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The #H2IQ Hour

Today's Topic:
45VH2-GREET Model

This presentation is part of the monthly H2IQ hour to highlight hydrogen and fuel cell research, development, and demonstration (RD&D) activities including projects funded by U.S. Department of Energy's Hydrogen and Fuel Cell Technologies Office (HFTO) within the Office of Energy Efficiency and Renewable Energy (EERE).

HOUSEKEEPING

This webinar is being recorded.

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Technical Issues:

- If you experience technical issues, please check your audio settings under the "Audio" tab.
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Questions?

- There will be a Q&A session at the end of the presentation
- To submit a question, please type it into the Q&A box; **do not** add questions to the Chat

DOE will only respond to questions on how to use 45VH2-GREET. DOE will not respond to questions about the 45V tax credit or eligibility for the credit.

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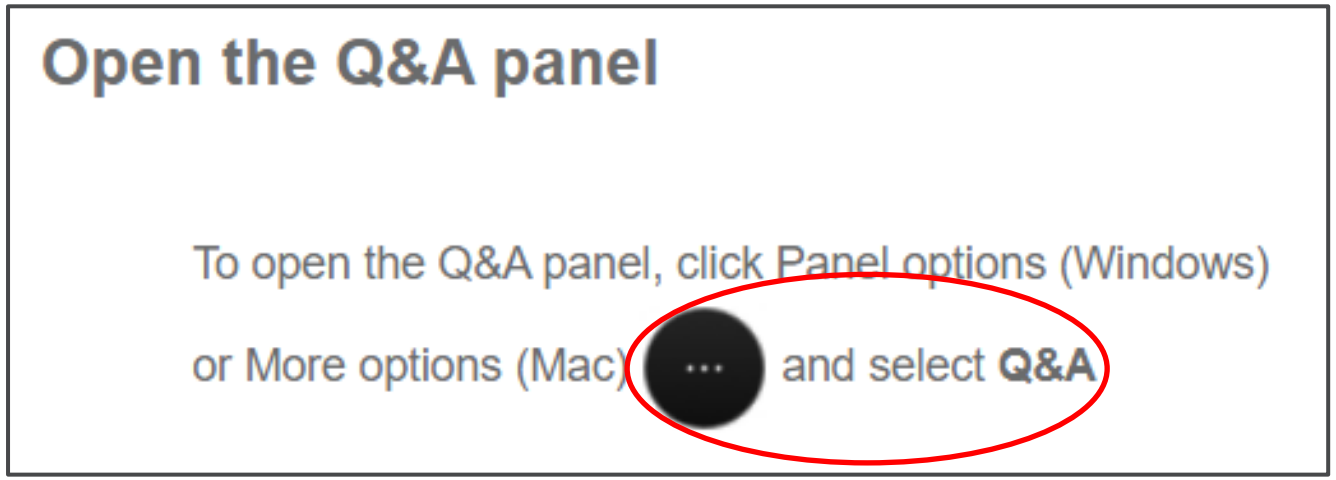
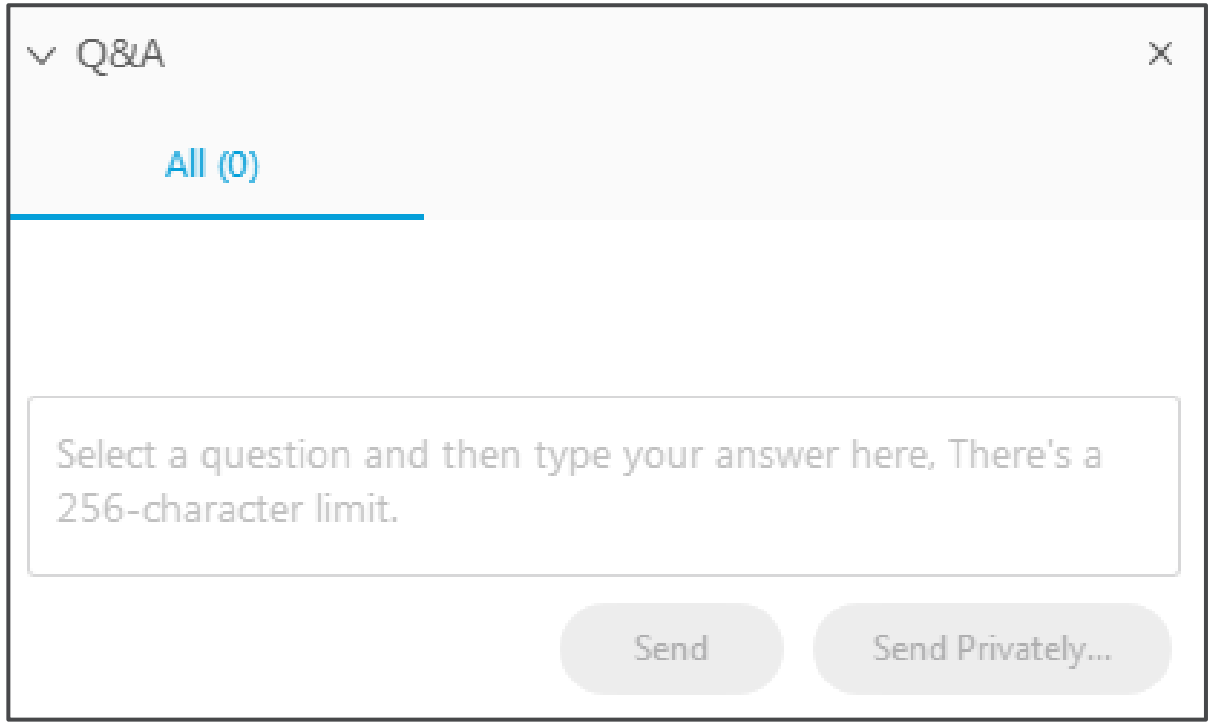
The #H2IQ Hour Q&A

Please type your questions into the Q&A Box





U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

45VH2-GREET Model for Well-to-Gate Emissions of Hydrogen Production

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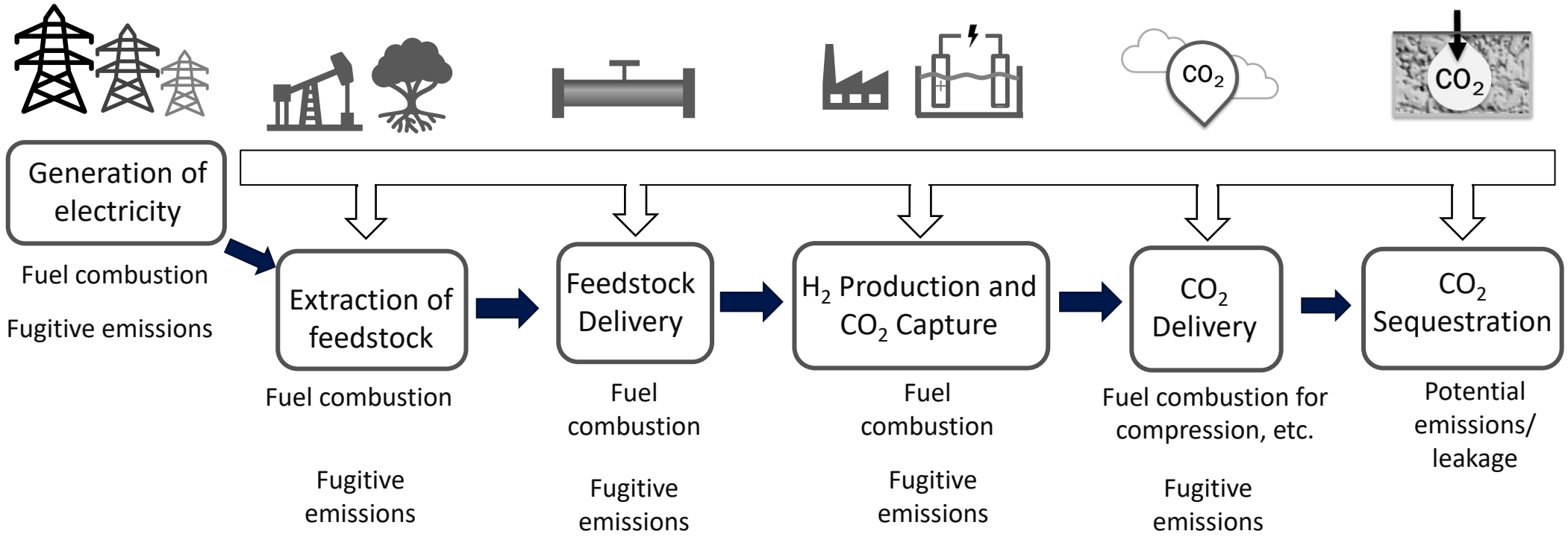
Webinar Agenda

- Background on 45VH2-GREET
- Demonstration of model
- Next steps for 45VH2-GREET
- Q&A about model

45VH2-GREET Background

- 45VH2-GREET is a tool that determines emissions rates for the Clean Hydrogen Production Tax Credit under Title 26, Section 45V
- The Internal Revenue Service Notice of Proposed Rulemaking (NPRM) on accessing the 45V tax credit is here: https://www.regulations.gov/docket/IRS-2023-0066
- The IRS's NPRM adopts a specific version of GREET, **45VH2-GREET**, to determine emissions rates for the purposes of 45V.
  - Model was released Dec. 22, 2023
  - Model, FAQs, and supporting documentation available at: https://www.energy.gov/eere/greet
- Questions on how to use 45VH2-GREET should be directed to DOE at: 45VH2GREETSupport@ee.doe.gov
- Questions on 45V tax credit and eligibility for the tax credit should be directed to the Internal Revenue Service at: https://www.irs.gov/

45VH2-GREET Well-to-Gate System Boundary



Net GHG emissions associated with production of biomass feedstocks

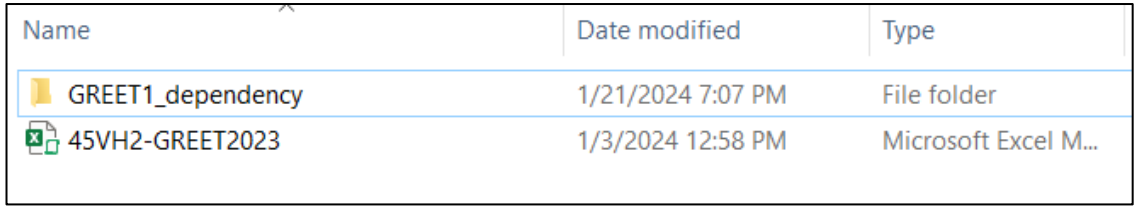
Illustrative - actual sources of emissions will vary based on feedstock type, technology type and deployment design. For a complete definition of the well-to-gate system boundary, please see the 45V NPRM.

Composition of 45VH2-GREET

- 45VH2-GREET includes two Microsoft Excel files:

  1) **45VH2-GREET** file

  2) **GREET1_2023** file inside **GREET1_dependency** folder



- Parameters within the model are categorized as:

  - "Background data" – Fixed assumptions that may not be changed by the user[1]

  - "Foreground data" – Values that users must input in order to characterize well-to-gate emissions. All user inputs should be in the 45VH2-GREET file

- Examples of background data: upstream methane emissions leakage, grid carbon intensity, counterfactual scenarios. Parameters are itemized in GREET1_2023.

- Examples of foreground data: amount of electricity consumption onsite, rate of carbon capture, amount of feedstock consumption. Values must be input in 45VH2-GREET file.

1. Defined in NPRM as "parameters for which bespoke inputs from hydrogen producers are unlikely to be independently verifiable with high fidelity, given the current status of verification mechanisms".

Key features of 45VH2-GREET

- Hydrogen production technology pathways

Hydrogen Production Technologies
Steam Methane Reforming (SMR)
Low Temperature Electrolysis
High-temperature electrolysis (Nuclear)
Coal Gasification
Biomass Gasification
Autothermal Reforming (ATR)

As described in user manual, any electricity input from a source other than "Grid Mix" (e.g. Solar, Wind, User-Defined Mix, etc.) must be verified via the purchase and retirement of qualifying energy attribute certificates (EACs), which are EACs that meet specified criteria provided in the 45V NPRM.

- Energy feedstock options

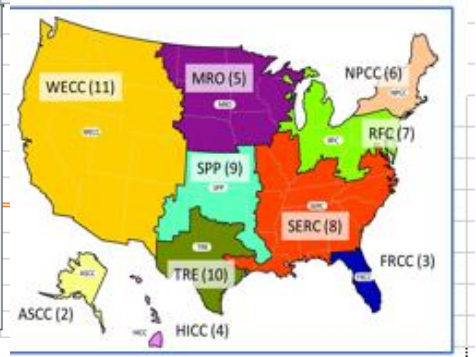
SMR Feedstock
Landfill Gas
Fossil Natural Gas

ATR Feedstock
Landfill Gas
Fossil Natural Gas

Biomass Feedstock
Corn Stover
Forest Residue

Process Inputs	Value	Units
	Low Temper	
Electricity	Enter Value	kWh
Electric Generation Source	Grid Mix	
Oxygen Co-Product	No	
Electricity Generation Mix*	ASCC Mix	

- ASCC Mix
- FRCC Mix
- HICC Mix
- MRO Mix
- NPCC Mix
- RFC Mix
- SERC Mix
- SPP Mix
- TRE Mix
- WECC Mix



Process Inputs	Value	Units	Process Outputs	Value
	Low Temperature Electrolysis			
Electricity	Enter Value	kWh	Hydrogen	Enter Value
Electric Generation Source	User-Defined Mix*		Hydrogen Production Pressure	300
Oxygen Co-Product	No			
Technology	Value [%]		Technology	Value [%]
Residual oil	Enter Value		Hydroelectric	Enter Value
Natural gas	Enter Value		Geothermal	Enter Value
Coal	Enter Value		Wind	Enter Value
Nuclear power	Enter Value		Solar PV	Enter Value
Combustion of logging residue	Enter Value		ASCC Mix	Enter Value
NGCC wCCS	Enter Value		Total	0.00%

Key features of 45VH2-GREET (continued)

- Input units for chemical energy should be in LHV

D	E	F	G	H
Process Inputs	Value	Units		

Elgowainy, Amgad A. F1
Energy in chemicals is LHV based

- Emissions are adjusted for hydrogen production pressure above and below 300 psia
  - Limited to between 14.5 psia - 725.2 psia

Process Outputs	Value
ture Electrolysis	
Hydrogen	Enter Value
Hydrogen Production Pressure	300

- Hydrogen purity and impurities in product gas must be specified
  - Impurity concentration affects functional unit
  - Carbon containing impurities assumed to ultimately be converted to CO_2

Product Hydrogen Composition	mol [%]	Molar Mass [g/mol]
H_2	100.00%	2.016
N_2	0.00%	28.020
O_2	0.00%	32.000
H_2O	0.00%	18.015
CO	0.00%	28.010
CO_2	0.00%	44.010
CH_4	0.00%	16.040
NH_3	0.00%	17.031
H_2S	0.00%	34.082
S	0.00%	32.065
Ar	0.00%	39.948
All others	0.00%	0.000
Total	100.00%	

User input for other impurities not listed

- Co-products must be specified if they are valorized
  - For SMR with and without CCS, user input values are capped in alignment with the 45V NPRM and based on independent lab modeling

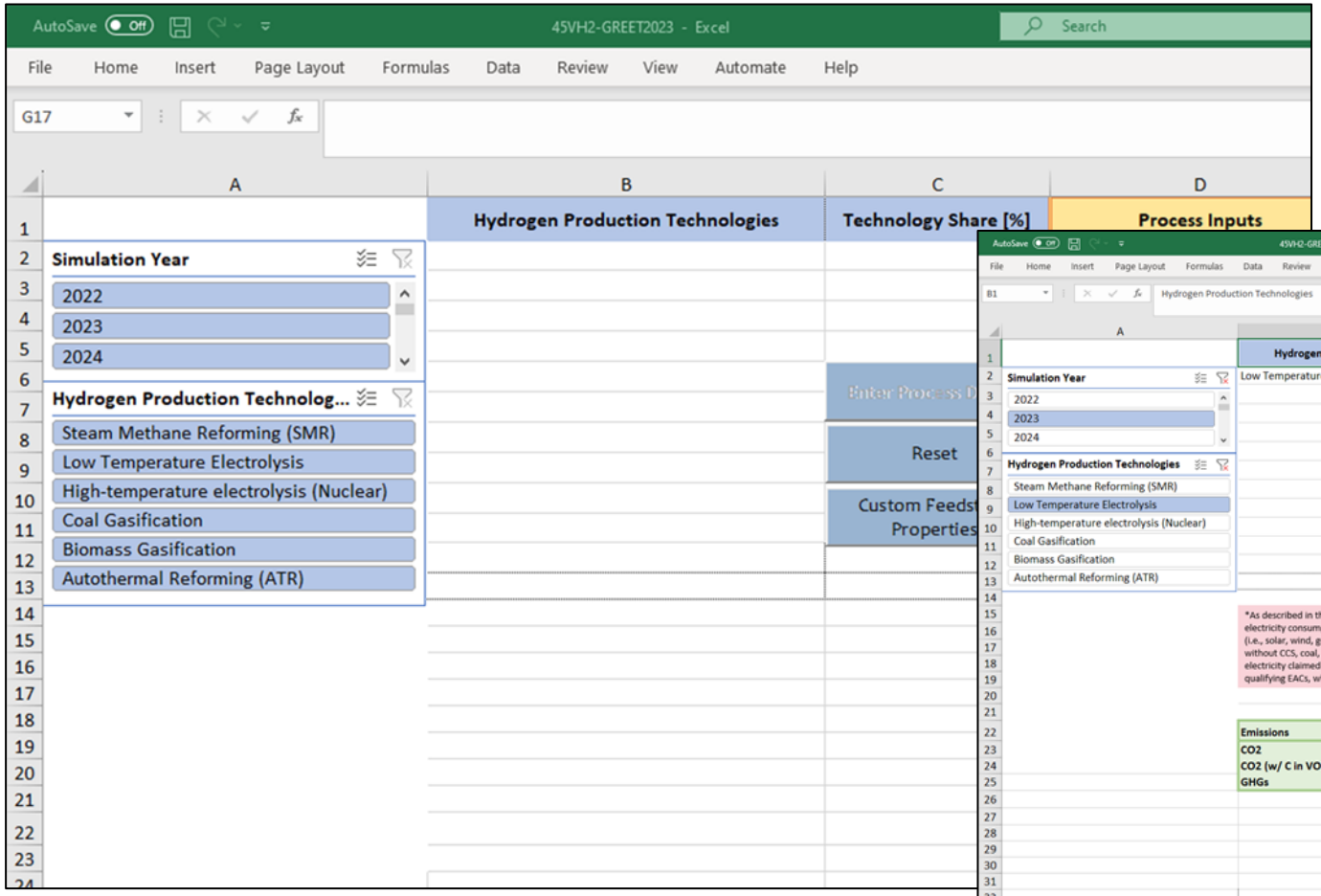
- User defined option for feedstock properties
  - Including LHV and C% by wt

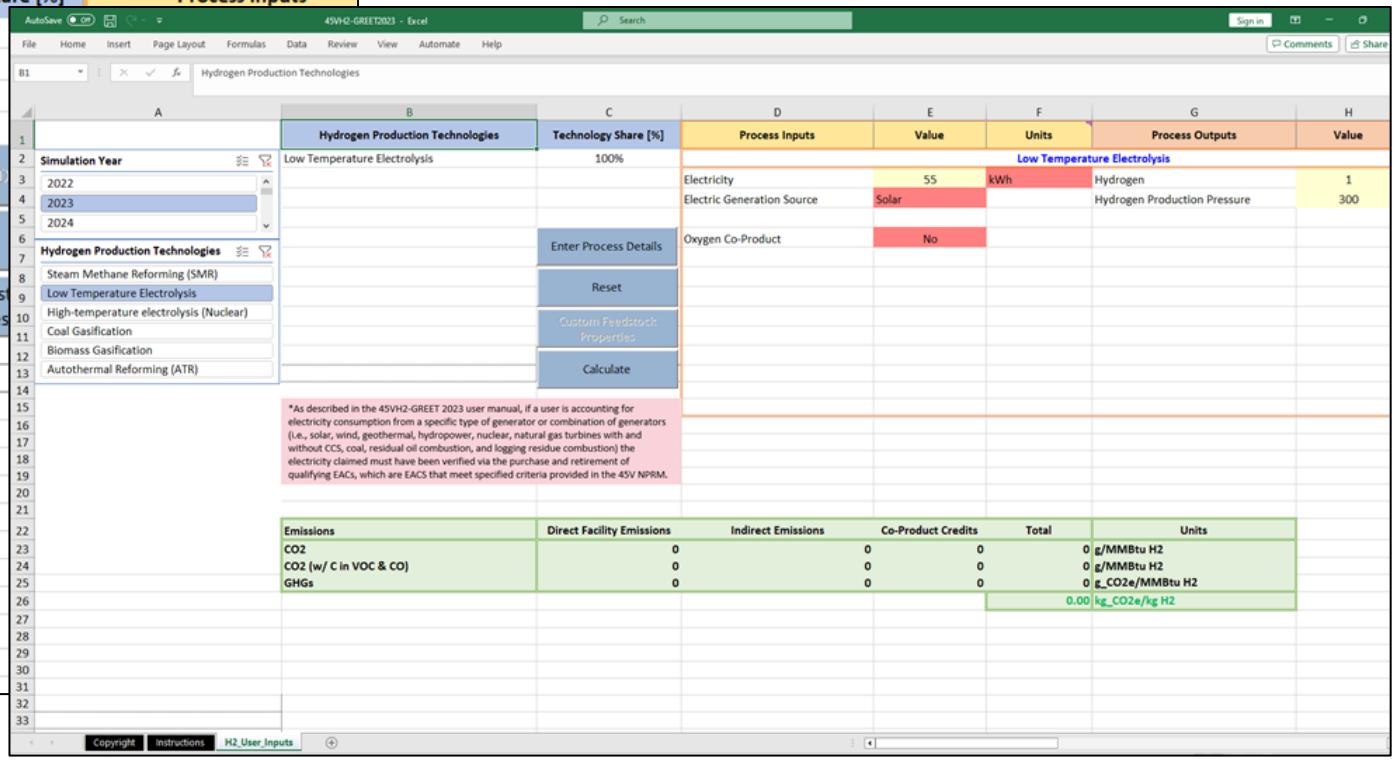
Custom Conventional Natural Gas Properties (at normal conditions, 32F and 1		
Lower Heating Value	983	Btu/ft3 at normal conditions
Density	22	g/ft3 at normal conditions
C ratio (% by wt)	72.4%	(g of Carbon)/(g of Fuel)

Custom Corn Stover Properties		
Lower Heating Value	14716000	Btu/short ton (dry)
C ratio (% by wt)	46.7%	(g of Carbon)/(g of Fuel)

Custom Coal Properties		
Lower Heating Value	22639319.98	Btu/short ton (as received)
C ratio (% by wt)	61.2%	(g of Carbon)/(g of Fuel)

45VH2-GREET demonstration for selected H_2 pathways





https://www.energy.gov/sites/default/files/2024-01/45vh2-greet-2023.zip

- ✓ User friendly interface
- ✓ Results include direct (i.e., facility level) and indirect (i.e. upstream) GHG emissions
- ✓ Process inputs and outputs by user in various units

Next Steps for 45VH2-GREET

- Grid regions will be adapted to include those in the DOE National Transmission Needs Study
- New hydrogen production pathways may be added periodically
- Background data may be updated periodically
- User-friendliness of model will continue to be improved

Acknowledgements

45VH2-GREET is being developed and maintained with funding from the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy's Hydrogen and Fuel Cell Technologies Office and U.S. Department of the Treasury.

Questions?

Thank You!

45VH2-GREET tool is available at:
GREET | Department of Energy

For questions, please contact
45VH2GREETSupport@ee.doe.gov