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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>

The screenshot shows the GREET website interface. On the left is a navigation menu with the GREET logo at the top. Below the logo are links for Publications, Databases, GREET Model Platforms, GREET Tools, and Refinery Products VOC. Under GREET Model Platforms, the 'GREET .Net' link is highlighted with a yellow box. Other links in this section include GREET Excel, Fuel-Cycle Model, and Vehicle-Cycle Model. Under GREET Tools, there are links for WTW Calculator, AFLEET Tool, AWARE-US Model, FD-CIC Tool, and Refinery Products VOC. The main content area on the right has a top navigation bar with links for Home, Versions, Features, Documents, APIs, Modules, and Contact us. Below this bar is a heading 'A fresh design for GREET life cycle analysis tool' followed by a paragraph describing the GREET® 2022 .Net software. A red note states: 'Note: The GREET.Net software can be only installed in Windows OS with Microsoft .Net Framework 4.5 installed.' Below this is a heading 'DOWNLOAD the new GREET® 2022 .Net software' and a blue link 'DOI: 10.11578/GREET-Net-2022/dc.20220908.2'. Further down, it says 'The most recent version of GREET.Net data file is 13991.' and 'The data file version can be checked or updated through "Database" → "Check for data updates"'. At the bottom, it says '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®**

Publications

Databases

GREET Model Platforms

**GREET .Net**

GREET Excel

Fuel-Cycle Model

Vehicle-Cycle Model

GREET Tools

WTW Calculator

AFLEET Tool

AWARE-US Model

FD-CIC Tool

Refinery Products VOC

Home Versions Features Documents APIs Modules Contact us

### 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**.

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

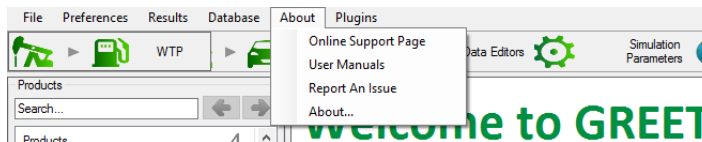
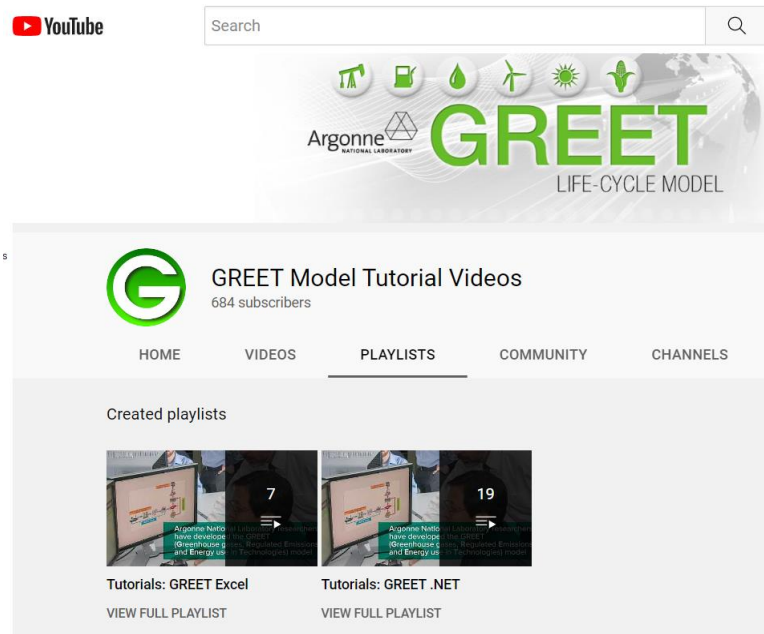
- Installation
- Introduction of GREET.Net GUI
- Explore WTP/WTW/C2G results
- Edit resource, emission, technology, process, pathway, mix, vehicle, etc.

## ■ Online documents

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

## ■ GREET .Net software

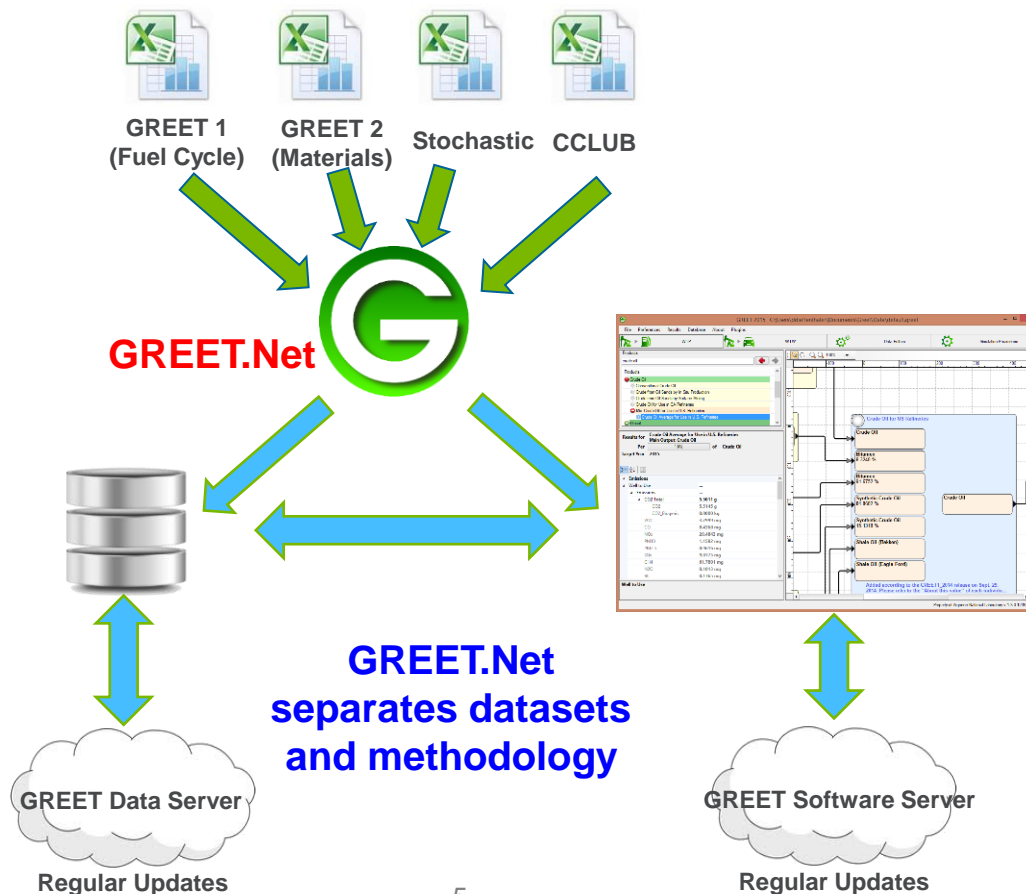
- GREET-Model.pdf
  - Mathematical methods
- GREET-Manual.pdf
  - How to use the model



# 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 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

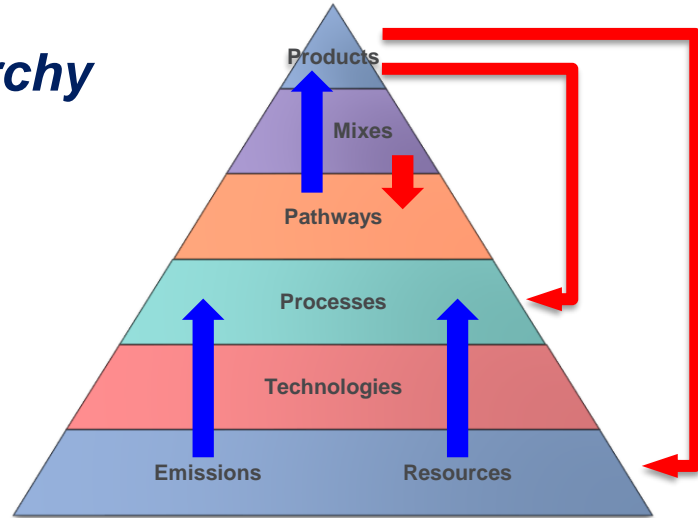
- Basic building blocks for pathways and pathway mixes
- Define inputs, outputs, and their relationship in a step
- May employ technologies and emissions

## ■ 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)
- Data Editors** (blue box)
- Simulation Parameters** (blue box)
- Mapping** (green box)
- Products** (left pane, containing a list of products like Propanediol, Acetylene, etc.)
- Results for** (bottom left pane, showing 'Select an item from above list' and 'Target Year 2022')
- Create and modify .net elements** (blue box, containing text: "(resources, emissions, technologies, processes, pathways, mixes, etc.)")
- Advanced feature for scenario simulation** (green box)
- Scenario Pane** (green box, with a blue arrow pointing to it and the word "Click")



# “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**

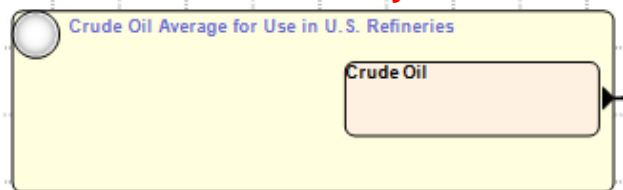
**Zone 3: Graphical representation of the selected pathway or mix**

Ready Project has been modified



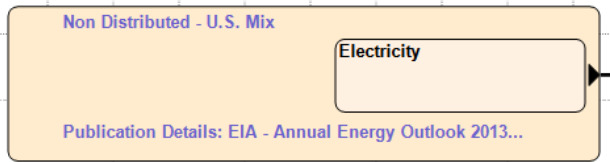
# Color Code of Graphical Representation of Pathways

## Feed Pathway

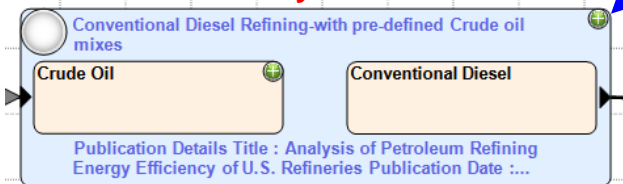


Main Product  
of the Pathway

## Feed Mix



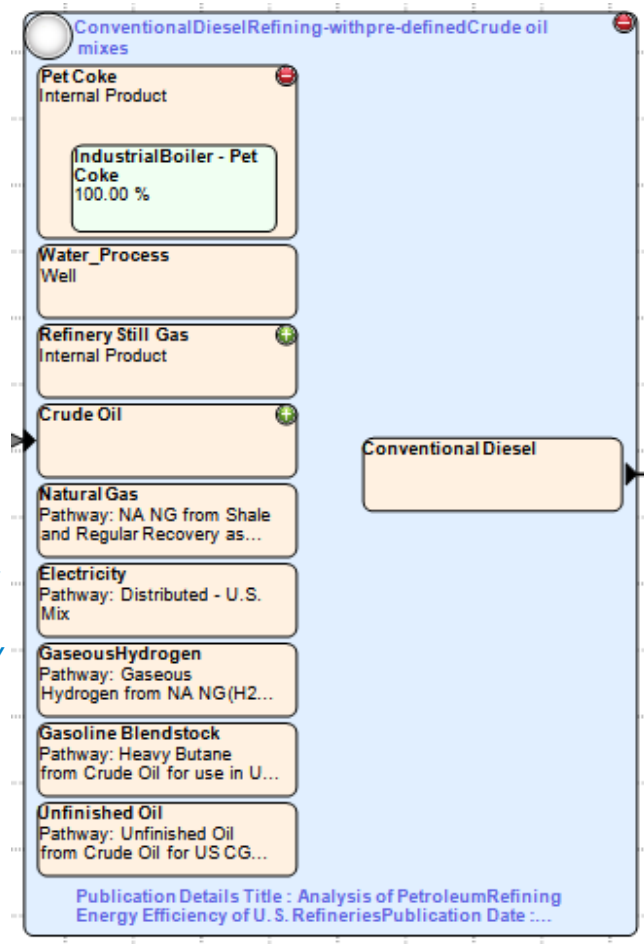
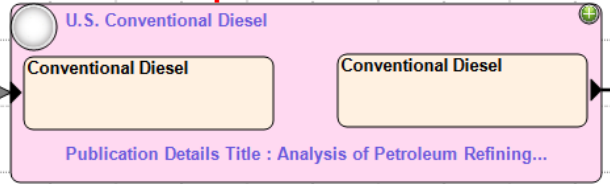
## Stationary Process



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

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

Most recent

Pathway - Hide: Carinata Oil-based Renewable Jet Fuel

Pathway - Hide: Soy Oil-based Renewable Jet Fuel

Pathway - Hide: Palm Oil-based Renewable Jet Fuel

☒ 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

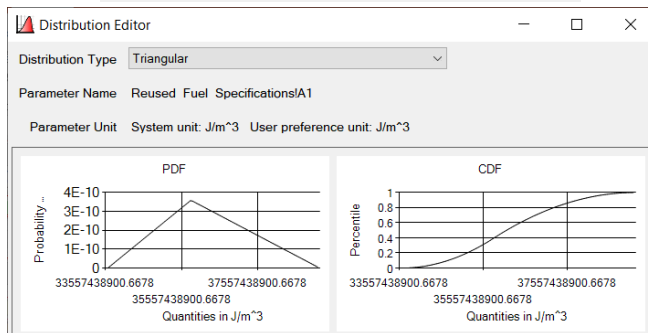
Add distribution

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 H<sub>2</sub> 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      H<sub>2</sub>      17.503 million normal cubic feet

– Co-product      Steam      528 thousand lb

*Displace steam produced from H<sub>2</sub> central plants using North American NG*

# Demo: Create a H<sub>2</sub> Production Pathway with Real-World Data

- **Step 1: Create a new resource “H<sub>2</sub> Demo” with the following properties**
  - State: gaseous, Density: 2.55 g/ft<sup>3</sup>, LHV: 290 Btu/ft<sup>3</sup>, Market Value: 1 \$/kg
- **Step 2: Create a new technology “CO<sub>2</sub> from SMR Demo” to handle CO<sub>2</sub> emissions**
- **Step 3: Create a new stationary process “H<sub>2</sub> Production from SMR Demo”**
  - Inputs
    - Feedstock      Natural gas      5.204 million ft<sup>3</sup>      *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    H<sub>2</sub>                  17.503 million ft<sup>3</sup>
    - Co-product      Steam                528 thousand lb      *Displace steam produced from H<sub>2</sub> central plants*
- **Step 4: Create a new pathway “H<sub>2</sub> 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

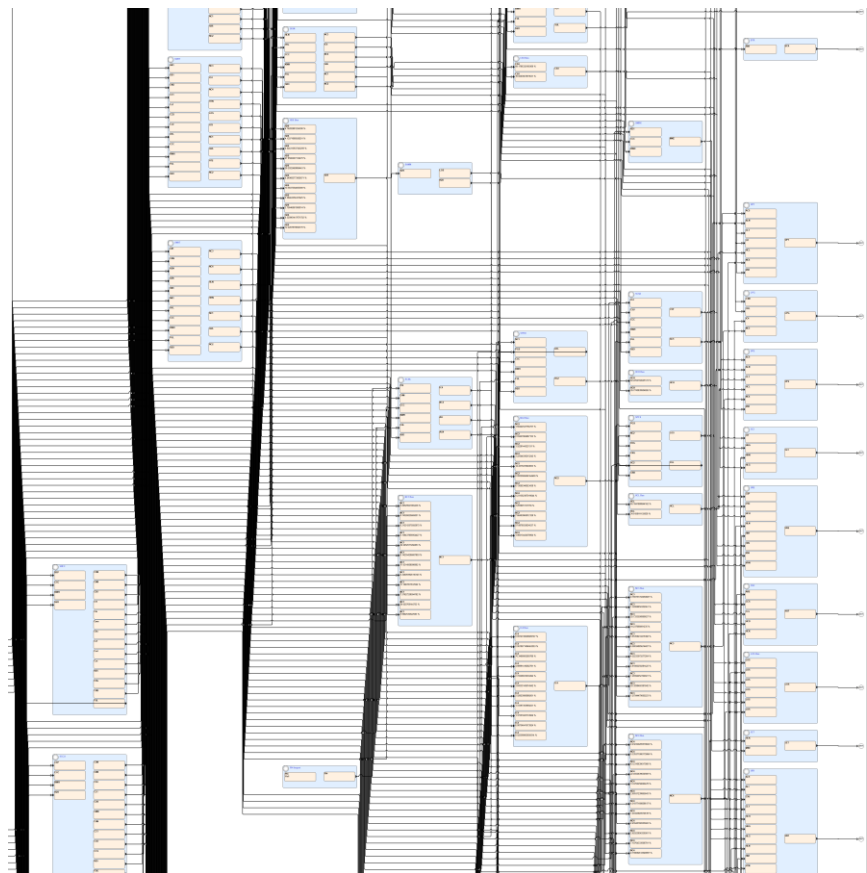
## ■ Advanced features

- 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](https://www.youtube.com/watch?v=BrqRhJ3qRml&list=PLLT1SPoEVQqxWRoFTABWU_ibyLSpS18pO)
- Online documents
- Software documents
- Send questions to [greet@anl.gov](mailto:greet@anl.gov)

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



# ACKNOWLEDGEMENT

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**Please visit**

***<https://greet.es.anl.gov/>***

**for**

- ***GREET models***
- ***GREET documents***
- ***LCA publications***
- ***GREET-based tools and calculators***