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GREET TRAINING WORKSHOP



Life-Cycle Analysis (LCA) with the GREET® Model

GREET .Net Platform Introduction & Demonstration

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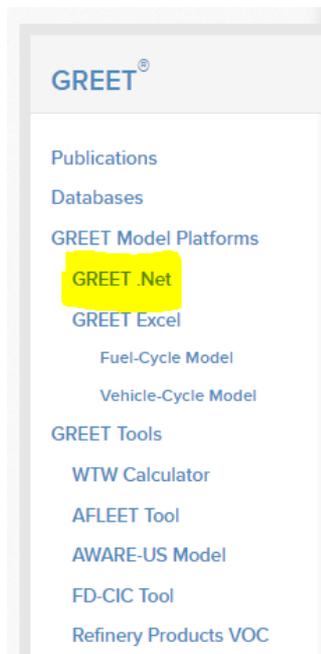
Why a New Platform?

- **To develop a general platform for LCA that is**
 - adaptable to a broad range of applications
 - expandable to include new pathways and expanded boundaries
 - transparent to enhance usability and maintain credibility
- **To overcome the limitations of the GREET Excel Platform, e.g.,**
 - Hard to find a specific process, pathway, mix, or vehicle
 - Time consuming to build a new process, pathway, and mix
 - Easy to make mistakes due to the flexibility of the Excel
 - Pay attention to functional unit in each step and unit conversions
 - Hard to update your own file when a new version of the GREET Excel is released
- **GREET .Net platform ...**
 - provides an easy to use, fully graphical, and interactive interface
 - allows users to quickly develop each element in the model and perform LCA
 - applies the same LCA method with the GREET Excel platform with a faster algorithm for model calculation
 - derives consistent results with the Excel platform

GREET .Net Download and Installation

- GREET.Net application can be only installed in Windows OS
- Requires the Microsoft .NET Framework 4.5 or newer version installed

<https://greet.es.anl.gov/index.php?content=greetdotnet>



A fresh design for GREET life cycle analysis tool

GREET® 2022 .Net software provides the user with an easy to use and fully graphical toolbox to perform life cycle analysis simulations of alternative transportation fuels and vehicle technologies in a matter of a few clicks. This new tool includes the data of the GREET Excel models, a fast algorithm for processing it and an interactive user interface. The interface allows faster development using graphical representation of each element in the model, and drag & drop editing approach to add and modify data.

Note: The GREET.Net software can be only installed in Windows OS with Microsoft .Net Framework 4.5 installed.

DOWNLOAD the new GREET® 2022 .Net software

DOI: [10.11578/GREET-Net-2022/dc.20220908.2](https://doi.org/10.11578/GREET-Net-2022/dc.20220908.2)

The most recent version of GREET.Net data file is **13991**.

The data file version can be checked or updated through "Database" → "Check for data updates"

For more information on the updates of this release, please refer to [Versions](#) or read [Summary of Expansions and Updates in GREET® 2022](#) (793KB pdf).

GREET .Net Resources

▪ YouTube channel and a series of tutorial videos

https://www.youtube.com/watch?v=BrqRhJ3qRml&list=PLLT1SPoEVQqxWRoFTABWU_ibyLSpS18pO

- Installation
- Introduction of GREET.Net GUI
- Explore WTP/WTW/C2G results
- Edit resource, emission, technology, process, pathway, mix, vehicle, etc.

▪ Online documents

– <https://greet.es.anl.gov/index.php?content=greetdotnet>

▪ GREET .Net software

- GREET-Model.pdf
 - Mathematical methods
- GREET-Manual.pdf
 - How to use the model

YouTube

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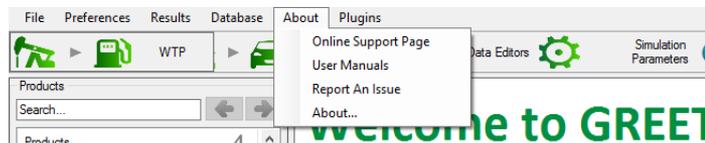
Tutorials: GREET Excel

VIEW FULL PLAYLIST

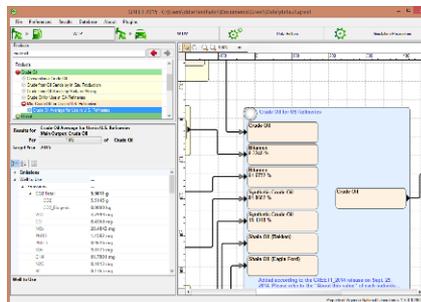
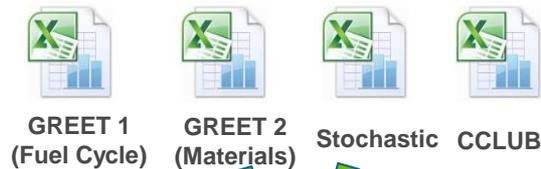


Tutorials: GREET .NET

VIEW FULL PLAYLIST



GREET .Net Model Design



GREET.Net integrates all databases in Excel Models

Local .greet file only stores data sets

Local GREET application only implements GREET methodology

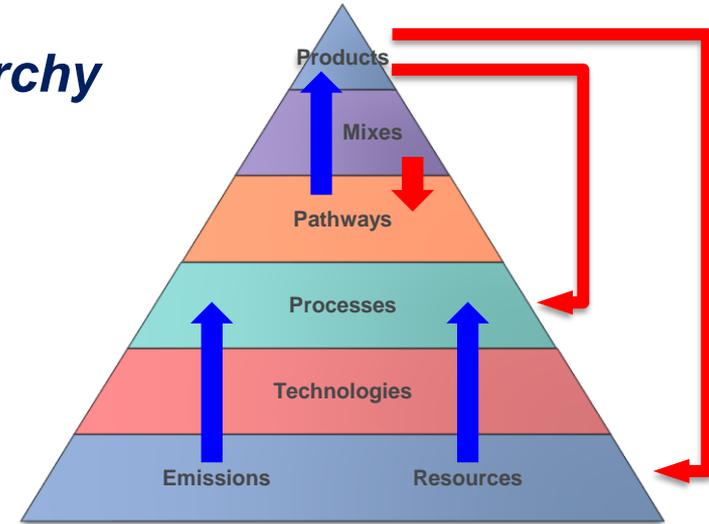


GREET.Net separates datasets and methodology



GREET .Net Terminology & Concepts Hierarchy

- **Emissions**
 - Greenhouse gases and air pollutants
- **Resources**
 - Inputs & outputs: fuels, materials, energy, products, items, etc.
- **Technologies**
 - Defined on top of the emissions and resources
 - Equipment, e.g., boiler, engine, turbine
 - Consume resources (e.g., fuels) and produce emissions
- **Processes**
 - Basic building blocks for pathways and pathway mixes
 - Define inputs, outputs, and their relationship in a step
 - May employ technologies and emissions
- **Pathways**
 - A series of processes towards products production
- **Pathway Mixes**
 - A proportional combination of multiple pathways which produce a same product
 - Energy, mass, or volume shares can be defined to reflect the contributions of individual pathways



General Statistics	
Number of pathways	1541
Number of processes	2398
Number of stationary processes	1997
Number of transportation processes	401
Number of modes	20
Number of gases	28
Number of resources	825
Number of technologies	304
Number of parameters	103388
Number of mixes	161
Number of vehicles	262

Main Panes

Explore WTW & C2G results for vehicle technologies



Key & additional parameters (e.g., simulation year)



The screenshot shows the GREET software interface with several panes and buttons highlighted:

- WTP Results** (red box)
- WTW and C2G Results** (red box)
- Products** list (left pane) with a callout: **Explore WTP results for pathways & mixes** (red box) and a **YouTube** icon.
- Data Editors** (blue box)
- Simulation Parameters** (blue box)
- Mapping** (green box)
- Create and modify .net elements** (blue box) with subtext: (resources, emissions, technologies, processes, pathways, mixes, etc.) and a **YouTube** icon.
- Advanced feature for scenario simulation** (green box)
- Scenario Pane** (green box) with a **Click** callout and a blue arrow pointing to it.

“WTP Results” Pane (Well-to-Pump, Well-to-Product)

- Explore the structure of pathways and mixes
- Explore the results of pathways and mixes at different levels

Zone 1: Products tree
Search the interested product
Expand the node and select a pathway or mix to review

Zone 2: Well-to-use results associated with the selected pathway or mix

Zone 3: Graphical representation of the selected pathway or mix

Per	of
1 mmBtu	Conventional Diesel

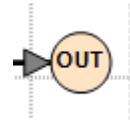
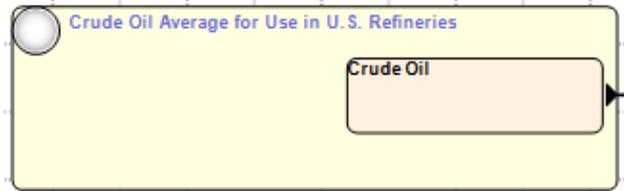
Target Year 2022

Well to Use	Emissions
CO2 Total	13.1822 kg
CO2	13.2032 kg
CO2_Biogenic	-0.0210 kg
VOC	7.4975 g
CO	12.4235 g
NOx	19.0726 g
PM10	1.3608 g
PM2.5	1.1439 g
SOx	5.2153 g
CH4	0.1117 kg
N2O	0.2441 g
BC	0.1730 g
POC	0.3111 g
Groups	...
GHG-100	16.6210 kg
GHG-20	22.5086 kg

Flow diagram: Crude Oil Average for Use in U.S. Refineries → Crude Oil → Conventional Diesel Refining with pre-defined Crude oil mixes → Conventional Diesel → U.S. Conventional Diesel → Conventional... → Conv. Diesel Storage → Conventional Diesel → Conventional Diesel → CO2

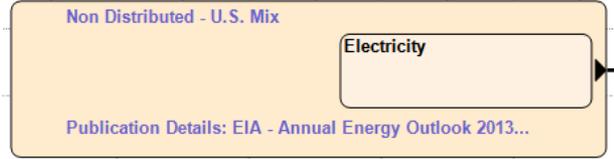
Color Code of Graphical Representation of Pathways

Feed Pathway

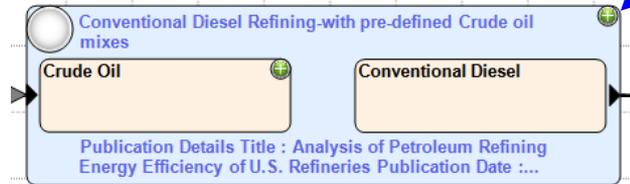


Main Product of the Pathway

Feed Mix



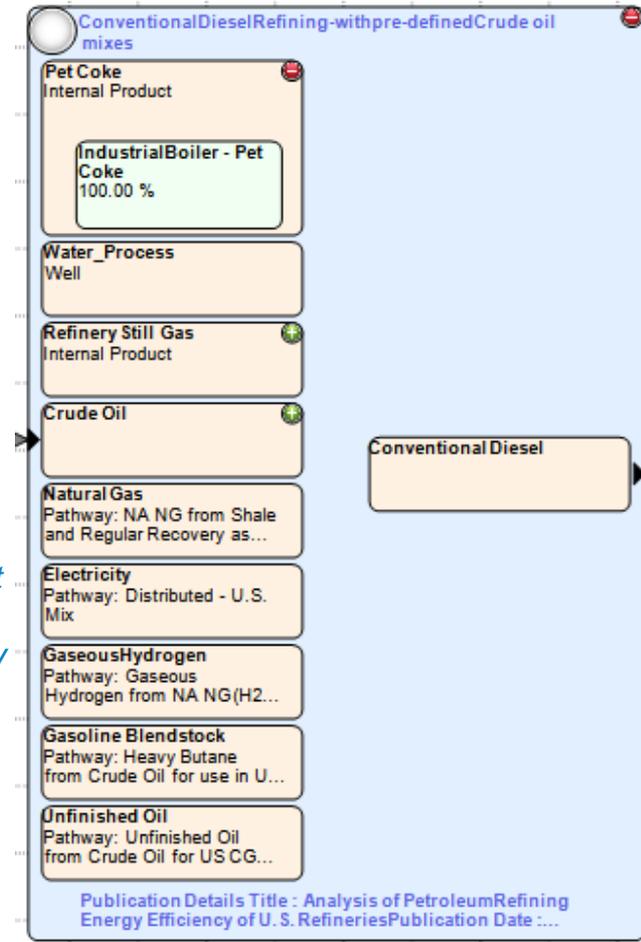
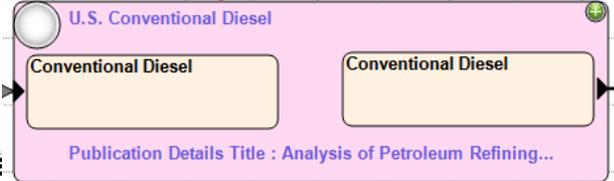
Stationary Process



Click

For stationary processes, we hide the inputs and outputs that are not directly connected to another process in this pathway

Transportation Process



“Data Editor” Pane and Its Sub-Menus



GREET® 2022 C:\Users\zlu\Documents\Greet\Data\default.greet

File Preferences Results Database About Plugins

WTP Results WTW and C2G Results Data Editors Simulation Parameters Mapping

Resources Technologies Processes Pathways Pathway Mix Modes Vehicles Emission

Select A Parameter To Modify

All parameters related to emissions, resources, technologies, processes, pathways, mixes, modes, and vehicles can be reviewed, modified, and created.

General Statistics

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Most recent

Pathway - Hide: Carinata Oil-based Renewable Jet Fuel 1

Pathway - Hide: Soy Oil-based Renewable Jet Fuel 1

Pathway - Hide: Palm Oil-based Renewable Jet Fuel 1

Exclude parameters from list

Powerful Data Cell in GREET.Net

- GREET.Net allows to enter user preferred data quantities and units directly to all data cells
- Information stored in each data box
 - Greet default quantity and unit (in black)
 - User preferred quantity and unit (in red)
 - Who create or modify the data
 - When the data was created or modified
 - Unique id for each data
 - Note for each data
- Enter formulas
- Change data to other units
- Change data to other unit bases
- Assign probability distributions
- Time series of the data

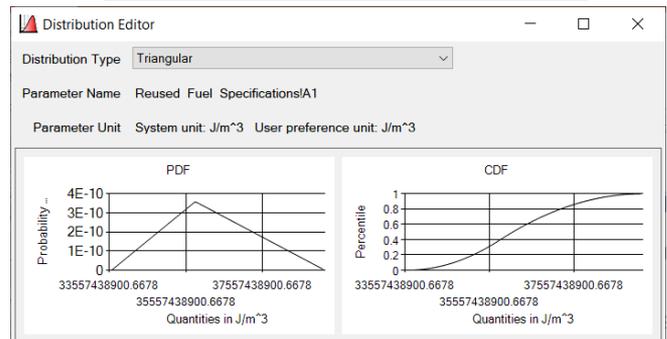
Density* 23971.56 g/ft^3

Density* 0.80 lb/L

- Switch to user value
- Edit Formula
- Change Unit
- Change Base >
- Edit values per simulation year
- About this value
- Add distribution

- To Energy
- To Mass
- To Volume

Low Heating Value* 130049.03 Btu/gal



1990	0.5244 %
1995	0.5148 %
2000	0.4186 %
2005	0.4578 %
2010	0.3975 %
2013	0.4220 %
2014	0.4463 %
2015	0.4609 %
2016	0.4758 %
2017	0.4639 %
2018	0.4907 %
2019	0.4737 %
2020	0.4771 %
2021	0.4413 %
2025	0.6185 %
2030	1.5092 %
2035	2.7507 %
2040	3.0739 %
2050	3.1218 %
2045	3.1122 %

Demo: Create a H₂ Production Pathway with Real-World Data

- Operational data below are from a refinery SMR unit (unit: per day)

- Inputs

Upstream assumptions

- Feedstock Natural gas 5.204 million normal cubic feet

North American NG from shale and conventional gas as stationary fuel

- Utility Electricity 15600 kWh

US electricity mix

- Utility Steam 1.632 million lb

From a small boiler using North American NG

- Outputs

Co-product handling method

- Main product H₂ 17.503 million normal cubic feet

- Co-product Steam 528 thousand lb

Displace steam produced from H₂ central plants using North American NG

Demo: Create a H₂ Production Pathway with Real-World Data

- **Step 1: Create a new resource “H₂ Demo” with the following properties**
 - State: gaseous, Density: 2.55 g/ft³, LHV: 290 Btu/ft³, Market Value: 1 \$/kg
- **Step 2: Create a new technology “CO₂ from SMR Demo” to handle CO₂ emissions**
- **Step 3: Create a new stationary process “H₂ Production from SMR Demo”**
 - Inputs
 - Feedstock Natural gas 5.204 million ft³ *NA NG from shale and conventional gas as stationary fuel*
 - Utility Electricity 15600 kWh *US electricity mix*
 - Utility Steam 1.632 million lb *From a small boiler using NA NG*
 - Outputs
 - Main product H₂ 17.503 million ft³
 - Co-product Steam 528 thousand lb *Displace steam produced from H₂ central plants*
- **Step 4: Create a new pathway “H₂ Production Pathway from SMR Demo”**
- **Step 5: Press F9 to run simulation**
- **Step 6: Explore the pathway results in the “WTP Results” pane**

More in GREET .Net

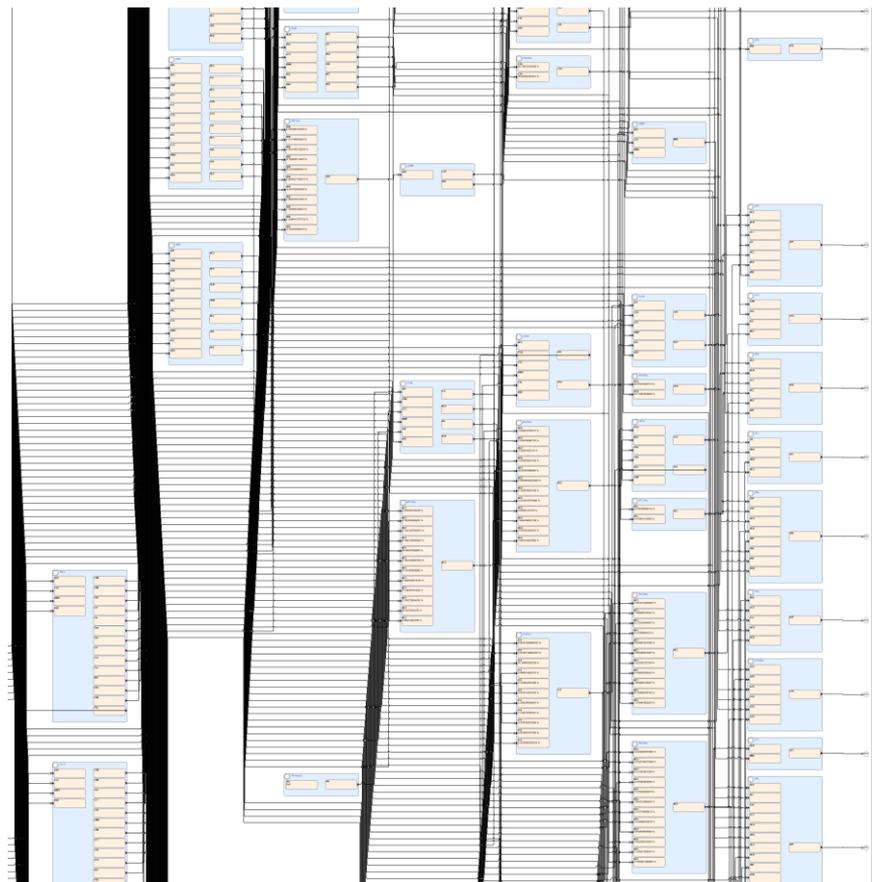
▪ Advanced features

- Scenario tool
- Mapping tool
- Time-series data importing tool
- Stochastic simulation tool
- CSV data importing tool
- Database merging
-

▪ For more information, please check

- YouTube tutorial videos
https://www.youtube.com/watch?v=BrqRhJ3qRml&list=PLLT1SPoEVQqxWRoFTABWU_ibyLSpS18pO
- Online documents
- Software documents
- Send questions to greet@anl.gov

GREET.Net can handle very complex input-output-type models



ACKNOWLEDGEMENT

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