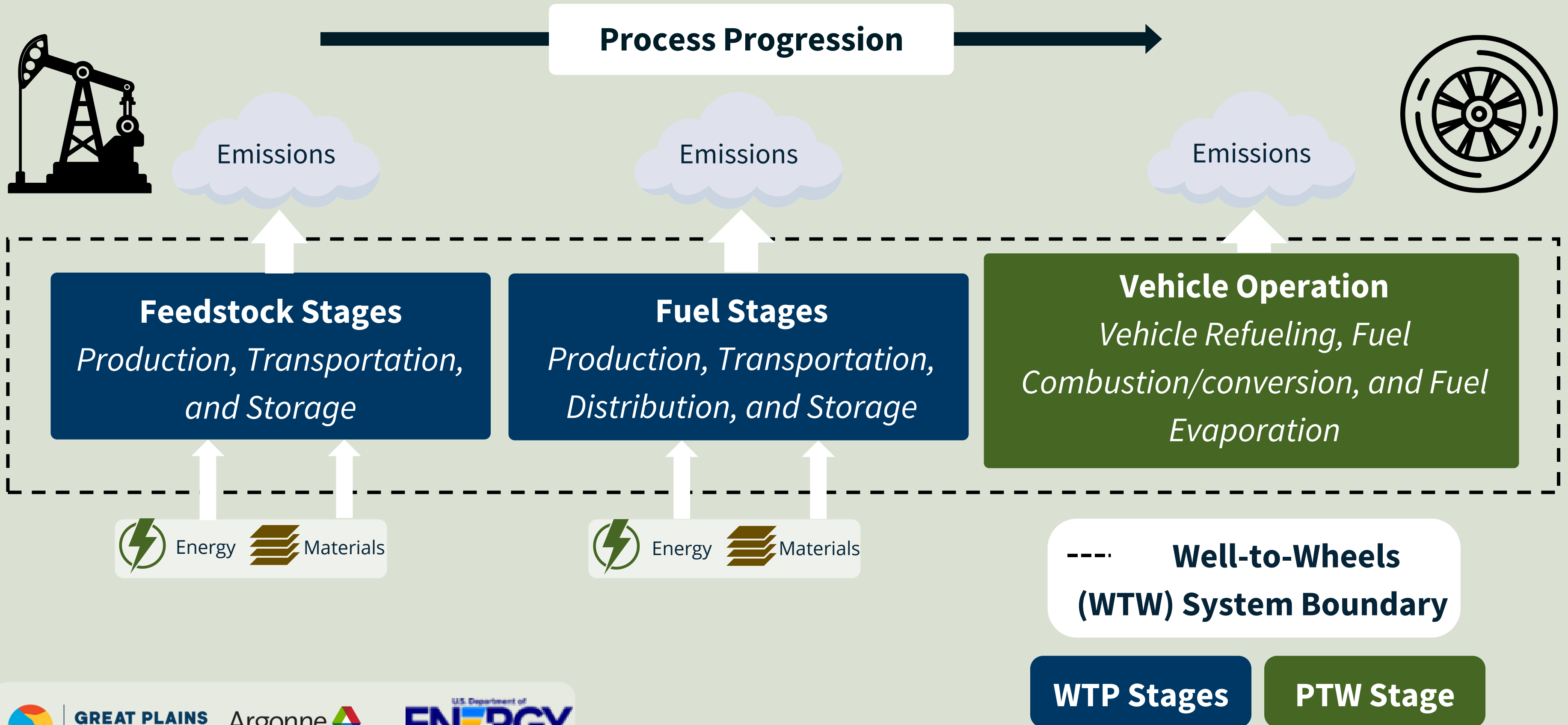


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# A simplified WTW pathway example: *total fuel pathway*



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RSELSIICEV Select Fuels

Home Inputs Back to Top WTP Results WTP Changes

**WTW Results Menu** Select a vehicle type from a pink drop down menu, then press "Go"

<b>SI ICE Vehicles</b>	Select Fuels	Go
<b>SIDI ICE Vehicles</b>	Select Fuels	Go
<b>CIDI ICE Vehicles</b>	Select Fuels	Go

**Unit Selection** Select units from a pink drop down menu for the Results

**Per Vehicle Distance Travelled** Energy Unit: Btu Emission Unit: g Service Functional Unit: mile

**Per Energy in Fuels** Energy Unit: Btu Emission Unit: g Energy Functional Unit: mmBtu

**SI Hybrid Vehicles (HEV)** Select Fuels Go

**CIDI Hybrid Vehicles (HEV)** Select Fuels Go

**BEV and FCV** Select Fuels Go

**SI Plug-in Hybrids (PHEV)** Select Fuels Go

**CIDI Plug-in Hybrids (PHEV)** Select Fuels Go

**Performance-enhancing Fuels** Select Fuels

**Gasoline Vehicle: Gasoline**

Item	Btu/mile or Gallon/mile or g/mile				Btu/mmBtu or Gallon/mmBtu or g/mmBtu			
	Feedstock	Fuel	Vehicle Operation	Total	Feedstock	Fuel	Vehicle Operation	Total
Total Energy	217	944	4,289	5,450	50,498	220,096	1,000,000	1,270,595
Fossil Fuels	203	837	4,003	5,042	47,218	195,069	933,326	1,175,613
Coal	19	30	0	49	4,492	6,898	0	11,391
Natural Gas	147	538	0	685	34,251	125,536	0	159,788
Petroleum	36	269	4,003	4,308	8,474	62,635	933,326	1,004,435
Water Consumption	0.1	0.2	0	0	15	38	0	53
CO2 (w/ C in VOC & CO)	-4	63	329	388	-839	14,592	76,702	90,455
CH4	0.315	0.173	0.015	0.503	73.544	40.320	3.414	117.279
N2O	0.000	0.012	0.004	0.016	0.066	2.787	0.911	3.764
GHGs	6	71	330	407	1,371	16,554	77,053	94,977
VOC: Total	0.013	0.114	0.230	0.356	2.988	26.524	53.597	83.110
CO: Total	0.026	0.043	2.741	2.810	6.071	10.068	639.104	655.243
NOx: Total	0.039	0.071	0.082	0.193	9.137	16.540	19.209	44.886
PM10: Total	0.002	0.010	0.035	0.047	0.443	2.360	8.044	10.847
PM2.5: Total	0.002	0.006	0.007	0.015	0.372	1.502	1.729	3.602

Overview Inputs Results Petroleum Co\_processing NG MeOH\_FTD EtOH Electric Generation\_mixes Bio

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RSELSICEV Select Fuels

Home Inputs Back to Top WTP Results WTP Changes

**WTW Results Menu**

1 Vehicles Fuels 2 Go 3 Go 4 Go

SI - Gasoline SI - CA gasoline SI - E10 SI - EtOH FFV SI - BtOH FFV SI - MeOH FFV SI - CNG Vehicle SI - LNG Vehicle SI - LPG Vehicle SI - Dedi. MeOH Vehicle SI - Dedi. EtOH Vehicle

Select a vehicle type from a pink drop down menu, then press "Go"

SI Hybrid Vehicles (HEV) Select Fuels Go  
 CIDI Hybrid Vehicles (HEV) Select Fuels Go  
 BEV and FCV Select Fuels Go

SI Plug-in Hybrids (PHEV) Select Fuels Go  
 CIDI Plug-in Hybrids (PHEV) Select Fuels Go  
 GCI ICE Vehicles Select Fuels Go

Performance-enhancing Fuels Select Fuels

Select units from a pink drop down menu for the Results

Per Energy in Fuels  
 Mission Unit: g Energy Unit: Btu Emission Unit: g  
 Operational Unit: mile Energy Functional Unit: mmBtu

Vehicle Operation	Total	Btu/mmBtu or Gallon/mmBtu or g/mmBtu			
		Feedstock	Fuel	Vehicle Operation	Total
4,289	5,450	50,498	220,096	1,000,000	1,270,595
4,003	5,042	47,218	195,069	933,326	1,175,613
19	30	0	49	0	11,391
147	538	0	685	0	159,788
36	269	4,003	4,308	933,326	1,004,435
0.1	0.2	0	0	0	53
-4	63	329	388	-839	90,455
0.315	0.173	0.015	0.503	73.544	117.279
0.000	0.012	0.004	0.016	0.066	3.764
6	71	330	407	1,371	94,977
0.013	0.114	0.230	0.356	2.988	83.110
0.026	0.043	2.741	2.810	6.071	655.243
0.039	0.071	0.082	0.193	9.137	44.886
0.002	0.010	0.035	0.047	0.443	10.847
0.002	0.006	0.007	0.015	0.372	3.602

Overview Inputs Results Petroleum Co\_processing NG MeOH\_FTD EtOH Electric Generation\_mixes Bio

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RSELSICEV SI - Gasoline

Home Inputs Back to Top WTP Results WTP Changes

**WTW Results Menu** Select a vehicle type from a pink drop down menu, then press "Go"

SI ICE Vehicles SI - Gasoline Go

SIDI ICE Vehicles Select Fuels Go

CIDI ICE Vehicles Select Fuels Go

SI Hybrid Vehicles (HEV) Select Fuels Go

CIDI Hybrid Vehicles (HEV) Select Fuels Go

BEV and FCV Select Fuels Go

SI Plug-in Hybrids (PHEV) Performance-enhancing Fuels

**Unit Selection** Select units from a pink drop down menu for the Results

Per Vehicle Distance Travelled Energy Unit: Btu Emission Unit: g Service Functional Unit: mile

Per Energy in Fuels Energy Unit: Btu Emission Unit: g Energy Functional Unit: mmBtu

**Gasoline Vehicle: Gasoline**

Item	Btu/mile or Gallon/mile or g/mile				Btu/mmBtu or Gallon/mmBtu or g/mmBtu			
	Feedstock	Fuel	Vehicle Operation	Total	Feedstock	Fuel	Vehicle Operation	Total
Total Energy								1,270,595
Fossil Fuel								1,175,613
Coal								11,391
Natural Gas								159,788
Petroleum								1,004,435
Water Conversion								53
CO2 (w/ Conversion)								90,455
CH4								117.279
N2O	0.000	0.012	0.004	0.016	0.006	2.787	0.911	3.764
GHGs	6	71	330	407	1,371	16,554	77,053	94,977
VOC: Total	0.013	0.114	0.230	0.356	2.988	26.324	53.597	83.110
CO: Total	0.026	0.043	2.741	2.810	6.071	10.068	639.104	655.243
NOx: Total	0.039	0.071	0.082	0.193	9.137	16.540	19.209	44.886
PM10: Total	0.002	0.010	0.035	0.047	0.443	2.360	8.044	10.847
PM2.5: Total	0.002	0.006	0.007	0.015	0.372	1.502	1.729	3.602

Overview Inputs Results Petroleum Co\_processing NG MeOH\_FTD EtOH Electric Generation\_mixes Bio

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**WTP = fuel + feedstock**

**WTP GHG emissions**  
77 g CO<sub>2</sub>e/mile or 17,925 g CO<sub>2</sub>e/mmBtu

**SI-ICE vehicle fueled by default gasoline**



# Well-to-Wheels (WTW) GHG Emissions



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RSELSICEV SI - Gasoline

Home Inputs Back to Top WTP Results WTW Changes

**WTW Results Menu** Select a vehicle type from a pink drop down menu, then press "Go"

SI ICE Vehicles: SI - Gasoline, SIDI ICE Vehicles, CIDI ICE Vehicles

SI Hybrid Vehicles (HEV): SI Hybrid Vehicles (HEV), CIDI Hybrid Vehicles (HEV), BEV and FCV

SI Plug-in Hybrids (PHEV): SI Plug-in Hybrids (PHEV), CIDI Plug-in Hybrids (PHEV)

Performance-enhancing Fuels

Unit Selection: Per Vehicle Distance Travelled (Energy Unit: Btu, Emission Unit: g, Service Functional Unit: mile), Per Energy in Fuels (Energy Unit: Btu, Emission Unit: g, Energy Functional Unit: mmBtu)

**WTW = fuel + feedstock + vehicle operation**

**WTW GHG emissions**  
407 g CO<sub>2</sub>e/mile and 94,977 g CO<sub>2</sub>e/mmBtu

**SI-ICE vehicle fueled by default gasoline**

Item	Btu/mile or Gallon/mile or g/mile				Btu/mmBtu or Gallon/mmBtu or g/mmBtu			
	Feedstock	Fuel	Vehicle Operation	Total	Feedstock	Fuel	Vehicle Operation	Total
Total Energy								
Fossil Fuels								
Coal								
Natural Gas								
Petroleum								
Water Consumption								
CO <sub>2</sub> (w/ C in VOC & CO)								
CH <sub>4</sub>								
N <sub>2</sub> O	0.000	0.012	0.004	0.016	0.066	2.787	0.911	3.764
GHGs	6	71	330	407	1,371	16,554	77,053	94,977
VOC: Total	0.013	0.114	0.230	0.356	2.988	26.524	53.597	85.110
CO: Total	0.026	0.043	2.741	2.810	6.071	10.068	639.104	655.243
NOx: Total	0.039	0.071	0.082	0.193	9.137	16.540	19.209	44.886
PM10: Total	0.002	0.010	0.035	0.047	0.443	2.360	8.044	10.847
PM2.5: Total	0.002	0.006	0.007	0.015	0.372	1.502	1.729	3.602

Overview Inputs Results Petroleum Co\_processing NG MeOH\_FTD EtOH Electric Generation\_mixes Bio

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# Carbon Intensity

With the correct units g/MJ, the carbon intensity (CI) score is equivalent to the WTW GHG emissions



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Results\_EnergyFunctionalUnit mmBtu

Home Inputs Back to Top WTP Results WTP Changes

**WTW Results Menu** Select a vehicle type from a pink drop down menu, then press "Go"

SI ICE Vehicles Go  
SI - Gasoline  
SIDI ICE Vehicles Go  
Select Fuels  
CIDI ICE Vehicles Go  
Select Fuels

SI Hybrid Vehicles (HEV) Go  
Select Fuels  
CIDI Hybrid Vehicles (HEV) Go  
Select Fuels  
BEV and FCV Go  
Select Fuels

SI Plug-in Hybrids (PHEV) Go  
Select Fuels  
CIDI Plug-in Hybrids (PHEV) Go  
N/A  
GCI ICE Vehicles Go  
Select Fuels

Performance-enhancing Fuels  
Select Fuels

**Unit Selection** Select units from a pink drop down menu for the Results

Per Vehicle Distance Travelled  
Energy Unit: Btu Emission Unit: g Service Functional Unit: mile

Per Energy in Fuels  
Energy Unit: Btu Emission Unit: g Energy Functional Unit: mmBtu

Gasoline Vehicle: Gasoline

Item	Btu/mile or Gallon/mile or g/mile				Btu/mmBtu or Gallon/mmBtu or g/mmBtu			
	Feedstock	Fuel	Vehicle Operation	Total	Feedstock	Fuel	Vehicle Operation	Total
Total Energy	217	944	4,289	5,450	50,498	220,096	1,000,000	1,270,594
Fossil Fuels	203	837	4,003	5,042	47,218	195,069	933,326	1,175,613
Coal	19	30	0	49	4,492	6,898	0	11,390
Natural Gas	147	538	0	685	34,251	125,536	0	159,787
Petroleum	36	269	4,003	4,308	8,474	62,635	933,326	1,004,435
Water Consumption	0.1	0.2	0	0	15	38	0	53
CO2 (w/ C in VOC & CO)	-4	63	329	388	-839	14,592	76,702	90,455
CH4	0.315	0.173	0.015	0.503	73.544	40.320	3.414	117.279
N2O	0.000	0.012	0.004	0.016	0.066	2.787	0.911	3.764
GHGs	6	71	330	407	1,371	16,554	77,053	94,977
VOC: Total	0.013	0.114	0.230	0.356	2.988	26.524	53.597	83.110
CO: Total	0.026	0.043	2.741	2.810	6.071	10.068	639.104	655.243
NOx: Total	0.039	0.071	0.082	0.193	9.137	16.540	19.209	44.886
PM10: Total	0.002	0.010	0.035	0.047	0.443	2.360	8.044	10.847
PM2.5: Total	0.002	0.006	0.007	0.015	0.372	1.502	1.729	3.602

Review Inputs Results Petroleum Co\_processing NG MeOH\_FTD EtOH Electric Generation\_mixes Bio

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Results\_EnergyFunctionalUnit MJ

Home Inputs Back to Top WTP Results WTP Changes

**WTW Results Menu** Select a vehicle type from a pink drop down menu, then press "Go"

<b>SI ICE Vehicles</b>	Go	<b>SI Hybrid Vehicles (HEV)</b>	Go	<b>SI Plug-in Hybrids (PHEV)</b>	Go	<b>Performance-enhancing Fuels</b>	Select Fuels
SI - Gasoline		Select Fuels		Select Fuels			
<b>SIDI ICE Vehicles</b>	Go	<b>CIDI Hybrid Vehicles (HEV)</b>	Go	<b>CIDI Plug-in Hybrids (PHEV)</b>	Go		
Select Fuels		Select Fuels		N/A			
<b>CIDI ICE Vehicles</b>	Go	<b>BEV and FCV</b>	Go				
Select Fuels		Select Fuels					

**Unit Selection** Select units from a pink drop down menu for the Results

Per Vehicle Distance Travelled  
Energy Unit: Btu Emission Unit: g Service Functional Unit: mile

Per Energy in Fuels  
Energy Unit: Btu Emission Unit: g Energy Functional Unit: MJ

**Gasoline Vehicle: Gasoline**

Item	Btu/mile or Gallon/mile or g/mile				Btu/MJ or Gallon/MJ or g/MJ			
	Feedstock	Fuel	Vehicle Operation	Total	Feedstock	Fuel	Vehicle Operation	Total
Total Energy	217							
Fossil Fuels	203							
Coal	19							
Natural Gas	147							
Petroleum	36							
Water Consumption	0.1							
CO2 (w/ C in VOC & CO)	-4							
CH4	0.315							
N2O	0.000	0.012	0.004	0.016	0.000	0.003	0.001	0.004
GHGs	6	71	330	407	1	16	73	90
VOC: Total	0.013	0.114	0.230	0.356	0.003	0.025	0.051	0.079
CO: Total	0.026	0.043	2.741	2.810	0.006	0.010	0.606	0.621
NOx: Total	0.039	0.071	0.082	0.193	0.009	0.016	0.018	0.043
PM10: Total	0.002	0.010	0.035	0.047	0.000	0.002	0.008	0.010
PM2.5: Total	0.002	0.006	0.007	0.015	0.000	0.001	0.002	0.003

Overview Inputs Results Petroleum Co\_processing NG MeOH\_FTD EtOH Electric Generation\_mixes Bio

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**Total WTW GHG emissions = carbon intensity score**

**Carbon intensity score**  
407 g CO<sub>2</sub>e/mile and 90 g CO<sub>2</sub>e/MJ

**SI-ICE vehicle fueled by default gasoline**



# Change the Model Year

Model a Spark-Ignition Internal Combustion Engine  
(SI-ICE) Vehicle Fueled by Gasoline in 2017



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# Review the Inputs Tab



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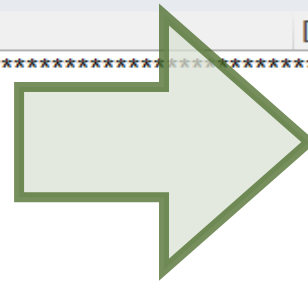
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Inputs Results  
Petroleum Ethanol Natural Gas MeOH & RNG  
Electric Hydrogen BioOil Pyrolysis & IDL Integrated Biorefinery  
Fuel Production Time Emission Factors Agricultural and Mining Machinery  
Light Duty Vehicle Time Series

Overview Inputs Results Petroleum Co\_processing NG MeOH\_FTD EtOH Electric Generation\_mixes Bio ... +



**Note:**  
this scenario is **not** modeling a car built in 2017, but rather the emissions from an average car on the road in 2017

Microsoft Excel ribbon: Home, Insert, Draw, Page Layout, Formulas, Data, Review, View, Automate, Help. Ribbon groups: Clipboard, Font, Alignment, Number, Styles, Cells, Editing, Sensitivity, Add-ins, Analyze Data.

Year: 2022

Worksheet tabs: Home, Results, Petroleum, MeOH & Ethanol, Electric, Vehicles, Car\_TS Tab, LDV1\_TS Tab, LDV2\_TS Tab, Natural Gas, Hydrogen, Bio Oil, Pyrolysis, WTP, Fuel Economy, Vehicles Tab, HDV\_TS Tab, HDV\_WTW Tab.

### Scenario Control Variables and Input Assumptions

#### 1. Key Options for Simulation

##### 1.1) Target Year for Simulation

2022

##### 1.2) Point-Estimate

2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022

#### 2. Vehicle Types for Simulation

Passenger Cars; 2 -- Light-Duty Trucks 1 (LDT1) (Sports utility vehicles [SUV]); 3 -- Light-Duty Trucks 2 (LDT2) (Pickup Truck [PUT])

#### 3. Petroleum-Based Fuels

##### 3.1) Petroleum Refinement

##### 3.1.a) Share

is of share of crude oil sources: 1 -- EIA projection, 2 -- User defined

	U.S. Domestic	Canada (Oil Sands)	Canada (Conv. Crude)	Mexico	Middle East	Latin America
2021	80.8%	6.6%	5.0%	1.9%	2.3%	
2022	0.0%	100.0%	0.0%	0.0%	2.3%	
Used in calculation	80.8%	6.6%	5.0%	1.9%	2.3%	
API gravity	34.0	18.1	26.5	26.5	31.8	
S Content (wt %)	1.4	2.9	1.9	2.2	2.3	
Average transportation distances (mi)	See T&D_Flowcharts tab	1,708	1,708	797	14,596	

U.S. Domestic crude	Shale Oil (Bakken)	Shale Oil (Eagle Ford)	Rest of U.S. domestic crude
API gravity	42	48	32.0
Vol. Share (%)	8.7%	8.0%	83.3%

Buttons: Reactivate GREET2 Links, Deactivate GREET2 Links

Worksheet tabs: Petroleum Worksheet, Results, Back to Top

Bottom ribbon: Review, Inputs, Results, Petroleum, Co\_processing, NG, MeOH\_FTD, EtOH, Electric, Generation\_mixes, Bio... +

Status bar: Ready, Calculate, Accessibility: Investigate, 73%

# Well-to-Pump (WTP) and Well-to-Wheels (WTW) GHG Emissions



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Year: 2017

Home Results Petroleum MeOH & Ethanol Electric Vehicles Car\_TS Tab LDV1\_TS Tab LDV2\_TS Tab  
 Natural Gas Hydrogen Bio Oil Pyrolysis WTP Fuel Economy Vehicles Tab HDV\_TS Tab HDV\_WTW Tab

### Scenario Control Variables and Input Assumptions

#### 1. Key Options for Simulation

1.1) Target Year for Simulation: 2017

1.2) Point-Estimation or Probability-Estimation Option: Load Stochastic Toolkit

Link with GREET2: Reactivate GREET2 Links, Deactivate GREET2 Links

Load Stochastic Toolkit ... To load the stochastic toolkit  
 Unload Stochastic Toolkit ... To unload the stochastic toolkit

#### 2. Vehicle Types for Simulation

1 -- Passenger Cars; 2 -- Light-Duty Trucks 1 (LDT1) (Sports utility vehicles [SUV]); 3 -- Light-Duty Trucks 2 (LDT2) (Pickup Truck [PUT])

#### 3. Petroleum-Based Fuels

##### 3.1) Petroleum Recovery Options

##### 3.1.a) Share of crude oil sources

1 -- Basis of share of crude oil sources: 1 -- EIA projection, 2 -- User defined

	U.S. Domestic	Canada (Oil Sands)	Canada (Conv. Crude)	Mexico	Middle East	Lati
EIA projection	57.4%	10.3%	10.2%	3.0%	8.5%	
User defined	0.0%	100.0%	0.0%	0.0%	2.3%	
Used in calculation	57.4%	10.3%	10.2%	3.0%	8.5%	
API gravity	36.0	17.8	26.5	26.5	31.8	
S Content (wt %)	1.4	2.9	1.9	2.2	2.3	
Average transportation distances (mi)	See T&D_Flowcharts tab	1,708	1,708	797	14,596	

U.S. Domestic crude

	Shale Oil (Bakken)	Shale Oil (Eagle Ford)	Rest of U.S. domestic crude
API gravity	42	48	32.0
Vol. Share (%)	14.3%	17.6%	68.2%

Overview Inputs Results Petroleum Co\_processing NG MeOH\_FTD EtOH Electric Generation\_mixes Bio

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RSELSIICEV SI - Gasoline

Home Inputs Back to Top WTP Results WTW Changes

**WTW Results Menu**  
 Select a vehicle type from a pink drop down menu, then press "Go"

SI ICE Vehicles  
 SI - Gasoline Go

SI Hybrid Vehicles (HEV) Go  
 Select Fuels

CIDI Hybrid Vehicles (HEV) Go  
 Select Fuels

BEV and FCV Go  
 Select Fuels

SI Plug-in Hybrids (PHEV) Go  
 Select Fuels

CIDI Plug-in Hybrids (PHEV) Go  
 N/A

GCI ICE Vehicles Go  
 Select Fuels

Performance-enhancing Fuels  
 Select Fuels

**Unit Selection**  
 Select units from a pink drop down menu for the Results

Per Vehicle Distance Travelled  
 Energy Unit: Btu Emission Unit: g Service Functional Unit: mile

Per Energy in Fuels  
 Energy Unit: Btu Emission Unit: g Energy Functional Unit: MJ

43 Gasoline Vehicle: Gasoline

Item	Btu/mile or Gallon/mile or g/mile				Btu/MJ or Gallon/MJ or g/MJ			
	Feedstock	Fuel	Vehicle Operation	Total	Feedstock	Fuel	Vehicle Operation	Total
46 Total Energy	272	974	4,302	5,548	60	215	948	1,222
47 Fossil Fuels	257	867	4,015	5,139	57	191	885	1,132
48 Coal	32	43	0	76	7	10	0	17
49 Natural Gas	175	542	0	717	38	119	0	158
50 Petroleum	50	282	4,015	4,347	11	62	885	958
51 Water Consumption	0.1	0.2	0	0	0	0	0	0
52 CO2 (w/ C in VOC & CO)	1	65	330	395	0	14	73	87
53 CH4	0.326	0.176	0.016	0.518	0.072	0.039	0.003	0.114
54 N2O	0.000	0.012	0.006	0.018	0.000	0.003	0.001	0.004
55 GHGs	11	73	332	416	2	16	73	92
56 VOC: Total	0.014	0.114	0.238	0.366	0.003	0.025	0.053	0.081
57 CO: Total	0.030	0.045	2.986	3.061	0.007	0.010	0.658	0.674
58 NOx: Total	0.070	0.083	0.090	0.243	0.015	0.018	0.020	0.054
59 PM10: Total	0.004	0.011	0.033	0.048	0.001	0.002	0.007	0.011
60 PM2.5: Total	0.003	0.007	0.006	0.016	0.001	0.002	0.001	0.004

Ready Calculate Accessibility: Investigate



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RSELSIICEV SI - Gasoline

Home Inputs Back to Top WTP Results WTP Changes

**WTW Results Menu** Select a vehicle type from a pink drop down menu, then press "Go"

SI ICE Vehicles SI - Gasoline Go

SIDI ICE Vehicles Select Fuels Go

CIDI ICE Vehicles Select Fuels Go

**Unit Selection** Select units from a pink drop down menu for the Results

Per Vehicle Distance Travelled Energy Unit: Btu Emission Unit: g Service Functional Unit: mile

Per Energy in Fuels Energy Unit: Btu Emission Unit: g

SI Hybrid Vehicles (HEV) Select Fuels Go

CIDI Hybrid Vehicles (HEV) Select Fuels Go

BEV and FCV Select Fuels Go

SI Plug-in Hybrids (PHEV) Select Fuels Go

CIDI Plug-in Hybrids (PHEV) N/A Go

GCI ICE Vehicles Select Fuels Go

Performance-enhancing Fuels Select Fuels

43 Gasoline Vehicle: Gasoline

Item	Btu/mile or Gallon/mile or g/mile			Total	g/MJ			
	Feedstock	Fuel	Vehicle Operation		Feedstock	Fuel	Vehicle Operation	Total
Total Energy	272	974	4,302	5,548				
Fossil Fuels	257	867	4,015	5,139				
Coal	32	43	0	76				
Natural Gas	175	542	0	717				
Petroleum	50	282	4,015	4,347				
Water Consumption	0.1	0.2	0	0				
CO2 (w/ C in VOC & CO)	1	65	330	395	0.003	0.114	0.004	0.121
CH4	0.326	0.176	0.016	0.518	0.072	0.039	0.003	0.114
N2O	0.009	0.042	0.006	0.016	0.009	0.003	0.001	0.004
GHGs	11	73	332	416	2	16	73	92
VOC: Total	0.014	0.114	0.238	0.366	0.003	0.025	0.053	0.081
CO: Total	0.029	0.045	2.986	3.060	0.007	0.010	0.658	0.674
NOx: Total					0.015	0.018	0.020	0.054
PM10: Total					0.001	0.002	0.007	0.011
PM2.5: Total					0.001	0.002	0.001	0.004

Overview Performance NG MeOH\_FTD EtOH Electric Generation\_mixes Bio

**WTW GHG emissions per fuel consumed**

**WTW GHG emissions per fuel consumed**

**WTW GHG emissions per distance**

**WTW GHG emissions per distance**

**SI-ICE vehicle used in 2017 and fueled by default gasoline**

# Default SI-ICE vehicle fueled by gasoline

# SI-ICE vehicle fueled by gasoline and used in 2017

Excel interface showing the "Default SI-ICE vehicle fueled by gasoline" configuration. The formula bar shows "MJ".

Vehicle selection options:

- SI Hybrid Vehicles (HEV) - Select Fuels
- CIDI Hybrid Vehicles (HEV) - Select Fuels
- BEV and FCV - Select Fuels
- SI Plug-in Hybrids (PHEV) - Select Fuels
- CIDI Plug-in Hybrids (PHEV) - Select Fuels
- GCI ICE Vehicles - Select Fuels

Units: Emission Unit: g, Energy Unit: Btu, Emission Unit: g, Energy Functional Unit: MJ

or g/mile	Btu/MJ or Gallon/M					
Fuel	Vehicle Operation	Total	Feedstock	Fuel		
944	4,289	5,450	48	209		
837	4,003	5,042	45	185		
30	0	49	4	7		
538	0	685	32	119		
269	4,003	4,308	8	59		
0.2	0	0	0	0		
63	329	388	-1	14		
0.173	0.015	0.503	0.070	0.038	0.003	0.111
0.012	0.004	0.016	0.000	0.003	0.001	0.004
71	330	407	1	16	73	90
0.114	0.230	0.356	0.003	0.025	0.051	0.079
0.043	2.741	2.810	0.006	0.010	0.606	0.621
0.071	0.082	0.193	0.009	0.016	0.018	0.043
0.010	0.035	0.047	0.000	0.002	0.008	0.010
0.006	0.007	0.015	0.000	0.001	0.002	0.003

Results: Petroleum, Co\_processing, NG, MeOH\_FTD, EtOH, Electric, Generation\_mixes, Bio...

**WTW GHG emissions**  
90 g CO<sub>2</sub>e/MJ

Excel interface showing the "SI-ICE vehicle fueled by gasoline and used in 2017" configuration. The formula bar shows "SI - Gasoline".

Vehicle selection options:

- SI Hybrid Vehicles (HEV) - Select Fuels
- CIDI Hybrid Vehicles (HEV) - Select Fuels
- BEV and FCV - Select Fuels
- SI Plug-in Hybrids (PHEV) - Select Fuels
- CIDI Plug-in Hybrids (PHEV) - Select Fuels
- GCI ICE Vehicles - Select Fuels

Units: Emission Unit: g, Energy Unit: Btu, Emission Unit: g, Energy Functional Unit: MJ

or g/mile	Btu/MJ or Gallon/M					
Fuel	Vehicle Operation	Total	Feedstock	Fuel		
974	4,302	5,548	60	215		
867	4,015	5,139	57	191		
43	0	76	7	10		
542	0	717	38	119		
282	4,015	4,347	11	62		
0.2	0	0	0	0		
65	330	395	0	14		
0.176	0.016	0.518	0.072	0.039	0.003	0.114
0.012	0.006	0.018	0.000	0.003	0.001	0.004
73	332	416	2	16	73	92
0.114	0.238	0.366	0.003	0.025	0.053	0.081
0.045	2.986	3.061	0.007	0.010	0.658	0.674
0.083	0.090	0.243	0.015	0.018	0.020	0.054
0.011	0.033	0.048	0.001	0.002	0.007	0.011
0.007	0.006	0.016	0.001	0.002	0.001	0.004

Results: Petroleum, Co\_processing, NG, MeOH\_FTD, EtOH, Electric, Generation\_mixes, Bio...

**WTW GHG emissions**  
92 g CO<sub>2</sub>e/MJ

# Change the Model Location

Model a Spark-Ignition Internal Combustion Engine (SI-ICE) Vehicle Fueled by Gasoline with a U.S. Midwest Electricity Grid Generation Mix



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Inputs Results

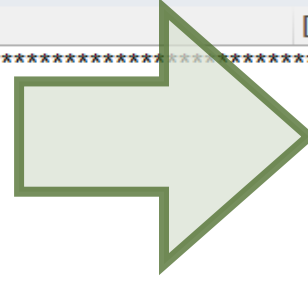
Petroleum Ethanol Natural Gas MeOH & RNG

Electric Hydrogen BioOil Pyrolysis & IDL Integrated Biorefiner

Fuel Production Time Emission Factors Agricultural and Mining Machinery

Light Duty Vehicle Time Series

Overview Inputs Results Petroleum Co\_processing NG MeOH\_FTD EtOH Electric Generation\_mixes Bio



**Note:**  
 this scenario is modeling the emissions from a vehicle driven in the Midwest using the Midwest electricity generation mix

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N15

Home Results Petroleum MeOH & Ethanol Electric Vehicles Car\_TS Tab LDV1\_TS Tab LDV2\_TS Tab  
 Natural Gas Hydrogen Bio Oil Pyrolysis WTP Vehicles Tab HDV\_TS Tab HDV\_WTW Tab  
 Fuel Economy

### Scenario Control Variables and Input Assumptions

#### 1. Key Options for Simulation

1.1) Target Year for Simulation: 2022

1.2) Point-Estimation or Probability-Estimation Option: Load Stochastic Toolkit

Link with GREET2: Reactivate GREET2 Links, Deactivate GREET2 Links

Load Stochastic Toolkit ... To load the stochastic toolkit  
 Unload Stochastic Toolkit ... To unload the stochastic toolkit

#### 2. Vehicle Types for Simulation

1 -- Passenger Cars; 2 -- Light-Duty Trucks 1 (LDT1) (Sports utility vehicles [SUV]); 3 -- Light-Duty Trucks 2 (LDT2) (Pickup Truck [PUT])

#### 3. Petroleum-Based Fuels

##### 3.1) Petroleum Recovery Options

##### 3.1.a) Share of crude oil sources

1 -- Basis of share of crude oil sources: 1 -- EIA projection, 2 -- User defined

	U.S. Domestic	Canada (Oil Sands)	Canada (Conv. Crude)	Mexico	Middle East	Lati
EIA projection	80.8%	6.6%	5.0%	1.9%	2.3%	
User defined	0.0%	100.0%	0.0%	0.0%	2.3%	
Used in calculation	80.8%	6.6%	5.0%	1.9%	2.3%	
API gravity	34.0	18.1	26.5	26.5	31.8	
S Content (wt %)	1.4	2.9	1.9	2.2	2.3	
Average transportation distances (mi)	See T&D, Flowcharts tab	1,708	1,708	797	14,596	

U.S. Domestic crude	Shale Oil (Bakken)	Shale Oil (Eagle Ford)	Rest of U.S. domestic crude
API gravity	42	48	32.0
Vol. Share (%)	8.7%	8.0%	83.3%

Overview Inputs Results Petroleum Co-processing NG MeOH FTD EtOH Electric Generation mixes Bio



L749

1 2 A B C D E F G H I J K

740 **10. Electric Generation**

741 Electric

745 Results

749 Back to Top

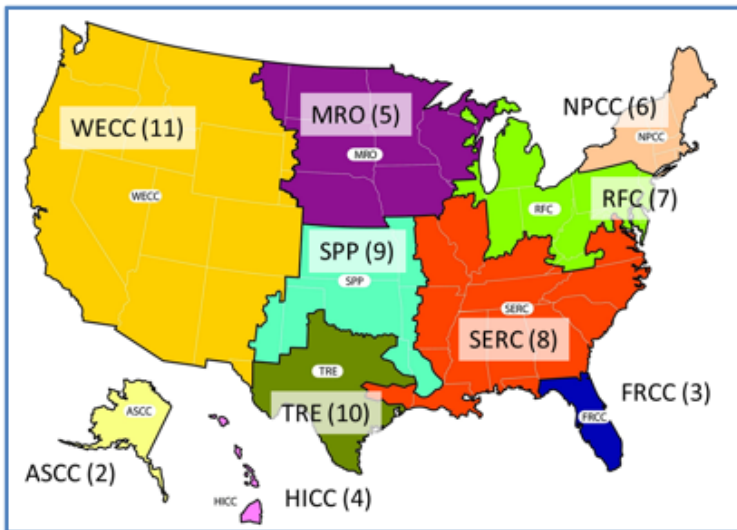
741 **10.1) GREET-Calculated or User-Inputted Emission Factors for Power Plants**

742 2 1 -- GREET-calculated emissions factors via emission factors in EF Sheet  
 743 2 -- Emission factors based on EPA and EIA database in g/kWh

744 **10.2) Electricity Generation Mix**

745 **10.2.a) Selection of Electricity Generation Mix for Transportation Use**

746 Mix for transportation use 1  
 747 Mix for stationary use 1



(U.S. EPA)

- 1 U.S. Mix
- 2 ASCC Mix
- 3 FRCC Mix
- 4 HICC Mix
- 5 MISO (former MRO) Mix
- 6 NPCC Mix
- 7 PJM (former RFC) Mix
- 8 SERC Mix
- 9 SPP Mix
- 10 TRE Mix
- 11 WECC Mix
- 12 CA Mix
- 13 User Defined Mix
- 14 NG Power Plants (transportation only)
- 15 Coal Power Plants (transportation only)
- 16 Nuclear Power Plants (transportation only)
- 17 Hydro Power Plants (transportation only)
- 18 NGCC Turbine (transportation only)
- 19 Geothermal (transportation only)

765 **10.2.b) Electric Generation Mixes: Data Table for Use in GREET (From Annual Energy Outlook 2023)**

	U.S. Mix		ASCC Mix		FRCC Mix
	Transportation	Stationary	Transportation	Stationary	Transportation
Residual oil	0.3%	0.3%	13.7%	13.7%	0.2%
Natural gas	38.5%	38.5%	46.7%	46.7%	71.3%
Coal	20.6%	20.6%	11.4%	11.4%	10.4%
Nuclear power	18.9%	18.9%	0.0%	0.0%	12.5%
Biomass	0.3%	0.3%	0.6%	0.6%	0.2%
Others	21.5%	21.5%	27.6%	27.6%	5.5%

774 **10.2.c) Electric Generation Mixes for GREET Simulations**

# Transportation and stationary electricity generation



## Transportation Mix

Users to switch the electricity generation mix for the vehicle-use phase of the life cycle assessment

## Stationary Mix

Users to switch the electricity generation mix for the phases of the life cycle assessment outside of the vehicle-use (i.e., electricity for coal production)



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Name Manager

Define Name

Use in Formula

Create from Selection

Defined Names

Trace Precedents

Trace Dependents

Remove Arrows

Show Formulas

Error Checking

Evaluate Formula

Formula Auditing

Watch Window

Calculation Options

Calculation

L743

		U.S. Mix		ASCC Mix		FRCC Mix	
		Transportation	Stationary	Transportation	Stationary	Transportation	Stationary
766	<b>10.2.b) Electric Generation Mixes: Data Table for Use in GREET (From Annual Energy Outlook 2023)</b>						
768	Residual oil	0.3%	0.3%	13.7%	13.7%	0.2%	0.2%
769	Natural gas	38.5%	38.5%	46.7%	46.7%	71.3%	71.3%
770	Coal	20.6%	20.6%	11.4%	11.4%	10.4%	10.4%
771	Nuclear power	18.9%	18.9%	0.0%	0.0%	12.5%	12.5%
772	Biomass	0.3%	0.3%	0.6%	0.6%	0.2%	0.2%
773	Others	21.5%	21.5%	27.6%	27.6%	5.5%	5.5%
774	<b>10.2.c) Electric Generation Mixes for GREET Simulations</b>						
775		Mix for Transportation Use	Mix for Stationary Use				
776	Residual oil	0.3%	0.3%				
777	Natural gas	38.5%	38.5%				
778	Coal	20.6%	20.6%				
779	Nuclear power	18.9%	18.9%				
780	Biomass	0.3%	0.3%				
781	Others	21.5%	21.5%				
782	<b>10.2.d) Shares of Technologies for Other Power Plants: Data Table for Use in GREET (From Annual Energy Outlook 2023)</b>						
783		U.S. Mix		ASCC Mix		FRCC Mix	
784		Transportation	Stationary	Transportation	Stationary	Transportation	Stationary
785	Hydroelectric	31.4%	31.4%	92.7%	92.7%	13.6%	13.6%
786	Geothermal	1.8%	1.8%	0.0%	0.0%	0.0%	0.0%
787	Wind	49.8%	49.8%	7.3%	7.3%	0.0%	0.0%
788	Solar PV	15.3%	15.3%	0.0%	0.0%	75.7%	75.7%
789	Others	1.7%	1.7%	0.0%	0.0%	10.7%	10.7%
790	<b>10.2.e) Shares of Technologies for Other Power Plants for GREET Simulations</b>						
791		Mix for Transportation Use	Mix for Stationary Use				
792	Hydroelectric	31.4%	31.4%				
793	Geothermal	1.8%	1.8%				
794	Wind	49.8%	49.8%				
795	Solar PV	15.3%	15.3%				
796	Others	1.7%	1.7%				

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Comments Share

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Trace Precedents  
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 Remove Arrows

Show Formulas  
 Error Checking  
 Evaluate Formula

Watch Window  
 Calculation Options  
 Calculation

Function Library

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	U.S. Mix		ASCC Mix		FRCC Mix		HICC Mix		MRO Mix	
	Transportation	Stationary	Transportation	Stationary	Transportation	Stationary	Transportation	Stationary	Transportation	Stationary
765 <b>2023)</b>										
766	0.3%	0.3%	13.7%	13.7%	0.2%	0.2%	67.0%	67.0%	0.2%	0.2%
767	38.5%	38.5%	46.7%	46.7%	71.3%	71.3%	0.0%	0.0%	30.9%	30.9%
768	20.6%	20.6%	11.4%	11.4%	10.4%	10.4%	11.8%	11.8%	36.6%	36.6%
769	18.9%	18.9%	0.0%	0.0%	12.5%	12.5%	0.0%	0.0%	14.2%	14.2%
770	0.3%	0.3%	0.6%	0.6%	0.2%	0.2%	3.1%	3.1%	0.2%	0.2%
771	21.5%	21.5%	27.6%	27.6%	5.5%	5.5%	18.1%	18.1%	17.9%	17.9%
772										
773										
774										
775	Transportation Use	Mix for Stationary Use								
776	0.3%	0.3%								
777	38.5%	38.5%								
778	20.6%	20.6%								
779	18.9%	18.9%								
780	0.3%	0.3%								
781	21.5%	21.5%								
782 <b>Annual Energy Outlook 2023)</b>										
783										
784	31.4%	31.4%	92.7%	92.7%	13.6%	13.6%	6.9%	6.9%	8.1%	8.1%
785	1.8%	1.8%	0.0%	0.0%	0.0%	0.0%	11.0%	11.0%	0.0%	0.0%
786	49.8%	49.8%	7.3%	7.3%	0.0%	0.0%	39.6%	39.6%	85.4%	85.4%
787	15.3%	15.3%	0.0%	0.0%	75.7%	75.7%	30.5%	30.5%	4.9%	4.9%
788	1.7%	1.7%	0.0%	0.0%	10.7%	10.7%	12.0%	12.0%	1.7%	1.7%
789										
790										
791	Transportation Use	Mix for Stationary Use								
792	31.4%	31.4%								
793	1.8%	1.8%								
794	49.8%	49.8%								
795	15.3%	15.3%								
796	1.7%	1.7%								
797										

Overview **Inputs** Results Petroleum Co\_processing NG MeOH\_FTD EtOH Electric Generation\_mixes Bio ... +

Microsoft Excel ribbon showing the 'Formulas' tab. The 'Function Library' includes Insert Function, AutoSum, Recently Used, Financial, Logical, Text, Date & Time, Lookup & Reference, Math & Trig, and More Functions. The 'Defined Names' group includes Name Manager, Define Name, Use in Formula, and Create from Selection. The 'Formula Auditing' group includes Trace Precedents, Trace Dependents, Remove Arrows, Show Formulas, Error Checking, and Evaluate Formula. The 'Calculation' group includes Watch Window and Calculation Options.

Formula bar: Electric\_Marginalmix\_EVsnHEVs = 1

### 10. Electric Generation

10.1) GREET-Calculated or User-Inputted Emission Factors for Power Plants

10.2) Electricity Generation Mix

10.2.a) Selection of Electricity Generation Mix for Transportation Use

Mix for transportation use: 1

Mix for stationary use: 1

Mix for transportation use: 1

Mix for stationary use: 1

1 U.S. Mix

2 ASCC Mix

3 FRCC Mix

4 HICC Mix

5 MISO (former MRO) Mix

6 NPCC Mix

7 PJM (former RFC) Mix

8 SERC Mix

9 SPP Mix

10 TRE Mix

11 WECC Mix

12 CA Mix

13 User Defined Mix

14 NG Power Plants (transportation only)

15 Coal Power Plants (transportation only)

16 Nuclear Power Plants (transportation only)

17 Hydro Power Plants (transportation only)

18 NGCC Turbine (transportation only)

19 Geothermal (transportation only)

10.2.b) Electric Generation Mixes: Data Table for Use in GREET (From Annual Energy Outlook 2023)

	U.S. Mix		ASCC Mix		FRCC Mix
	Transportation	Stationary	Transportation	Stationary	Transportation
Residual oil	0.3%	0.3%	13.7%	13.7%	0.2%
Natural gas	38.5%	38.5%	46.7%	46.7%	71.3%
Coal	20.6%	20.6%	11.4%	11.4%	10.4%
Nuclear power	18.9%	18.9%	0.0%	0.0%	12.5%
Biomass	0.3%	0.3%	0.6%	0.6%	0.2%

Navigation tabs: Overview, Inputs, Results, Petroleum, Co\_processing, NG, MeOH\_FTD, EtOH, Electric, Generation\_mixes, Bio. Status bar: Ready, Calculate, Accessibility: Investigate, Display Settings, 75% zoom.

Microsoft Excel ribbon showing the Function Library (Insert Function, AutoSum, Recently Used, Financial, Logical, Text, Date & Time, Lookup & Reference, Math & Trig, More Functions) and Formula Auditing (Trace Precedents, Trace Dependents, Remove Arrows, Show Formulas, Error Checking, Evaluate Formula) tabs.

Formula bar: Electric\_Averagemix\_FacilityUse 1

### 10. Electric Generation

10.1) GREET-Calculated or User-Inputted Emission Factors for Power Plants

10.2) Electricity Generation Mix

10.2.a) Selection of Electricity Generation Mix for Transportation Use

Mix for transportation use	5
Mix for stationary use	1

- 1 U.S. Mix
- 2 ASCC Mix
- 3 FRCC Mix
- 4 HICC Mix
- 5 MISO (former MRO) Mix
- 6 NPCC Mix
- 7 PJM (former RFC) Mix
- 8 SERC Mix
- 9 SPP Mix
- 10 TRE Mix
- 11 WECC Mix
- 12 CA Mix
- 13 User Defined Mix
- 14 NG Power Plants (transportation only)
- 15 Coal Power Plants (transportation only)
- 16 Nuclear Power Plants (transportation only)
- 17 Hydro Power Plants (transportation only)
- 18 NGCC Turbine (transportation only)
- 19 Geothermal (transportation only)

10.2.b) Electric Generation Mixes: Data Table for Use in GREET (From Annual Energy Outlook 2023)

	U.S. Mix		ASCC Mix		FRCC Mix
	Transportation	Stationary	Transportation	Stationary	Transportation
Residual oil	0.3%	0.3%	13.7%	13.7%	0.2%
Natural gas	38.5%	38.5%	46.7%	46.7%	71.3%
Coal	20.6%	20.6%	11.4%	11.4%	10.4%
Nuclear power	18.9%	18.9%	0.0%	0.0%	12.5%
Biomass	0.3%	0.3%	0.6%	0.6%	0.2%

Excel interface showing the 'Calculate' button highlighted in the bottom left corner.

# Well-to-Pump (WTP) and Well-to-Wheels (WTW) GHG Emissions



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Name Manager Use in Formula Create from Selection
Trace Dependents Error Checking Watch Window
Remove Arrows Evaluate Formula
Calculation Options

Electric\_Averagemix\_FacilityUse 5

10.2.b) Electric Generation Mixes: Data Table for Use in GREET (From Annual Energy Outlook 2023)					
	U.S. Mix		ASCC Mix		FRCC Mix
	Transportation	Stationary	Transportation	Stationary	Transportation
Residual oil	0.3%	0.3%	13.7%	13.7%	0.2%
Natural gas	38.5%	38.5%	46.7%	46.7%	71.3%
Coal	20.6%	20.6%	11.4%	11.4%	10.4%
Nuclear power	18.9%	18.9%	0.0%	0.0%	12.5%
Biomass	0.3%	0.3%	0.6%	0.6%	0.2%
Others	21.5%	21.5%	27.6%	27.6%	5.5%

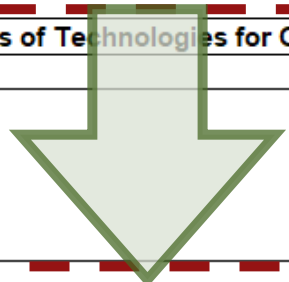
10.2.c) Electric Generation Mixes for GREET Simulations		
	Mix for Transportation Use	Mix for Stationary Use
Residual oil	0.2%	0.2%
Natural gas	30.9%	30.9%
Coal	36.6%	36.6%
Nuclear power	14.2%	14.2%
Biomass	0.2%	0.2%
Others	17.9%	17.9%

10.2.d) Shares of Technologies for Other Power Plants: Data Table for Use in GREET (From Annual Energy Outlook 2023)					
	U.S. Mix		ASCC Mix		FRCC Mix
	Transportation	Stationary	Transportation	Stationary	Transportation
Hydroelectric	31.4%	31.4%	92.7%	92.7%	13.6%
Geothermal	1.8%	1.8%	0.0%	0.0%	0.0%
Wind	49.8%	49.8%	7.3%	7.3%	0.0%
Solar PV	15.3%	15.3%	0.0%	0.0%	75.7%
Others	1.7%	1.7%	0.0%	0.0%	10.7%

10.2.e) Shares of Technologies for Other Power Plants for GREET Simulations		
	Mix for Transportation Use	Mix for Stationary Use
Hydroelectric	8.1%	8.1%
Geothermal	0.0%	0.0%
Wind	85.4%	85.4%
Solar PV	4.9%	4.9%
Others	1.7%	1.7%



Microsoft Excel interface showing the 'RSELSICEV' spreadsheet. The ribbon includes Clipboard, Font, Alignment, Number, Styles, Cells, and Editing. The spreadsheet content is as follows:

**WTW Results Menu**

Select a vehicle type from a pink drop down menu, then press "Go"

**SI ICE Vehicles**

Select Fuels [dropdown] Go

Select Fuels Go

SI - Gasoline

SI - CA gasoline

SI - Ethanol FFV

SI - BtOH FFV

SI - MeOH FFV

SI - CNG Vehicle

SI - LNG Vehicle

SI - LPG Vehicle

SI - Dedi. MeOH Vehicle

SI - Dedi. EtOH Vehicle

**SI Hybrid Vehicles (HEV)**

Select Fuels Go

**CIDI Hybrid Vehicles (HEV)**

Select Fuels Go

**BEV and FCV**

Select Fuels Go

**SI Plug-in Hybrids (PHEV)**

Select Fuels Go

**Performance-enhancing Fuels**

Select Fuels

**CIDI Plug-in Hybrids (PHEV)**

N/A Go

**GCI ICE Vehicles**

Select Fuels Go

**Per Energy in Fuels**

Energy Unit: Btu Emission Unit: g

Functional Unit: mile Energy Functional Unit: MJ

Vehicle Operation	Btu/MJ or Gallon/MJ or g/MJ					
	Total	Feedstock	Fuel	Vehicle Operation	Total	
4,289	5,471	50	211	948	1,209	
4,003	5,070	47	188	885	1,120	
35	50	8	11	0	19	
143	534	32	118	0	150	
37	269	8	59	885	952	
0.1	0.2	0	0	0	0	
-2	64	0	14	73	86	
0.317	0.175	0.070	0.039	0.003	0.112	
0.000	0.012	0.000	0.003	0.001	0.004	
7	73	2	16	73	91	
0.013	0.114	0.003	0.025	0.051	0.079	
0.027	0.044	0.006	0.010	0.606	0.621	
0.042	0.073	0.009	0.016	0.018	0.044	
0.002	0.010	0.000	0.002	0.008	0.010	
0.002	0.007	0.000	0.001	0.002	0.003	
0.012	0.024	0.003	0.005	0.000	0.008	
0.000	0.001	0.000	0.000	0.001	0.001	
0.001	0.001	0.000	0.000	0.000	0.001	

Navigation tabs: Overview, Inputs, Results, Petroleum, Co\_processing, NG, MeOH\_FTD, EtOH, Electric, Generation\_mixes, Bio...



RNAVGASCRFG Gasoline Vehicle: Gasoline

**WTW Results Menu** Select a vehicle type from a pink drop down menu, then press "Go"

<b>SI ICE Vehicles</b>	Go	<b>SI Hybrid Vehicles (HEV)</b>	Go	<b>SI Plug-in Hybrids (PHEV)</b>	Go	<b>Performance-enhancing Fuels</b>	Select Fuels
SI - Gasoline		Select Fuels		Select Fuels			
<b>SIDI ICE Vehicles</b>	Go	<b>CIDI Hybrid Vehicles (HEV)</b>	Go	<b>CIDI Plug-in Hybrids (PHEV)</b>	Go		
Select Fuels		Select Fuels		N/A			
<b>CIDI ICE Vehicles</b>	Go	<b>BEV and FCV</b>	Go	<b>GCI ICE Vehicles</b>	Go		
Select Fuels		Select Fuels		Select Fuels			

**Unit Selection** Select units from a pink drop down menu for the Results

**Per Vehicle Distance Travelled** Energy Unit: Btu Emission Unit: g Service Functional Unit: mile

**Per Energy in Fuels** Energy Unit: Btu Emission Unit: g Energy Functional Unit: MJ

**Gasoline Vehicle: Gasoline**

Item	Btu/mile or Gallon/mile or g/mile				Op	Op	Op	Op
	Feedstock	Fuel	Vehicle Operation	Total				
Total Energy	226	956	4,289	5,471				
Fossil Fuels	215	852	4,003	5,070				
Coal	35	50	0	85				
Natural Gas	143	534	0	677				
Petroleum	37	269	4,003	4,309				
Water Consumption	0.1	0.2	0	0				
CO2 (w/ C in VOC & CO)	-2	64	329	391				
CH4	0.317	0.175	0.015	0.507	0.339	0.008	0.001	0.004
N2O	0.000	0.012	0.004	0.016	0.000	0.002	0.001	0.004
GHGs	7	73	330	411	2	16	73	91
VOC: Total	0.015	0.114	0.230	0.357	0.005	0.025	0.051	0.079
CO: Total		0.044	2.7		0.006	0.010	0.606	0.621
NOx: Total					0.009	0.016	0.018	0.044
PM10: Total					0.000	0.002	0.008	0.010
PM2.5: Total					0.000	0.001	0.002	0.003
SOx: Total					0.003	0.005	0.000	0.008
BC Total					0.000	0.000	0.001	0.001
OC Total					0.000	0.000	0.000	0.001

**WTW GHG emissions per fuel consumed**

**WTW GHG emissions per fuel consumed**

**WTW GHG emissions per distance**

**WTW GHG emissions per distance**

**SI-ICE vehicle used in the Midwest and fueled by default gasoline**

Overview Overview NG MeOH\_FTD EtOH Electric Generation\_mixes Bio



# Default SI-ICE vehicle fueled by gasoline

# SI-ICE vehicle fueled by gasoline and used in the Midwest

Excel interface showing the default SI-ICE vehicle configuration. The vehicle type is set to SI-ICE. The fuel is gasoline. The unit is MJ. The WTW GHG emissions are 90 g CO<sub>2</sub>e/MJ.

Per Energy in Fuels		Per Energy in Fuels	
g/mile	Energy Functional Unit: MJ	g/mile	Energy Functional Unit: MJ
944	4,289	5,450	48
837	4,003	5,042	45
30	0	49	4
538	0	685	32
269	4,003	4,308	8
0.2	0	0	0
63	329	388	-1
0.173	0.015	0.503	0.070
0.012	0.004	0.016	0.000
71	330	407	1
0.114	0.230	0.356	0.003
0.043	2.741	2.810	0.006
0.071	0.082	0.193	0.009
0.010	0.035	0.047	0.000
0.006	0.007	0.015	0.000

**WTW GHG emissions**  
90 g CO<sub>2</sub>e/MJ

Excel interface showing the SI-ICE vehicle configuration for gasoline use in the Midwest. The vehicle type is SI-ICE. The fuel is gasoline. The unit is MJ. The WTW GHG emissions are 91 g CO<sub>2</sub>e/MJ.

Per Energy in Fuels		Per Energy in Fuels	
g/mile	Energy Functional Unit: MJ	g/mile	Energy Functional Unit: MJ
56	4,289	5,471	50
52	4,003	5,070	47
50	0	85	8
54	0	677	32
59	4,003	4,309	8
2	0	0	0
54	329	391	0
75	0.015	0.507	0.070
2	0.004	0.016	0.000
73	330	411	2
4	0.230	0.357	0.003
44	2.741	2.812	0.006
73	0.082	0.197	0.009
10	0.035	0.047	0.000
07	0.007	0.016	0.000
24	0.002	0.038	0.003
01	0.003	0.004	0.000
01	0.002	0.004	0.000

**WTW GHG emissions**  
91 g CO<sub>2</sub>e/MJ

# Fuel Efficiency in R&D GREET



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# SI and SIDI ICE vehicles



SI = Spark Ignition  
Internal Combustion Engine

SIDI = Spark Ignition Direct Injection  
Internal Combustion Engine



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# SIDI vehicles



Separates the fuel and air at the intake through direct injection

Improves fuel efficiency

Improves power



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# Review the Vehicles Tab



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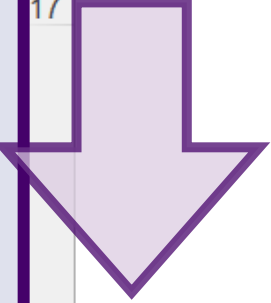
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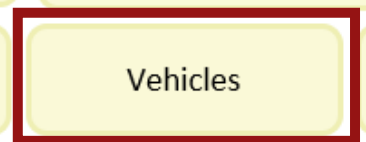
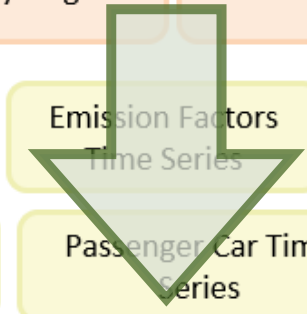
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Inputs Results  
Petroleum Ethanol Natural Gas MeOH & RNG  
Electric Hydrogen BioOil Pyrolysis & IDL Integrated Biorefinery  
Fuel Production Time Series Emission Factors Time Series Agricultural and Mining Machinery Emission Factors Time Series  
Water Consumption Factors Passenger Car Time Series Light Duty Truck 1 Time Series Light Duty Truck 2 Time Series  
Fuel Specifications Vehicles Ag Inputs

Overview Inputs Results Petroleum Co\_processing NG MeOH\_FTD EtOH Electric Generation\_mixes Bio



**Right click**



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fx Insert Function | AutoSum | Recently Used | Financial | Logical | Text | Date & Time | Lookup & Reference | Math & Trig | More Functions | Name Manager | Define Name | Use in Formula | Create from Selection | Trace Precedents | Trace Dependents | Remove Arrows | Show Formulas | Error Checking | Evaluate Formula | Watch Window | Calculation Options | Calculation

M80 : X ✓ fx = \$B80\*L57

1 **Energy Use and Emissions of Vehicle Operations**

2

3 1) Scenario Control and Key Input Parameters (from the *Inputs* sheet) Home Inputs Results

4 Volumetric share of an alternative fuel in a fuel blend

5	Methanol in FFV fuel	85.0%
6	Methanol in dedicated vehicle fuel	90.0%
7	Ethanol in low-level blend of gasoline and ethanol	9.8%
8	Ethanol in FFV fuel	83.3%
9	Ethanol in dedicated vehicle fuel	83.3%
10	Ethanol in high octane fuel (HOF E25)	24.5%
11	Ethanol in high octane fuel (HOF E40)	39.2%
12	Butanol in FFV fuel	100.0%
13	FT diesel in CIDI fuel	100.0%
14	Biodiesel in CIDI fuel	20.0%
15	Renewable diesel in CIDI fuel	100.0%
16	Renewable gasoline in SI fuel	100.0%
17	Ethanol in EtOH-diesel	10.0%
18	Additives in EtOH-diesel	1.0%
19	Renewable diesel in MCCI fuel	10.0%
20	Isobutanol in BSI fuel	20.0%
21	ARHC in BSI fuel	20.0%
22	Methanol in MM fuel	20.0%
23	Isoalkane in MCCI fuel	20.0%
24	Fatty alkyl ether (FAE) in MCCI fuel	20.0%
25	FAFE (fatty acid fusel esters) in MCCI fuel	20.0%

MPGGE gains by high octane fuel	E10	E25	E40
	5%	5%	5%

26

27 Vehicle miles traveled (VMT) share by CD and CS operations for grid-connected (plug-in) hybrid electric vehicles Note: This VMT % will be used to calculate a weighted average performance of combined CD and CS operations

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A B C D E F G H I J K L M N O P Q R S T U V W X

**3) Per-Mile Fuel Consumption and Emissions of Vehicle Operations**

	Baseline Gasoline Vehicle: Gasoline	Gasoline Vehicle: CA gasoline	Gasoline Vehicle: Low-Level EtOH Blend with Gasoline	Bi-Fueled CNGV on CNG	Dedicated CNGV	Dedicated LNGV	Dedicated LPGV	MeOH Flexible-Fuel Vehicle	Dedicated MeOH Vehicle	EtOH Flexible-Fuel Vehicle	BtOH Flexible-Fuel Vehicle	Dedicated EtOH Vehicle	G.H2 ICE Vehicle	L.H2 ICE Vehicle	RG100 Vehicle	RG100 Vehicle: IDL	RG100 Vehicle: Ex Situ CFP	High Octane Fuel Vehicle: HOF	H.E. Fuel Vehicle: HOF	H.E. Fuel Vehicle: HOF	SIDI Vehicle: Gasoline	SIDI Vehicle: CA gasoline	SIDI Vehicle: Low-Level EtOH Blend with Gasoline
Urban Emission Shares	70.0%	82.0%	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%	70%	70%	70%	70.0%	82.0%	70.0%
MPGGE (per gasoline equivalent gallon)	26.2	26.2	26.2	24.2	24.8	24.8	26.2	26.2	28.0	26.2	26.2	28.0	31.4	31.4	26.2	26.2	26.2	27.5	27.5	27.5	30.1	30.1	30.1
Total fuel use (Btu/mile)	4,289	4,289	4,289	4,637	4,515	4,515	4,289	4,289	4,008	4,289	4,289	4,008	3,574	3,574	4,289	4,289	4,289	4,085	4,085	4,085	3,730	3,730	3,730
Fossil fuel use (Btu/mile)	4,003	4,003	4,003	4,637	4,515	4,515	4,289	4,289	4,008	1,002	0	937	3,574	3,574	0	0	0	3,367	3,367	2,869	3,481	3,481	3,481
Coal use (Btu/mile)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Natural gas use (Btu/mile)	0	0	0	4,637	4,515	4,515	3,714	3,159	3,271	0	0	0	3,574	3,574	0	0	0	0	0	0	0	0	0
Petroleum use (Btu/mile)	4,003	4,003	4,003	0	0	0	575	1,130	737	1,002	0	937	0	0	0	0	0	3,367	3,367	2,869	3,481	3,481	3,481
Emissions: grams/mile																							
VOC: exhaust	0.069	0.069	0.069	0.069	0.069	0.069	0.069	0.069	0.069	0.069	0.069	0.069	0.014	0.014	0.069	0.069	0.069	0.069	0.069	0.069	0.069	0.069	0.069
VOC: evaporation	0.161	0.161	0.161	0.081	0.000	0.000	0.000	0.137	0.137	0.137	0.137	0.137	0.000	0.000	0.161	0.161	0.161	0.161	0.161	0.161	0.161	0.161	0.161
CO	2.741	2.741	2.741	2.741	2.741	2.741	2.741	2.741	2.741	2.741	2.741	2.741	0.548	0.548	2.741	2.741	2.741	2.741	2.741	2.741	2.741	2.741	2.741
NOx	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082
PM10: exhaust	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.000	0.000	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
PM10: brake and tire wear	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031
PM2.5: exhaust	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.000	0.000	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
PM2.5: brake and tire wear	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
SOx	0.002	0.002	0.002	0.001	0.001	0.000	0.000	0.001	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
BC	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.000	0.000	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
OC	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
CH4	0.015	0.015	0.015	0.146	0.146	0.146	0.015	0.015	0.015	0.015	0.015	0.015	0.001	0.001	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
N2O	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
CO2	324	324	324	270	263	264	287	310	288	318	308	297	0	0	317	308	337	308	307	306	281	281	281

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**SIDI-ICE**

< > ... E\_fuel Fuel\_Prod\_TS EF\_TS AgMining\_EF\_TS EF WCF Fuel\_Specs Car\_TS LDT1\_TS LDT2\_TS Vehicles Ur ... + :

# Greenhouse Gas Modeling in R&D GREET



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# Global Warming Potential (GWP)



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# Global warming potential

1 kg, or 1 ton, of a greenhouse gas  
is emitted as an instantaneous  
pulse

[- Climate Change 2022  
Synthesis Report | IPCC](#)



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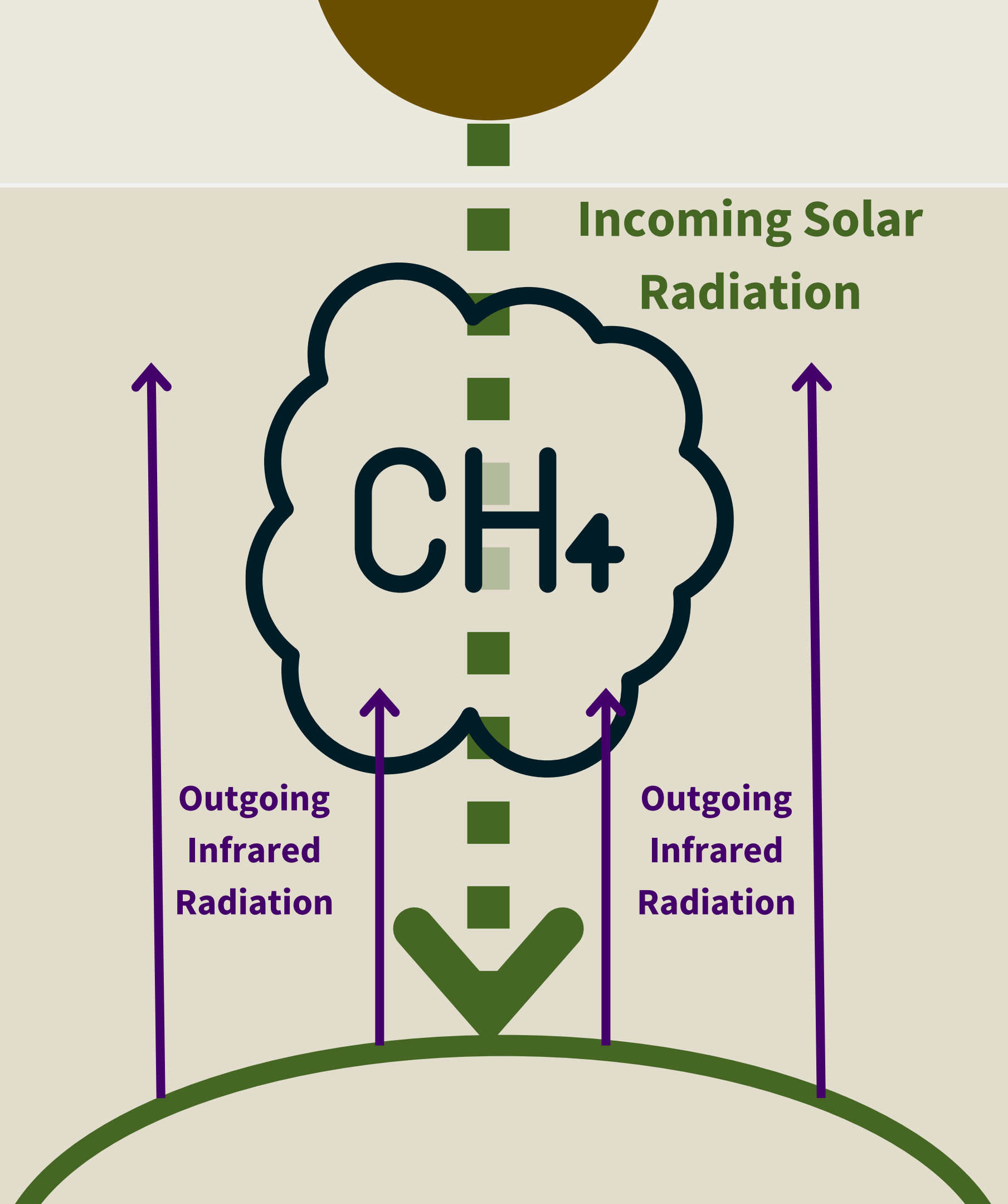
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# Global warming potential

Over a period of time, these particles *absorb* some infrared radiation but *do not absorb* incoming solar radiation

This period of time is the **Time Horizon**



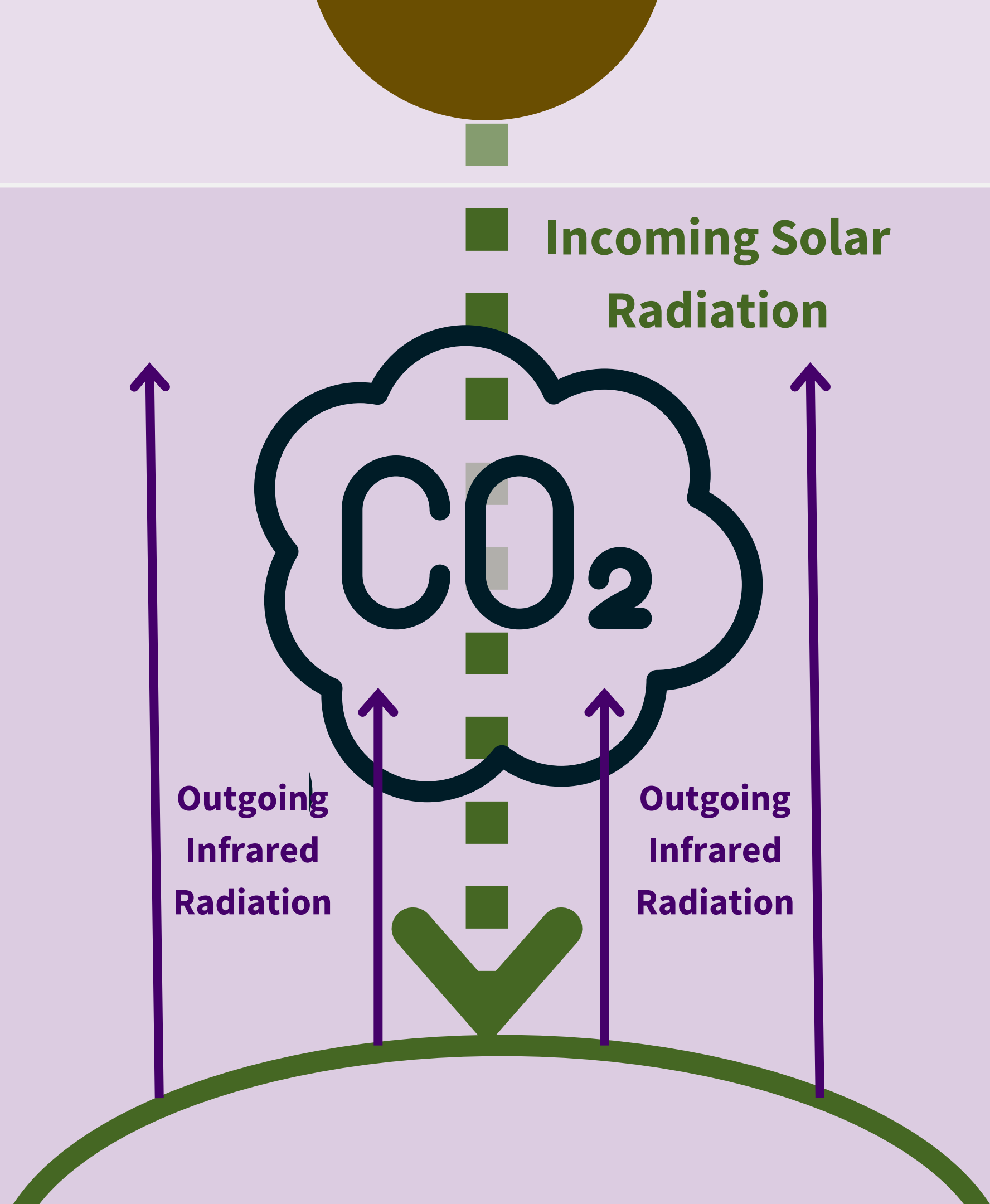
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# Global warming potential

Compare the amount of radiation absorbed by the greenhouse gas to the amount absorbed by 1 kg of CO<sub>2</sub>



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# Global Temperature Change Potential (GTP)



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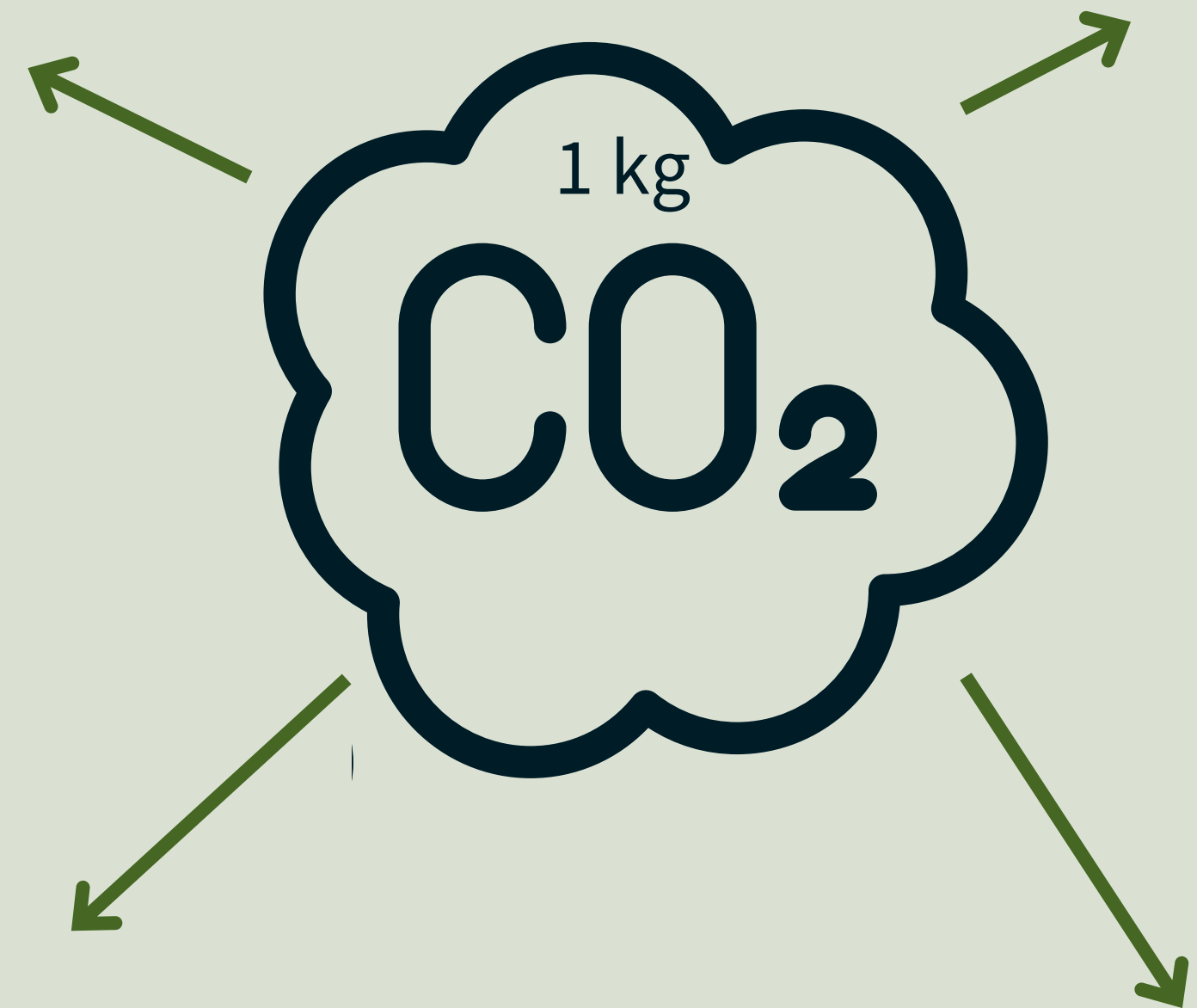


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# Global temperature change potential (GTP)

Accounts for temperature change based on the radiative absorption



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Earth

# Review the Fuel Specs Tab



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		Inputs		Results								
		Petroleum		Ethanol		Natural Gas		MeOH &		RNG		
		Electric		Hydrogen		BioOil		Pyrolysis & IDL		Integrated Biorefinery		
		Fuel Production Time Series		Emission Factors Time Series		Agricultural and Mining Machinery Emission Factors Time Series						
		Water Consumption Factors		Passenger Car Time Series		Light Duty Truck 1 Time Series		Light Duty Truck 2 Time Series				
		Fuel Specifications		Vehicles		Ag Inputs						

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Overview

Inputs

Results

Petroleum

Co\_processing

NG

MeOH\_FTD

EtOH

Electric

Generation\_mixes

Bio



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Specifications of Fuels, Global Warming Potentials of Greenhouse Gases, and Carbon and Sulfur Ratios of Pollutants								
1) Specifications of Fuels and Other Substances								
Fuel	Heating Value			Density	C ratio	S ratio	S ratio	LHV/HHV
	Calculation:	LHV	HHV					
Use LHV or HHV in calculations?	1	1 -- LHV; 2 -- HHV						
Liquid Fuels:	Btu/gal	Btu/gal	Btu/gal	grams/gal	(% by wt)	(ppm by wt)	by wt	
Crude oil	129,670	129,670	138,350	3,205	85.3%	16,000	0.016000	0.937
Synthetic crude oil (SCO)	135,085	135,085	144,476	3,266	85.6%	1,800	0.001800	0.935
Bitumen	152,371	152,371	162,964	3,840	83.0%	48,000	0.048000	0.935
Dilbit (After Recovery)	152,371	152,371	162,964	3,840	83.0%	48,000	0.048000	0.935
Dilbit (Before Recovery)	145,194	145,194	155,288	3,500	83.2%	37,227	0.037227	0.935
Diluent	128,449	128,449	137,378	2,709	84.1%	1,600	0.001600	0.935
Shale Oil (Bakken)	125,601	125,601	134,009	3,087	0.853	16000	0.016000	0.937
Shale Oil (Eagle Ford)	122,493	122,493	130,692	2,984	0.853	16000	0.016000	0.937
Gasoline blendstock	116,090	116,090	124,340	2,819	86.3%	10	0.000010	0.934
Gasoline	112,194	112,194	120,439	2,836	82.8%	9	0.000009	0.932
CA gasoline	112,194	112,194	120,439	2,836	82.8%	9	0.000009	0.932
High Octane Fuel (E25)	106,150	106,150	114,388	2,861	77.8%	8	0.000008	0.928
High Octane Fuel (E40)	100,186	100,186	108,416	2,887	72.7%	6	0.000006	0.924
U.S. conventional diesel	128,450	128,450	137,380	3,167	86.5%	200	0.000200	0.935
CA diesel	129,488	129,488	138,490	3,206	87.1%	11	0.000011	
Diesel for non-road engines	128,450	128,450	137,380	3,167	86.5%	11	0.000011	0.935
Low-sulfur diesel	129,488	129,488	138,490	3,206	87.1%	11	0.000011	0.935
Petroleum naphtha	116,920	116,920	125,080	2,745	85.0%	1	0.000001	0.935
Low Octane Gasoline-Like Fuel (LOF)	118,237	118,237	126,586	2,834	85.3%	10	0.000010	0.934
Conventional Jet Fuel	124,307	124,307	132,949	3,036	86.2%	700	0.000700	0.935
ULS Jet Fuel	123,041	123,041	131,595	2,998	86.0%	11	0.000011	0.935
NG-based FT naphtha	111,520	111,520	119,740	2,651	84.2%	0	0.000000	0.931
Residual oil	140,353	140,353	150,110	3,752	86.8%	5,000	0.005000	0.935

Home    **Inputs**    Results

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**2) Global Warming Potentials of Greenhouse Gases: relative to CO2**

Metrics for Carbon Dioxide, Methane, Nitrous Oxide

AR Edition/Type	AR6/GWP	AR6/GWP	AR6/GWP	AR6/GWP	AR6/GWP	AR5/GWP	AR5/GWP	AR5/GWP	AR5/GWP	AR4/GWP	AR4/GWP	AR3/GWP	AR3/GWP	AR2/GWP
Time Horizon (YR)	100	100	20	100	50	100	20	100	20	100	20	100	20	100
CO2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
CH4	29.8	29.8	82.5	7.5	13.2	30	85	6	68	25	72	23	62	21
N2O	273	273	273	233	290	265	264	234	277	298	289	296	275	310

Metrics for Near Term Climate Forcers

Type	None	None	GWP	GWP	GTP	GTP
Time Horizon (YR)	100	100	100	20	100	20
VOC	0	0	4.5	14	0.66	7.5
CO	0	0	2.65	7.65	0.42	4.9
NOx	0	0	-11	19	-2.9	-87
BC	0	0	900	3200	130	920
OC	0	0	-69	-240	-10	-71

**3) Carbon and Sulfur Ratios of Pollutants**

Carbon ratio of VOC	0.85
Carbon ratio of CO	0.43
Carbon ratio of CH4	0.75
Carbon ratio of CO2	0.27
Sulfur ratio of SO2	0.50

**4) Regulated Sulfur Content in Gasoline Blendstock and Conventional Diesel over Time**

10	200.0	11.0	11.0
10	200.0	11.0	11.0

Sulfur Content

IBR | E\_fuel | Fuel\_Prod\_TS | EF\_TS | AgMining\_EF\_TS | EF | WCF | Fuel\_Specs | Car\_TS | LDT1\_TS | LDT2\_TS | Vehicle

**CO<sub>2</sub> w/ (VOC, and CO),  
CH<sub>4</sub>, N<sub>2</sub>O**



# Transportation and Distribution in R&D GREET



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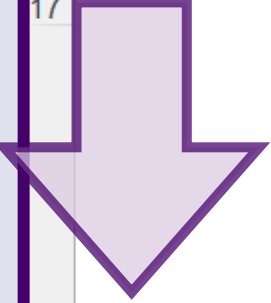
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<table border="1"> <tr> <td colspan="2">Inputs</td> <td colspan="2">Results</td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2"></td> </tr> <tr> <td>Petroleum</td> <td>Ethanol</td> <td>Natural Gas</td> <td>MeOH &amp;</td> <td colspan="2">RNG</td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2"></td> </tr> <tr> <td>Electric</td> <td>Hydrogen</td> <td>BioOil</td> <td>Pyrolysis &amp; IDL</td> <td colspan="2">Integrated Biorefinery</td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2"></td> </tr> <tr> <td colspan="2">Fuel Production Time Series</td> <td colspan="2">Emission Factors Time Series</td> <td colspan="8">Agricultural and Mining Machinery Emission Factors Time Series</td> </tr> <tr> <td colspan="2">Water Consumption Factors</td> <td colspan="2">Passenger Car Time Series</td> <td colspan="2">Light Duty Truck 1 Time Series</td> <td colspan="6">Light Duty Truck 2 Time Series</td> </tr> <tr> <td colspan="2">Fuel Specifications</td> <td colspan="2">Vehicles</td> <td colspan="8">Ag Inputs</td> </tr> </table>													Inputs		Results										Petroleum	Ethanol	Natural Gas	MeOH &	RNG								Electric	Hydrogen	BioOil	Pyrolysis & IDL	Integrated Biorefinery								Fuel Production Time Series		Emission Factors Time Series		Agricultural and Mining Machinery Emission Factors Time Series								Water Consumption Factors		Passenger Car Time Series		Light Duty Truck 1 Time Series		Light Duty Truck 2 Time Series						Fuel Specifications		Vehicles		Ag Inputs							
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Overview Inputs Results Petroleum Co\_processing NG MeOH\_FTD EtOH Electric Generation\_mixes Bio ... +



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Row 18: Petroleum Co\_processing NG MeOH\_FTD EtOH Electric Generation\_mixes Bio ... + : < >

Row 19: Display Settings 80%

Right Panel: Inputs (yellow), Results (green)

Row 3: Petroleum, Ethanol, Natural Gas, MeOH & FTD, RNG, Algae

Row 4: Electric, Hydrogen, BioOil, Pyrolysis & IDL, Integrated Biorefinery, Plastic Fuel

Row 5: Fuel Production Time Series, Emission Factors Time Series, Agricultural and Mining Machineries Emission Factors Time Series, Emission Factors Time Series

Row 6: Water Consumption Factors, Passenger Car Time Series, Light Duty Truck 1 Time Series, Light Duty Truck 2 Time Series

Row 7: Fuel Specifications, Vehicles, Ag Inputs

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 More Functions  
 Name Manager  
 Define Name  
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 Defined Names  
 Trace Precedents  
 Trace Dependents  
 Remove Arrows  
 Show Formulas  
 Error Checking  
 Evaluate Formula  
 Formula Auditing  
 Watch Window  
 Calculation Options  
 Calculation

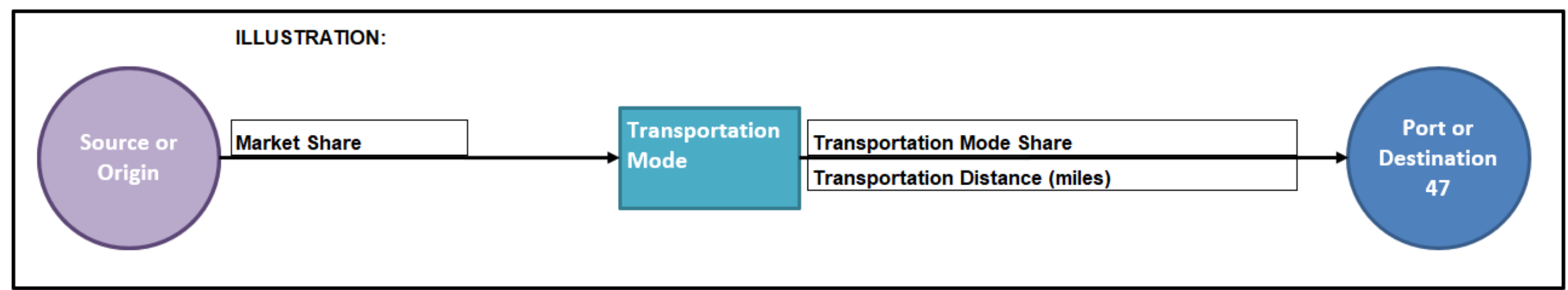
Y12



**Navigation Menu:** Select the desired pathway from the following drop down lists (highlighted yellow) and click "Go"

Home	<b>Petroleum &amp; Petroleum Products</b>	Go	<b>Natural Gas &amp; Fossil Fuels</b>	Go
Inputs	Conventional Crude Oil for Use in US Refinery		Natural Gas (NG)	
Results	<b>Alternative Fuels</b>	Go	<b>Crops and Feedstocks</b>	Go
Back to Top	Ethanol		Corn	
	<b>Agricultural Products and Chemicals</b>	Go		
	Ammonia as a Final Fertilizer			

**Flowcharts for Transportation and Distribution of Transportation Fuels and Feedstocks**



**1. Conventional Crude Oil for Use in US Refinery**

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 ⋮ More Functions

Function Library

Name Manager  
 Define Name  
 Use in Formula  
 Create from Selection  
 Defined Names

Trace Precedents  
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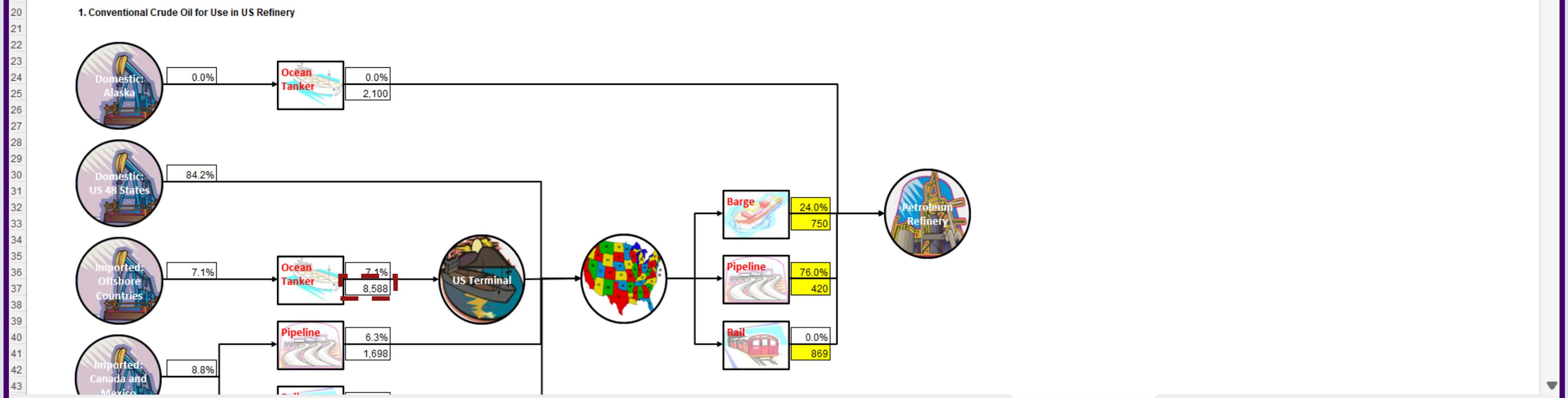
Show Formulas  
 Error Checking  
 Evaluate Formula

Watch Window  
 Calculation Options  
 Calculation

AA36

**Navigation Menu:** Select the desired pathway from the following drop down lists (highlighted yellow) and click "Go"

Home	<b>Petroleum &amp; Petroleum Products</b>	Go	<b>Natural Gas &amp; Fossil Fuels</b>	Go
Inputs	Conventional Crude Oil for Use in US Refinery	Go	Natural Gas (NG)	Go
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Back to Top	Ethanol	Go	Corn	Go
	Agricultural Products and Chemicals	Go		
	Ammonia as a Final Fertilizer	Go		



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## Questions?

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