

February 10, 2025

Demo for Electricity and Electric Infrastructure in R&D GREET[®]

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

Instructors

Gabrielle Olson, Great Plains Institute

Branden Leonhardt, Department of Energy

Argonne National Laboratory Subject Matter Experts

Zifeng Lu, Taemin Kim



**GREAT PLAINS
INSTITUTE**

Argonne
NATIONAL LABORATORY

U.S. Department of
ENERGY

R&D GREET disclaimer

The R&D GREET effort at Argonne National Laboratory is supported by the Office of Energy Efficiency and Renewable Energy, the Office of Fossil Energy and Carbon Management, the Office of Clean Energy Demonstration, the Office of Technology Transitions, the Office of Nuclear Energy, and ARPA-E of the US Department of Energy (DOE) under contract DE-AC02-06CH11357. The views and opinions expressed herein do not necessarily state or reflect those of the US government or any agency thereof. Neither the US government nor any agency thereof, nor any of their employees, makes any warranty, expressed or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights.

Argonne's R&D GREET is to inform the life cycle analysis of technical community. Not all pathways and data in R&D GREET are appropriate for use in circumstances where a high level of quantitative certainty or precision is required. GREET is referenced in numerous independent state and federal compliance and incentive programs (including solicitations, rulemakings, and tax incentives), but it is important to note that R&D GREET is not the version used by any of these specific programs. Argonne does not warrant that use of R&D GREET is consistent with the requirements of any particular regulatory or incentive program.



**GREAT PLAINS
INSTITUTE**

Argonne
NATIONAL LABORATORY

U.S. Department of
ENERGY

GREET end-user licensing terms and conditions

Commercial use:

For commercial use, please contact www.anl.gov/partners.

Non-commercial use:

This license is based on the Creative Commons Attribution-Non Commercial 4.0 International Public License, with the following modified definition. Non-Commercial means internal use (including use for internal business or operational purposes by for-profit entities), use by non-profit entities, or use for United States federal, state, or local government purposes. Government purposes include work performed pursuant to a United States federal, state, or local government funding agreement, and work performed by or on behalf of the United States federal, state, or local government. For purposes of this Public License, the exchange of the Licensed Material for other material subject to Copyright and Similar Rights by digital file-sharing or similar means is Non-Commercial provided there is no payment of monetary compensation in connection with the exchange.

Redistribution and use of the GREET software are permitted for non-commercial uses and provided that the following conditions are met:

1. Redistributions of the GREET software must retain the above copyright notice, this list of conditions, and the following disclaimer. Modification or reverse compilation of the source code is not permitted.
2. Neither the names of UChicago Argonne, LLC or the Department of Energy nor the names of its contributors may be used to endorse or promote products derived from this software without prior written permission.
3. The software redistribution, if any, must include the following acknowledgment: "This product includes software produced by UChicago Argonne, LLC under Contract No. DE-AC02-06CH11357 with the Department of Energy."
4. Any published results should indicate that the GREET software was developed by Argonne National Laboratory. If you publish results generated using GREET you should identify the GREET software version number. If you publish results generated using input data other than the input data supplied with the GREET software you must indicate that these results relied upon changed input data.



**GREAT PLAINS
INSTITUTE**

Argonne
NATIONAL LABORATORY

U.S. Department of
ENERGY

Table of contents

1. Outline Steps for Electricity and Electric Infrastructure Scenarios
2. Electricity Scenarios
 - a. Model a CIDI Car Using Renewable Diesel from Biooil
 - b. Model a CIDI Car Using a 50% Coal/50% NG Electricity Generation Mix
 - c. Model an FCV Using Gaseous Hydrogen and Charged in Florida
 - d. Model a 2022 SUV BEV Charged in WECC
3. Electricity Infrastructure Scenarios
 - a. Model a 2022 SUV BEV Including Power-plant Construction Materials
 - b. Model a 2022 SUV BEV Charged by an Onshore Wind Turbine
 - c. Model a 2022 SUV BEV Charged by an Deep Water Offshore Wind Turbine



Outline Steps for Electricity and Electric Infrastructure Scenarios



**GREAT PLAINS
INSTITUTE**



Argonne
NATIONAL LABORATORY



U.S. Department of

ENERGY

Electricity Overview



**GREAT PLAINS
INSTITUTE**



Argonne
NATIONAL LABORATORY



U.S. Department of
ENERGY

General Settings for Altering the Electric Generation Mix



**GREAT PLAINS
INSTITUTE**

Argonne 
NATIONAL LABORATORY

U.S. Department of
ENERGY

File Home Insert Draw Page Layout Formulas Data Review View Automate Help

R&D GREET 1 10 A^ A^

Paste B I U Font Alignment Number Styles Cells Editing Sensitivity Add-ins Analyze Data

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 FtOH Electric Generation mixes Bio



R&D GREET 1

Function Library: Insert Function, AutoSum, Recently Used, Financial, Logical, Text, Date & Time, Lookup & Reference, Math & Trig, More Functions

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

Formula Auditing: Trace Precedents, Trace Dependents, Remove Arrows, Show Formulas, Error Checking, Evaluate Formula

Calculation: Watch Window, Calculation Options

L749

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

740 **10. Electric Generation**

741 Electric

742

743

744 Results

745

746

747

748 Back to Top

749

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

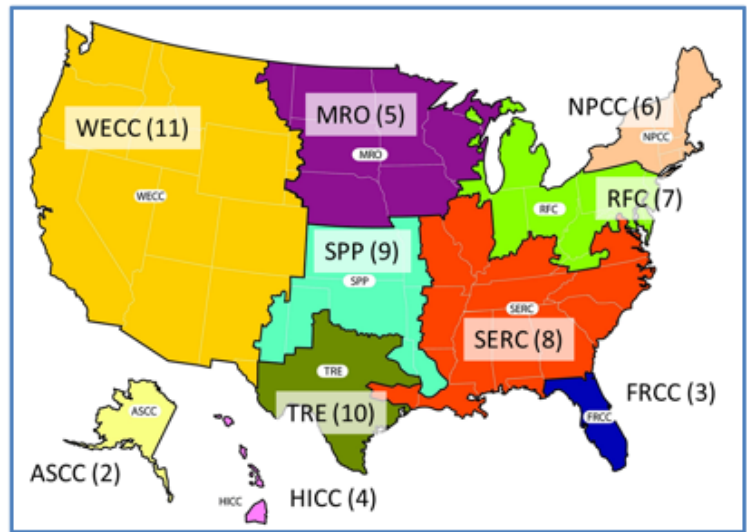
743 2 -- Emission factors based on EPA and EIA database in g/kWh

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



- 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**

Overview Inputs Results Petroleum Co_processing NG MeOH_FTD EtOH Electric Generation_mixes Bio ...

Further Explore the Electric Generation Mix in a Pathway



**GREAT PLAINS
INSTITUTE**

Argonne 
NATIONAL LABORATORY

U.S. Department of
ENERGY

Electricity tabs in R&D GREET 1

Primary
Electric
Generation_mixes
Bioelectricity

Some Secondary

Inputs
Results
Petroleum
NG
RNG
BioOil
Fuel_Specs
Vehicles
T&D
T&D Flowcharts



**GREAT PLAINS
INSTITUTE**



R&D GREET 1

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

Excel formula bar and column headers (A-M). The formula bar contains 'T13' and a function icon.

COPYRIGHT NOTIFICATION

GREET® SOFTWARE

GREET 1 Model

Email contact: greet@anl.gov

LLC ALL RIGHTS RESERVED

ALL PROTECTED UNDER COPYRIGHT LAW, AND FURTHER DISSEMINATION IS WITHOUT THE CONSENT OF THE PATENT COUNSEL OF ARGONNE NATIONAL LABORATORY, UNDER THE "STANDARD TERMS AND CONDITIONS" NOTED BELOW.

CHICAGO ARGONNE, LLC, WHICH OPERATES AS A FEDERAL RESEARCH FACILITY IN THE STATE OF ILLINOIS, IS OWNED BY THE UNITED STATES OF AMERICA. CHICAGO ARGONNE, LLC UNDER PROVISION OF A CONTRACT WITH THE U.S. DEPARTMENT OF ENERGY.

GOVERNMENT LICENSE

Chicago Argonne, LLC under Contract No. DE-AC02-06CH11357 with the Department of Energy, is hereby granted a nonexclusive, irrevocable, worldwide license in such copyrighted data to reproduce, distribute copies to the public, to perform publicly and display publicly, and to permit others to do so. The specific terms of this license are set forth in the license agreement by inquiry made to UChicago Argonne, LLC or DOE.

Inputs Results

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

Activate dialog box

Activate: Overview

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

Petroleum Co_processing NG MeOH_FTD EtOH Electric Generation_mixes Bio ... +

Electricity Infrastructure



**GREAT PLAINS
INSTITUTE**



Argonne
NATIONAL LABORATORY



U.S. Department of
ENERGY

General Settings for Including the Construction of Electric Infrastructure Within the System Boundary



**GREAT PLAINS
INSTITUTE**

Argonne
NATIONAL LABORATORY

U.S. Department of
ENERGY

File Home Insert Draw Page Layout Formulas Data Review View Automate Help

R&D GREET 1 10 A^ A^

Paste B I U Font Alignment Number Styles Cells Editing Sensitivity Add-ins Analyze Data

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

Restore Time Series Table Value

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 FtOH Electric Generation mixes Bio



R&D GREET 1

Function Library: Insert Function, AutoSum, Recently Used, Financial, Logical, Text, Date & Time, Lookup & Reference, Math & Trig, More Functions

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

Formula Auditing: Trace Precedents, Trace Dependents, Remove Arrows, Show Formulas, Error Checking, Evaluate Formula

Calculation: Watch Window, Calculation Options

L749

10. Electric Generation

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

Electric: 2

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

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

(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)

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

File Home Insert Draw Page Layout Formulas Data Review View Automate Help

R&D GREET 1

Clipboard Font Alignment Number Styles Cells Editing Sensitivity Add-ins Analyze Data

NavInputsZoomElectric 10. Electric Generation

10.4) Share of Feedstock for Biomass Power Plants					
	Willow	Poplar	Switchgrass	Miscanthus	Forest Residue
	0.0%	0.0%	0.0%	0.0%	100.0%

10.5) Share of Geothermal Technologies and Fugitive CO2 emissions from geofluid			
	Hydrothermal-Flash	Hydrothermal-Binary	Geothermal-EGS
Shares of Geothermal Technologies	100.0%	0.0%	0.0%
Fugitive CO2 emissions from geofluid (g CO2/kWh)	91	0	0

10.6) Energy Use of Power Plant Construction Materials

No To consider energy and emissions for infrastructure of power plants?

No To include battery storage for solar PV system?

10.7) The Types of Electricity Displaced by Co-Produced Electricity in NG-based, Coal-based, and Biomass-based Fuel Plants for Export to Grid

10.7.a) NG-Based Fuel Plants (Including NG to MeOH, DME, FT Diesel, FT Naphtha, and H2)

1 1-- Electricity generation mix (Could be U.S. mix, NE U.S. mix, CA mix, or user defined mix, which is defined for stationary use in sec
2-- NGCC electricity
3-- Coal IGCC electricity
4-- Biomass IGCC electricity

10.7.b) Biomass-Based Fuel Plants (Including Biomass to EtOH, MeOH, DME, FT Diesel, and H2)

1 1-- Electricity generation mix (Could be U.S. mix, NE U.S. mix, CA mix, or user defined mix, which is defined for stationary use in sec
2-- NGCC electricity
3-- Biomass IGCC electricity

10.7.c) Coal-Based Fuel Plants (Including Coal to H2, and MeOH, DME, and FT Diesel)

1 1-- Electricity generation mix (Could be U.S. mix, NE U.S. mix, CA mix, or user defined mix, which is defined for stationary use in sec
2-- NGCC electricity
3-- Coal IGCC electricity

10.7.d) Pet Coke-Based Fuel Plants (Including Pet Coke to H2)

1 1-- Electricity generation mix (Could be U.S. mix, NE U.S. mix, CA mix, or user defined mix, which is defined for stationary use in sec
2-- NGCC electricity
3-- Coal IGCC electricity

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



Further Explore the Electric Infrastructure in a Pathway



**GREAT PLAINS
INSTITUTE**

Argonne
NATIONAL LABORATORY

U.S. Department of
ENERGY

Electric infrastructure tabs in R&D GREET 1

Primary

Electric

ElecInfra

OilGasCoalInfra

Some Secondary

Inputs

Results

Fuel_Specs

EF

T&D

T&D Flowcharts



GREAT PLAINS
INSTITUTE



R&D GREET 1

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

Excel formula bar: T13, fx

Excel grid columns: A, B, C, D, E, F, G, H, I, J, K, L, M

COPYRIGHT NOTIFICATION

GREET® SOFTWARE

GREET 1 Model

Email contact: greet@anl.gov

LLC ALL RIGHTS RESERVED

ALL PROTECTED UNDER COPYRIGHT LAW, AND FURTHER DISSEMINATION IS WITHOUT THE CONSENT OF THE PATENT COUNSEL OF ARGONNE NATIONAL LABORATORY, UNDER "STANDARD TERMS AND CONDITIONS" NOTED BELOW.

CHICAGO ARGONNE, LLC, WHICH IS LOCATED AT 9700 SOUTH ARLINGDALE AVENUE, CHICAGO, ILLINOIS 60632, IS OWNED BY THE UNITED STATES OF AMERICA THROUGH THE U.S. DEPARTMENT OF ENERGY. CHICAGO ARGONNE, LLC UNDER PROVISION OF A CONTRACT WITH THE U.S. DEPARTMENT OF ENERGY, IS GRANTING TO YOU A LIMITED LICENSE TO USE THE SOFTWARE FOR RESEARCH AND DEVELOPMENT PURPOSES ONLY. YOU MAY NOT REPRODUCE, COPY, DISTRIBUTE, OR DISSEMINATE THE SOFTWARE OR ITS CONTENTS IN ANY MANNER WITHOUT THE EXPRESS WRITTEN PERMISSION OF THE U.S. DEPARTMENT OF ENERGY. THIS LICENSE IS VALID FOR THE TERM OF THE CONTRACT AND IS SUBJECT TO THE TERMS AND CONDITIONS OF THE CONTRACT. FOR MORE INFORMATION, PLEASE CONTACT THE PATENT COUNSEL OF ARGONNE NATIONAL LABORATORY AT greet@anl.gov.

GOVERNMENT LICENSE

Chicago Argonne, LLC under Contract No. DE-AC02-06CH11357 with the Department of Energy, is hereby granting to you a limited license to use the software for research and development purposes only. This license is valid for the term of the contract and is subject to the terms and conditions of the contract. For more information, please contact the Patent Counsel of Argonne National Laboratory at greet@anl.gov.

Inputs	Results				
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		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			

Activate dialog box

Activate: Overview, 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

1 (arrow pointing to Electric)

2 (arrow pointing to OK)

OK, Cancel

Excel status bar: Petroleum, Co_processing, NG, MeOH_FTD, EtOH, Electric, Generation_mixes, Bio, ...

R&D GREET 1

Clipboard Font Alignment Number Styles Cells Editing Sensitivity Add-ins Analyze Data

A1 Electricity Generation

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Electricity Generation												
2													
3	1) Scenario Control and Key Input Parameters (from the Inputs sheet)												
4		2	Control variable for selecting power plant emission factors										
5			1 -- GREET-calculated emissions factors via emission factors in EF Sheet										
6			2 -- Emission factors based on EIA/eGRID database										
7													
8		G.H2	L.H2										
9	Selecting nuclear reactor technologies for electrolysis at refueling stations	1	1	1 -- Light Water Reactor (LWR); 2-- High Temperature Gas Reactor (HTGR)									
10													
11		LWR	HTGR										
12	Conversion factor for nuclear power plants (MWh/g of U-235)	6.59	8.70										
13													
14	Energy Use of Power Plant Infrastructure												
15	No	To consider energy and emissions for infrastructure of power plants?											
16	No	To include battery storage for solar PV system?											
17		Pressurized Water Reactor (PWR)	Boiling Water Reactor (BWR)										
18	Shares of LWR technologies for infrastructure	65.4%	34.6%										
19													
20		Geothermal-Flash	Geothermal-Binary	Geothermal-EGS									
21	Shares of Geothermal Technologies	100.0%	0.0%	0.0%									
22	Fugitive CO2 emissions from geofluid (g CO2/kWh)	91	0	0									
23													
24	2) Electricity Generation Mixes, Combustion Technology Shares, and Power Plant Energy Conversion Efficiencies												

Home Inputs Results

Overview Inputs Results Petroleum Co_processing NG MeOH_FTD EtOH Electric Generation_mixes Bio

File Home Insert Draw Page Layout Formulas Data Review View Automate Help

R&D GREET 1

Clipboard Font Alignment Number Styles Cells Editing Sensitivity Add-ins Analyze Data

A1 Electricity Generation

2) Electricity Generation Mixes, Combustion Technology Shares, and Power Plant Energy Conversion Efficiencies												
2.1) Regional Combustion Technology Shares and Power Plant Energy Conversion Efficiencies												
Fuel	Coal											
Combustion Technology	Boiler											
Region	U.S.	ASCC	FRCC	HICC	MRO	NPCC	RFC	SERC	SPP	TRE	WECC	U.S.
Efficiency	34.5%	24.7%	34.1%	34.5%	34.2%	31.7%	34.6%	34.8%	34.8%	34.5%	34.3%	39.0%
Technology Share	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	0.0%
Emissions (g/kWh)												
VOC	0.013	0.013	0.005	0.013	0.018	0.012	0.011	0.015	0.012	0.010	0.014	0.001
CO	0.297	0.297	0.308	0.297	0.339	0.198	0.138	0.181	0.651	1.166	0.284	0.013
NOx	0.708	0.708	0.440	0.708	0.847	0.620	0.597	0.684	0.641	0.662	0.974	0.235
PM10	0.076	0.076	0.133	0.076	0.086	0.017	0.078	0.056	0.074	0.117	0.095	0.028
PM2.5	0.060	0.060	0.109	0.060	0.072	0.015	0.064	0.044	0.058	0.073	0.068	0.008
SOx	0.942	0.942	1.022	0.942	1.252	1.040	0.866	0.897	1.177	2.066	0.530	0.005
BC	0.003	0.003	0.005	0.003	0.003	0.001	0.003	0.002	0.002	0.003	0.003	0.000
OC	0.005	0.005	0.009	0.005	0.006	0.001	0.005	0.004	0.005	0.006	0.005	0.001
CH4	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.008
N2O	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.012
Fuel												
Combustion Technology												
Region	U.S.	ASCC	FRCC	HICC	MRO	NPCC	RFC	SERC	SPP	TRE	WECC	U.S.
Efficiency	51.6%	44.6%	52.4%	51.6%	51.9%	50.9%	52.1%	52.1%	50.8%	51.2%	50.4%	32.9%
Technology Share	83.1%	64.6%	86.2%	0.0%	69.6%	83.2%	81.0%	82.9%	76.4%	86.7%	83.7%	8.8%
Emissions (g/kWh)												

Overview Inputs Results Petroleum Co_processing NG MeOH_FTD EtOH Electric Generation_mixes Bio ...



R&D GREET 1

Microsoft Excel ribbon showing tabs: Clipboard, Font, Alignment, Number, Styles, Cells, Editing, Sensitivity, Add-ins, Analyze Data.

A1 Electricity Generation

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Electricity Generation												
71	IGCC				0.0%	0.0%	39.0%	39.0%					
72	Biomass Power Plants		0.3%	0.3%			21.7%	21.7%	1.3%	1.3%			
73	Boiler				100.0%	100.0%	21.7%	21.7%					
74	IGCC				0.0%	0.0%	45.0%	45.0%					
75	Nuclear Power Plants		18.9%	18.9%			100.0%	100.0%	22.9%	22.9%			
76	Other Power Plants (hydro, wind, geothermal, etc.)		21.5%	21.5%			100.0%	100.0%					
77	Hydroelectric				31.4%	31.4%							
78	Geothermal				1.8%	1.8%							
79	Wind				49.8%	49.8%							
80	Solar PV				15.3%	15.3%							
81	Others (Biogenic Waste, Pumped Storage, etc.)				1.7%	1.7%							

2.3) Combined Heat and Power Generation Technologies

	Equivalent electric	Overall Plant Energy Conversion Efficiency
84 Natural Gas-Fired Combined Heat and Power Plants (CHP)		
85 Boiler	52.8%	80.6%
86 Simple-cycle gas turbine	65.8%	79.4%
87 Combined-cycle gas turbine	68.1%	77.9%
88		
89 Coal-Fired Combined Heat and Power Plants (CHP)		
90 Boiler	46.9%	77.4%

2.4) Power Generation Technologies with Carbon Capture and Storage (CCS)

	Power Plant Energy Conversion Efficiency	Percentage of Efficiency of Auxilliary NG plant
94 Coal Boiler		
95 Integrated CCS design	25.9%	90.0%
96 Auxiliary (power-matched) NG turbine for CCS	29.4%	86.0%
97 NGCC		38.30%
98 Integrated CCS design	46.2%	90.0%
99 Auxiliary (power-matched) NG turbine for CCS	46.3%	89.6%

	Coal	NG
Theta	31.15	24.20
Epsi	5.28	7.29

3) Electric Transmission and Distribution Loss

101		4.9%
-----	--	------

Navigation tabs: Overview, Inputs, Results, Petroleum, Co_processing, NG, MeOH_FTD, EtOH, Electric, Generation_mixes, Bio...

R&D GREET 1

A1 Electricity Generation

Electricity Generation

(11) Emission Factors for EPA/EIA Database over Time (g/kWh)

Oil Boiler

	0.022	0.147	4.528	0.180	0.140	7.623			0.033	0.007
	0.022	0.147	4.528	0.180	0.140	7.623			0.033	0.007
	0.011	0.082	2.251	0.161	0.131	2.737			0.029	0.006
	0.011	0.082	2.251	0.161	0.131	2.737			0.029	0.006
5-year period	VOC	CO	NOx	PM10	PM2.5	SOx	BC	OC	CH4	N2O
1990	0.027	0.173	1.926	0.032	0.024	5.660			0.010	0.004
1995	0.026	0.173	1.866	0.031	0.023	5.660			0.010	0.004
2000	0.026	0.173	1.809	0.030	0.023	5.660			0.009	0.004
2005	0.026	0.200	1.716	0.028	0.021	5.660			0.009	0.004
2010	0.022	0.168	4.483	0.180	0.140	7.644			0.033	0.007
2015	0.020	0.158	4.226	0.169	0.132	3.604			0.031	0.006
2020	0.011	0.082	2.251	0.161	0.131	2.737			0.029	0.006
2025	0.011	0.082	2.251	0.161	0.131	2.737			0.029	0.006
2030	0.011	0.082	2.251	0.161	0.131	2.737			0.029	0.006
2035	0.011	0.082	2.251	0.161	0.131	2.737			0.029	0.006
2040	0.011	0.082	2.251	0.161	0.131	2.737			0.029	0.006
2045	0.011	0.082	2.251	0.161	0.131	2.737			0.029	0.006
2020	0.011	0.082	2.251	0.161	0.131	2.737			0.029	0.006

Fixed (original for Default values fro

Oil Internal Combustion Engine

	0.012	0.031		0.014	0.013				0.030	0.006
	0.012	0.031		0.014	0.013				0.030	0.006
	0.689	2.114	13.614	0.814	0.832	0.483			0.070	0.069
	0.689	2.114	13.614	0.814	0.832	0.483			0.070	0.069
5-year period	VOC	CO	NOx	PM10	PM2.5	SOx	BC	OC	CH4	N2O
1990	0.012	0.032	4.744	0.014	0.013	0.227			0.030	0.006

Fixed (original for Default values fro

Electric infrastructure tabs in R&D GREET 2

Primary

Wind_Turbine
Solar_PV
Hydropower
Nuclear_Power

Some Secondary

TEC_Results
MHDV_TEC_Results



GREAT PLAINS
INSTITUTE



R&D GREET 2

Clipboard Font Alignment Number Styles Cells Editing Sensitivity Add-ins Analyze Data

A1

A B C N O P Q R

1 *****
 2 **COPYRIGHT NOTIFICATION**
 3 **GREET® SOFTWARE**
 4 **GREET 2 Model**
 5 **Email contact: greet@anl.gov**
 6 *****

17 UChicago Argonne, LLC ALL RIGHTS RESERVED

DISCLOSES MATERIAL PROTECTED UNDER COPYRIGHT LAW, AND FURTHER DISSEMINATION IS PROHIBITED WITHOUT CONSENT OF THE PATENT COUNSEL OF ARGONNE NATIONAL LABORATORY, EXCEPT AS NOTED IN THE "LICENSING CONDITIONS" NOTED BELOW.

ARGONNE NATIONAL LABORATORY, WITH A FACILITY IN THE STATE OF ILLINOIS, IS OWNED BY THE UNITED STATES GOVERNMENT, AND UCHICAGO ARGONNE, LLC UNDER PROVISION OF A CONTRACT WITH THE DEPARTMENT OF ENERGY.

GOVERNMENT LICENSE

Model was produced by UChicago Argonne, LLC under Contract No. DE-AC02-06CH11357 with the Department of Energy. During the commercialization or such other time period specified by DOE, the Government is granted for itself and others acting on its behalf a paid-up, nonexclusive, irrevocable worldwide license in such copyrighted data to reproduce, prepare derivative works, and to use, sell, and display publicly, by or on behalf of the Government. Subsequent to that period the Government is granted for itself and others acting on its behalf a paid-up, nonexclusive, irrevocable worldwide license in such copyrighted data to reproduce, prepare derivative works, and to use, sell, and display publicly, by or on behalf of the Government.

t_Inputs | Car | SUV | PUT | Steel | C.Iron | W.AI | C.AI | Lead | Nickel | Cobalt | Copper | Zinc | M ... + : ◀ ▶

Display Settings 85%

Activate

Activate:

- Battery Recycling
- Vehi_Comp_Sum
- Vehi_Sum
- TEC_Reguls
- Electrolyzers
- Wind_Turbine
- Solar_PV
- Hydropower
- Nuclear_Power
- Traction
- GREET1_Import_Export
- GREET2_Factors_T&D
- GREET_Building_Import_Export
- MHDV_Inputs
- MHDV_Mat_Parameters
- Class 6 PnD Trucks
- Class 8 Day-cab Trucks
- Class 8 Sleeper-cab Trucks
- MHDV_Fluids
- MHDV_Trailer_Fluids

OK Cancel

Electric Generation Mix Scenarios



**GREAT PLAINS
INSTITUTE**



Argonne
NATIONAL LABORATORY



U.S. Department of
ENERGY

CIDI RD from BioOil

Model a Compression Ignition Direct Injection (CIDI)
Internal Combustion Engine Passenger Car Using
Renewable Diesel from Biooil



**GREAT PLAINS
INSTITUTE**

Argonne
NATIONAL LABORATORY

U.S. Department of
ENERGY

Well-to-Wheel (WTW) GHG Emissions



**GREAT PLAINS
INSTITUTE**



Argonne
NATIONAL LABORATORY



U.S. Department of

ENERGY

R&D GREET 1

RNAVRENDIESEL1CIDI

= "CIDI Vehicle: "&IF(Inputs!E690=1,IF(Inputs!\$G\$650=2,"Palm FFB",IF(Inputs!\$G\$650=3,"Canola",IF(Inputs!\$G\$650=4,"Jatropha",IF(Inputs!\$G\$650=5,"Camelina",IF(Inputs!\$G\$650=6,"Algae",IF(Inputs!\$G\$650=7,"Tallow",IF(Inputs!\$G\$650=8,"Corn Oil","Soybean"))))))),IF(Inputs!E690=3,IF(Inputs!\$I\$650=2,"Palm FFB",IF(Inputs!

- 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
- CIDI - RD from Bio Oil
 - 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)
 - Select Fuels
 - Go
- CIDI Plug-in Hybrids (PHEV)
 - Select Fuels
 - Go
- GCI ICE Vehicles
 - Select Fuels
 - Go

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

CIDI Vehicle: Soybean-based RDII 100

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	171	1,678	2,552	5,402	46	148	948	1,144
Fossil Fuels	161	767						
Coal	14	74						
Natural Gas	68	653						
Petroleum	79	41						
Water Consumption	2.2	0.0						
CO2 (w/ C in VOC & CO)	-260	83						
CH4	0.021	0.138						
N2O	0.082	0.001	0.001	0.084	0.022	0.000	0.000	0.022
GHGs	-237	88	275	125	-63	23	73	33
VOC: Total	0.008	0.067	0.143	0.219	0.002	0.018	0.038	0.058
CO: Total	0.036	0.030	3.531	3.597	0.010	0.008	0.942	0.960
NOx: Total	0.035	0.051	0.097	0.183	0.009	0.014	0.026	0.049
PM10: Total	0.003	0.003	0.034	0.040	0.001	0.001	0.009	0.011
PM2.5: Total	0.003	0.002	0.007	0.012	0.001	0.001	0.002	0.003

WTW GHG emissions
125 g CO₂e/mile or 33 g CO₂e/MJ

CIDI vehicle fueled by renewable diesel from biooil

Press F9

- Overview
- Inputs
- Results
- Petroleum
- Co_processing
- NG
- MeOH_FTD
- EtOH
- Electric
- Generation_mixes
- Bio

50% Coal/50% NG Electricity

Model a Compression Ignition Direct Injection (CIDI)
Internal Combustion Engine Passenger Car Using
Renewable Diesel from Biooil Produced with a 50%
Coal/50% Natural Gas Electricity Generation Mix



GREAT PLAINS
INSTITUTE

Argonne
NATIONAL LABORATORY

U.S. Department of
ENERGY

Default Electricity Generation Mix



**GREAT PLAINS
INSTITUTE**



Argonne
NATIONAL LABORATORY



U.S. Department of
ENERGY

L749

10. Electric Generation

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

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

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

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)

(U.S. EPA)

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

Transportation compared to 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)



GREAT PLAINS
INSTITUTE

Argonne
NATIONAL LABORATORY

U.S. Department of
ENERGY

10. Electric Generation

Electric Worksheet
Results
Back to Top

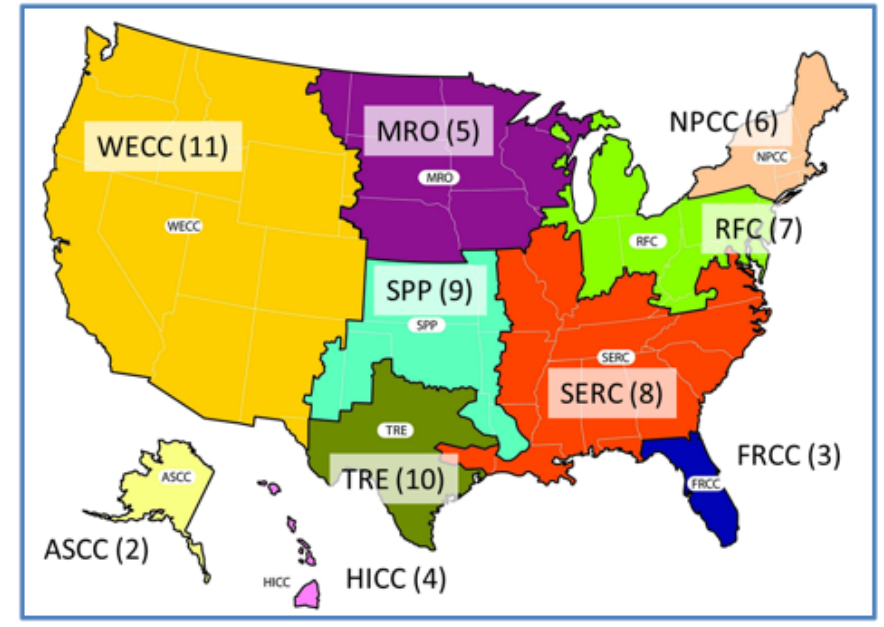
10.1) GREET-Calculated or User-Inputted Emission Factors for Power Plants

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

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: 13



Dropdown menu showing options 1 through 13. Option 13 is selected and highlighted. A large green arrow points down from the top of the dropdown to the selected option.

- 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	
	Transportation	Stationary	Transportation	Stationary
Residual oil	0.3%	0.3%	13.7%	13.7%
Natural gas	38.5%	38.5%	46.7%	46.7%

File Home Insert Draw Page Layout Formulas Data Review View Automate Help

R&D GREET 1

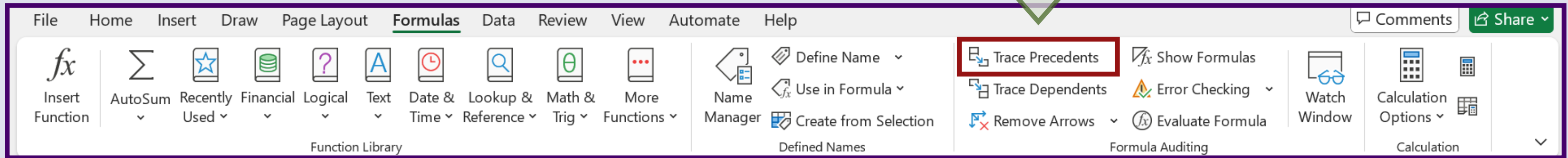
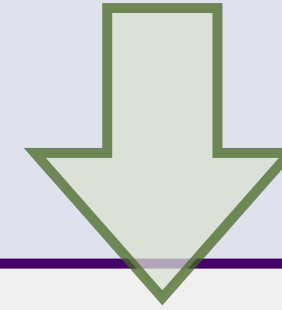
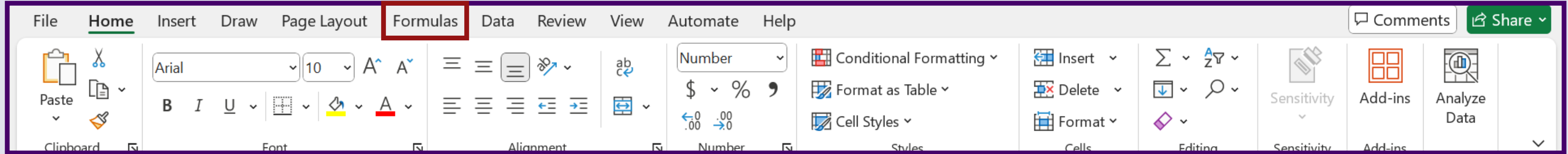
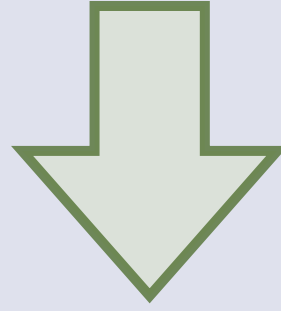
Clipboard Font Alignment Number Styles Cells Editing Sensitivity Add-ins Analyze Data

AI774

	SPP Mix		TRE Mix		WECC Mix		CA Mix		User Defined	
	Transportation	Stationary	Transportation	Stationary	Transportation	Stationary	Transportation	Stationary	Transportation	Stationary
765										
766										
767	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.0%	0.0%	0.3%	0.3%
768	23.8%	23.8%	44.5%	44.5%	30.7%	30.7%	42.8%	42.8%	38.5%	38.5%
769	26.2%	26.2%	13.9%	13.9%	15.9%	15.9%	3.4%	3.4%	20.6%	20.6%
770	5.7%	5.7%	10.1%	10.1%	7.9%	7.9%	8.3%	8.3%	18.9%	18.9%
771	0.0%	0.0%	0.0%	0.0%	0.4%	0.4%	0.9%	0.9%	0.3%	0.3%
772	44.2%	44.2%	31.4%	31.4%	45.0%	45.0%	44.7%	44.7%	21.5%	21.5%
773										
774										
775										
776										
777										
778										
779										
780										
781										
782										
783										
784	12.4%	12.4%	0.6%	0.6%	51.0%	51.0%	28.0%	28.0%	31.4%	31.4%
785	0.0%	0.0%	0.0%	0.0%	4.6%	4.6%	8.5%	8.5%	1.8%	1.8%
786	86.7%	86.7%	84.1%	84.1%	24.6%	24.6%	16.6%	16.6%	49.8%	49.8%
787	0.7%	0.7%	15.1%	15.1%	19.2%	19.2%	45.4%	45.4%	15.3%	15.3%
788	0.1%	0.1%	0.1%	0.1%	0.6%	0.6%	1.6%	1.6%	1.7%	1.7%
789										
790										
791										
792										
793										
794										
795										

Overview Inputs Results Petroleum Co_processing NG MeOH_FTD EtOH Electric Generation mixes Bio





**GREAT PLAINS
INSTITUTE**

Argonne
NATIONAL LABORATORY

U.S. Department of
ENERGY

R&D GREET 1

Function Library: Logical, Text, Date & Time, More Functions, Lookup & Reference, Math & Trig, Python, Diagnostics, Initialization, Python, Name Manager, Define Name, Use in Formula, Create from Selection, Trace Precedents, Trace Dependents, Remove Arrows, Formula Auditing, Watch Window, Calculation Options, Calculation

UD_Mix_Stationary_Use_Others =1-SUM(CN941:CR941)

	CB	CC	CD	CE	CF	CG	CH	CI	CJ	CK	CL	CM	CN	CO	CP	CQ	CR	CS
933	0.1%	58.8%		2030	0.1%	28.1%	0.0%	22.9%	1.2%	47.8%		2030	0.1%	28.1%	0.0%	22.9%	1.2%	47.8%
934	0.1%	66.1%		2035	0.0%	23.4%	0.0%	21.8%	1.1%	53.7%		2035	0.0%	23.4%	0.0%	21.8%	1.1%	53.7%
935	0.1%	68.1%		2040	0.0%	21.3%	0.0%	21.3%	1.1%	56.3%		2040	0.0%	21.3%	0.0%	21.3%	1.1%	56.3%
936	0.1%	69.2%		2045	0.0%	21.0%	0.0%	20.2%	1.0%	57.7%		2045	0.0%	21.0%	0.0%	20.2%	1.0%	57.7%
937	0.2%	72.2%		2050	0.0%	20.3%	0.0%	18.9%	1.0%	59.9%		2050	0.0%	20.3%	0.0%	18.9%	1.0%	59.9%
938																		
939																		
940																		
941	0.9%	44.7%			0.3%	38.5%	20.6%	18.9%	0.3%	21.5%			0.0%	50.0%	50.0%	0.0%	0.0%	0.0%
942	0.9%	44.7%			0.3%	38.5%	20.6%	18.9%	0.3%	21.5%			0.3%	38.5%	20.6%	18.9%	0.3%	21.5%
943																		
944	Biomass	Others		5-year period	Residual Oil	Natural Gas	Coal	Nuclear	Biomass	Others		5-year period	Natural Gas	Coal	Nuclear	Biomass	Others	
945	1.6%	25.7%		1990	4.2%	12.3%	52.5%	19.0%	1.1%	10.9%		1990	2.3%	52.5%	19.0%	1.1%	10.9%	
946	1.6%	34.8%		1995	2.2%	14.8%	51.0%	20.1%	1.2%	10.7%		1995	2.8%	51.0%	20.1%	1.2%	10.7%	
947	1.6%	24.5%		2000	2.9%	15.8%	51.7%	19.8%	1.1%	8.7%		2000	2.8%	51.7%	19.8%	1.1%	8.7%	
948	1.6%	25.0%		2005	2.9%	15.7%	51.7%	20.3%	1.2%	8.2%		2005	2.7%	51.7%	20.3%	1.2%	8.2%	
949	1.3%	26.3%		2010	0.9%	22.7%	46.0%	20.3%	0.3%	9.8%		2010	2.7%	46.0%	20.3%	0.3%	9.8%	
950	1.5%	27.7%		2013	0.6%	26.2%	40.3%	20.2%	0.3%	12.3%		2013	2.6%	40.3%	20.2%	0.3%	12.3%	
951	1.6%	26.2%		2014	0.7%	26.2%	39.8%	20.2%	0.4%	12.6%		2014	0.7%	26.2%	39.8%	20.2%	0.4%	12.6%
952	1.5%	27.0%		2015	0.7%	31.6%	34.2%	20.3%	0.4%	12.8%		2015	0.7%	31.6%	34.2%	20.3%	0.4%	12.8%
953	1.2%	38.3%		2016	0.6%	32.7%	31.4%	20.5%	0.3%	14.5%		2016	0.6%	32.7%	31.4%	20.5%	0.3%	14.5%
954	1.1%	46.1%		2017	0.5%	30.6%	31.0%	20.9%	0.4%	16.6%		2017	0.5%	30.6%	31.0%	20.9%	0.4%	16.6%
955	1.1%	46.0%		2018	0.4%	33.4%	29.0%	20.3%	0.3%	16.5%		2018	0.4%	33.4%	29.0%	20.3%	0.3%	16.5%
956	1.2%	46.0%		2019	0.4%	36.7%	24.6%	20.4%	0.3%	17.5%		2019	0.4%	36.7%	24.6%	20.4%	0.3%	17.5%
957	1.1%	44.0%		2020	0.4%	39.6%	20.0%	20.4%	0.3%	19.4%		2020	0.4%	39.6%	20.0%	20.4%	0.3%	19.4%
958	1.1%	44.0%		2021	0.3%	36.5%	23.8%	19.6%	0.3%	19.5%		2021	0.3%	36.5%	23.8%	19.6%	0.3%	19.5%
959	1.1%	44.0%		2022	0.3%	38.5%	20.6%	18.9%	0.3%	21.5%		2022	0.3%	38.5%	20.6%	18.9%	0.3%	21.5%
960	1.1%	44.0%		2025	0.2%	32.1%	18.7%	19.1%	0.3%	29.6%		2025	0.2%	32.1%	18.7%	19.1%	0.3%	29.6%
961	1.0%	40.7%		2030	0.2%	24.7%	8.3%	17.9%	0.2%	48.8%		2030	0.2%	24.7%	8.3%	17.9%	0.2%	48.8%
962	1.0%	40.7%		2035	0.2%	20.6%	7.0%	15.0%	0.2%	55.2%		2035	0.2%	20.6%	7.0%	15.0%	0.2%	55.2%

Fill out cells as shown

Press F9

Well-to-Wheel (WTW) GHG Emissions



**GREAT PLAINS
INSTITUTE**

Argonne
NATIONAL LABORATORY

U.S. Department of
ENERGY

R&D GREET 1

RNAVRENDIESEL1CIDI

```
= "CIDI Vehicle: "&IF(Inputs!E690=1,IF(Inputs!$G$650=2,"Palm FFB",IF(Inputs!$G$650=3,"Canola",IF(Inputs!$G$650=4,"Jatropha",IF(Inputs!$G$650=5,"Camelina",IF(Inputs!$G$650=6,"Algae",IF(Inputs!$G$650=7,"Tallow",IF(Inputs!$G$650=8,"Corn Oil","Soybean"))))))),IF(Inputs!E690=3,IF(Inputs!$I$650=2,"Palm FFB",IF(Inputs!
```

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]
- CIDI - RD from Bio Oil: 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: MJ

CIDI Vehicle: Soybean-based RDII 100

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	189							
Fossil Fuels	189							
Coal	35							
Natural Gas	74							
Petroleum	79							
Water Consumption	2.2							
CO2 (w/ C in VOC & CO)	-258							
CH4	0.026	0.146	0.092	0.265	0.007	0.059	0.024	0.071
N2O	0.082	0.001	0.001	0.084	0.022	0.000	0.000	0.022
GHGs	-235	94	275	134	-63	25	73	36
VOC: Total	0.009	0.067	0.143	0.219	0.002	0.018	0.038	0.059
CO: Total	0.037	0.032	3.531	3.600	0.010	0.009	0.942	0.960
NOx: Total	0.037	0.055	0.097	0.189	0.010	0.015	0.026	0.050
PM10: Total	0.004	0.004	0.034	0.041	0.001	0.001	0.009	0.011
PM2.5: Total	0.003	0.003	0.007	0.012	0.001	0.001	0.002	0.003

WTW GHG emissions
134 g CO₂e/mile or 36 g CO₂e/MJ

CIDI vehicle fueled by renewable diesel from biooil with 50% coal/50% NG electricity generation mix

- Results
- Petroleum
- Co_processing
- NG
- MeOH_FTD
- EtOH
- Electric
- Generation_mixes
- Bio_electricity
- Hydroger

Default electricity generation mix

50% coal/50% NG electricity generation mix

Excel interface showing the default electricity generation mix. The formula bar contains a complex IF statement for vehicle selection. The spreadsheet includes sections for vehicle selection, unit selection, and a table of WTW GHG emissions.

WTW GHG emissions: 33 g CO₂e/MJ

Emissions or g/mile			Btu/MJ or Gallon/MJ			
Fuel	Vehicle Operation	Total	Feedstock	Fuel	...	...
1,678	3,553	5,402	46	448	...	...
767	0	929	43	205	...	...
74	0	88	4	20	...	...
653	0	720	18	174	...	...
41	0	120	21	11	...	...
0.0	0	2	1	0	...	...
83	272	95	-69	22	...	...
0.138	0.092	0.251	0.006	0.037	0.024	0.067
0.001	0.001	0.084	0.022	0.000	0.000	0.022
88	275	125	-63	23	73	33
0.067	0.143	0.219	0.002	0.018	0.038	0.058
0.030	3.531	3.597	0.010	0.008	0.942	0.960
0.051	0.097	0.183	0.009	0.014	0.026	0.049
0.003	0.034	0.040	0.001	0.001	0.009	0.011
0.002	0.007	0.012	0.001	0.001	0.002	0.003

Excel interface showing the 50% coal/50% NG electricity generation mix. The formula bar contains a complex IF statement for vehicle selection. The spreadsheet includes sections for vehicle selection, unit selection, and a table of WTW GHG emissions.

WTW GHG emissions: 36 g CO₂e/MJ

Emissions or g/mile			Btu/MJ or Gallon/MJ			
Fuel	Vehicle Operation	Total	Feedstock	Fuel	...	...
1,719	3,553	5,460	50	459	...	...
832	0	1,020	50	222	...	...
123	0	158	9	33	...	...
668	0	742	20	178	...	...
41	0	120	21	11	...	...
0.0	0	2	1	0	...	...
89	272	103	-69	24	...	...
0.148	0.092	0.265	0.007	0.039	0.024	0.071
0.001	0.001	0.084	0.022	0.000	0.000	0.022
94	275	134	-63	25	73	36
0.067	0.143	0.219	0.002	0.018	0.038	0.059
0.032	3.531	3.600	0.010	0.009	0.942	0.960
0.055	0.097	0.189	0.010	0.015	0.026	0.050
0.004	0.034	0.041	0.001	0.001	0.009	0.011
0.003	0.007	0.012	0.001	0.001	0.002	0.003

FCV in Florida

Model a Fuel Cell Electric Vehicle (FCV) Using
Gaseous Hydrogen Produced with a Florida-specific
Electricity Grid (EIA Form-923) Electricity Generation
Mix



**GREAT PLAINS
INSTITUTE**

Argonne
NATIONAL LABORATORY

U.S. Department of
ENERGY

10. Electric Generation

Electric Worksheet
Results
Back to Top

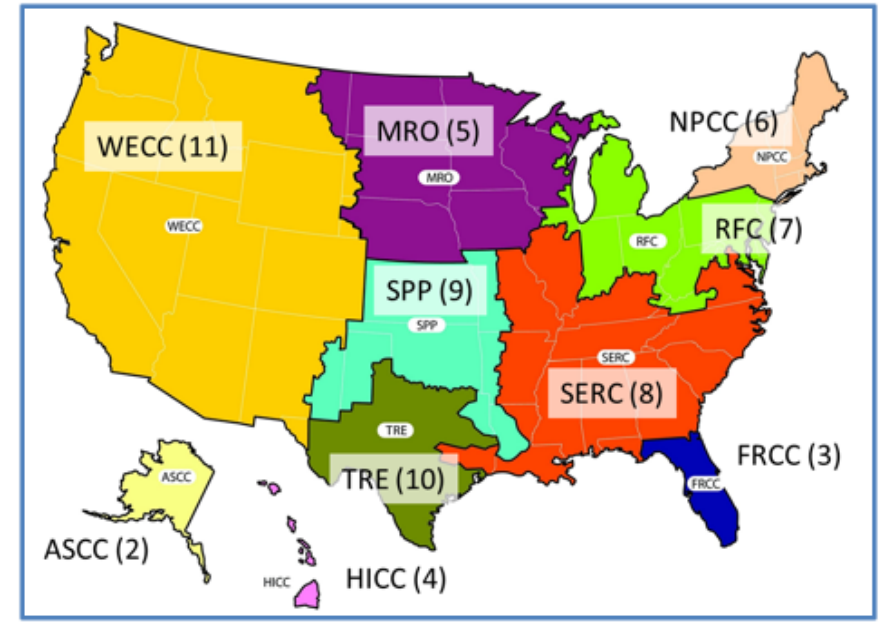
10.1) GREET-Calculated or User-Inputted Emission Factors for Power Plants

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

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: 13



Dropdown menu showing options 1 through 19. Option 13 is selected. A green arrow points to the dropdown, and another green arrow points to the selected value 13. A purple circle with the number 1 is next to the dropdown, and a purple circle with the number 2 is next to the value 13.

- 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	
	Transportation	Stationary	Transportation	Stationary
Residual oil	0.3%	0.3%	13.7%	13.7%
Natural gas	38.5%	38.5%	46.7%	46.7%

R&D GREET 1

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

Excel formula bar: T13, fx

Spreadsheet content:

- Row 1: *****
- Row 2: **COPYRIGHT NOTIFICATION**
- Row 3: **GREET® SOFTWARE**
- Row 4: **GREET 1 Model**
- Row 5: **Email contact: greet@anl.gov**
- Row 6: *****
- Row 7: LLC ALL RIGHTS RESERVED
- Row 8: ALL PROTECTED UNDER COPYRIGHT LAW, AND FURTHER DISSEMINATION IS WITHOUT THE CONSENT OF THE PATENT COUNSEL OF ARGONNE NATIONAL LABORATORY, UNDER THE "STANDARD TERMS AND CONDITIONS" NOTED BELOW.
- Row 9: *****
- Row 10: CHICAGO ARGONNE, LLC WITH A FACILITY IN THE STATE OF ILLINOIS, IS OWNED BY THE UNITED STATES DEPARTMENT OF ENERGY. CHICAGO ARGONNE, LLC UNDER PROVISION OF A CONTRACT WITH THE U.S. DEPARTMENT OF ENERGY.
- Row 11: *****
- Row 12: **GOVERNMENT LICENSE**
- Row 13: *****
- Row 14: Chicago Argonne, LLC under Contract No. DE-AC02-06CH11357 with the Department of Energy, is hereby authorized to make available for public use, for the time period specified by DOE, the Government is granted a nonexclusive, irrevocable worldwide license in such copyrighted data to reproduce, distribute copies to the public, to perform publicly and display publicly, by or on behalf of the Government, and to permit others to do so. The specific terms and conditions of this license are set forth in the license agreement available by inquiry made to UChicago Argonne, LLC or DOE.
- Row 15: *****

Navigation buttons: Inputs (yellow), Results (green)

Category buttons: Petroleum, Ethanol, Natural Gas, MeOH & FTD, RNG, Algae, Electric, Hydrogen, BioOil, Pyrolysis & IDL, Integrated Biorefinery, Plastic Fuel

Time Series buttons: 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

Other buttons: Fuel Specifications, Vehicles, Ag Inputs

Activate dialog box:

- Activate: Overview, 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
- Number 1 points to the list.
- Number 2 points to the OK button.
- Buttons: OK, Cancel

Excel status bar: Petroleum, Co_processing, NG, MeOH_FTD, EtOH, Electric, Generation_mixes, Bio, +, : < >

R&D GREET 1

Microsoft Excel ribbon with tabs: Clipboard, Font, Alignment, Number, Styles, Cells, Editing, Sensitivity, Add-ins, Analyze Data.

A1 Electricity Generation Mixes

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Electricity Generation Mixes												
2													
3	1. By NEEDS Regions, 2022 (EIA Form-923)												
4		per mmBtu	US Total	California	Delta	Florida	Mid-Atlantic	Midwest	Mountain	New England	New York	Northwest	Pa
5		Energy use: Btu											
6		Total energy	2,060,518	1,790,812	2,282,357	2,249,174	2,075,302	2,284,553	2,325,461	1,949,162	1,806,458	1,401,341	2,014,300
7		Fossil fuels	1,610,444	1,194,424	1,994,180	2,021,344	1,655,792	1,887,454	2,012,169	1,367,755	1,290,251	526,558	1,509,200
8		Coal	600,314	83,286	317,486	190,128	653,818	1,360,901	1,329,637	11,952	1,663	55,345	969,500
9		Natural gas	980,638	1,105,075	1,618,657	1,809,061	978,899	491,036	652,035	1,291,401	1,238,476	468,038	524,200
10		Petroleum	29,493	6,063	58,038	22,155	23,076	35,517	30,497	64,402	50,112	3,176	15,500
11		Water consumption, gallons	158.949	177.624	94.922	71.962	106.862	105.417	140.995	153.319	338.750	867.026	120.700
12		Total emissions: grams											
13		VOC	14.915	11.463	19.047	19.218	15.226	16.759	17.885	13.569	12.516	5.099	13.400
14		CO	54.948	43.598	70.775	68.027	54.694	62.531	63.923	56.063	43.886	21.405	48.900
15		NOx	96.042	57.135	113.810	98.680	96.738	131.794	133.281	82.938	70.139	27.034	97.400
16		PM10	13.304	5.043	11.509	9.062	13.913	24.031	23.753	6.114	4.926	2.600	17.300
17		PM2.5	7.743	4.170	8.359	7.143	7.891	11.661	11.676	5.699	4.682	2.039	8.500
18		SOx	75.882	21.172	60.739	42.869	79.855	146.974	144.747	28.064	24.020	10.942	104.500
19		BC	0.441	0.299	0.572	0.475	0.428	0.552	0.540	0.488	0.357	0.155	0.400
20		OC	2.225	2.138	3.375	3.469	2.198	1.744	1.954	2.744	2.425	0.959	1.500
21		CH4	256.210	190.644	314.945	321.327	263.886	301.516	321.459	214.410	202.205	84.250	241.600
22		N2O	2.491	1.461	2.571	2.254	2.537	3.797	3.736	1.813	1.263	0.778	2.800
23		CO2	120,870	76,051	132,903	128,440	125,452	168,117	174,709	83,463	78,098	33,648	129,500
24		Urban emissions: grams											
25		VOC	1.016	0.769	1.328	1.309	1.031	1.128	1.203	0.967	0.894	0.339	0.800
26		CO	11.061	5.656	10.565	9.812	11.636	17.725	17.998	5.775	5.285	2.658	13.300
27		NOx	22.806	9.282	19.190	16.690	24.222	40.662	40.771	8.808	8.057	4.502	30.000
28		PM10	2.603	1.175	2.321	2.084	2.755	4.436	4.474	1.155	1.066	0.559	3.300
29		PM2.5	2.188	1.096	2.074	1.919	2.305	3.534	3.590	1.115	1.035	0.512	2.600

Navigation tabs: Inputs, Results, Petroleum, Co_processing, NG, MeOH_FTD, EtOH, Electric, Generation_mixes, Bio_electricity

R&D GREET 1

A1 Electricity Generation Mixes

3. By U.S. States, 2022 (EIA Form-923)		US Total	AK	AL	AR	AZ	CA	CO	CT	DC	DE	FL	GA	HI	IA	ID	IL	IN
Energy use: Btu																		
Total energy	per mmbtu	2,060,518	2,279,749	2,103,830	2,285,724	1,922,270	1,777,771	2,196,385	1,873,307	1,744,596	2,435,910	2,254,026	2,162,107	3,117,017	1,706,104	1,509,421	1,658,398	2,615,411
Fossil fuels		1,610,444	1,979,990	1,608,795	1,928,058	1,450,622	1,179,288	1,811,700	1,417,901	1,219,571	2,405,278	2,024,345	1,586,449	2,854,974	1,022,648	651,974	949,716	2,481,901
Coal		600,314	334,709	547,604	942,886	393,003	4,811	1,141,197	2,031	843	62,178	184,505	405,891	227,793	759,147	1,639	668,899	1,597,901
Natural gas		980,638	1,205,980	1,048,390	965,194	1,049,158	1,169,610	651,022	1,389,022	1,217,846	2,271,381	1,817,691	1,154,654	181,506	247,374	647,659	268,400	855,251
Petroleum		29,493	439,301	12,801	19,978	8,461	4,867	19,481	26,848	881	71,719	22,149	25,904	2,445,675	16,128	2,676	12,417	28,751
Water consumption, gallons		158,949	410,762	187,300	169,070	156,377	185,451	98,769	96,464	33,651	59,526	71,546	117,110	154,507	58,904	718,878	110,077	96,731
Total emissions: grams																		
VOC		14,915	20,136	15,042	17,586	13,464	11,405	16,146	13,642	11,621	23,114	19,263	15,261	36,070	9,003	6,468	8,403	22,061
CO		54,948	72,588	59,700	65,943	47,154	43,488	57,893	47,263	39,299	78,902	68,495	67,539	145,208	32,340	29,650	30,141	78,501
NOx		96,042	227,079	91,937	117,341	75,446	53,968	116,140	68,226	51,539	124,780	98,829	95,035	873,681	70,368	32,743	63,368	160,331
PM10		13,304	18,921	12,581	18,560	9,594	3,980	20,532	4,833	3,659	9,384	9,019	11,414	60,048	13,157	2,511	11,701	28,561
PM2.5		7,743	14,736	7,506	9,938	5,950	3,809	10,173	4,629	3,553	8,469	7,149	7,540	51,960	6,275	2,404	5,628	14,061
SOx		75,882	138,524	67,587	107,446	51,851	13,854	123,791	20,772	13,476	45,857	42,386	57,043	538,748	81,021	7,254	71,441	173,071
BC		0,441	1,209	0,455	0,522	0,334	0,292	0,472	0,338	0,241	0,606	0,479	0,542	5,042	0,281	0,214	0,257	0,641
OC		2,225	3,912	2,351	2,361	2,123	2,215	1,825	2,606	2,189	4,365	3,488	2,662	9,271	0,886	1,327	0,863	2,441
CH4		256,210	284,519	257,516	308,402	231,589	188,178	289,932	224,230	194,382	378,418	321,827	253,442	278,388	163,503	104,546	151,982	397,031
N2O		2,491	2,412	2,662	3,333	1,929	1,350	3,303	1,367	1,113	2,302	2,267	2,840	3,768	2,015	1,017	1,843	4,531
CO2		120,870	142,860	118,072	153,227	102,337	71,961	154,327	85,083	72,573	147,425	128,390	111,337	244,218	91,893	39,029	83,794	212,871
Urban emissions: grams																		
VOC		1,016	1,813	1,001	1,175	0,905	0,766	1,078	0,946	0,783	1,631	1,312	1,022	5,014	0,604	0,426	0,562	1,471
CO		11,061	9,478	10,789	14,926	8,909	5,030	15,827	5,882	5,105	10,312	9,789	9,742	6,737	9,751	2,852	8,798	21,911
NOx		22,806	18,865	21,738	32,087	17,418	7,527	35,537	8,895	7,662	16,293	16,593	18,633	19,146	22,488	4,181	20,116	49,401
PM10		2,603	2,223	2,500	3,595	2,037	0,997	3,913	1,180	1,020	2,117	2,075	2,185	2,109	2,449	0,554	2,198	5,431
PM2.5		2,188	1,950	2,118	2,957	1,758	0,968	3,153	1,147	0,993	2,024	1,914	1,892	1,798	1,947	0,538	1,755	4,361
SOx		22,181	13,768	20,251	34,545	14,649	0,637	41,602	0,681	0,505	3,324	7,438	15,195	14,931	27,612	0,313	24,340	58,231
BC		0,102	0,106	0,099	0,135	0,083	0,050	0,141	0,060	0,051	0,105	0,096	0,091	0,156	0,086	0,028	0,078	0,191
OC		0,626	0,713	0,652	0,683	0,621	0,612	0,556	0,726	0,635	1,199	0,984	0,683	0,258	0,273	0,340	0,266	0,741
Grid mixes																		
Oil		1%	13%	0%	0%	0%	0%	0%	1%	0%	2%	1%	0%	71%	0%	0%	0%	0%
Natural Gas		40%	48%	43%	40%	43%	48%	27%	57%	50%	93%	75%	47%	0%	10%	27%	11%	35%
Coal		20%	11%	18%	31%	13%	0%	37%	0%	0%	2%	6%	13%	7%	25%	0%	22%	52%
Biomass		1%	0%	2%	1%	0%	1%	0%	0%	0%	0%	1%	4%	1%	0%	2%	0%	0%
Nuclear		18%	0%	29%	22%	31%	9%	0%	38%	0%	0%	12%	27%	0%	0%	0%	53%	0%
Hydroelectric		6%	26%	7%	5%	5%	9%	2%	1%	0%	0%	0%	2%	1%	1%	51%	0%	0%
Geothermal		0%	0%	0%	0%	0%	5%	0%	0%	0%	0%	0%	0%	2%	0%	1%	0%	0%
Wind		10%	2%	0%	0%	1%	7%	29%	0%	0%	0%	0%	0%	7%	63%	15%	13%	10%
Solar PV		3%	0%	1%	1%	7%	19%	4%	1%	14%	1%	4%	5%	6%	1%	3%	1%	1%
Others		1%	1%	0%	0%	0%	1%	0%	2%	36%	1%	2%	0%	5%	0%	1%	0%	1%

Inputs Results Petroleum Co_processing NG MeOH_FTD EtOH Electric Generation_mixes Bio_electricity

R&D GREET 1

Function Library: Logical, Text, Date & Time, More Functions, Lookup & Reference, Math & Trig, Python, Diagnostics, Initialization, Name Manager, Defined Names, Trace Precedents, Trace Dependents, Remove Arrows, Watch Window, Calculation Options

CR940

Grid mixes				User Defined Mix: Stationary Use												
	Oil	Natural Gas	Coal	Biomass	Nuclear	Hydroelectric	Geothermal	Wind	Solar PV	Others	Residual Oil	Natural Gas	Coal	Nuclear	Biomass	Others
1990	1%	75%	6%	1%	12%	0%	0%	0%	4%	2%	4.2%	12.3%	52.5%	19.0%	1.1%	10.9%
2000	1%	75%	6%	1%	12%	0%	0%	0%	4%	2%	4.2%	12.3%	51.0%	19.0%	1.2%	10.7%
2010	1%	75%	6%	1%	12%	0%	0%	0%	4%	2%	4.2%	12.3%	51.7%	19.8%	1.1%	8.7%
2020	1%	75%	6%	1%	12%	0%	0%	0%	4%	2%	4.2%	12.3%	51.7%	20.3%	1.2%	8.2%
2030	1%	75%	6%	1%	12%	0%	0%	0%	4%	2%	4.2%	12.3%	46.0%	20.3%	0.3%	9.8%
2040	1%	75%	6%	1%	12%	0%	0%	0%	4%	2%	4.2%	12.3%	40.3%	20.2%	0.3%	12.3%
2050	1%	75%	6%	1%	12%	0%	0%	0%	4%	2%	4.2%	12.3%	39.8%	20.2%	0.4%	12.6%

Fill out cells as shown

Press F9

File Home Insert Draw Page Layout Formulas Data Review View Automate Help

R&D GREET 1

Paste B I U Font Alignment Number Styles Cells Editing Sensitivity Add-ins Analyze Data

SUM fx **=CL999/CS941**

	CF		CJ	CK	CL	CM	CN	CO	CP	CQ	CR	CS
993	22.1%	Oil	26.9%			2050	22.1%	0.0%	30.8%	20.2%	26.9%	
994		Natural Gas										
995		Coal										
996		Biomass										
997	31.4%	Nuclear	1.7%				=CL999/CS941	1.8%	49.8%	15.3%		
998	31.4%	Hydroelectric	1.7%				31.4%	1.8%	49.8%	15.3%	1.7%	
999		Geothermal										
1000	88.7%	Wind										
1001	88.7%	Solar PV										
1002	88.7%	Others										
1003	84.2%											
1004	67.2%											
1005	56.5%											
1006	53.4%											
1007	50.4%											
1008	47.6%											
1009	47.0%											
1010												
1011												
1012												
1013	33.5%											
1014	31.4%											

User Defined Mix: Stationary Use

5-year period	Hydroelectric	Geothermal	Wind	Solar PV	Others
1990	38.7%	4.6%	1.8%	0.0%	4.8%
1995	38.7%	4.6%	1.8%	0.0%	4.8%
2000	38.7%	4.6%	1.8%	0.0%	4.8%
2005	84.2%	4.6%	1.8%	0.0%	5.6%
2010	67.2%	4.6%	1.8%	0.0%	3.4%
2013	56.5%	4.6%	1.8%	0.0%	3.5%
2014	53.4%	4.6%	1.8%	0.0%	3.6%
2015	50.4%	4.6%	1.8%	0.0%	3.3%
2016	47.6%	4.6%	1.8%	0.0%	2.8%
2017	47.0%	4.6%	1.8%	0.0%	3.0%
2018	43.0%	4.6%	1.8%	0.0%	2.7%
2019	41.7%	4.6%	1.8%	0.0%	2.5%
2020	38.1%	4.6%	1.8%	0.0%	2.3%
2021	33.5%	4.6%	1.8%	0.0%	1.7%
2022	31.4%	4.6%	1.8%	0.0%	1.7%

Press F9

Using CS941 as the total for renewable sources, calculate % for each renewable source

File Home Insert Draw Page Layout Formulas Data Review View Automate Help

R&D GREET 1

Clipboard Font Alignment Number Styles Cells Editing Sensitivity Add-ins Analyze Data

UD_Mix_Stationary_Use_Solar_PV =CL1002/CS941

Grid mixes	
Oil	1%
Natural Gas	75%
Coal	6%
Biomass	1%
Nuclear	12%
Hydroelectric	0%
Geothermal	0%
Wind	0%
Solar PV	4%
Others	2%

	CI	CJ	CK	CL	CM	CN	CO	CP	CQ	CR
2045	14.4%	29.6%			2045	25.0%	0.0%	31.0%	14.4%	29.6%
2050	20.2%	26.9%			2050	22.1%	0.0%	30.8%	20.2%	26.9%
User Defined Mix: Stationary Use										
	15.3%	1.7%			1.5%	0.0%	0.0%	71.3%		27.3%
	15.3%	1.7%			31.4%	1.8%	49.8%	15.3%		1.7%
5-year period	Solar PV	Others	Hydro	0.00089	5-year period	Hydroelectric	Geothermal	Wind	Solar PV	Others
1990	0.0%	4.8%	Geo	0	1990	88.7%	4.6%	1.8%	0.0%	4.8%
1995	0.0%	4.8%	Wind	0	1995	88.7%	4.6%	1.8%	0.0%	4.8%
2000	0.0%	4.8%	Solar PV	0.04381	2000	88.7%	4.6%	1.8%	0.0%	4.8%
2005	0.0%	5.6%	Other	0.01675	2005	84.2%	4.6%	5.6%	0.0%	5.6%
2010	0.3%	4.1%			2010	67.2%	3.9%	24.4%	0.3%	4.1%
2013	1.9%	3.4%			2013	56.5%	3.4%	34.8%	1.9%	3.4%
2014	3.5%	3.5%			2014				3.5%	3.5%
2015	4.9%	3.6%			2015				4.9%	3.6%
2016	6.3%	3.3%			2016				6.3%	3.3%
2017	8.2%	2.8%			2017				8.2%	2.8%
2018	10.1%	3.0%			2018				10.1%	3.0%
2019	10.5%	2.7%			2019	41.7%	2.4%	42.7%	10.5%	2.7%
2020	11.4%	2.5%			2020	38.1%	2.1%	45.9%	11.4%	2.5%
2021	13.7%	2.3%			2021	33.5%	2.0%	48.5%	13.7%	2.3%

Press F9

Fill out cells as shown

Conversion Factor for Light Water Reactor (LWR) Nuclear Power Plants



**GREAT PLAINS
INSTITUTE**



Argonne
NATIONAL LABORATORY



U.S. Department of

ENERGY

R&D GREET 1

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

Formula bar: A1 Electricity Generation

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Electricity Generation												
2													
3	1) Scenario Control and Key Input Parameters (from the Inputs sheet)												
4		2	Control variable for selecting power plant emission factors 1 -- GREET-calculated emissions factors via emission factors in EF Sheet 2 -- Emission factors based on EIA/eGRID database										
8		G.H2	L.H2										
9	Selecting nuclear reactor technologies for electrolysis at refueling stations	1	1	1 -- Light Water Reactor (LWR); 2-- High Temperature Gas Reactor (HTGR)									
11		LWR	HTGR										
12	Conversion factor for nuclear power plants (MWh/g of U-235)	6.59	8.70										
14	Energy Use of Power Plant Infrastructure	To consider energy and emissions for infrastructure of power plants?											
15	No	To include battery storage for solar PV system?											
16	No												
17		Pressurized Water Reactor (PWR)	Boiling Water Reactor (BWR)										
18	Shares of LWR technologies for infrastructure	65.4%	34.6%										
20		Geothermal-Flash	Geothermal-Binary	Geothermal-EGS									
21	Shares of Geothermal Technologies	100.0%	0.0%	0.0%									
22	Fugitive CO2 emissions from geofluid (g CO2/kWh)	91	0	0									
24	2) Electricity Generation Mixes, Combustion Technology Shares, and Power Plant Energy Conversion Efficiencies												

Navigation buttons: Home (blue), Inputs (yellow), Results (green)

Worksheet tabs: Overview, Inputs, Results, Petroleum, Co_processing, NG, MeOH_FTD, EtOH, Electric, Generation_mixes, Bio, ...

Well-to-Wheel (WTW) GHG Emissions



**GREAT PLAINS
INSTITUTE**



Argonne
NATIONAL LABORATORY



U.S. Department of
ENERGY

File Home Insert Draw Page Layout Formulas Data Review View Automate Help

R&D GREET 1

Clipboard Font Alignment Number Styles Cells Editing Sensitivity Add-ins Analyze Data

Results_EnergyFunctionalUnit MJ

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

SI Hybrid Vehicles (HEV) Select Fuels Go

CIDI Hybrid Vehicles (HEV) Select Fuels Go

BEV and FCV Select Fuels Go

FCV - Gaseous H2

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

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

FCV: G.H2, Central Plants, NA NG

Item	Btu/mile or Gallon/mile or g/mile				Btu/MJ or Gallon/MJ or g/MJ			
	Feedstock	Vehicle			Feedstock	Vehicle		
Total Energy	197							
Fossil Fuels	197							
Coal	0							
Natural Gas	195							
Petroleum	1							
Water Consumption	0.0							
CO2 (w/ C in VOC & CO)	12							
CH4	0.370	0.126	0.000	0.496	0.192	0.065	0.000	0.257
N2O	0.002	0.001	0.000	0.004	0.001	0.001	0.000	0.002
GHGs	24	156	0	179	12	81	0	93
VOC: Total	0.020	0.010	0.000	0.029	0.010	0.005	0.000	0.015
CO: Total	0.061	0.027	0.000	0.088	0.032	0.014	0.000	0.046
NOx: Total	0.072	0.030	0.000	0.103	0.038	0.016	0.000	0.053
PM10: Total	0.001	0.005	0.031	0.036	0.000	0.003	0.016	0.019
PM2.5: Total	0.001	0.004	0.004	0.009	0.000	0.002	0.002	0.005

WTW GHG emissions
 179 g CO₂e/mile or 93 g CO₂e/MJ

FCV fueled by gaseous hydrogen with a Florida-specific electricity generation mix

Inputs Results Petroleum Co_processing NG MeOH_FTD EtOH Electric Generation_mixes Bio_electricity

Cradle-to-Grave (C2G) GHG Emissions



**GREAT PLAINS
INSTITUTE**

Argonne
NATIONAL LABORATORY

U.S. Department of
ENERGY

File Home Insert Draw Page Layout Formulas Data Review View Automate Help

R&D GREET 1 10 A A

Paste B I U Font Alignment Number Styles Cells Editing Sensitivity Add-ins Analyze Data

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

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

Link with GREET2
 Reactivate GREET2 Links
 Deactivate GREET2 Links

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



T15

A B C D E F G H I J K L M N O P Q R

Energy Use and Emissions of Well-to-Pump, Vehicle Cycle and Vehicle Operation

1) Well-to-Pump, Vehicle Cycle and Vehicle Operation Energy Use and Emissions: Btu or g per mile

Energy Unit: Btu Emission Unit: g

Service Functional Unit: mile

Gasoline Vehicle: CG and RFG, Conventional Material

Item	Btu/mile or g/mile				Vehicle Cycle Credits	Percentage of each stage				Vehicle Cycle Credits
	WTP	Vehicle Cycle	Vehicle Operation	Total		WTP	Vehicle Cycle	Vehicle Operation	Total	
Total energy	1,176	547	4,289	6,013	0	19.6%	9.1%	71.3%	100.0%	0.0%
Fossil fuels	1,070	511	4,003	5,585	0	19.2%	9.2%	71.7%	100.0%	0.0%
Coal	16	111	0	128	0	12.9%	87.1%	0.0%	100.0%	0.0%
Natural gas	749	299	0	1,048	0	71.4%	28.6%	0.0%	100.0%	0.0%
Petroleum	305	101	4,003	4,409	0	6.9%	2.3%	90.8%	100.0%	0.0%
Water consumption	0.219	0.035	0.000	0.254	0	86.2%	13.8%	0.0%	100.0%	0.0%
CO2 (VOC, CO, CO2)	60	34	329	422	0	14.1%	8.0%	77.9%	100.0%	0.0%
CH4	0.493	0.085	0.015	0.593	0	83.2%	14.3%	2.5%	100.0%	0.0%
N2O	0.012	0.001	0.004	0.017	0	71.4%	5.7%	22.8%	100.0%	0.0%
GHGs	78	37	330	445	0	17.4%	8.3%	74.3%	100.0%	0.0%
VOC: Total	0.127	0.189	0.230	0.546	0	23.2%	34.7%	42.1%	100.0%	0.0%
CO: Total	0.070	0.112	2.741	2.924	0	2.4%	3.8%	93.8%	100.0%	0.0%
NOx: Total	0.111	0.038	0.082	0.232	0	48.0%	16.5%	35.5%	100.0%	0.0%
PM10: Total	0.012	0.012	0.035	0.059	0	20.1%	20.9%	59.0%	100.0%	0.0%
PM2.5: Total	0.008	0.006	0.007	0.022	0	37.0%	29.1%	34.0%	100.0%	0.0%
SOx: Total	0.027	0.084	0.002	0.113	0	24.1%	74.2%	1.7%	100.0%	0.0%
BC: Total	0.001	0.000	0.003	0.004	0	27.8%	5.2%	67.0%	100.0%	0.0%
OC: Total	0.002	0.001	0.002	0.004	0	44.2%	13.4%	42.4%	100.0%	0.0%
VOC: Urban	0.068	0.111	0.161	0.340	0	20.0%	32.7%	47.3%	100.0%	0.0%
CO: Urban	0.012	0.002	1.919	1.932	0	0.6%	0.1%	99.3%	100.0%	0.0%
NOx: Urban	0.018	0.004	0.058	0.080	0	22.5%	5.1%	72.4%	100.0%	0.0%

Per Vehicle Distance Travelled

Energy Unit	Btu	mBtu	J	kJ	
	1.000	0.001	1055	1.055	0.0
Emission Unit	g	mg	kg	lb	0.0
	1.000	1000	0.001	0.002	0.0
Functional Unit	mile	km			
	1.000	1.609			

R&D GREET 2

$$C2G = WTW + \text{vehicle cycle}$$

C2G GHG emissions
230 g CO₂e/mile

FCV fueled by gaseous hydrogen with a Florida-specific electricity generation mix

Item	Btu/mile or g/mile				Percentage of each stage				
	WTW	Vehicle Cycle	Vehicle Cycle	Vehicle Cycle	WTW	Vehicle Cycle	Vehicle Operation	Total	Vehicle Cycle Credits
Total energy	930	772			26.2%	21.8%	52.0%	100.0%	0.0%
Fossil fuels	888	720			25.7%	20.9%	53.4%	100.0%	0.0%
Coal	34	135			20.1%	79.9%	0.0%	100.0%	0.0%
Natural gas	791	475			25.4%	15.3%	59.3%	100.0%	0.0%
Petroleum	62	111			35.9%	64.1%	0.0%	100.0%	0.0%
Water consumption	0.089	0.058			60.6%	39.4%	0.0%	100.0%	0.0%
CO2 (VOC, CO, CO2)	165	45			78.6%	21.4%	0.0%	100.0%	0.0%
CH4	0.501	0.121	0.000	0.622	80.6%	19.4%	0.0%	100.0%	0.0%
N2O	0.004	0.002	0.000	0.005	69.5%	30.5%	0.0%	100.0%	0.0%
GHGs	181	49	0	230	78.6%	21.4%	0.0%	100.0%	0.0%
VOC: Total	0.030	0.193	0.000	0.223	13.2%	86.8%	0.0%	100.0%	0.0%
CO: Total	0.089	0.127	0.000	0.216	41.2%	58.8%	0.0%	100.0%	0.0%
NOx: Total	0.104	0.048	0.000	0.151	68.6%	31.4%	0.0%	100.0%	0.0%
PM10: Total	0.006	0.017	0.031	0.053	10.9%	31.2%	57.9%	100.0%	0.0%
PM2.5: Total	0.005	0.007	0.004	0.017	30.4%	45.1%	24.5%	100.0%	0.0%
SOx: Total	0.031	0.125	0.000	0.156	20.1%	79.9%	0.0%	100.0%	0.0%
BC: Total	0.000	0.000	0.001	0.001	34.0%	20.2%	45.9%	100.0%	0.0%
OC: Total	0.001	0.001	0.001	0.003	47.9%	27.9%	24.2%	100.0%	0.0%
VOC: Urban	0.002	0.111	0.000	0.113	2.2%	97.8%	0.0%	100.0%	0.0%
CO: Urban	0.013	0.002	0.000	0.016	84.9%	15.1%	0.0%	100.0%	0.0%
NOx: Urban	0.013	0.004	0.000	0.017	76.9%	23.1%	0.0%	100.0%	0.0%
PM10: Urban	0.001	0.000	0.021	0.023	6.0%	1.8%	92.2%	100.0%	0.0%
PM2.5: Urban	0.001	0.000	0.003	0.004	26.2%	8.6%	65.2%	100.0%	0.0%
SOx: Urban	0.002	0.002	0.000	0.004	44.4%	55.6%	0.0%	100.0%	0.0%

How Does a Change in the Electric Grid Used to Charge EVs Affect Their WTW Emissions and C2G Emissions?



**GREAT PLAINS
INSTITUTE**

Argonne
NATIONAL LABORATORY

U.S. Department of
ENERGY

SUV BEV Charged in WECC

Model a 2022 Sport Utility Vehicle (SUV) Battery Electric Vehicle (BEV) Using an NMC622 Battery Charged with a WECC Electricity Generation Mix



GREAT PLAINS
INSTITUTE

Argonne
NATIONAL LABORATORY

U.S. Department of
ENERGY

File Home Insert Draw Page Layout Formulas Data Review View Automate Help

R&D GREET 1

Veh_Type_Option : 1

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-Estimation or Probability-Estimation Option: Load 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 [F

3. Petroleum-Based Fuels

3.1) Petroleum R: 3

3.1.a) Share of crude oil sources

Basis of share of crude oil sources: 1 -- E	
U.S. Domestic	80.8%
EIA projection	80.8%
User defined	0.0%
Used in calculation	80.8%
API gravity	34.0
S Content (wt %)	1.4
Average transportation distances (mi)	See T&D_Flowcharts tab

1,708 1,708 797

Inputs Results Petroleum Co_processing NG MeOH_FTD EtOH Electric Generation mixes Bio_electricity

Note:
 this scenario is modeling an SUV built in 2022

Fuel Economy and Emission Rates of LDT1 Vehicles: Baseline Vehicles and New Vehicles

1) Fuel Economy and Emission Rates of LDT1 Baseline Vehicles: gasoline-equivalent MPG and grams/mile emissions
 (fuel economy is adjusted for inflation using the EPA mpg-based method, and using 43%city/57%highway VMT split)

Model Year: 2017
 Lag year: 0
 Gasoline LDT1: Values from model year and for adjustments to distribution functions
 Model year is 5 years earlier than simulated technology year

Type 0

Model Year	MPGGE	VOC (Exhaust)	VOC (Evap.)	CO	NOx	PM10 (Exhaust)	PM10 (TBW)	PM2.5 (Exhaust)	PM2.5 (TBW)	BC	OC	CH4	N2O
MY 1990	16.60	1.564	1.774	25.201	4.396	0.027	0.031	0.024	0.004	0.005	0.013	0.262	0.077
MY 1995	16.20	0.937	1.766	16.021	2.911	0.019	0.031	0.016	0.004	0.003	0.009	0.157	0.056
MY 2000	16.30	0.310	1.759	6.841	1.427	0.010	0.031	0.009	0.004	0.002	0.005	0.052	0.034
MY 2005	17.30	0.117	0.130	4.042	0.232	0.003	0.031	0.003	0.004	0.001	0.002	0.024	0.007
MY 2010	20.06	0.075	0.120	3.027	0.107	0.004	0.031	0.003	0.004	0.001	0.002	0.016	0.007
MY 2015	20.06	0.074	0.116	2.882	0.103	0.006	0.031	0.005	0.004	0.003	0.002	0.016	0.005
MY 2020	26.54	0.044	0.085	1.530	0.050	0.006	0.031	0.005	0.004	0.003	0.001	0.009	0.005
MY 2025	26.86	0.031	0.076	0.984	0.025	0.004	0.031	0.004	0.004	0.003	0.001	0.006	0.005
MY 2030	29.69	0.031	0.075	0.982	0.025	0.004	0.031	0.004	0.004	0.003	0.001	0.006	0.005
MY 2035	32.33	0.031	0.075	0.982	0.025	0.004	0.031	0.004	0.004	0.003	0.001	0.006	0.005
MY 2050	37.67	0.031	0.073	0.971	0.024	0.004	0.031	0.004	0.004	0.003	0.001	0.005	0.005

Default values from times series or user input

Gasoline LDT1: stochastic simulation distribution

Distribution Functions of Fuel Economy and Emission Rates

Model Year	MPGGE	VOC (Exhaust)	VOC (Evap.)
MY 1990	20.80	1.114	0.545
MY 1995	20.80	0.668	0.426
MY 2000	20.80	0.203	0.112
MY 2005	20.80	0.144	0.069
MY 2010	20.80	0.115	0.067
MY 2015	21.30	0.115	0.067
MY 2020	21.70	0.112	0.067
MY 2025	21.70	0.112	0.067
MY 2030	21.70	0.112	0.067
MY 2035	21.70	0.112	0.067
MY 2050	21.70	0.112	0.067

2) Diesel LDT1: stochastic simulations and for adjustments to distribution functions
 Model year is 5 years earlier than simulated technology year

Press F9

Model Year	MPGGE	VOC (Exhaust)	VOC (Evap.)	CO	NOx	PM10 (Exhaust)	PM10 (TBW)	PM2.5 (Exhaust)	PM2.5 (TBW)	BC	OC	CH4	N2O
MY 1990	16.60	1.564	1.774	25.201	4.396	0.027	0.031	0.024	0.004	0.005	0.013	0.262	0.077
MY 1995	16.20	0.937	1.766	16.021	2.911	0.019	0.031	0.016	0.004	0.003	0.009	0.157	0.056
MY 2000	16.30	0.310	1.759	6.841	1.427	0.010	0.031	0.009	0.004	0.002	0.005	0.052	0.034
MY 2005	17.30	0.117	0.130	4.042	0.232	0.003	0.031	0.003	0.004	0.001	0.002	0.024	0.007
MY 2010	20.06	0.075	0.120	3.027	0.107	0.004	0.031	0.003	0.004	0.001	0.002	0.016	0.007
MY 2015	20.06	0.074	0.116	2.882	0.103	0.006	0.031	0.005	0.004	0.003	0.002	0.016	0.005
MY 2020	26.54	0.044	0.085	1.530	0.050	0.006	0.031	0.005	0.004	0.003	0.001	0.009	0.005
MY 2025	26.86	0.031	0.076	0.984	0.025	0.004	0.031	0.004	0.004	0.003	0.001	0.006	0.005
MY 2030	29.69	0.031	0.075	0.982	0.025	0.004	0.031	0.004	0.004	0.003	0.001	0.006	0.005
MY 2035	32.33	0.031	0.075	0.982	0.025	0.004	0.031	0.004	0.004	0.003	0.001	0.006	0.005
MY 2050	37.67	0.031	0.073	0.971	0.024	0.004	0.031	0.004	0.004	0.003	0.001	0.005	0.005

Default values from times series or user input

Diesel LDT1: stochastic simulation distribution

Distribution Functions of Fuel Economy and Emission Rates

Model Year	MPGGE	VOC (Exhaust)	VOC (Evap.)
MY 1990	20.80	1.114	0.545
MY 1995	20.80	0.668	0.426
MY 2000	20.80	0.203	0.112
MY 2005	20.80	0.144	0.069
MY 2010	20.80	0.115	0.067
MY 2015	21.30	0.115	0.067
MY 2020	21.70	0.112	0.067
MY 2025	21.70	0.112	0.067
MY 2030	21.70	0.112	0.067
MY 2035	21.70	0.112	0.067
MY 2050	21.70	0.112	0.067

R&D GREET 2

B3 1

Scenario Control Variables and Input Assumptions Related to Vehicle and its Components

1. Selection of Vehicle Types for Simulation

- 1 Passenger Cars
- 2 -- Sport Utility Vehicles
- 3 -- Pick-Up Trucks

When the "Passenger Cars" option is selected, select one of the following two vehicles for ICEVs

- 1 -- Passenger Cars 1, 2 -- Passenger Cars 2

When the "Sport Utility Vehicles" option is selected, select one of the following two vehicles for ICEVs

- 1 -- Sport Utility Vehicles 1, 2 -- Sport Utility Vehicles 2

When the "Pick-Up Trucks" option is selected, select one of the following two vehicles for ICEVs

- 1 -- Pick-Up Trucks 1, 2 -- Pick-Up Trucks 2

2. Specification of Total Vehicle Weight, pounds

ICEV:	ICEV:	HEV:	HEV:	PHEV:	PHEV:	EV:	EV:	FCV:	FCV:
Conventional	ICEV: Lightweight	Conventional	HEV: Lightweight	Conventional	Lightweight	Conventional	Lightweight	Conventional	Lightweight
Material	Material	Material	Material	Material	Material	Material	Material	Material	Material
3,264	2,692	3,517	2,839	3,626	3,007	3,861	3,193	3,401	2,930

3. Vehicle Battery and Fluids Weight, pounds per vehicle

3.1) Battery Weight

ICEV:	ICEV:	HEV:	HEV:	PHEV:	PHEV:	EV:	EV:	FCV:	FCV:
Conventional	ICEV: Lightweight	Conventional	HEV: Lightweight	Conventional	Lightweight	Conventional	Lightweight	Conventional	Lightweight
Material	Material	Material	Material	Material	Material	Material	Material	Material	Material
36.0	23.4	22.1	14.4	22.1	14.4	22.1	14.4	22.1	14.4
		90.8	75.3	716.1	495.8	2,625.6	2,162.3	145.4	94.1
	Li-Ion	30.6	25.3	221.6	153.4	966.0	795.5	42.9	27.8

Press F9

Vehi_Inputs



GREAT PLAINS INSTITUTE



R&D GREET 2

197

Scenario Control Variables and Input Assumptions Related to Vehicle and its Components

1. Selection of Vehicle Types for Simulation

2
1 -- Passenger Cars
2 -- Sport Utility Vehicles
3 -- Pick-Up Trucks

When the "Passenger Cars" option is selected, select one of the following

1 1 -- Passenger Cars 1, 2 -- Passenger Cars

When the "Sport Utility Vehicles" option is selected, select one of the following

1 1 -- Sport Utility Vehicles 1, 2 -- Sport Utility Vehicles

When the "Pick-Up Trucks" option is selected, select one of the following

1 1 -- Pick-Up Trucks 1, 2 -- Pick-Up Trucks

2. Specification of Total Vehicle Weight, pounds

ICEV:	
Conventional Material	ICEV: Lightweight Material
3,427	

FCV:	FCV:
Conventional Material	Lightweight Material
3,566	3,639

3. Vehicle Battery and Fluids Weight, pounds per vehicle

3.1) Battery Weight

	ICEV: Conventional Material	ICEV: Lightweight Material	HEV: Conventional Material	HEV: Lightweight Material	PHEV: Conventional Material	PHEV: Lightweight Material	EV: Conventional Material	EV: Lightweight Material	FCV: Conventional Material	FCV: Lightweight Material
Lead-Acid	53.5	35.0	36.0	23.8	36.0	23.8	36.0	23.8	36.0	23.8
Ni-MH			90.8	103.5	859.8	637.9	3,040.0	2,827.1	109.0	103.5
Li-Ion			30.6	34.8	262.0	194.4	1,117.3	1,039.1	34.7	33.0

Microsoft Excel

You have changed the type of vehicles. You must ensure the GREET1 setting matches with this selection to have correct LCA results. Do you want to proceed? If you click the Cancel button, the cell will use the default.

1

OK Cancel

2

Microsoft Excel ribbon showing tabs: Clipboard, Font, Alignment, Number, Styles, Cells, Editing, Sensitivity, Add-ins, Analyze Data.

Formula bar: C104, fx, 2

5.5) Li-ion Battery Cathode Material

HEV	2	1. LMO, 2. NMC111, 3. LFP: Hydrothermal, 4. LFP: Solid State, 5. NMC622, 6. NMC811, 7. NCA, 8. NMC532, 9. NMC95
PHEV	2	1. LMO, 2. NMC111, 3. LFP: Hydrothermal, 4. LFP: Solid State, 5. NMC622, 6. NMC811, 7. NCA, 8. NMC532, 9. NMC95
EV	2	1. LMO, 2. NMC111, 3. LFP: Hydrothermal, 4. LFP: Solid State, 5. NMC622, 6. NMC811, 7. NCA, 8. NMC532, 9. NMC95
FCV	1	1. LMO, 2. NMC111, 3. LFP: Hydrothermal, 4. LFP: Solid State, 5. NMC622, 6. NMC811, 7. NCA, 8. NMC532, 9. NMC95

5.6) Battery Specific Power

	Type	W/lb	W/kg	Li-ion specific power by type (W/kg)							
				LMO	NMC111	LFP	NMC622	NMC811	NCA	NMC532	NMC95
HEV	Ni-MH	363	2,378	2,050	2,378	2,221	2,421	2,484	2,438	2,419	2,527
FCV	Li-Ion	363	2,513	1,890	2,513	2,342	2,565	2,635	2,584	2,558	2,677

5.7) Battery Specific Energy

	Type	Wh/lb	Wh/kg	Li-ion Battery Specific Energy (Wh/kg)							
				LMO	NMC111	LFP	NMC622	NMC811	NCA	NMC532	NMC95
PHEV	Ni-MH	24	174	141	165	137	173	181	177	171	187
EV	Li-Ion	29	177	PHEV: 35-mile							

6. Key Input Parameters for Fluids

6.1) Fluids Replacements During Lifetime of Vehicle

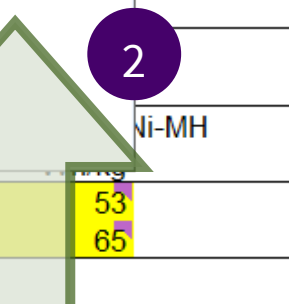
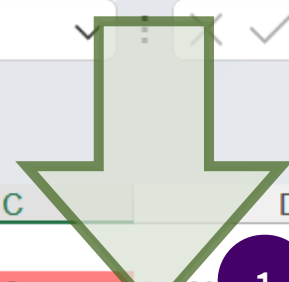
Engine Oil	Power Steering Fluid	Brake Fluid	Transmission Fluid	Powertrain Coolant	Windshield Fluid	Adhesives
44	0	4	1	4	22	0

6.2) Ratio of Waste to Product when Fluids is Disposed

Engine Oil	Power Steering Fluid	Brake Fluid	Transmission Fluid	Powertrain Coolant	Windshield Fluid	Adhesives
66.7%	66.7%	66.7%	66.7%	66.7%	0.0%	66.7%

7. GREET Default Key Assumptions for Vehicle Assembly

Vehi_Inputs | Mat_Inputs | Car | SUV | PUT | Steel | C.Iron | W.AI | C.AI | Lead | Nickel | Cobalt | Copper | Zinc | Magnesium



1

2

R&D GREET 2

Life cycle GHG emissions
per mile traveled

2022 SUV BEV using an
NMC622 battery charged by
GREET default

Item	Btu/mile or g/mile				Vehicle Cycle Credits	Percentage of each stage				Vehicle Cycle Credits
	WTP	Vehicle Cycle	Vehicle Operation	Total		WTP	Vehicle Cycle	Vehicle Operation	Total	
Total energy	1,918	911	1,867	4,696	0	40.8%	19.4%	39.8%	100.0%	0.0%
Fossil fuels					0	40.2%	21.7%	38.1%	100.0%	0.0%
Coal					0	40.5%	16.1%	43.4%	100.0%	0.0%
Natural gas					0	41.5%	21.4%	37.1%	100.0%	0.0%
Petroleum					0	18.0%	76.8%	5.2%	100.0%	0.0%
Water consumption					0	80.1%	19.9%	0.0%	100.0%	0.0%
CO2 (VOC, CO, CO2)					0	79.4%	20.6%	0.0%	100.0%	0.0%
CH4					0	69.0%	31.0%	0.0%	100.0%	0.0%
N2O	0.004	0.002	0.000	0.006	0	69.5%	30.5%	0.0%	100.0%	0.0%
GHGs	240	66	0	306	0	78.6%	21.4%	0.0%	100.0%	0.0%
VOC: Total	0.027	0.338	0.000	0.365	0	7.5%	92.5%	0.0%	100.0%	0.0%
CO: Total	0.097	0.151	0.000	0.248	0	39.0%	61.0%	0.0%	100.0%	0.0%
NOx: Total	0.171	0.070	0.000	0.242	0	71.0%	29.0%	0.0%	100.0%	0.0%
PM10: Total	0.025	0.022	0.031	0.078	0	31.7%	28.3%	40.0%	100.0%	0.0%
PM2.5: Total	0.014	0.010	0.004	0.028	0	49.9%	35.4%	14.7%	100.0%	0.0%
SOx: Total	0.144	0.280	0.000	0.424	0	33.9%	66.1%	0.0%	100.0%	0.0%
BC: Total	0.001	0.000	0.000	0.002	0	45.5%	27.2%	27.3%	100.0%	0.0%
OC: Total	0.004	0.001	0.001	0.006	0	69.3%	19.1%	11.5%	100.0%	0.0%
VOC: Urban	0.002	0.210	0.000	0.212	0	0.9%	99.1%	0.0%	100.0%	0.0%
CO: Urban	0.021	0.003	0.000	0.024	0	87.8%	12.2%	0.0%	100.0%	0.0%
NOx: Urban	0.043	0.005	0.000	0.049	0	89.0%	11.0%	0.0%	100.0%	0.0%
PM10: Urban	0.005	0.001	0.022	0.027	0	18.0%	1.9%	80.1%	100.0%	0.0%
PM2.5: Urban	0.004	0.000	0.003	0.007	0	55.5%	5.7%	38.8%	100.0%	0.0%
SOx: Urban	0.043	0.004	0.000	0.048	0	90.9%	9.1%	0.0%	100.0%	0.0%

Electric_Marginalmix_EVsnHEVs 1

Note:
this scenario is modeling an SUV charged in the West

10. Electric Generation

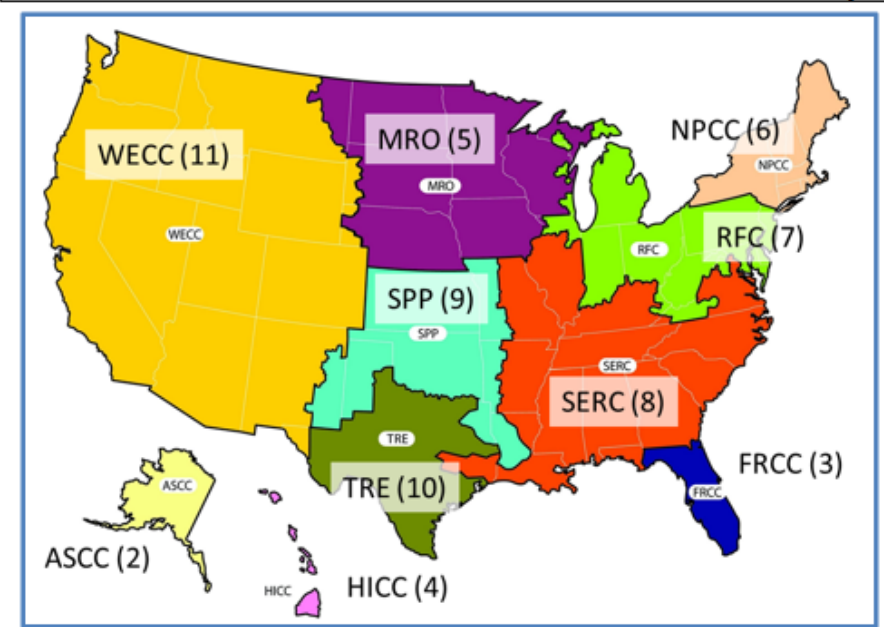
10.1) GREET-Calculated or User-Inputted Emission Factors for Power Plants

- 1 -- GREET-calculated emissions factors via
- 2 -- Emission factors based on EPA and EIA

10.2) Electricity Generation Mix

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

Mix for transportation use
Mix for stationary use



1

2

3

4

5

6

7

8

9

10

11

12

- 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	
	Transportation	Stationary	Transportation	Stationary
Residual oil	0.3%	0.3%	13.7%	13.7%
Natural gas	38.5%	38.5%	46.7%	46.7%

Well-to-Pump (WTP) and Well-to-Wheel (WTW) GHG Emissions



**GREAT PLAINS
INSTITUTE**

Argonne
NATIONAL LABORATORY

U.S. Department of
ENERGY

R&D GREET 1

R2086

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: MJ

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

Electric Vehicle: WECC Mix

Item	Feedstock	Fuel	Vehicle Operation	Total
Total Energy	148	1,411	1,865	3,424
Fossil Fuels	146	950	1,255	2,351
Coal	3	392	518	913
Natural Gas	127	554	733	1,414
Petroleum	16	3	5	24
Water Consumption	0.0	0.5	0	1
CO2 (w/ C in VOC & CO)	9	169	0	179
CH4	0.359	0.017	0.000	0.376
N2O	0.001	0.002	0.000	0.004
GHGs	20	170	0	191
VOC: Total	0.019	0.003	0.000	0.022
CO: Total	0.000	0.018	0.000	0.018
NOx: Total	0.000	0.023	0.000	0.023
PM10: Total	0.000	0.004	0.000	0.004

WTP GHG emissions per fuel consumed

WTW GHG emissions per fuel consumed

WTP GHG emissions per distance

WTW GHG emissions per distance

2022 SUV BEV using a WECC electricity generation mix

Cradle-to-Grave (C2G) GHG Emissions



**GREAT PLAINS
INSTITUTE**



Argonne
NATIONAL LABORATORY



U.S. Department of

ENERGY

R&D GREET 2

C2G = WTP + vehicle operation + vehicle cycle

C2G GHG emissions
257 g CO₂e/mile

2022 SUV BEV using a WECC electricity generation mix

Item	Btu/mile or g/mile			Percentage of each stage				
	WTP	Vehicle Cycle	Vehicle	WTP	Vehicle Cycle	Vehicle Operation	Total	Vehicle Cycle Credits
Total energy	1,560	911		36.0%	21.0%	43.0%	100.0%	0.0%
Fossil fuels	1,097	823		34.5%	25.9%	39.6%	100.0%	0.0%
Coal	395	226		34.7%	19.8%	45.5%	100.0%	0.0%
Natural gas	682	476		36.0%	25.2%	38.8%	100.0%	0.0%
Petroleum	19	121		13.4%	83.5%	3.1%	100.0%	0.0%
Water consumption	0.559	0.079		87.6%	12.4%	0.0%	100.0%	0.0%
CO2 (VOC, CO, CO2)	179	58		75.3%	24.7%	0.0%	100.0%	0.0%
CH4	0.376	0.212		63.9%	36.1%	0.0%	100.0%	0.0%
N2O	0.004	0.002	0.000	64.6%	35.4%	0.0%	100.0%	0.0%
GHGs	191	66	0	74.4%	25.6%	0.0%	100.0%	0.0%
VOC: Total	0.022	0.338	0.000	6.0%	94.0%	0.0%	100.0%	0.0%
CO: Total	0.075	0.151	0.000	33.0%	67.0%	0.0%	100.0%	0.0%
NOx: Total	0.153	0.070	0.000	68.6%	31.4%	0.0%	100.0%	0.0%
PM10: Total	0.021	0.022	0.031	28.3%	29.7%	42.0%	100.0%	0.0%
PM2.5: Total	0.012	0.010	0.004	45.5%	38.5%	16.0%	100.0%	0.0%
SOx: Total	0.078	0.280	0.000	21.7%	78.3%	0.0%	100.0%	0.0%
BC: Total	0.001	0.000	0.000	40.2%	29.9%	29.9%	100.0%	0.0%
OC: Total	0.003	0.001	0.001	65.1%	21.8%	13.1%	100.0%	0.0%
VOC: Urban	0.001	0.210	0.000	0.7%	99.3%	0.0%	100.0%	0.0%
CO: Urban	0.016	0.003	0.000	84.3%	15.7%	0.0%	100.0%	0.0%
NOx: Urban	0.041	0.005	0.000	88.5%	11.5%	0.0%	100.0%	0.0%
PM10: Urban	0.005	0.001	0.022	16.8%	1.9%	81.3%	100.0%	0.0%
PM2.5: Urban	0.004	0.000	0.003	51.5%	6.3%	42.3%	100.0%	0.0%
SOx: Urban	0.020	0.004	0.000	82.5%	17.5%	0.0%	100.0%	0.0%

Phase of the Fuel Cycle Responsible for the Reduction of C2G GHG Emissions



**GREAT PLAINS
INSTITUTE**

Argonne
NATIONAL LABORATORY

U.S. Department of
ENERGY

2022 SUV BEV charged by GREET default

2022 SUV BEV charged in West

Life cycle GHG emissions per mile traveled

Item	Btu/mile or g/mile				Vehicle Cycle Credits	Percentage of each		
	WTP	Vehicle Cycle	Vehicle Operation	Total		WTP	Vehicle Cycle	Vehicle Operation
Total energy	0.004	0.002	0.000	0.006	0	40.8%	19.4%	39.8%
Fossil fuels	0.240	0.066	0.000	0.306	0	40.2%	21.7%	38.1%
Coal	0.027	0.358	0.000	0.385	0	40.5%	16.1%	43.4%
Natural gas	0.097	0.151	0.000	0.248	0	41.5%	21.4%	37.1%
Petroleum	0.171	0.070	0.000	0.241	0	18.0%	76.8%	5.2%
Water consumption	0.025	0.022	0.031	0.078	0	80.1%	19.9%	0.0%
CO2 (VOC, CO, CH4)	0.014	0.010	0.004	0.028	0	79.4%	20.6%	0.0%
CH4	0.014	0.010	0.004	0.028	0	69.0%	31.0%	0.0%
N2O	0.001	0.000	0.000	0.001	0	69.5%	30.5%	0.0%
GHGs	0.001	0.000	0.000	0.001	0	78.6%	21.4%	0.0%
VOC: Total	0.027	0.358	0.000	0.385	0	7.5%	92.5%	0.0%
CO: Total	0.097	0.151	0.000	0.248	0	39.0%	61.0%	0.0%
NOx: Total	0.171	0.070	0.000	0.241	0	71.0%	29.0%	0.0%
PM10: Total	0.025	0.022	0.031	0.078	0	31.7%	28.3%	40.0%
PM2.5: Total	0.014	0.010	0.004	0.028	0	49.9%	35.4%	14.7%
SOx: Total	0.014	0.010	0.004	0.028	0	33.9%	66.1%	0.0%
BC: Total	0.001	0.000	0.000	0.001	0	45.5%	27.2%	27.3%
OC: Total	0.004	0.001	0.001	0.006	0	69.3%	19.1%	11.5%
VOC: Urban	0.002	0.210	0.000	0.212	0	0.9%	99.1%	0.0%
CO: Urban	0.021	0.003	0.000	0.024	0	87.8%	12.2%	0.0%
NOx: Urban	0.043	0.005	0.000	0.048	0	89.0%	11.0%	0.0%
PM10: Urban	0.005	0.001	0.022	0.027	0	18.0%	1.9%	80.1%
PM2.5: Urban	0.004	0.000	0.003	0.007	0	55.5%	5.7%	38.8%
SOx: Urban	0.043	0.004	0.000	0.047	0	90.9%	9.1%	0.0%



Electric Infrastructure Scenarios



**GREAT PLAINS
INSTITUTE**

Argonne
NATIONAL LABORATORY

U.S. Department of
ENERGY

Power-plant Construction

Model a 2022 Sport Utility Vehicle (SUV) Battery
Electric Vehicle (BEV) Using an NMC622 Battery
Charged with a WECC Electricity Generation Mix.
*Include Emissions Associated with Constructing the
Power-plant from Raw Materials*



GREAT PLAINS
INSTITUTE

Argonne
NATIONAL LABORATORY

U.S. Department of
ENERGY

Ensure R&D GREET 2 also has the inputs from the previous example

Scenario Control Variables and Input Assumptions Related to Vehicle and its Components

1. Selection of Vehicle Types for Simulation

1 -- Passenger Cars
2 -- Sport Utility Vehicles
3 -- Pick-Up Trucks

When the "Passenger Cars" option is selected, select one of the following two vehicles for ICEVs
1 -- Passenger Cars 1, 2 -- Passenger Cars 2

When the "Sport Utility Vehicles" option is selected, select one of the following two vehicles for ICEVs
1 -- Sport Utility Vehicles 1, 2 -- Sport Utility Vehicles 2

When the "Pick-Up Trucks" option is selected, select one of the following two vehicles for ICEVs
1 -- Pick-Up Trucks 1, 2 -- Pick-Up Trucks 2

2. Specification of Total Vehicle Weight, pounds

	ICEV: Conventional Material	ICEV: Lightweight Material	HEV: Conventional Material	HEV: Lightweight Material	PHEV: Conventional Material
Lightweight	3,427	3,315	3,707	3,500	3,854

3. Vehicle Battery and Fluids Weight, pounds per vehicle

3.1) Battery Weight

	ICEV: Conventional Material	ICEV: Lightweight Material	HEV: Conventional Material	HEV: Lightweight Material	PHEV: Conventional Material
Lead-Acid	53.5	35.0	36.0	23.8	36.0
Ni-MH			90.8	103.5	859.8
Li-Ion			30.6	34.8	262.0

5.5) Li-ion Battery Cathode Material

	2	1. LMO, 2. NMC111, 3.LFP: Hydrothermal, 4. LFP: Solid State, 5. NMC622, 6. NMC811, 7. N
HEV	2	1. LMO, 2. NMC111, 3.LFP: Hydrothermal, 4. LFP: Solid State, 5. NMC622, 6. NMC811, 7. N
PHEV	2	1. LMO, 2. NMC111, 3.LFP: Hydrothermal, 4. LFP: Solid State, 5. NMC622, 6. NMC811, 7. N
EV	5	1. LMO, 2. NMC111, 3.LFP: Hydrothermal, 4. LFP: Solid State, 5. NMC622, 6. NMC811, 7. N
FCV	2	1. LMO, 2. NMC111, 3.LFP: Hydrothermal, 4. LFP: Solid State, 5. NMC622, 6. NMC811, 7. N

5.6) Battery Specific Power

	Ni-MH		Li-Ion		LMO
	W/kg	W/lb	W/kg	W/lb	
HEV	800	363	2,378	1,079	2,050
FCV	800	363	2,513	1,140	1,890

5.7) Battery Specific Energy

	Ni-MH		Li-Ion	
	Wh/kg	Wh/lb	Wh/kg	Wh/lb
PHEV	53	24	174	79
EV	65	29	186	84

6. Key Input Parameters for Fluids

6.1) Fluids Replacements During Lifetime of Vehicle

	Engine Oil	Power Steering Fluid	Brake Fluid	Transmission Fluid	Powertrain Coolant	Windshield Fluid
Replacements	44	0	4	1	4	22

6.2) Ratio of Waste to Product when Fluids is Disposed

	Engine Oil	Power Steering Fluid	Brake Fluid	Transmission Fluid	Powertrain Coolant	Windshield Fluid
Ratio	66.7%	66.7%	66.7%	66.7%	66.7%	0.0%

7. GREET Default Key Assumptions for Vehicle Assembly



R&D GREET 1

File Home Insert Draw Page Layout Formulas Data Review View Automate Help

Clipboard Font Alignment Number Styles Cells Editing Sensitivity Add-ins Analyze Data

A1

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-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

2

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

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
EIA projection		80.8%	6.6%	5.0%	1.9%
User defined		80.8%	6.6%	5.0%	1.9%
Used in calculation		80.8%	6.6%	5.0%	1.9%
API gravity		34.0	18.1	26.5	26.5
S Content (wt %)		1.4	2.9	1.9	2.2
Average transportation distances (mi)		See T&D_Flowcharts tab	1,708	1,708	797

Inputs Results Petroleum Co_processing NG MeOH_FTD EtOH Electric Generation_mixes Bio_electricity



10. Electric Generation

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

Electric Worksheet: 2

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

10.2) Electricity Generation Mix

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

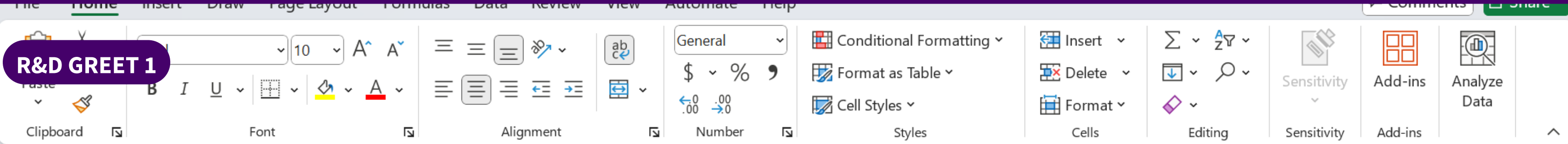
Mix for transportation use: 11
 Mix for stationary use: 1

(U.S. EPA)

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

	U.S. Mix		ASCC Mix	
	Transportation	Stationary	Transportation	Stationary
Residual oil	0.3%	0.3%	13.7%	13.7%
Natural gas	38.5%	38.5%	46.7%	46.7%

R&D GREET 1



Electric_Infra_Option No

806									
807									
808									
809									
810									
811									
812									
813									
814									
815									
816									
817									
818									
819									
820									
821									
822									
823									
824									
825									
826									

Note:
you can optionally include battery storage for solar PV systems

Cradle-to-Grave (C2G) GHG Emissions



**GREAT PLAINS
INSTITUTE**

Argonne
NATIONAL LABORATORY

U.S. Department of
ENERGY

R&D GREET 2

T15

Item	Btu/mile or g/mile			Percentage of each stage				Vehicle Cycle Credits
	WTP	Vehicle Cycle	Vehicle Cycle Credits	WTP	Vehicle Cycle	Vehicle Operation	Total	
Total energy	1,606	914	0	36.6%	20.8%	42.6%	100.0%	0.0%
Fossil fuels	1,132	826	0	35.2%	25.6%	39.2%	100.0%	0.0%
Coal	410	226	0	35.4%	19.6%	45.0%	100.0%	0.0%
Natural gas	700	477	0	36.6%	25.0%	38.4%	100.0%	0.0%
Petroleum	23	122	0	15.0%	79.0%	6.0%	100.0%	0.0%
Water consumption	0.568	0.079	0	87.7%	12.3%	0.0%	100.0%	0.0%
CO2 (VOC, CO, CO2)	182	59	0	75.6%	24.4%	0.0%	100.0%	0.0%
CH4	0.384	0.213	0	64.3%	35.7%	0.0%	100.0%	0.0%
N2O	0.004	0.002	0	65.1%	34.9%	0.0%	100.0%	0.0%
GHGs	194	66	0	74.7%	25.3%	0.0%	100.0%	0.0%
VOC: Total	0.024	0.338	0	6.5%	93.5%	0.0%	100.0%	0.0%
CO: Total	0.088	0.152	0	36.6%	63.4%	0.0%	100.0%	0.0%
NOx: Total	0.158	0.070	0	69.2%	30.8%	0.0%	100.0%	0.0%
PM10: Total	0.022	0.022	0	29.6%	29.2%	41.2%	100.0%	0.0%
PM2.5: Total	0.012	0.010	0	46.8%	37.6%	15.6%	100.0%	0.0%
SOx: Total	0.086	0.281	0	23.4%	76.6%	0.0%	100.0%	0.0%
BC: Total	0.001	0.000	0	43.4%	28.5%	28.1%	100.0%	0.0%
OC: Total	0.003	0.001	0	65.5%	21.6%	12.9%	100.0%	0.0%
VOC: Urban	0.002	0.210	0	0.8%	99.2%	0.0%	100.0%	0.0%
CO: Urban	0.016	0.003	0	84.5%	15.5%	0.0%	100.0%	0.0%
NOx: Urban	0.042	0.005	0	88.6%	11.4%	0.0%	100.0%	0.0%
PM10: Urban	0.005	0.001	0	17.1%	1.9%	80.9%	100.0%	0.0%
PM2.5: Urban	0.004	0.000	0	51.8%	6.3%	41.9%	100.0%	0.0%
SOx: Urban	0.021	0.004	0	82.6%	17.4%	0.0%	100.0%	0.0%

C2G GHG emissions
260 g CO₂e/mile

2022 SUV BEV including infrastructure emissions

Battery_Materials | Anode | LiMn2O4 | Li_Chemicals | Other_Cathodes | Battery_Recycling | Vehi_Comp_Sum | Vehi_Sum | TEC_Results

2022 SUV BEV charged in West

2022 SUV BEV including infrastructure emissions

Life cycle GHG emissions per mile traveled

Item	Btu/mile or g/mile				Vehicle Cycle Credits	Percentage of each		
	WTP	Vehicle Cycle	Vehicle Operation	Total		WTP	Vehicle Cycle	Vehicle Operation
Total energy	0	0	0	0	0	36.0%	21.0%	43.0%
Fossil fuels	0	0	0	0	0	34.5%	25.9%	39.6%
Coal	0	0	0	0	0	34.7%	19.8%	45.5%
Natural gas	0	0	0	0	0	36.0%	25.2%	38.8%
Petroleum	0	0	0	0	0	13.4%	83.5%	3.1%
Water consumption	0	0	0	0	0	87.6%	12.4%	0.0%
CO2 (VOC, CO, CO2)	0	0	0	0	0	75.3%	24.7%	0.0%
CH4	0	0	0	0	0	63.9%	36.1%	0.0%
N2O	0	0	0	0	0	64.6%	35.4%	0.0%
GHGs	0.191	0.066	0.000	0.257	0	74.4%	25.6%	0.0%
VOC: Total	0.022	0.338	0.000	0.359	0	6.0%	94.0%	0.0%
CO: Total	0.075	0.151	0.000	0.226	0	33.0%	67.0%	0.0%
NOx: Total	0.138	0.070	0.000	0.223	0	68.6%	31.4%	0.0%
PM10: Total	0.021	0.022	0.031	0.075	0	28.3%	29.7%	42.0%
PM2.5: Total	0.012	0.010	0.004	0.026	0	45.5%	38.5%	16.0%
SOx: Total	0.078	0.280	0.000	0.358	0	21.7%	78.3%	0.0%
BC: Total	0.001	0.000	0.000	0.001	0	40.2%	29.9%	29.9%
OC: Total	0.003	0.001	0.001	0.005	0	65.1%	21.8%	13.1%
VOC: Urban	0.001	0.210	0.000	0.211	0	0.7%	99.3%	0.0%
CO: Urban	0.018	0.003	0.000	0.018	0	84.3%	15.7%	0.0%
NOx: Urban	0.041	0.005	0.000	0.047	0	88.5%	11.5%	0.0%
PM10: Urban	0.005	0.001	0.022	0.027	0	16.8%	1.9%	81.3%
PM2.5: Urban	0.004	0.000	0.003	0.007	0	51.5%	6.3%	42.3%
SOx: Urban	0.020	0.004	0.000	0.025	0	82.5%	17.5%	0.0%

Life cycle GHG emissions per mile traveled

Item	Btu/mile or g/mile				Vehicle Cycle Credits	Percentage of each		
	WTP	Vehicle Cycle	Vehicle Operation	Total		WTP	Vehicle Cycle	Vehicle Operation
Total energy	0	0	0	0	0	36.6%	20.8%	42.6%
Fossil fuels	0	0	0	0	0	35.2%	25.6%	39.2%
Coal	0	0	0	0	0	35.4%	19.6%	45.0%
Natural gas	0	0	0	0	0	36.6%	25.0%	38.4%
Petroleum	0	0	0	0	0	15.0%	79.0%	6.0%
Water consumption	0	0	0	0	0	87.7%	12.3%	0.0%
CO2 (VOC, CO, CO2)	0	0	0	0	0	75.6%	24.4%	0.0%
CH4	0	0	0	0	0	64.3%	35.7%	0.0%
N2O	0	0	0	0	0	65.1%	34.9%	0.0%
GHGs	0.194	0.066	0.000	0.260	0	74.7%	25.3%	0.0%
VOC: Total	0.024	0.338	0.000	0.361	0	6.5%	93.5%	0.0%
CO: Total	0.088	0.152	0.000	0.240	0	36.6%	63.4%	0.0%
NOx: Total	0.138	0.070	0.000	0.228	0	69.2%	30.8%	0.0%
PM10: Total	0.022	0.022	0.031	0.076	0	29.6%	29.2%	41.2%
PM2.5: Total	0.012	0.010	0.004	0.027	0	46.8%	37.6%	15.6%
SOx: Total	0.086	0.281	0.000	0.366	0	23.4%	76.6%	0.0%
BC: Total	0.001	0.000	0.000	0.002	0	43.4%	28.5%	28.1%
OC: Total	0.003	0.001	0.001	0.005	0	65.5%	21.6%	12.9%
VOC: Urban	0.001	0.210	0.000	0.211	0	0.8%	99.2%	0.0%
CO: Urban	0.019	0.003	0.000	0.019	0	84.5%	15.5%	0.0%
NOx: Urban	0.047	0.005	0.000	0.047	0	88.6%	11.4%	0.0%
PM10: Urban	0.027	0.001	0.022	0.027	0	17.1%	1.9%	80.9%
PM2.5: Urban	0.007	0.000	0.003	0.007	0	51.8%	6.3%	41.9%
SOx: Urban	0.025	0.004	0.000	0.025	0	82.6%	17.4%	0.0%

Onshore Wind Turbine

Model a Passenger *Car* Battery Electric Vehicle (BEV)
in 2022 Using an *NMC111* Battery Charged from a
Wind Turbine Located Onshore the U.S. *Include*
Infrastructure Emissions



GREAT PLAINS
INSTITUTE

Argonne
NATIONAL LABORATORY

U.S. Department of
ENERGY

Capacity factor

Capacity Factor (CF)

Ratio of the average power output and rated power, affected by the wind speed

Major wind potentials are in the Midwest and Offshore the U.S.

Off-shore average CF > On-shore average CF

Deep water off-shore average CF > shallow water off-shore average CF



**GREAT PLAINS
INSTITUTE**

Argonne
NATIONAL LABORATORY

U.S. Department of
ENERGY

Capacity factor

Capacity Factor Lifetime

The average lifetime of the wind turbine is
20-30 years

Capacity Factor Degradation

CF degrades 85% over the lifetime of the
wind turbine



**GREAT PLAINS
INSTITUTE**

Argonne
NATIONAL LABORATORY

U.S. Department of
ENERGY

Change R&D GREET 2 inputs to a car using an NMC111 battery

File Home Insert Draw Page Layout Formulas Data Review View Automate Help

B3

1 Scenario Control Variables and Input Assumptions Related to Vehicle and its Components

2 1. Selection of Vehicle Types for Simulation

3 -- Passenger Cars

4 2 -- Sport Utility Vehicles

5 3 -- Pick-Up Trucks

7 When the "Passenger Cars" option is selected, select one of the following two vehicles for ICEVs

8 1 -- Passenger Cars 1, 2 -- Passenger Cars 2

10 When the "Sport Utility Vehicles" option is selected, select one of the following two vehicles for ICEVs

11 1 -- Sport Utility Vehicles 1, 2 -- Sport Utility Vehicles 2

13 When the "Pick-Up Trucks" option is selected, select one of the following two vehicles for ICEVs

14 1 -- Pick-Up Trucks 1, 2 -- Pick-Up Trucks 2

16 2. Specification of Total Vehicle Weight, pounds

	ICEV: Conventional Material	ICEV: Lightweight Material	HEV: Conventional Material	HEV: Lightweight Material	PHEV: Conventional Material	Lightweight
	3,183	2,692	3,429	2,839	3,713	

20 3. Vehicle Battery and Fluids Weight, pounds per vehicle

21 3.1) Battery Weight

	ICEV: Conventional Material	ICEV: Lightweight Material	HEV: Conventional Material	HEV: Lightweight Material	PHEV: Conventional Material	Lightweight
Lead-Acid	36.0	23.4	22.1	14.4	22.1	
Ni-MH			89.1	75.3	635.3	
Li-Ion			30.0	25.3	196.6	

Vehi_Inputs Mat_Inputs Car SUV PUT Steel C.Iron W.AI C.AI Lead

File Home Insert Draw Page Layout Formulas Data Review View Automate Help

S122

101 5.5) Li-ion Battery Cathode Material

	2	1. LMO, 2. NMC111, 3.LFP: Hydrothermal, 4. LFP: Solid State, 5. NMC622, 6. NMC811, 7. NMC811, 8. NMC811
HEV	2	1. LMO, 2. NMC111, 3.LFP: Hydrothermal, 4. LFP: Solid State, 5. NMC622, 6. NMC811, 7. NMC811, 8. NMC811
PHEV	2	1. LMO, 2. NMC111, 3.LFP: Hydrothermal, 4. LFP: Solid State, 5. NMC622, 6. NMC811, 7. NMC811, 8. NMC811
EV	2	1. LMO, 2. NMC111, 3.LFP: Hydrothermal, 4. LFP: Solid State, 5. NMC622, 6. NMC811, 7. NMC811, 8. NMC811
FCV	2	1. LMO, 2. NMC111, 3.LFP: Hydrothermal, 4. LFP: Solid State, 5. NMC622, 6. NMC811, 7. NMC811, 8. NMC811

107 5.6) Battery Specific Power

	Ni-MH		Li-Ion		LMO
	W/kg	W/lb	W/kg	W/lb	
HEV	800	363	2,378	1,079	2,050
FCV	800	363	2,513	1,140	1,890

113 5.7) Battery Specific Energy

	Ni-MH		Li-Ion		Li-Ion Ba
	Wh/kg	Wh/lb	Wh/kg	Wh/lb	LMO
PHEV	53	24	174	79	
EV	65	29	186	84	

119 6. Key Input Parameters for Fluids

120 6.1) Fluids Replacements During Lifetime of Vehicle

	Engine Oil	Power Steering Fluid	Brake Fluid	Transmission Fluid	Powertrain Coolant	Windshield Fluid	Ac
	44	0	4	1	4	22	

124 6.2) Ratio of Waste to Product when Fluids is Disposed

	Engine Oil	Power Steering Fluid	Brake Fluid	Transmission Fluid	Powertrain Coolant	Windshield Fluid	Ac
	66.7%	66.7%	66.7%	66.7%	66.7%	0.0%	

128 7. GREET Default Key Assumptions for Vehicle Assembly

Vehi_Inputs Mat_Inputs Car SUV PUT Steel C.Iron W.AI C.AI Lead



Change R&D GREET 1 inputs to a car using a user input electric grid

The image displays two screenshots of the GREET 1 software interface, illustrating the process of changing R&D GREET 1 inputs to a car using a user input electric grid.

Left Screenshot: Scenario Control Variables and Input Assumptions

- Navigation:** Home, Results, Petroleum, MeOH & Hydrogen, Ethanol, Bio Oil, Electric (highlighted), Vehicles, WTP, Fuel Economy, Pyrolysis.
- 1. Key Options for Simulation**
 - 1.1) Target Year for Simulation: 2022
 - 1.2) Point-Estimation or Probability-Estimation Option: Load Stochastic Toolkit
- 2. Vehicle Types for Simulation:** 1 (1 -- Passenger Cars; 2 -- ...)
- 3. Petroleum-Based Fuels**
 - 3.1) Petroleum Recovery Options
 - 3.1.a) Share of crude oil sources: 1

Right Screenshot: 10. Electric Generation

- 10.1) GREET-Calculated or User-Inputted Emission Factors for Power Plants:** 2
- 10.2) Electricity Generation Mix**
 - 10.2.a) Selection of Electricity Generation Mix for Transportation Use: 13
- 10.2.b) Electric Generation Mixes: Data Table for Use in GREET (From Annual Energy Outlook 2023)**

The map shows the following regions: WECC (11), MRO (5), NPCC (6), RFC (7), SPP (9), SERC (8), FRCC (3), ASCC (2), TRE (10), HCC (4).

Data Table for Use in GREET (From Annual Energy Outlook 2023)

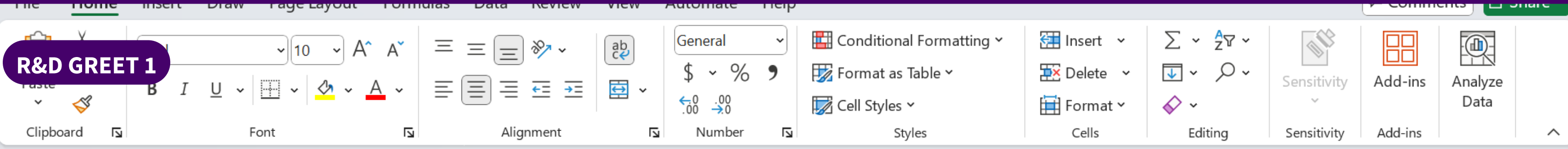
Category	U.S. Mix
Transportation	0.3%
Residual oil	38.5%
Natural gas	



GREAT PLAINS INSTITUTE



R&D GREET 1



Electric_Infra_Option No

806									
807									
808									
809									
810									
811									
812									
813									
814									
815									
816									
817									
818									
819									
820									
821									
822									
823									
824									
825									
826									

Note:
you can optionally include battery storage for solar PV systems

Change R&D GREET 1 inputs to a 100% wind generated transportation

User Defined Mix: Transportation Use

5-year period	Residual Oil	Natural Gas	Coal	Nuclear	Biomass	Others
1990	4.2%	14.3%	52.5%	19.0%	1.1%	10.0%
1995	2.2%	14.8%	51.0%	20.1%		
2000	2.9%	15.8%	51.7%	19.8%		
2005	2.9%	15.7%	51.7%	20.3%		
2010	0.9%	22.7%	46.0%	20.3%		
2013	0.6%	26.2%	40.3%	20.2%		
2014	0.7%	26.2%	39.8%	20.2%		
2015	0.7%	31.6%	34.2%	20.3%		
2016	0.6%	32.7%	31.4%	20.5%		
2017	0.5%	30.6%	31.0%	20.9%	0.4%	16.6%
2018	0.4%	33.4%	29.0%	20.3%	0.3%	16.5%
2019	0.4%	36.7%	24.6%	20.4%	0.3%	17.5%
2020	0.4%	39.6%	20.0%	20.4%	0.3%	19.4%
2021	0.3%	36.5%	23.8%	19.6%	0.3%	19.5%
2022	0.3%	33.5%	20.6%	18.9%	0.3%	21.5%
2025	0.2%	33.5%	18.7%	19.1%	0.3%	29.6%
2030	0.2%	24.7%	8.3%	17.9%	0.2%	48.8%
2035	0.2%	20.6%	7.9%	15.9%	0.2%	55.2%
2040	0.1%	6.8%	13.7%	13.7%	0.2%	57.7%
2045	0.1%	6.0%	13.2%	13.2%	0.2%	59.1%
2050	0.1%	5.0%	12.6%	12.6%	0.2%	61.1%

User Defined Mix: Stationary Use

5-year period	Residual Oil	Natural Gas
1990	4.2%	12.3%
1995	2.2%	14.8%
2000	2.9%	15.8%
2005	2.9%	15.7%
2010	0.9%	22.7%
2013	0.6%	26.2%
2014	0.7%	26.2%
2015	0.7%	31.6%
2016	0.6%	32.7%
2017	0.5%	30.6%
2018	0.4%	33.4%
2019	0.4%	36.7%
2020	0.4%	39.6%
2021	0.3%	36.5%
2022	0.3%	38.5%
2025	0.2%	32.1%
2030	0.2%	24.7%
2035	0.2%	20.6%
2040	0.1%	21.4%
2045	0.1%	21.4%
2050	0.1%	21.0%

User Defined Mix: Transportation Use

5-year period	Hydro	Geothermal	Wind	Solar PV	Others
1990	88.7%	0.0%	1.8%	0.0%	4.8%
1995	88.7%	4.6%	1.8%	0.0%	4.8%
2000	88.7%	4.6%	1.8%	0.0%	4.8%
2005	84.2%	4.6%	5.6%	0.0%	5.6%
2010	67.2%	3.9%	24.4%	0.3%	4.1%
2013	56.5%	3.4%	34.8%	1.0%	2.4%
2014	53.4%	3.2%	36.3%	1.0%	2.4%
2015	50.4%	3.2%	38.0%	1.0%	2.4%
2016	47.6%	2.8%	40.0%	1.0%	2.4%
2017	47.0%	2.5%	39.5%	1.0%	2.4%
2018	43.0%	2.5%	41.4%	1.0%	2.4%
2019	41.7%	2.4%	42.7%	1.0%	2.4%
2020	38.1%	2.1%	45.9%	1.0%	2.4%
2025	33.5%	2.0%	48.5%	1.0%	2.4%
2030	31.4%	1.8%	49.8%	15.3%	1.7%
2035	24.5%	1.4%	41.8%	30.4%	1.9%
2040	14.0%	1.0%	45.1%	37.3%	2.5%
2045	11.5%	1.0%	43.2%	40.0%	4.4%
2050	10.1%	1.1%	40.5%	43.8%	4.6%
2050	9.1%	1.1%	39.0%	46.2%	4.6%
2050	8.0%	1.2%	37.2%	49.1%	4.5%

Press F9

Fill out cells as shown

Press F9

Fill out cells as shown



GREAT PLAINS INSTITUTE



Capacity Factor (CF), Assumed Lifespan, and Recycled Steel Content for Onshore Wind Turbine in U.S.



**GREAT PLAINS
INSTITUTE**



Argonne
NATIONAL LABORATORY



U.S. Department of

ENERGY

R&D GREET 2

Clipboard Font Alignment Number Styles Cells Editing Sensitivity Add-ins Analyze Data

A1 1. Assumptions

A B C D E F G H

1. Assumptions

1.1 Recycled rates

	Wind turbine	
	Virgin Material Product	Recycled Material Product
Steel	70%	30%

1.2 Rated power, technologies and total weight of wind turbines

	Rated power (MW)	Total mass (ton)	Energy consumption in manufacturing, installation, operation and end-of life		
			Electricity (mmbtu)	Diesel (mmbtu)	Natural gas (mmbtu)
On-shore wind turbine (V82)	1.65	1188	167	2294	0
On-shore wind turbine (G87)	2.00	1630	252	4532	0
On-shore wind turbine (V136)	4.20	2385	285	5129	0

1.3 Capacity factor, location, life span of wind turbine

	Locations	Capacity Factor (CF) IEC Clas	Share of installed capacity
Onshore wind turbine	US average, onshore	0.42	99.97%
Offshore wind turbine	US average, offshore-shallow water	0.45	0.03%

	Average degradation of CF over life time	Lifespan of wind turbine (yr)
Value	0.85	25

	Capacity Factor (CF) IEC Class II
Riverside county, CA	0.37
Dupage county, IL	0.34
Palo Alto county, IA	0.49
Taylor county, TX	0.47
Kiowa county, KS	0.55
US average, onshore	0.42
Custom input	0.32

Li_Chemicals Other_Cathodes Battery Recycling Vehi_Comp_Sum Vehi_Sum TEC_Results Electrolyzers Wind_Turbine Solar_PV

File Home Insert Draw Page Layout Formulas Data Review View Automate Help

R&D GREET 2

Clipboard Font Alignment Number Styles Cells Editing Sensitivity Add-ins Analyze Data

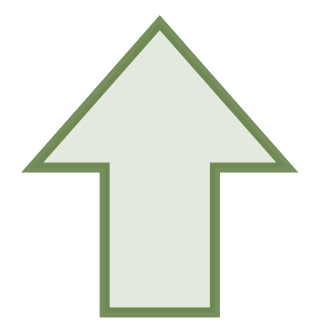
N22

fx

	Rated power (MW)	Total mass (ton)	Foundation concept
Offshore, shallow water	5.00	1642	OC4 Jacket (bottom-fixed foundation)
Offshore, deep water	5.00	1790	SWAY (floating)
Offshore, deep water	5.00	4312	Umaine Semi-S (floating)
Offshore, deep water	5.00	2616	Umaine Spar (floating)
Offshore, deep water	5.00	1438	Umaine TLP (floating)
Offshore, deep water	5.00	1005	MIT TLB (floating)

	Share of installed capacity	
	2020	2025
Onshore wind turbine	100.00%	95.16%
Offshore wind turbine	0.00%	4.84%

	Capacity Factor (CF) IEC Class II
Riverside county, CA	0.37
Dupage county, IL	0.34
Palo Alto county, IA	0.49
Taylor county, TX	0.47
Kiowa county, KS	0.55
US average, onshore	0.42
Custom input	0.32
Offshore, Lake Michigan	0.56
Offshore, Eastern Gulf of Mexico	0.44
Offshore, Offshore Massachusetts &	0.60
US average, offshore-shallow water	0.45



Fill out cells as shown

Li_Chemicals | Other_Cathodes | Battery Recycling | Vehi_Comp_Sum | Vehi_Sum | TEC_Results | Electrolyzers | Wind_Turbine | Solar_PV

Default Installation Type for Small Residential Solar Photovoltaic Systems



**GREAT PLAINS
INSTITUTE**

Argonne
NATIONAL LABORATORY

U.S. Department of
ENERGY

File Home Insert Draw Page Layout Formulas Data Review View Automate Help

R&D GREET 2

Clipboard Font Alignment Number Styles Cells Editing Sensitivity Add-ins Analyze Data

A1 1. Assumptions

	From	US	China	APAC	Europe	Total	
1. Assumptions							
1.1 Silicon and solar PV supply chain and shipping distance							
Solar grade silicon consumed in							
US		100%	0%	0%	0%	100%	
China		1%	79%	8%	11%	100%	
APAC		34%	0%	66%	0%	100%	
Europe		0%	0%	0%	100%	100%	
Ocean shipping distance (mile) to							
US		0	12897	11440	4509		
China		12897	0	2848	12424		
APAC		11440	2848	0	9337		
Europe		4509	12424	9337	0		
1.2 Weight and conversion efficiency of polysilicon PV panels							
		Weight (kg/m ²)				Conversion efficiency	Percentage of installatic
	Silicon wafer	PV cell	PV panel	PV laminate			
Single cSi	0.396	0.468	12.830	10.705	19.5%	83.8%	
Multi cSi	0.419	0.496	13.294	11.169	17.5%	16.2%	
1.3 Solar irradiation and location							
Location	Global tilted irradiation at optimum angle (kWh/m ² /yr)						

File Home Insert Draw Page Layout Formulas Data Review View Automate Help

R&D GREET 2

Clipboard Font Alignment Number Styles Cells Editing Sensitivity Add-ins Analyze Data

A1 1. Assumptions

1.3 Solar irradiation and location		Global tilted irradiation at optimum angle (kWh/m2/yr)	
Location			
US average (pop-weighted)		1796	
US average (pop-weighted)		1796	
Boston, MA		1707	
Chicago, IL		1658	
San Francisco, CA		2103	
Columbia, SC		1931	
Corpus Christi, TX		1954	
Customer input		1254	

Solar irradiation are available in <https://globalsolaratlas.info/>

1.4 Key parameters of solar PV system		Small residential system			Selected installation type for small residential system	Utility/commercial system	
Installation		Façade	Flat roof	Slanted roof	Slanted roof	Flat roof	Slanted roof
Lifespan (yr)		30	30	30	30	30	30
Performance ratio		0.75	0.75	0.75	0.75	0.77	0.77
Annual average irradiation on tilted panels (kWh/m2/yr)		1162	1654	1654	1654	1654	1654
Average yield (kWh/kWp)		871	1241	1241	1241	1271	1271
Average degradation rate per year (%)		0.70%	0.70%	0.70%	0.7%	0.70%	0.70%
Lifetime average degradation		0.895	0.895	0.895	0.895	0.895	0.895
Average yield (include degradation, kWh/kWp)		780	1111	1111	1111	1137	1137

1.5 PV electric system and montage

Cradle-to-Grave (C2G) GHG Emissions



**GREAT PLAINS
INSTITUTE**



Argonne
NATIONAL LABORATORY



U.S. Department of

ENERGY

Item	Btu/mile or g/mile				Percentage of each stage				
	WTP	Vehicle Cycle	Vehicle Operation	Vehicle Cycle Credits	WTP	Vehicle Cycle	Vehicle Operation	Total	Vehicle Cycle Credits
Total energy	109	905			4.9%	40.5%	54.7%	100.0%	0.0%
Fossil fuels	3	812			0.4%	95.0%	4.6%	100.0%	0.0%
Coal	1	232			0.5%	93.5%	6.0%	100.0%	0.0%
Natural gas	1	472			0.2%	97.4%	2.4%	100.0%	0.0%
Petroleum	1	108			0.9%	88.6%	10.5%	100.0%	0.0%
Water consumption	0.004	0.086			4.1%	95.9%	0.0%	100.0%	0.0%
CO2 (VOC, CO, CO2)	3	58			5.7%	94.3%	0.0%	100.0%	0.0%
CH4	0.006	0.211			2.7%	97.3%	0.0%	100.0%	0.0%
N2O	0.000	0.002	0.000	0.002	3.2%	96.8%	0.0%	100.0%	0.0%
GHGs	4	65	0	68	5.4%	94.6%	0.0%	100.0%	0.0%
VOC: Total	0.002	0.193	0.000	0.196	1.2%	98.8%	0.0%	100.0%	0.0%
CO: Total	0.014	0.151	0.000	0.165	8.5%	91.5%	0.0%	100.0%	0.0%
NOx: Total	0.004	0.067	0.000	0.071	5.6%	94.4%	0.0%	100.0%	0.0%
PM10: Total	0.002	0.027	0.031	0.059	2.8%	45.2%	51.9%	100.0%	0.0%
PM2.5: Total	0.001	0.010	0.004	0.015	5.0%	68.6%	26.5%	100.0%	0.0%
SOx: Total	0.008	0.218	0.000	0.226	3.4%	96.6%	0.0%	100.0%	0.0%
BC: Total	0.000	0.000	0.001	0.001	1.9%	42.9%	55.2%	100.0%	0.0%
OC: Total	0.000	0.001	0.001	0.002	2.7%	58.0%	39.3%	100.0%	0.0%
VOC: Urban	0.000	0.111	0.000	0.111	0.2%	99.8%	0.0%	100.0%	0.0%
CO: Urban	0.000	0.003	0.000	0.003	6.5%	93.5%	0.0%	100.0%	0.0%
NOx: Urban	0.000	0.005	0.000	0.006	5.7%	94.3%	0.0%	100.0%	0.0%
PM10: Urban	0.000	0.001	0.021	0.022	0.5%	2.4%	97.1%	100.0%	0.0%
PM2.5: Urban	0.000	0.000	0.003	0.003	1.5%	13.2%	85.3%	100.0%	0.0%
SOx: Urban	0.000	0.004	0.000	0.005	4.7%	95.3%	0.0%	100.0%	0.0%

C2G GHG emissions
68 g CO₂e/mile

2022 car BEV with onshore wind electricity including infrastructure emissions

Offshore Wind Turbine

Model a Passenger Car Battery Electric Vehicle (BEV)
in 2022 Using an NMC111 Battery Charged from a
Wind Turbine Located Offshore the U.S. in Deep
Water. *Include Infrastructure Emissions*



GREAT PLAINS
INSTITUTE

Argonne
NATIONAL LABORATORY

U.S. Department of
ENERGY

Change R&D GREET 2 inputs to a car using an NMC111 battery

File Home Insert Draw Page Layout Formulas Data Review View Automate Help

B3

1 Scenario Control Variables and Input Assumptions Related to Vehicle and its Components

2 1. Selection of Vehicle Types for Simulation

3 -- Passenger Cars

4 2 -- Sport Utility Vehicles

5 3 -- Pick-Up Trucks

7 When the "Passenger Cars" option is selected, select one of the following two vehicles for ICEVs

8 1 -- Passenger Cars 1, 2 -- Passenger Cars 2

10 When the "Sport Utility Vehicles" option is selected, select one of the following two vehicles for ICEVs

11 1 -- Sport Utility Vehicles 1, 2 -- Sport Utility Vehicles 2

13 When the "Pick-Up Trucks" option is selected, select one of the following two vehicles for ICEVs

14 1 -- Pick-Up Trucks 1, 2 -- Pick-Up Trucks 2

16 2. Specification of Total Vehicle Weight, pounds

	ICEV: Conventional Material	ICEV: Lightweight Material	HEV: Conventional Material	HEV: Lightweight Material	PHEV: Conventional Material	Lightweight
	3,183	2,692	3,429	2,839	3,713	

20 3. Vehicle Battery and Fluids Weight, pounds per vehicle

21 3.1) Battery Weight

	ICEV: Conventional Material	ICEV: Lightweight Material	HEV: Conventional Material	HEV: Lightweight Material	PHEV: Conventional Material	Lightweight
Lead-Acid	36.0	23.4	22.1	14.4	22.1	
Ni-MH			89.1	75.3	635.3	
Li-Ion			30.0	25.3	196.6	

Ready Calculate Accessibility: Investigate

File Home Insert Draw Page Layout Formulas Data Review View Automate Help

S122

101 5.5) Li-ion Battery Cathode Material

		1. LMO	2. NMC111	3. LFP: Hydrothermal	4. LFP: Solid State	5. NMC622	6. NMC811	7. NMC111
HEV	<input type="text" value="2"/>							
PHEV	<input type="text" value="2"/>							
EV	<input type="text" value="2"/>							
FCV	<input type="text" value="2"/>							

107 5.6) Battery Specific Power

	Ni-MH		Li-Ion		LMO
	W/kg	W/lb	W/kg	W/lb	
HEV	800	363	2,378	1,079	2,050
FCV	800	363	2,513	1,140	1,890

113 5.7) Battery Specific Energy

	Ni-MH		Li-Ion		LMO
	Wh/kg	Wh/lb	Wh/kg	Wh/lb	
PHEV	53	24	174	79	
EV	65	29	186	84	

119 6. Key Input Parameters for Fluids

120 6.1) Fluids Replacements During Lifetime of Vehicle

	Engine Oil	Power Steering Fluid	Brake Fluid	Transmission Fluid	Powertrain Coolant	Windshield Fluid
	44	0	4	1	4	22

124 6.2) Ratio of Waste to Product when Fluids is Disposed

	Engine Oil	Power Steering Fluid	Brake Fluid	Transmission Fluid	Powertrain Coolant	Windshield Fluid
	66.7%	66.7%	66.7%	66.7%	66.7%	0.0%

128 7. GREET Default Key Assumptions for Vehicle Assembly

Ready Calculate Accessibility: Investigate



Change R&D GREET 1 inputs to a car using a user input electric grid

File Home Insert Draw Page Layout Formulas Data Review View Automate Help

Paste Clipboard Font Alignment Number

K15

Home Results Petroleum MeOH & Ethanol **Electric** Vehicles
Natural Gas Hydrogen Bio Oil Pyrolysis WTP 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

2. Vehicle Types for Simulation

1 -- Passenger Cars; 2 --

3. Petroleum-Based Fuels

3.1) Petroleum Recovery Options

3.1.a) Share of crude oil sources: 1

	Basis of share of crude oil
EIA projection	U.S. Domestic
User defined	80.0%
Used in calculation	80.0%
API gravity	30.0
S Content (wt %)	
Average transportation distances (mi)	See T&D Flowcharts

Inputs Results Petroleum Co_processing NG MeOH_FTD EtOH Electric Genera

File Home Insert Draw Page Layout Formulas Data Review View Automate Help

Paste Clipboard Font Alignment Number Styles

K15

10. Electric Generation

10.1) GREET-Calculated or User-Inputted Emission Factors for Power Plants: 2

10.2) Electricity Generation Mix

10.2.a) Selection of Electricity Generation Mix for Transportation Use: 13

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

	U.S. Mix
Residual oil	Transportation 0.3%
Natural gas	38.5%

Inputs Results Petroleum Co_processing NG MeOH_FTD EtOH Electric Genera

R&D GREET 1

Microsoft Excel ribbon: Home, Insert, Draw, Page Layout, Formulas, Data, Review, View, Automate, Help. Font: 10, Bold, Italic, Underline, Paragraph, Styles. Number: General, Currency, Percentage, Decimals. Cells: Conditional Formatting, Format as Table, Cell Styles, Insert, Delete, Format. Editing: Undo, Redo, Find, Replace, Sensitivity. Add-ins: Add-ins. Analyze Data: Analyze Data.

Formula bar: Electric_Infra_Option No

806									
807									
808									
809									
810									
811									
812									
813									
814									
815									
816									
817									
818									
819									
820									
821									
822									
823									
824									
825									
826									
827									
828									
829									
830									
831									
832									
833									
834									
835									

10.4) Share of Feedstock for Biomass Power Plants

Willow	Poplar	Switchgrass	Miscanthus	Forest Residue
0.0%	0.0%	0.0%	0.0%	100.0%

10.5) Share of Geothermal Technologies and Fugitive CO2 emissions from geofluid

Shares of Geothermal Technologies	Hydrothermal-Flash	Hydrothermal-Binary	Geothermal-EGS
	100.0%	0.0%	0.0%
Fugitive CO2 emissions from geofluid (g CO2/kWh)	91	0	0

10.6) Energy Use of Power Plant Construction Materials

No Yes

To consider energy and emissions for infrastructure of power plants?

To include battery storage for solar PV system?

10.7) The Types

10.7.a) NG-Based Fuel Plants (Including NG to MeOH, DME, FT Diesel, FT Naphtha, and H2)

1

1-- Electricity generation mix (Could be U.S. mix, NE U.S. mix, CA mix, or user defined mix, which is defined for stationary use in sec
2-- NGCC electricity
3-- Coal IGCC electricity
4-- Biomass IGCC electricity

10.7.b) Biomass-Based Fuel Plants (Including Biomass to EtOH, MeOH, DME, FT Diesel, and H2)

1

1-- Electricity generation mix (Could be U.S. mix, NE U.S. mix, CA mix, or user defined mix, which is defined for stationary use in sec
2-- NGCC electricity
3-- Biomass IGCC electricity

10.7.c) Coal-Based Fuel Plants (Including Coal to H2, and MeOH, DME, and FT Diesel)

1

1-- Electricity generation mix (Could be U.S. mix, NE U.S. mix, CA mix, or user defined mix, which is defined for stationary use in sec
2-- NGCC electricity
3-- Coal IGCC electricity

10.7.d) Pet Coke-Based Fuel Plants (Including Pet Coke to H2)

1

1-- Electricity generation mix (Could be U.S. mix, NE U.S. mix, CA mix, or user defined mix, which is defined for stationary use in sec
2-- NGCC electricity

Navigation bar: Inputs, Results, Petroleum, Co_processing, NG, MeOH_FTD, EtOH, Electric, Generation_mixes, Bio_electricity

Change R&D GREET 1 inputs to a 100% wind generated transportation

User Defined Mix: Transportation Use

5-year period	Residual Oil	Natural Gas	Coal	Nuclear	Biomass	Others
1990	4.2%	14.3%	52.5%	19.0%	1.1%	10.0%
1995	2.2%	14.8%	51.0%	20.1%		
2000	2.9%	15.8%	51.7%	19.8%		
2005	2.9%	15.7%	51.7%	20.3%		
2010	0.9%	22.7%	46.0%	20.3%		
2013	0.6%	26.2%	40.3%	20.2%		
2014	0.7%	26.2%	39.8%	20.2%		
2015	0.7%	31.6%	34.2%	20.3%		
2016	0.6%	32.7%	31.4%	20.5%		
2017	0.5%	30.6%	31.0%	20.9%	0.4%	16.6%
2018	0.4%	33.4%	29.0%	20.3%	0.3%	16.5%
2019	0.4%	36.7%	24.6%	20.4%	0.3%	17.5%
2020	0.4%	39.6%	20.0%	20.4%	0.3%	19.4%
2021	0.3%	36.5%	23.8%	19.6%	0.3%	19.5%
2022	0.3%	33.3%	20.6%	18.9%	0.3%	21.5%
2025	0.2%	33.3%	18.7%	19.1%	0.3%	29.6%
2030	0.2%	24.7%	8.3%	17.9%	0.2%	48.8%
2035	0.2%	20.6%	7.9%	15.9%	0.2%	55.2%
2040	0.2%	6.8%	13.7%	13.7%	0.2%	57.7%
2045	0.2%	6.0%	13.2%	13.2%	0.2%	59.1%
2050	0.2%	5.0%	12.6%	12.6%	0.2%	61.1%

User Defined Mix: Stationary Use

5-year period	Residual Oil	Natural Gas
1990	4.2%	12.3%
1995	2.2%	14.8%
2000	2.9%	15.8%
2005	2.9%	15.7%
2010	0.9%	22.7%
2013	0.6%	26.2%
2014	0.7%	26.2%
2015	0.7%	31.6%
2016	0.6%	32.7%
2017	0.5%	30.6%
2018	0.4%	33.4%
2019	0.4%	36.7%
2020	0.4%	39.6%
2021	0.3%	36.5%
2022	0.3%	38.5%
2025	0.2%	32.1%
2030	0.2%	24.7%
2035	0.2%	20.6%
2040	0.1%	21.4%
2045	0.1%	21.4%
2050	0.1%	21.0%

User Defined Mix: Transportation Use

5-year period	Hydroelectric	Geothermal	Wind	Solar PV	Others
1990	88.7%	0.0%	1.8%	0.0%	4.8%
1995	88.7%	4.6%	1.8%	0.0%	4.8%
2000	88.7%	4.6%	1.8%	0.0%	4.8%
2005	84.2%	4.6%	5.6%	0.0%	5.6%
2010	67.2%	3.9%	24.4%	0.3%	4.1%
2013	56.5%	3.4%	34.8%	1.0%	2.4%
2014	53.4%	3.2%	36.3%	1.0%	2.4%
2015	50.4%	3.2%	38.0%	1.0%	2.4%
2016	47.6%	2.8%	40.0%	1.0%	2.4%
2017	47.0%	2.5%	39.5%	1.0%	2.4%
2018	43.0%	2.5%	41.4%	1.0%	2.4%
2019	41.7%	2.4%	42.7%	1.0%	2.4%
2020	38.1%	2.1%	45.9%	1.0%	2.4%
2025	33.5%	2.0%	48.5%	1.0%	2.4%
2030	31.4%	1.8%	49.8%	15.3%	1.7%
2035	24.5%	1.4%	41.8%	30.4%	1.9%
2040	14.0%	1.0%	45.1%	37.3%	2.5%
2045	11.5%	1.0%	43.2%	40.0%	4.4%
2050	10.1%	1.1%	40.5%	43.8%	4.6%

Taskbar Buttons: Hydrogen, BioOil, Algae, Macroalgae, Waste, RNG, Pyrolysis_IDL, IBR, E_fuel, Fuel_Prod_TS, EF_TS, AgMining_EF_TS, EF, WCF, Fuel_Specs, Car_T



GREAT PLAINS INSTITUTE



File Home Insert Draw Page Layout Formulas Data Review View Automate Help

R&D GREET 2

Clipboard Font Alignment Number Styles Cells Editing Sensitivity Add-ins Analyze Data

O21

	Rated power (MW)	Total mass (ton)	Foundation concept
Offshore, shallow water	5.00	1642	OC4 Jacket (bottom-fixed foundation)
Offshore, deep water	5.00	1790	SWAY (floating)
Offshore, deep water	5.00	4312	Umaine Semi-S (floating)
Offshore, deep water	5.00	2616	Umaine Spar (floating)
Offshore, deep water	5.00	1438	Umaine TLP (floating)
Offshore, deep water	5.00	1005	MIT TLB (floating)

	Share of installed capacity	
	2020	2025
Onshore wind turbine	0.00%	95.16%
Offshore wind turbine	100.00%	4.84%

	Capacity Factor (CF) IEC Class II
Riverside county, CA	0.37
Dupage county, IL	0.34
Palo Alto county, IA	0.49
Taylor county, TX	0.47
Kiowa county, KS	0.55
US average, onshore	0.42
Custom input	0.32
...	0.56
...	0.44
...	0.60
...	0.45

Press F9

1



Fill out cells as shown

File Home Insert Draw Page Layout Formulas Data Review View Automate Help

R&D GREET 2

Paste B I U Font Alignment Number Styles Cells Editing Sensitivity Add-ins Analyze Data

B24 US average, offshore-shallow water

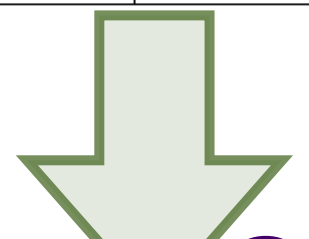
7
8

9 **1.2 Rated power, technologies and total weight of wind turbines**

	Rated power (MW)	Total mass (ton)	Energy consumption in manufacturing, installation, operation and end-of life		
			Electricity (mmbtu)	Diesel (mmbtu)	Natural gas (mmbtu)
On-shore wind turbine (V82)	1.65	1188	167	2294	0
On-shore wind turbine (G87)	2.00	1630	252	4532	0
On-shore wind turbine (V136)	4.20	2385	285	5129	0

20 **1.3 Capacity factor, location, life span of wind turbine**

	Locations	Capacity factor (CF)	IEC Class	Share of installed capacity
Onshore wind turbine	US average, onshore	0.42		0.00%
Offshore wind turbine	US average, offshore-shallow water	0.45		100.00%



1

- Custom input
- Offshore, Lake Michigan
- Offshore, Eastern Gulf of Mexico
- Offshore, Offshore Massachusetts & Rhode Island
- US average, offshore-shallow water
- US average, offshore-deep water

2



Value	Life span of wind turbine (yr)
Onshore wind turbine	154.68627000
Offshore wind turbine	419

	Capacity Factor (CF) IEC Class II
Riverside county, CA	0.37
Dupage county, IL	0.34
Palo Alto county, IA	0.49
Taylor county, TX	0.47
Kiowa county, KS	0.55
US average, onshore	0.42
Custom input	0.32
Offshore, Lake Michigan	0.56
Offshore, Eastern Gulf of Mexico	0.44
Offshore, Offshore Massachusetts &	0.60
US average, offshore-shallow water	0.45

3

Press F9

Capacity Factor (CF) for Offshore Wind Turbine in Deep Water



**GREAT PLAINS
INSTITUTE**

Argonne
NATIONAL LABORATORY

U.S. Department of
ENERGY

R&D GREET 2

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

L24

Worksheet grid headers: A, B, C, D, E, F, G, H

1.2 Rated power, technologies and total weight of wind turbines

	Rated power (MW)	Total mass (ton)	Energy consumption in manufacturing, installation, operation and end-of life		
			Electricity (mmbtu)	Diesel (mmbtu)	Natural gas (mmbtu)
On-shore wind turbine (V82)	1.65	1188	167	2294	0
On-shore wind turbine (G87)	2.00	1630	252	4532	0
On-shore wind turbine (V136)	4.20	2385	285	5129	0

1.3 Capacity factor, location, life span of wind turbine

	Locations	Capacity Factor (CF) IEC Clas	Share of installed capacity
Onshore wind turbine	US average, onshore	0.42	0.00%
Offshore wind turbine	US average, offshore-deep water	0.47	100.00%

	Average degradation of CF over life time	Lifespan of wind turbine (yr)
Value	0.85	25

	Total electricity generation (GWh)
Onshore wind turbine	154.68627000
Offshore wind turbine	438

	Capacity Factor (CF) IEC Class II
Riverside county, CA	0.37
Dupage county, IL	0.34
Palo Alto county, IA	0.49
Taylor county, TX	0.47
Kiowa county, KS	0.55
US average, onshore	0.42
Custom input	0.32
Offshore, Lake Michigan	0.56
Offshore, Eastern Gulf of Mexico	0.44
Offshore, Offshore Massachusetts &	0.60
US average, offshore-shallow water	0.45

Navigation bar: Li_Chemicals, Other_Cathodes, Battery Recycling, Vehi_Comp_Sum, Vehi_Sum, TEC_Results, Electrolyzers, Wind_Turbine, Solar_PV

Cradle-to-Grave (C2G) GHG Emissions



**GREAT PLAINS
INSTITUTE**

Argonne
NATIONAL LABORATORY

U.S. Department of
ENERGY

Item	Btu/mile or g/mile				Percentage of each stage				
	WTP	Vehicle Cycle	Vehicle Operation	Vehicle Cycle Credits	WTP	Vehicle Cycle	Vehicle Operation	Total	Vehicle Cycle Credits
Total energy	117	905	0	0	5.2%	40.3%	54.5%	100.0%	0.0%
Fossil fuels	4	812	0	0	0.5%	94.1%	5.4%	100.0%	0.0%
Coal	2	232	0	0	0.7%	92.2%	7.1%	100.0%	0.0%
Natural gas	1	472	0	0	0.3%	97.0%	2.7%	100.0%	0.0%
Petroleum	1	108	0	0	1.2%	86.4%	12.4%	100.0%	0.0%
Water consumption	0.003	0.086	0	0	3.1%	96.9%	0.0%	100.0%	0.0%
CO2 (VOC, CO, CO2)	4	58	0	0	6.8%	93.2%	0.0%	100.0%	0.0%
CH4	0.007	0.211	0	0	3.2%	96.8%	0.0%	100.0%	0.0%
N2O	0.000	0.002	0.000	0	3.5%	96.5%	0.0%	100.0%	0.0%
GHGs	4	65	0	0	6.4%	93.6%	0.0%	100.0%	0.0%
VOC: Total	0.003	0.193	0.000	0	1.5%	98.5%	0.0%	100.0%	0.0%
CO: Total	0.020	0.151	0.000	0	11.8%	88.2%	0.0%	100.0%	0.0%
NOx: Total	0.005	0.067	0.000	0	6.4%	93.6%	0.0%	100.0%	0.0%
PM10: Total	0.002	0.027	0.031	0	3.3%	45.0%	51.7%	100.0%	0.0%
PM2.5: Total	0.001	0.011	0.004	0	5.9%	67.9%	26.2%	100.0%	0.0%
SOx: Total	0.010	0.218	0.000	0	4.5%	95.5%	0.0%	100.0%	0.0%
BC: Total	0.000	0.000	0.001	0	2.1%	42.8%	55.1%	100.0%	0.0%
OC: Total	0.000	0.001	0.001	0	3.1%	57.8%	39.1%	100.0%	0.0%
VOC: Urban	0.000	0.111	0.000	0	0.1%	99.9%	0.0%	100.0%	0.0%
CO: Urban	0.000	0.003	0.000	0	4.0%	96.0%	0.0%	100.0%	0.0%
NOx: Urban	0.000	0.005	0.000	0	4.1%	95.9%	0.0%	100.0%	0.0%
PM10: Urban	0.000	0.001	0.021	0	0.1%	2.4%	97.5%	100.0%	0.0%
PM2.5: Urban	0.000	0.000	0.003	0	0.7%	13.3%	86.0%	100.0%	0.0%
SOx: Urban	0.000	0.004	0.000	0	4.0%	96.0%	0.0%	100.0%	0.0%

C2G GHG emissions
69 g CO₂e/mile

2022 car BEV with offshore wind electricity including infrastructure emissions

Onshore wind electricity

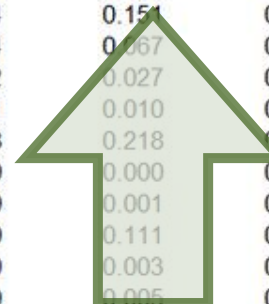
Offshore deep-water wind electricity

Energy Use and Emissions of Well-to-Pump, Vehicle Cycle and

Item	Btu/mile or g/mile				Vehicle Cycle Credits	Percentage of each		
	WTP	Vehicle Cycle	Vehicle Operation	Total		WTP	Vehicle Cycle	Vehicle Operation
Total energy	0.000	0.002	0.000	0.002	0	4.9%	40.5%	54.7%
Fossil fuels	0.000	0.002	0.000	0.002	0	0.4%	95.0%	4.6%
Coal	0.000	0.002	0.000	0.002	0	0.5%	93.5%	6.0%
Natural gas	0.000	0.002	0.000	0.002	0	0.2%	97.4%	2.4%
Petroleum	0.000	0.002	0.000	0.002	0	0.9%	88.6%	10.5%
Water consumption	0.000	0.000	0.000	0.000	0	4.1%	95.9%	0.0%
CO2 (VOC, CO, CO2)	0.000	0.002	0.000	0.002	0	5.7%	94.3%	0.0%
CH4	0.000	0.000	0.000	0.000	0	2.7%	97.3%	0.0%
N2O	0.000	0.000	0.000	0.000	0	3.2%	96.8%	0.0%
GHGs	0.000	0.002	0.000	0.002	0	5.4%	94.6%	0.0%
VOC: Total	0.002	0.193	0.000	0.196	0	1.2%	98.8%	0.0%
CO: Total	0.014	0.151	0.000	0.165	0	8.5%	91.5%	0.0%
NOx: Total	0.004	0.067	0.000	0.071	0	5.6%	94.4%	0.0%
PM10: Total	0.002	0.027	0.031	0.059	0	2.8%	45.2%	51.9%
PM2.5: Total	0.001	0.010	0.004	0.015	0	5.0%	68.6%	26.5%
SOx: Total	0.008	0.218	0.000	0.226	0	3.4%	96.6%	0.0%
BC: Total	0.000	0.000	0.001	0.001	0	1.9%	42.9%	55.2%
OC: Total	0.000	0.001	0.001	0.002	0	2.7%	58.0%	39.3%
VOC: Urban	0.000	0.111	0.000	0.111	0	0.2%	99.8%	0.0%
CO: Urban	0.000	0.003	0.000	0.003	0	6.5%	93.5%	0.0%
NOx: Urban	0.000	0.005	0.000	0.006	0	5.7%	94.3%	0.0%
PM10: Urban	0.000	0.001	0.021	0.022	0	0.5%	2.4%	97.1%
PM2.5: Urban	0.000	0.000	0.003	0.003	0	1.5%	13.2%	85.3%
SOx: Urban	0.000	0.004	0.000	0.005	0	4.7%	95.3%	0.0%

Ready Calculate Accessibility: Investigate

Life cycle GHG emissions per mile traveled

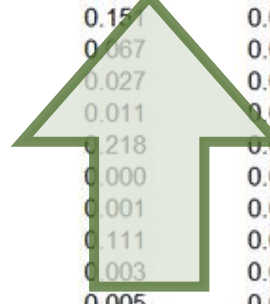


Energy Use and Emissions of Well-to-Pump, Vehicle Cycle and

Item	Btu/mile or g/mile				Vehicle Cycle Credits	Percentage of each		
	WTP	Vehicle Cycle	Vehicle Operation	Total		WTP	Vehicle Cycle	Vehicle Operation
Total energy	0.000	0.002	0.000	0.002	0	5.2%	40.3%	54.5%
Fossil fuels	0.000	0.002	0.000	0.002	0	0.5%	94.1%	5.4%
Coal	0.000	0.002	0.000	0.002	0	0.7%	92.2%	7.1%
Natural gas	0.000	0.002	0.000	0.002	0	0.3%	97.0%	2.7%
Petroleum	0.000	0.002	0.000	0.002	0	1.2%	86.4%	12.4%
Water consumption	0.000	0.000	0.000	0.000	0	3.1%	96.9%	0.0%
CO2 (VOC, CO, CO2)	0.000	0.002	0.000	0.002	0	6.8%	93.2%	0.0%
CH4	0.000	0.000	0.000	0.000	0	3.2%	96.8%	0.0%
N2O	0.000	0.000	0.000	0.000	0	3.5%	96.5%	0.0%
GHGs	0.000	0.002	0.000	0.002	0	6.4%	93.6%	0.0%
VOC: Total	0.003	0.193	0.000	0.196	0	1.5%	98.5%	0.0%
CO: Total	0.020	0.151	0.000	0.171	0	11.8%	88.2%	0.0%
NOx: Total	0.005	0.067	0.000	0.072	0	6.4%	93.6%	0.0%
PM10: Total	0.002	0.027	0.031	0.059	0	3.3%	45.0%	51.7%
PM2.5: Total	0.001	0.011	0.004	0.015	0	5.9%	67.9%	26.2%
SOx: Total	0.010	0.218	0.000	0.228	0	4.5%	95.5%	0.0%
BC: Total	0.000	0.000	0.001	0.001	0	2.1%	42.8%	55.1%
OC: Total	0.000	0.001	0.001	0.002	0	3.1%	57.8%	39.1%
VOC: Urban	0.000	0.111	0.000	0.111	0	0.1%	99.9%	0.0%
CO: Urban	0.000	0.003	0.000	0.003	0	4.0%	96.0%	0.0%
NOx: Urban	0.000	0.005	0.000	0.006	0	4.1%	95.9%	0.0%
PM10: Urban	0.000	0.001	0.021	0.022	0	0.1%	2.4%	97.5%
PM2.5: Urban	0.000	0.000	0.003	0.003	0	0.7%	13.3%	86.0%
SOx: Urban	0.000	0.004	0.000	0.005	0	4.0%	96.0%	0.0%

Ready Calculate Accessibility: Investigate

Life cycle GHG emissions per mile traveled



GREAT PLAINS INSTITUTE

Argonne NATIONAL LABORATORY

U.S. Department of **ENERGY**

Questions?

hcai@anl.gov

golson@gpisd.net

Visit <https://greet.anl.gov/>

Contributors

Gabrielle Olson, Branden Leonhardt, Zifeng Lu,
Longwen Ou, and Hao Cai



**GREAT PLAINS
INSTITUTE**

Argonne
NATIONAL LABORATORY

U.S. Department of
ENERGY

THANK YOU



**GREAT PLAINS
INSTITUTE**



Argonne
NATIONAL LABORATORY



U.S. Department of
ENERGY