February 3, 2025

Demo for R&D GREET®2: Vehicle/Material Cycle Analysis

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

Instructors

Gabrielle Olson, Great Plains Institute

Branden Leonhardt, Department of Energy

Argonne National Laboratory Subject Matter Experts

Rakesh Iyer, Jarod Kelly

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Table of contents

Navigate in R&D GREET 2

Sync the Results Between R&D GREET 1 and R&D GREET 2

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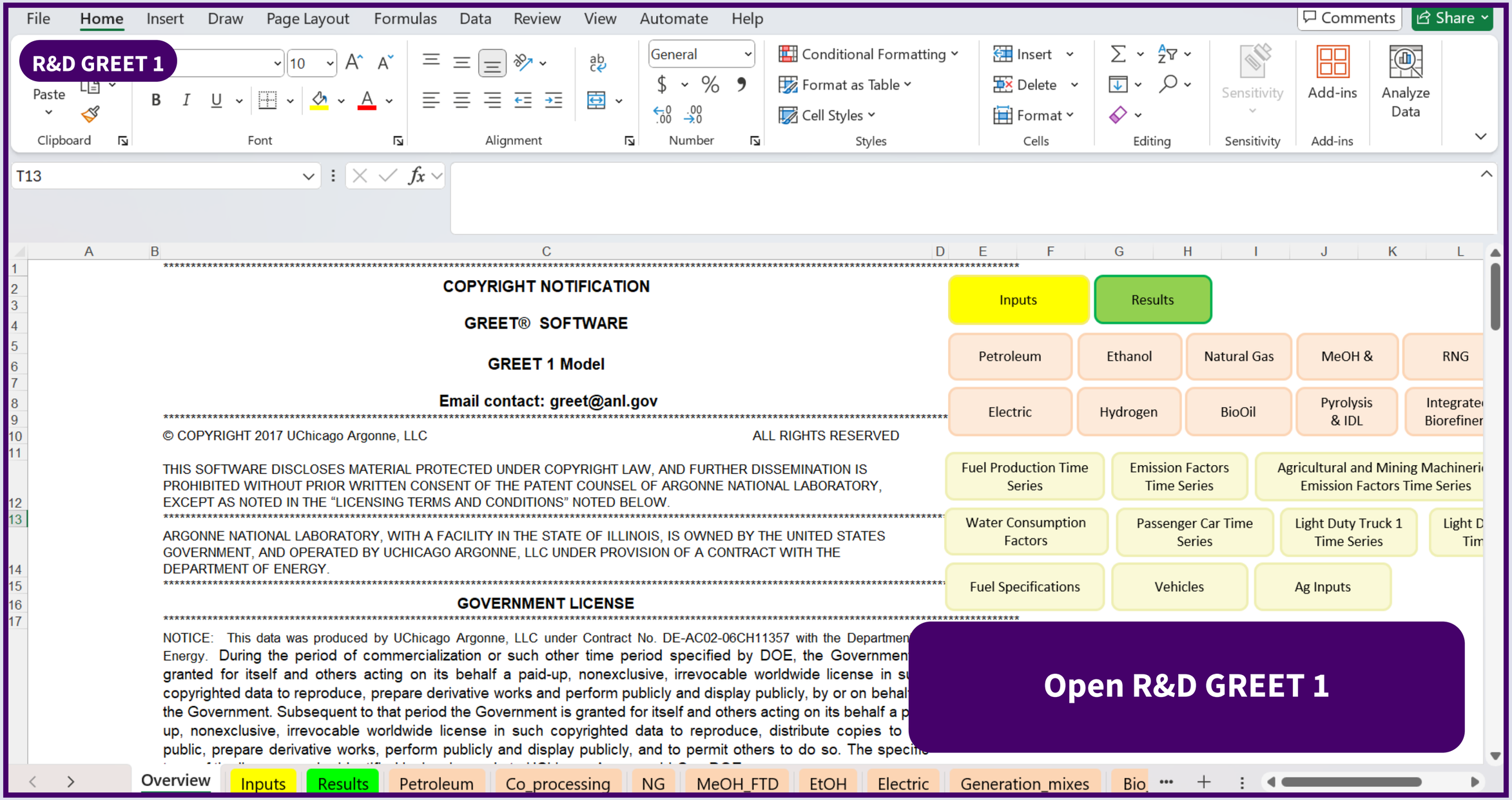

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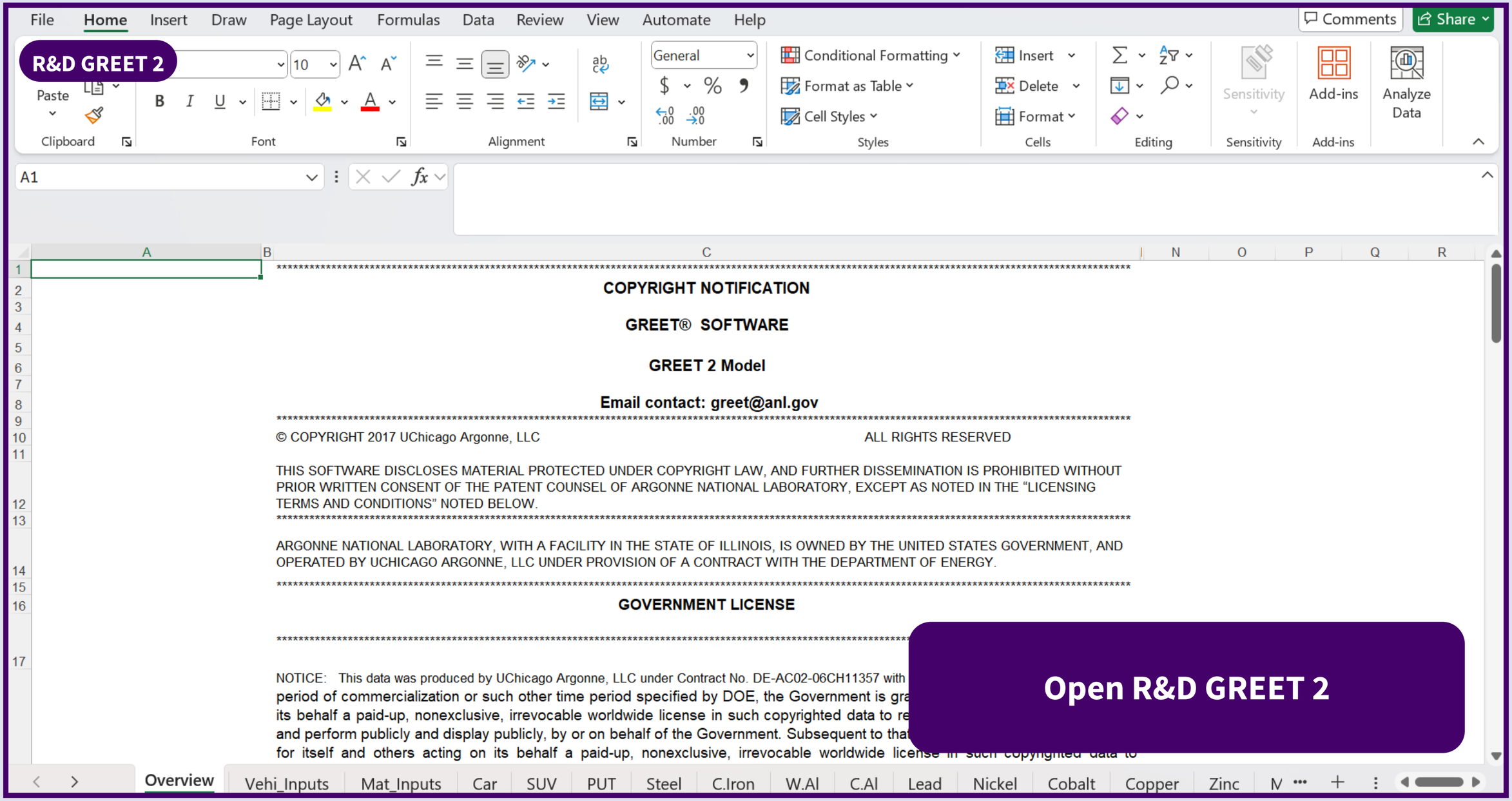

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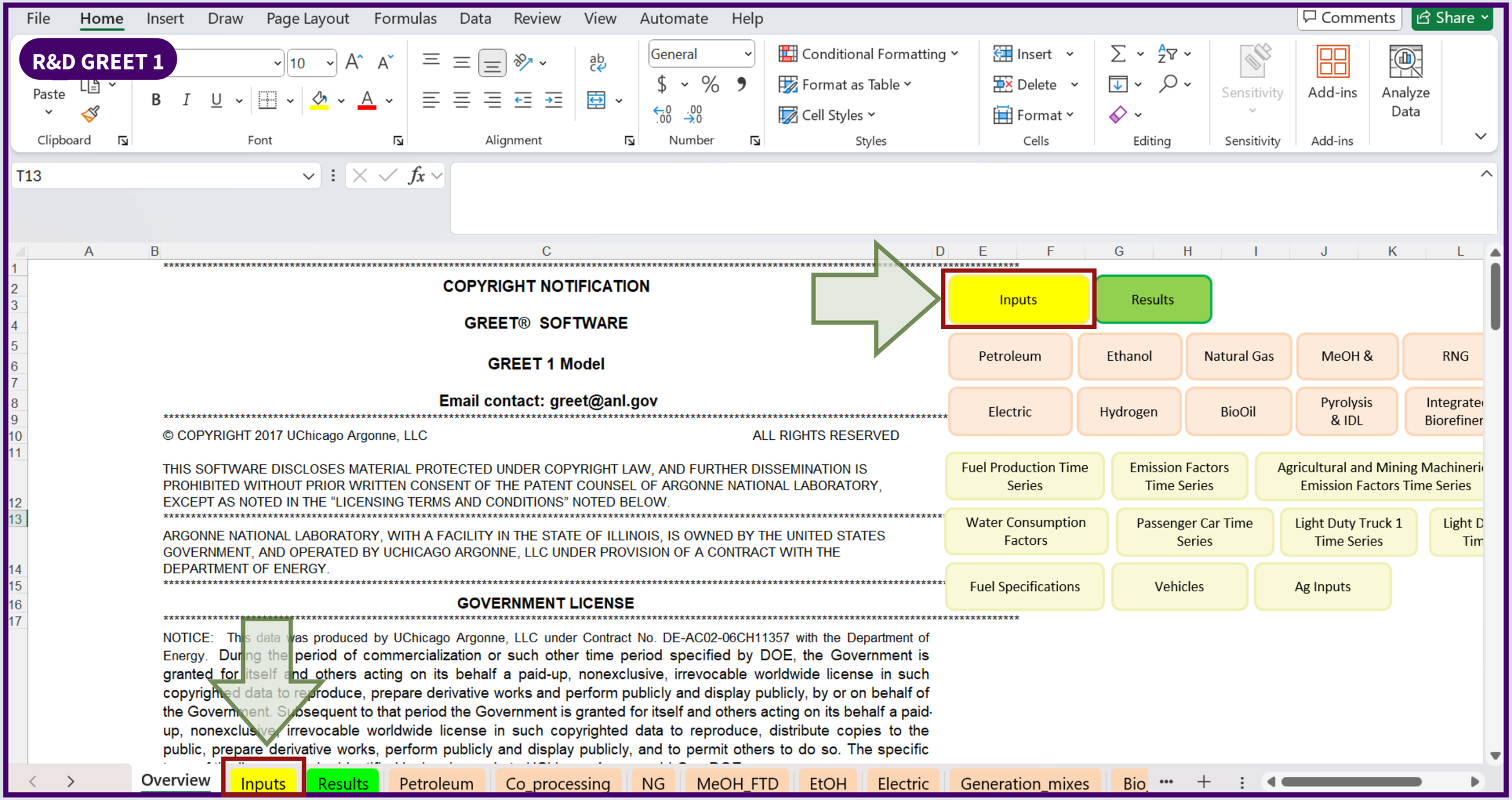

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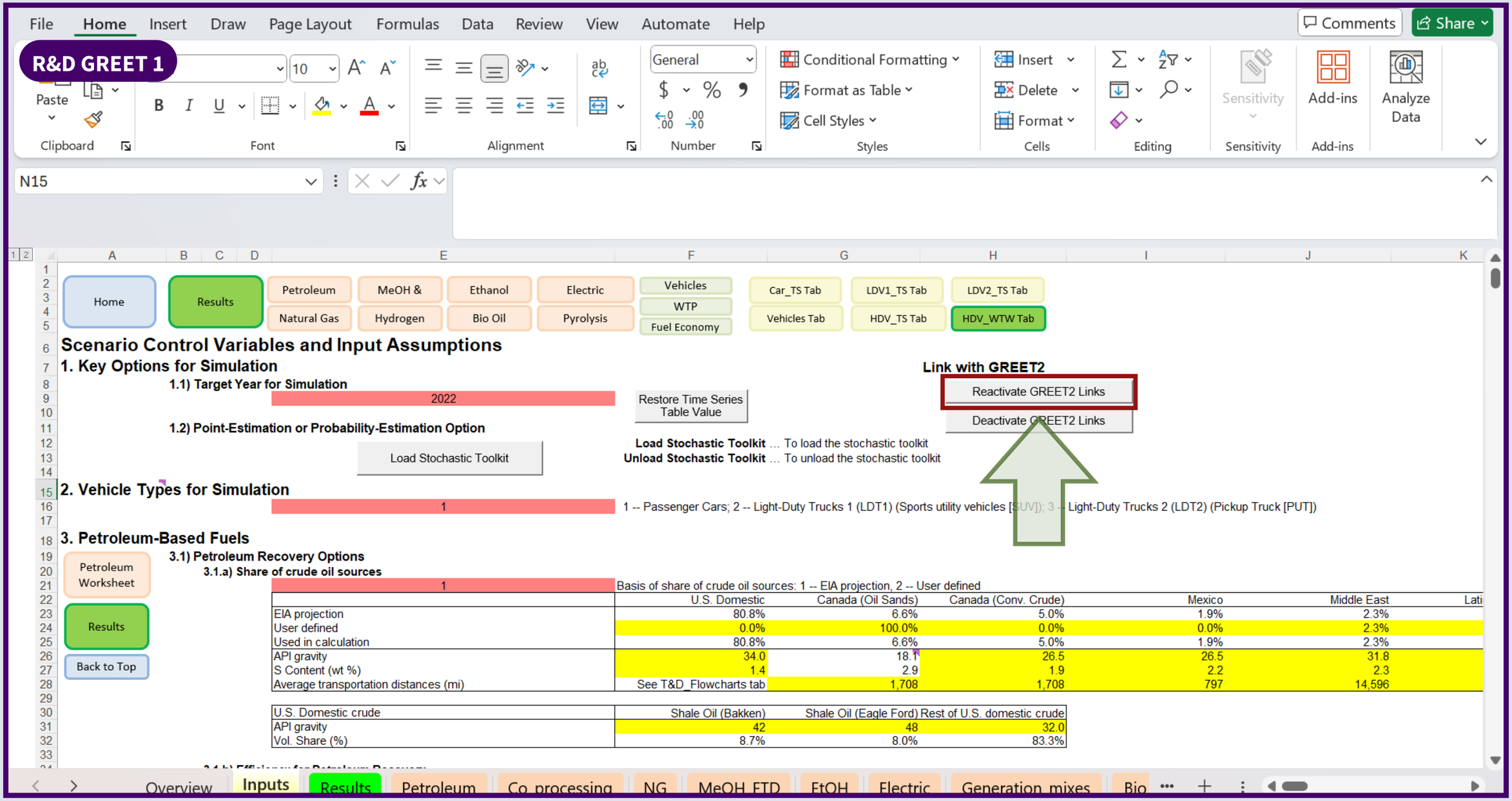

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Main Way to Navigate Through R&D GREET 2

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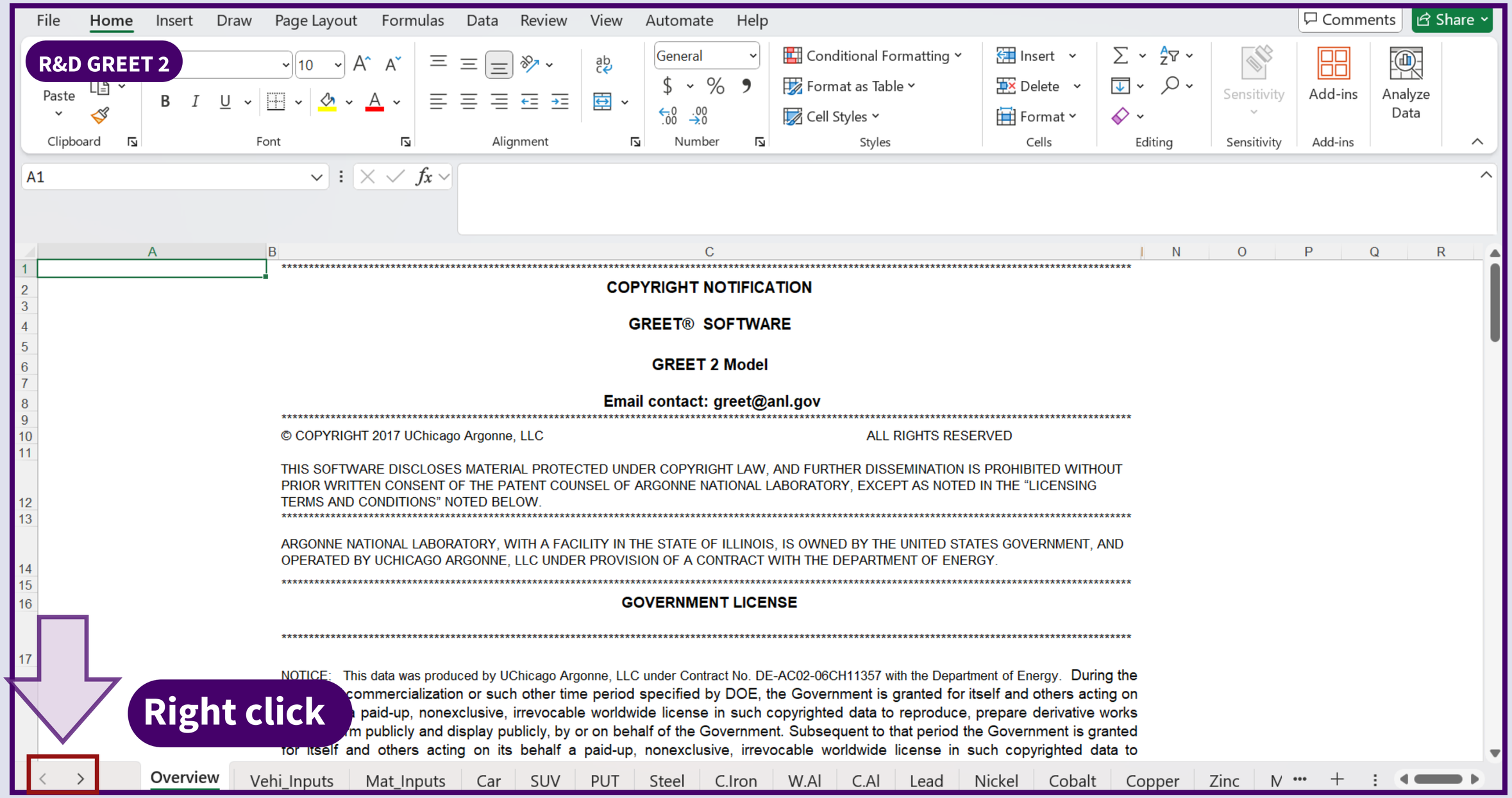

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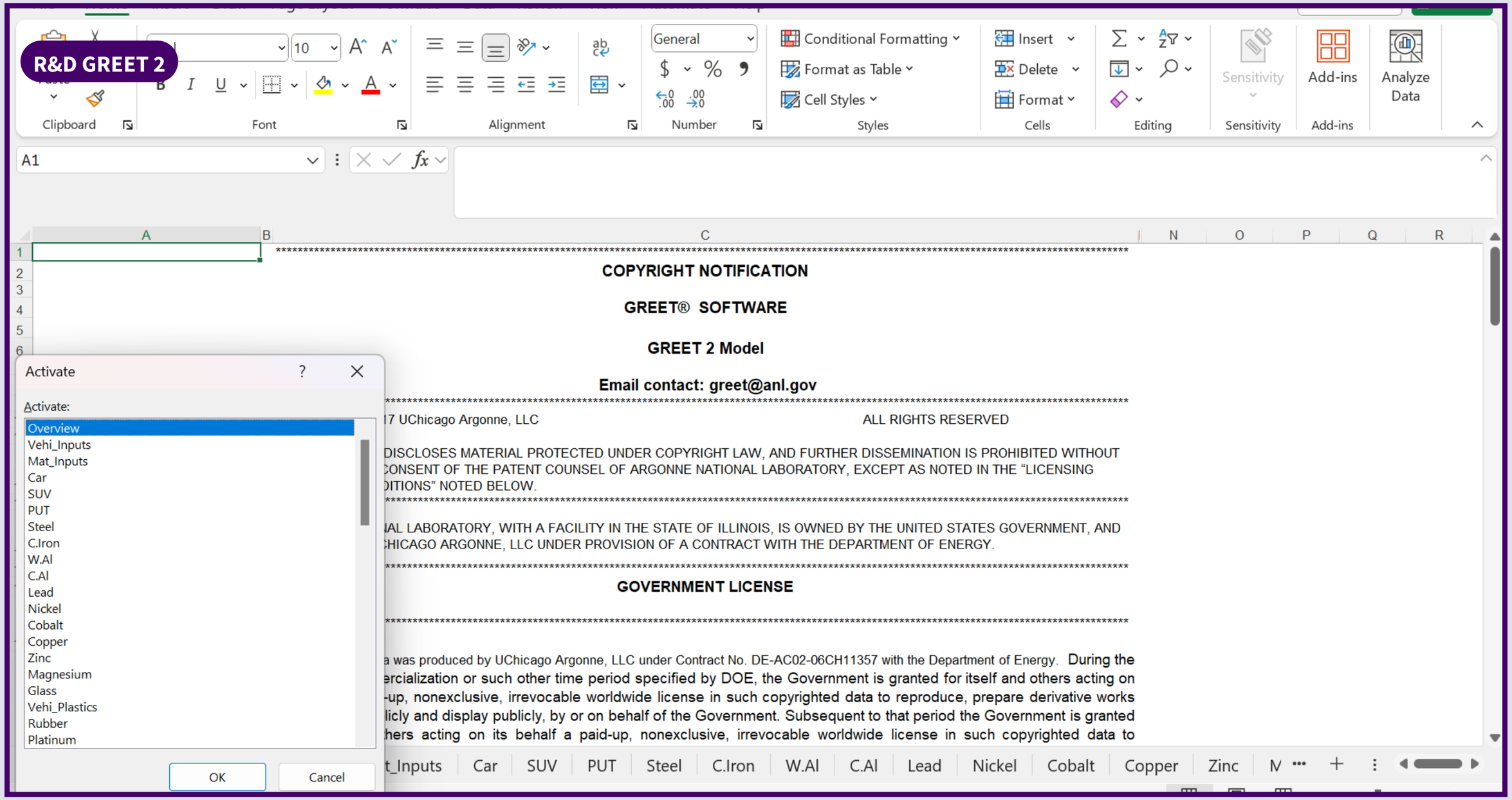

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Main Categories of Tabs in R&D GREET 2

Main tabs in R&D GREET 2

Categories of Tabs in R&D GREET 2

- Materials
- Vehicle-related Details
- Impact Calculation Tabs for Vehicle Components
- Vehicle Fluids
- ADR (assembly, disposal, and recycling)
- Trailer Components
- Trailer Fluids
- Sum of all Vehicle-cycle Results
- Sum of Full Life-cycle Results

Steps to Model a Scenario in R&D GREET 2

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Steps to model an LDV scenario in R&D GREET 2

Go to the "TEC_Results" Tab

Are the results for your scenario generated by default?

Go to the "Inputs (R&D GREET 1)," "Vehi_Inputs," or "Mat_Inputs" Tab

Have I made the necessary changes on all these tabs?

If Yes,

Make your changes and go to the "TEC_Results" tab to see your results

If No,

Determine whether the changes are related to the vehicle/material type, vehicle fluids/processing, or battery

Dive into the formulas on the "TEC_Results" tab

Vehicle/material Type

Go to the "vehicle/material-specific" tab

Vehicle Fluids/processing

Go to "Vehi_Fluids," "Vehi_ADR," "Vehi_Sum," "Vehi_Comp_Sum," or technology-specific tab

Battery

Go to one of the "Battery_Assembly/ Sum/Materials/Recycling" tab

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Steps to model an MHDV scenario in R&D GREET 2

Go to the "MHDV_TEC_Results" Tab

Are the results for your scenario generated by default?

Go Through the Full LDV Chart and the "MHDV_Inputs" Tab

Have I made the necessary changes on all these tabs?

If Yes,

Make your changes and go to the "MHDV_TEC_Results" tab to see your results

If No,

Determine whether the changes are related to the material parameters, vehicle fluids/ processing, or battery

Dive into the formulas on the "MHDV_TEC_Results" tab

Material Parameters

Go to the "MHDV_Mat_Parameters" or "vehicle-specific" tab

Vehicle Fluids/processing

Go to the "MDHV_Fluids/Trailer_Fluids" "MHDV_ADR/Trailer_ADR," "MHDV_Sum" or MHDV_Comp_Sum/Trailer_Comp_Sum" tab

Battery

Go to the "MHDV_Battery_Sum" tab

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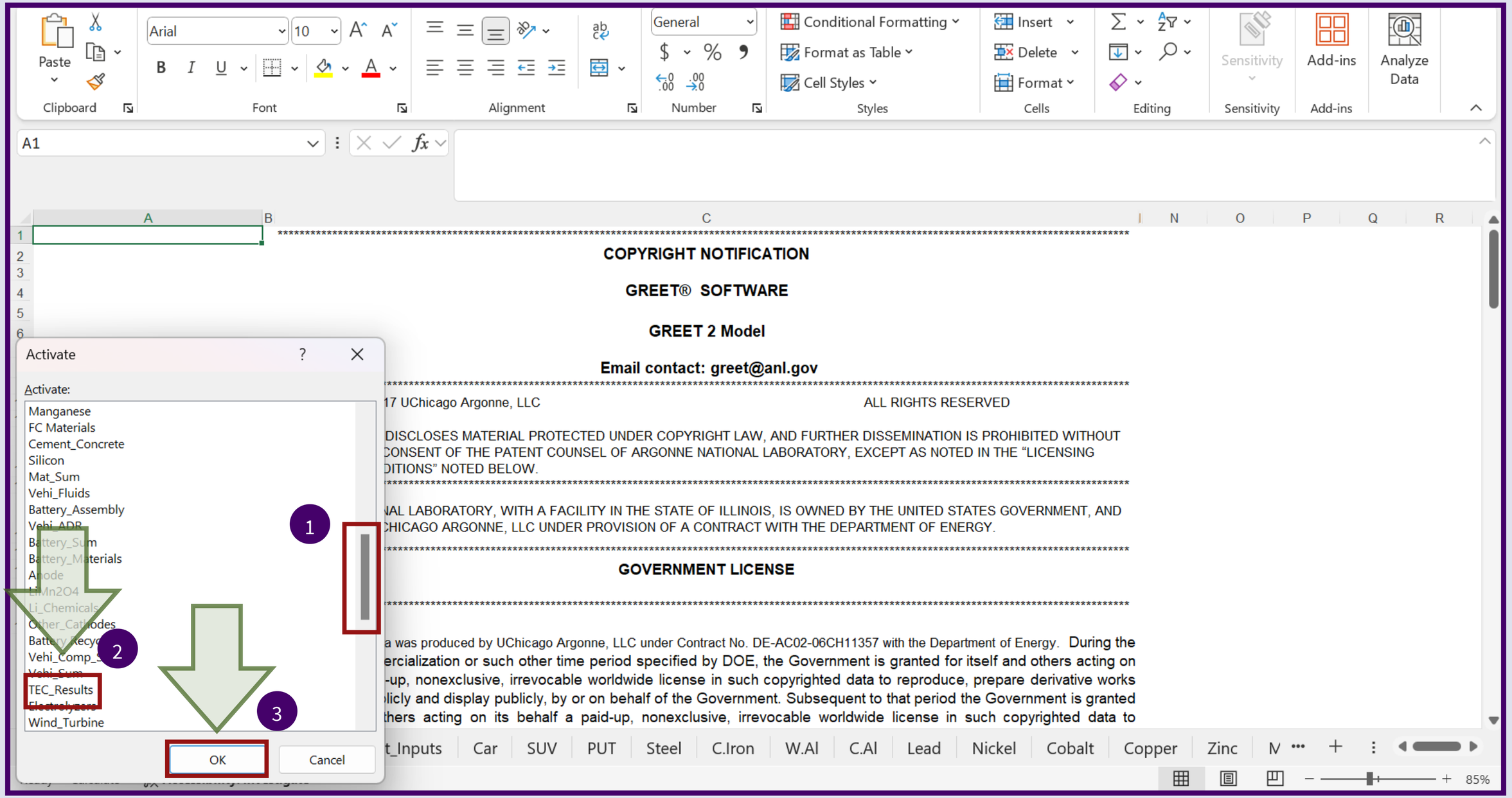
Vehicle Outputs

Light-duty Vehicle Outputs



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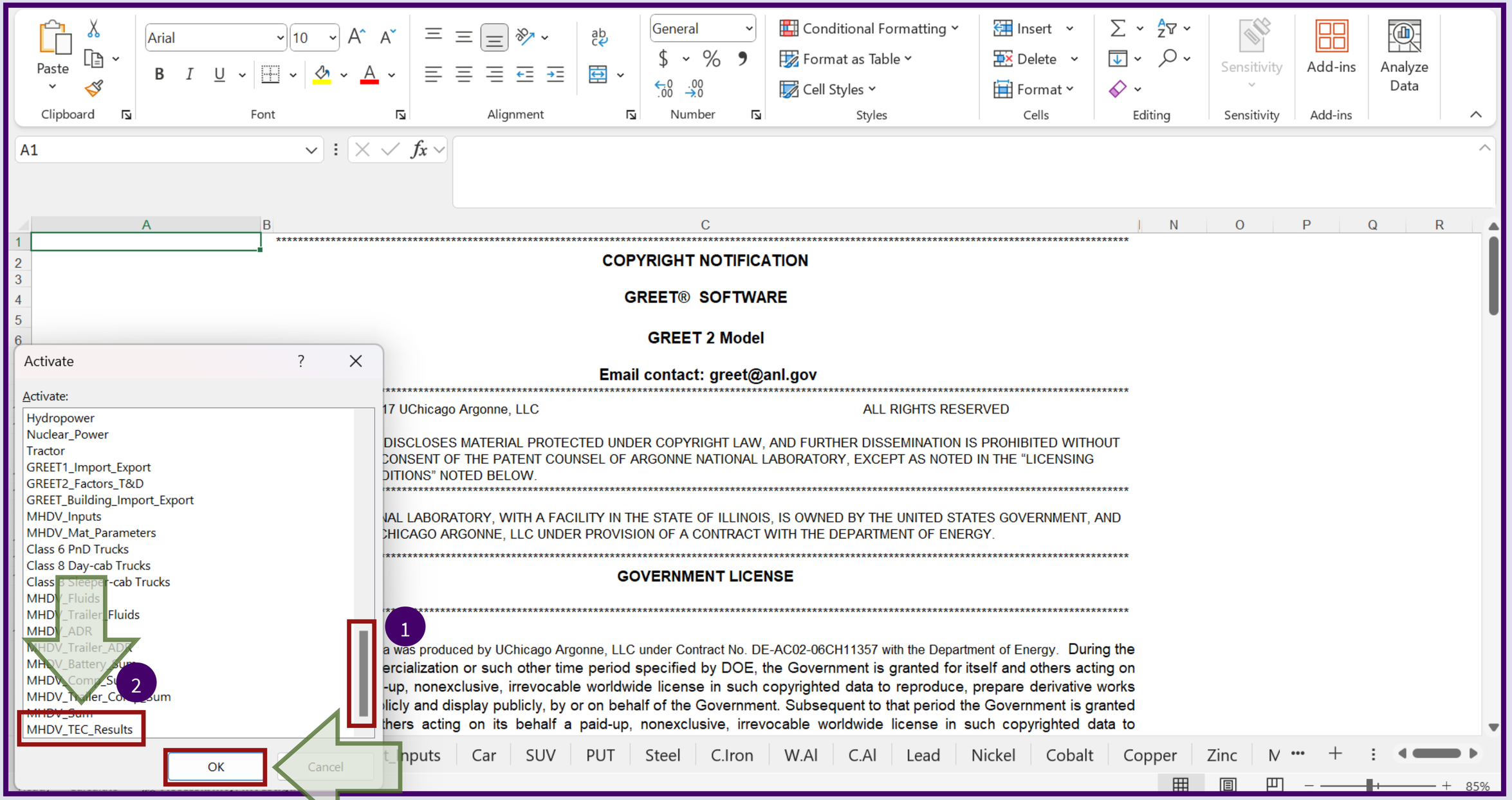
Medium and Heavy-duty Vehicle Outputs



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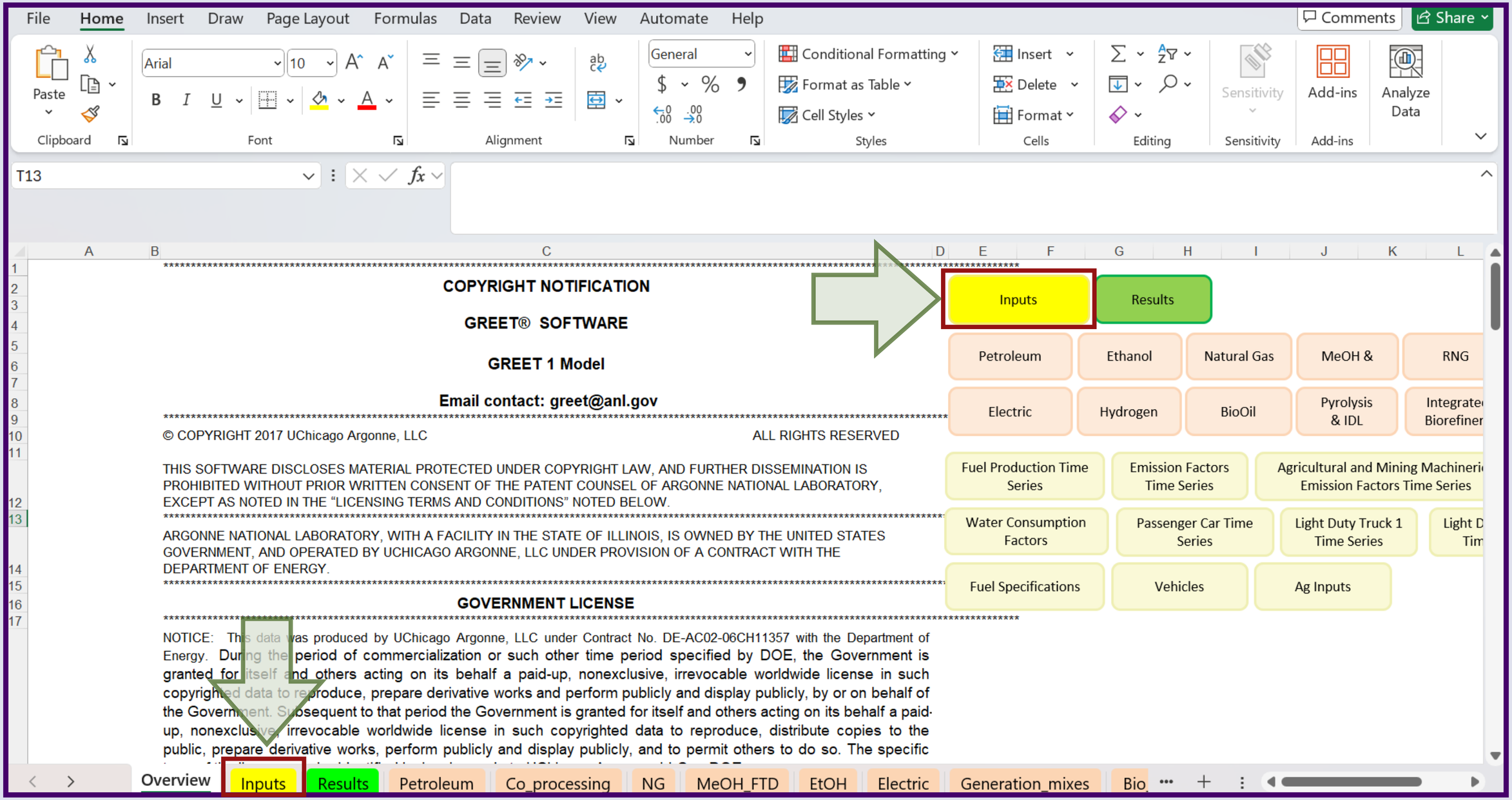
Adjust General Battery Settings



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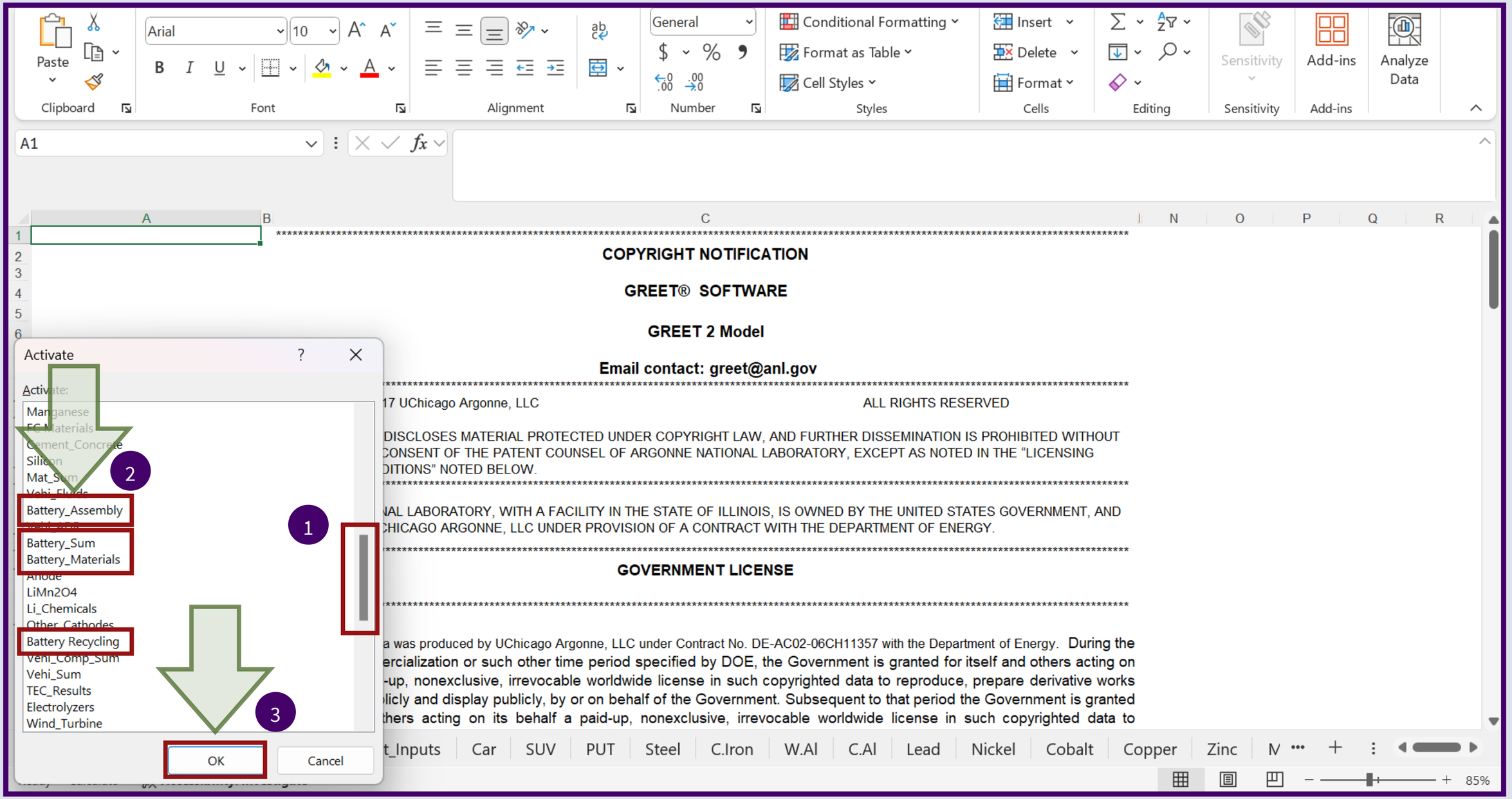
Adjust More-specified Simulation Settings



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Example Scenarios

2017 SI-ICE

Model a 2017 Spark-Ignition Internal Combustion Engine (SI-ICE) Light-duty Vehicle (LDV) Fueled by Gasoline in R&D GREET

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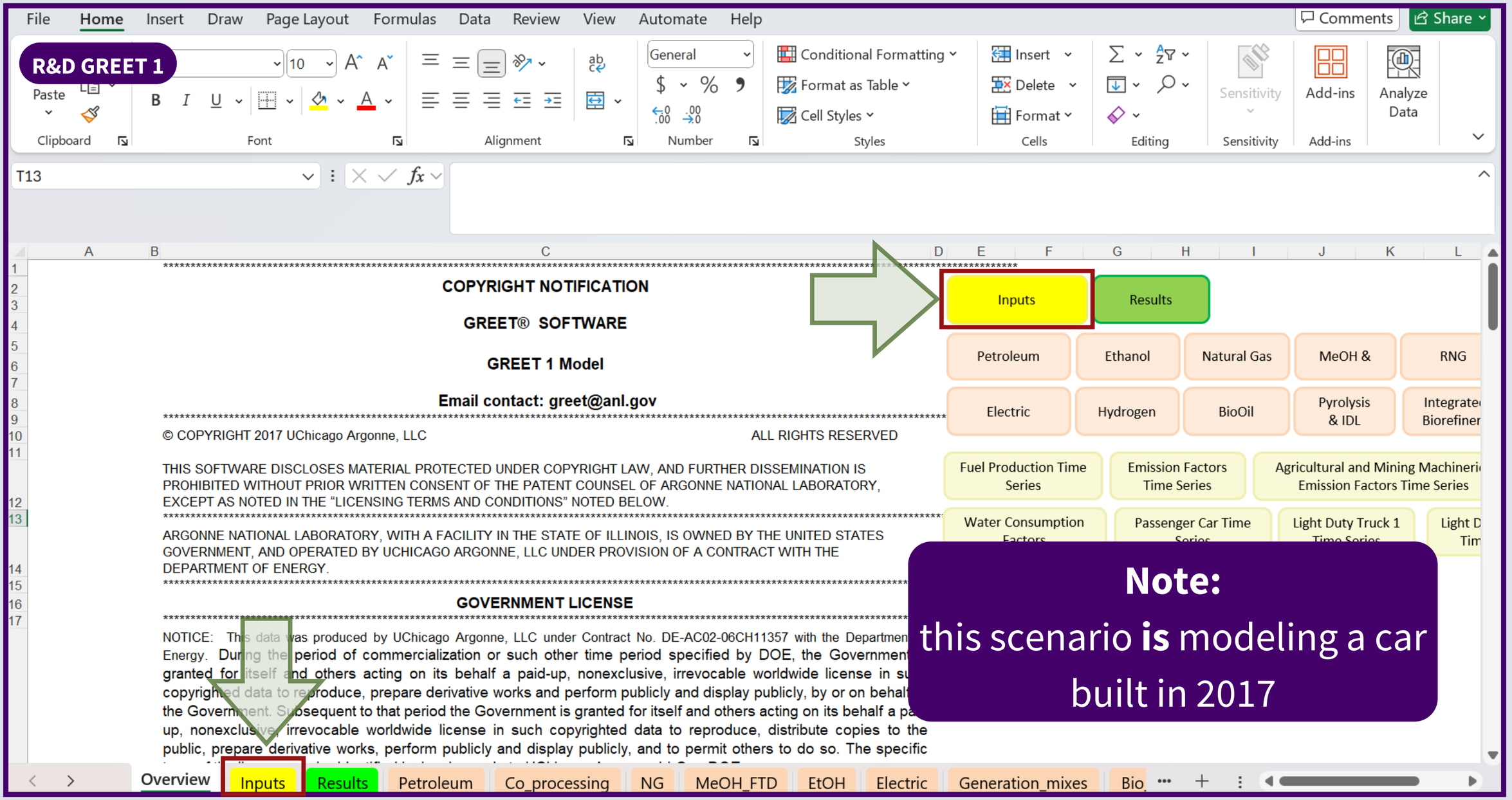

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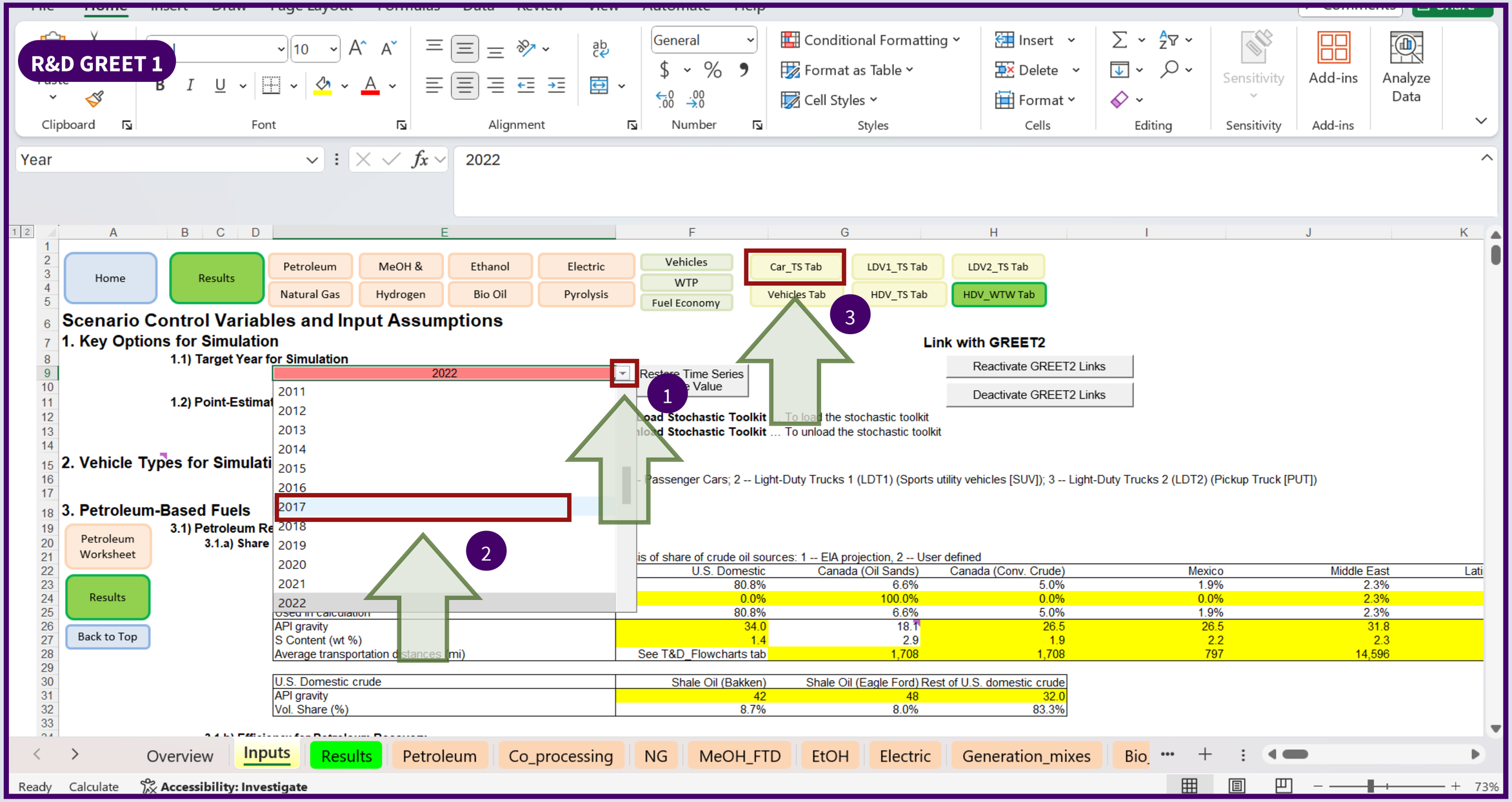
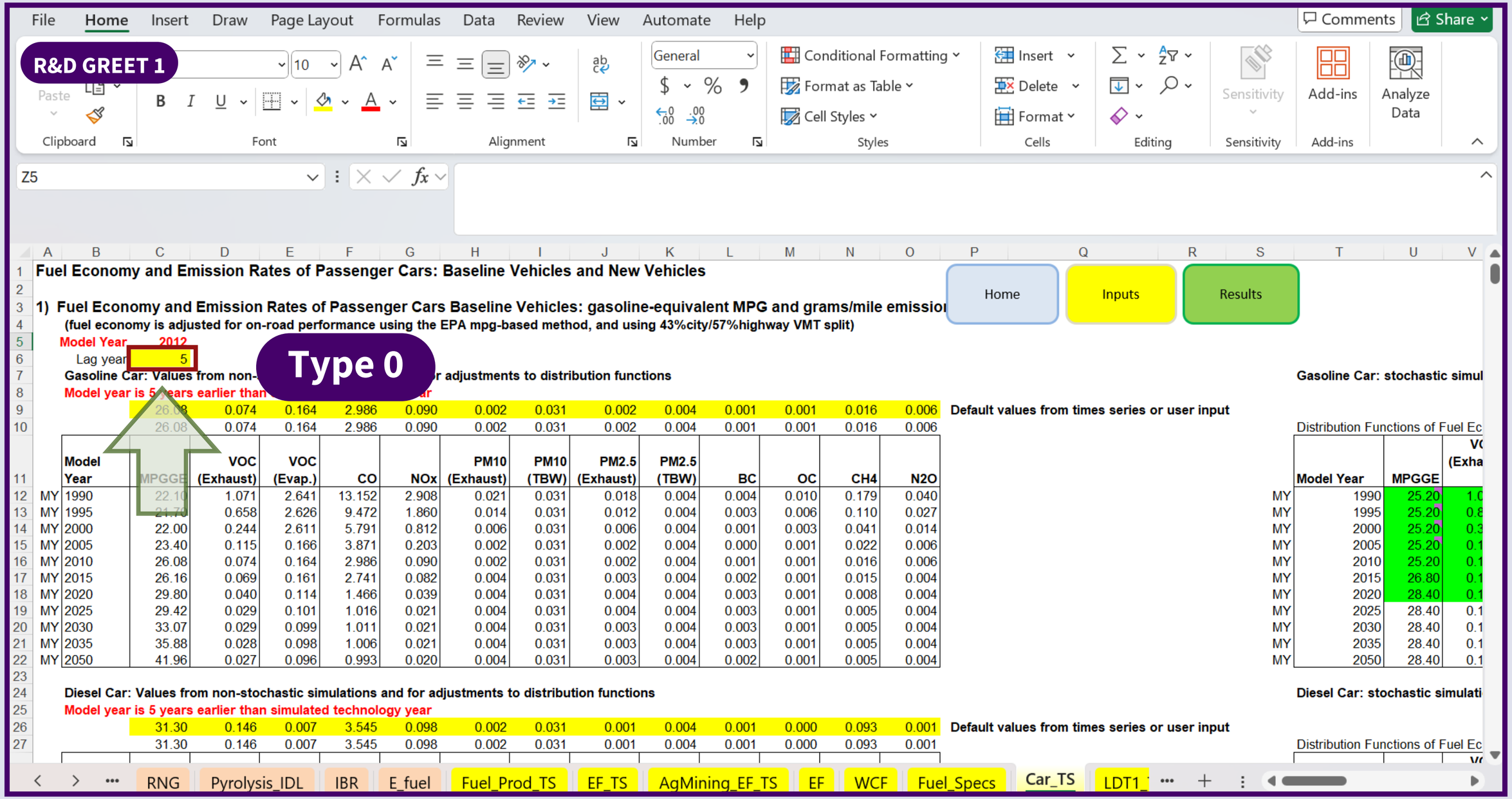

R&D GREET 1
Year
2022
Home
Results
Petroleum
MeOH &
Ethanol
Electric
Natural Gas
Hydrogen
Bio Oil
Pyrolysis
Vehicles
WTP
Fuel Economy
Car_TS Tab
LDV1_TS Tab
LDV2_TS Tab
Vehicles Tab
HDV_TS Tab
HDV_WTW Tab
Scenario Control Variables and Input Assumptions
1. Key Options for Simulation
1.1) Target Year for Simulation
2022
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Restore Time Series Value
1
2
3
Link with GREET2
Reactivate GREET2 Links
Deactivate GREET2 Links
2. Vehicle Types for Simulati
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
Petroleum Worksheet
Results
Back to Top
U.S. Domestic
Canada (Oil Sands)
Canada (Conv. Crude)
Mexico
Middle East
API gravity
S Content (wt %)
Average transportation distances (mi)
See T&D_Flowcharts tab
Shale Oil (Bakken)
Shale Oil (Eagle Ford)
Rest of U.S. domestic crude
Vol. Share (%)
Overview
Inputs
Results
Petroleum
Co_processing
NG
MeOH_FTD
EtOH
Electric
Generation_mixes
Ready
Calculate
Accessibility: Investigate



	Model Year	MPGGE	VOC (Exhaust)	VOC (Evap.)	CO	NOx	PM10 (Exhaust)	PM10 (TBW)	PM2.5 (Exhaust)	PM2.5 (TBW)	BC	OC	CH4	N2O
		26.08	0.074	0.164	2.986	0.090	0.002	0.031	0.002	0.004	0.001	0.001	0.016	0.006
		26.08	0.074	0.164	2.986	0.090	0.002	0.031	0.002	0.004	0.001	0.001	0.016	0.006
MY	1990	22.10	1.071	2.641	13.152	2.908	0.021	0.031	0.018	0.004	0.004	0.010	0.179	0.040
MY	1995	21.70	0.658	2.626	9.472	1.860	0.014	0.031	0.012	0.004	0.003	0.006	0.110	0.027
MY	2000	22.00	0.244	2.611	5.791	0.812	0.006	0.031	0.006	0.004	0.001	0.003	0.041	0.014
MY	2005	23.40	0.115	0.166	3.871	0.203	0.002	0.031	0.002	0.004	0.000	0.001	0.022	0.006
MY	2010	26.08	0.074	0.164	2.986	0.090	0.002	0.031	0.002	0.004	0.001	0.001	0.016	0.006
MY	2015	26.16	0.069	0.161	2.741	0.082	0.004	0.031	0.003	0.004	0.002	0.001	0.015	0.004
MY	2020	29.80	0.040	0.114	1.466	0.039	0.004	0.031	0.004	0.004	0.003	0.001	0.008	0.004
MY	2025	29.42	0.029	0.101	1.016	0.021	0.004	0.031	0.004	0.004	0.003	0.001	0.005	0.004
MY	2030	33.07	0.029	0.099	1.011	0.021	0.004	0.031	0.003	0.004	0.003	0.001	0.005	0.004
MY	2035	35.88	0.028	0.098	1.006	0.021	0.004	0.031	0.003	0.004	0.003	0.001	0.005	0.004
MY	2050	41.96	0.027	0.096	0.993	0.020	0.004	0.031	0.003	0.004	0.002	0.001	0.005	0.004

	Model Year	MPGGE	VO (Exha
MY	1990	25.20	1.0
MY	1995	25.20	0.8
MY	2000	25.20	0.3
MY	2005	25.20	0.1
MY	2010	25.20	0.1
MY	2015	26.80	0.1
MY	2020	28.40	0.1
MY	2025	28.40	0.1
MY	2030	28.40	0.1
MY	2035	28.40	0.1
MY	2050	28.40	0.1

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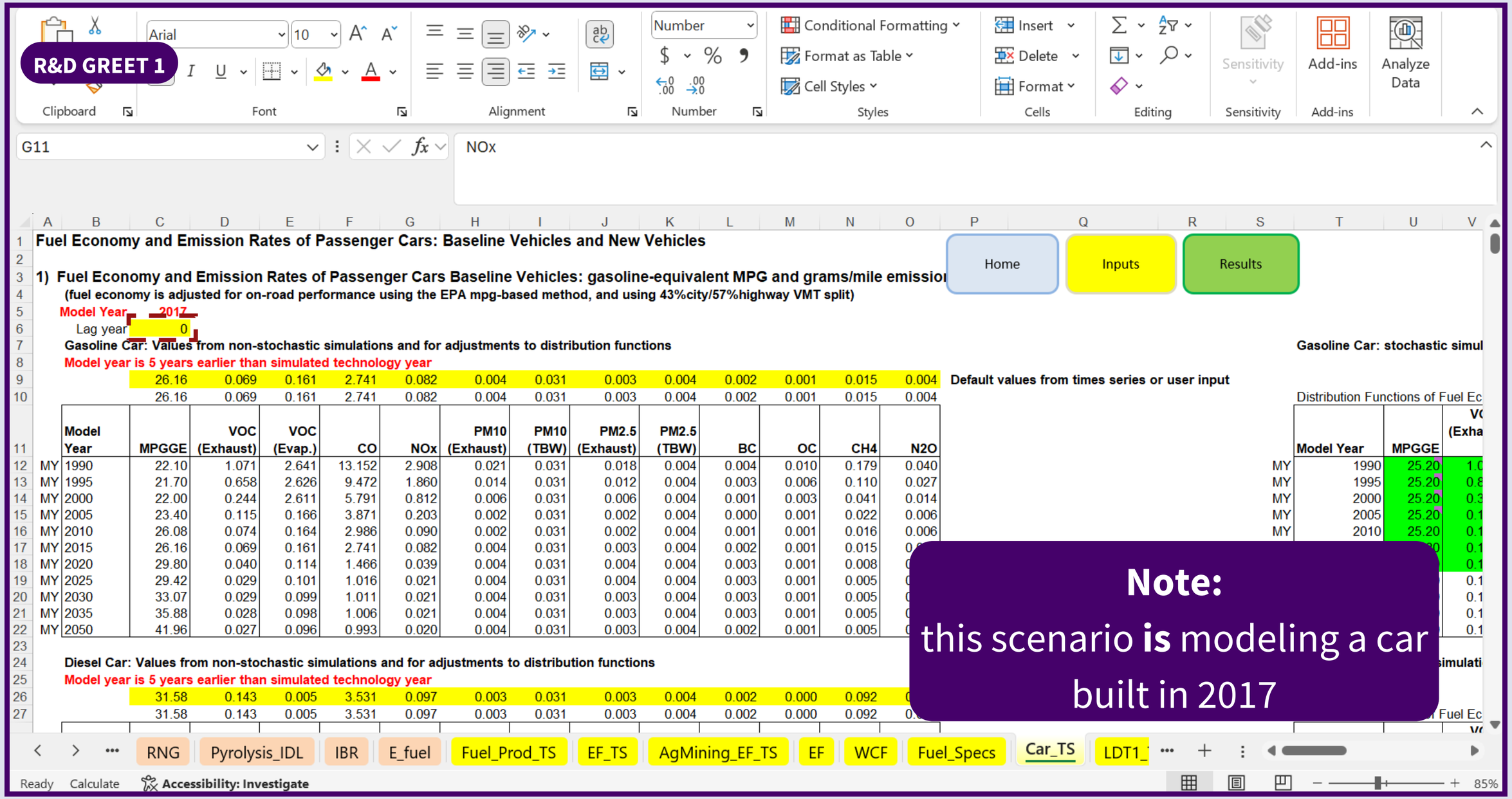

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Well-to-Pump (WTP) and Well-to-Wheel (WTW) GHG Emissions

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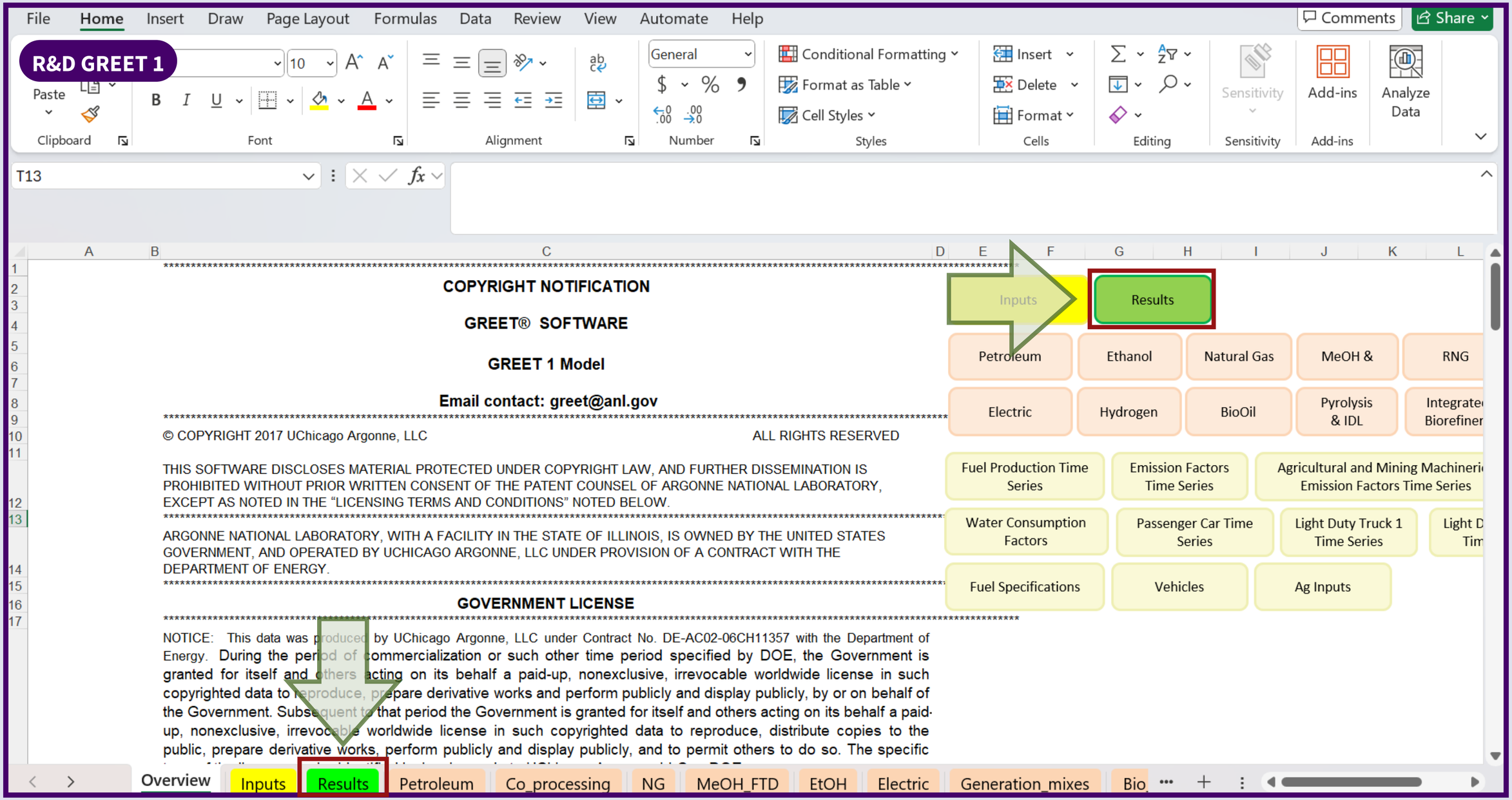

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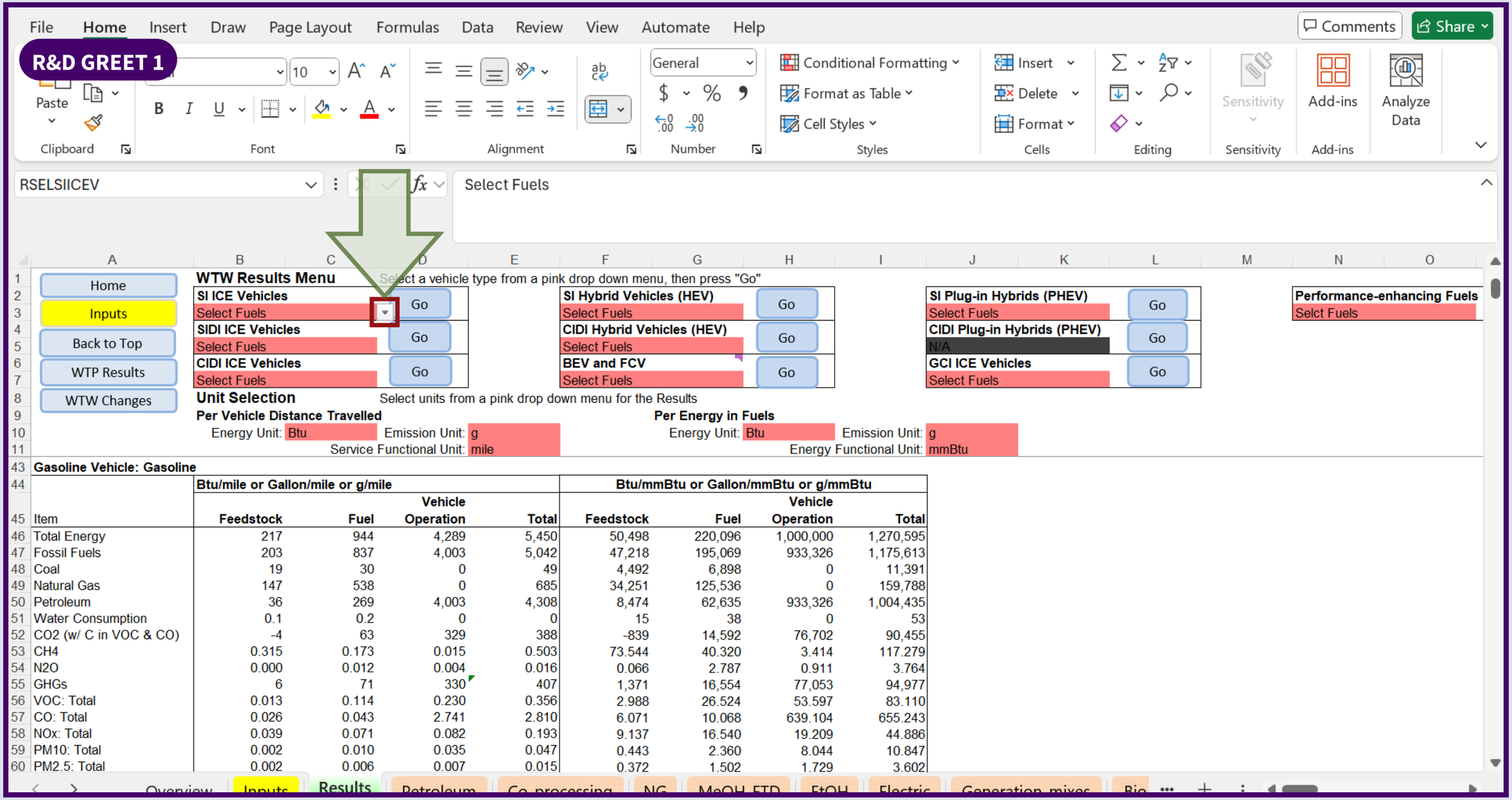

Item	Btu/mile or Gallon/mile or g/mile				Btu/mmBtu or Gallon/mmBtu or g/mmBtu			
	Feedstock	Fuel	Vehicle Operation	Total	Feedstock	Fuel	Vehicle Operation	Total
Total Energy	217	944	4,289	5,450	50,498	220,096	1,000,000	1,270,595
Fossil Fuels	203	837	4,003	5,042	47,218	195,069	933,326	1,175,613
Coal	19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

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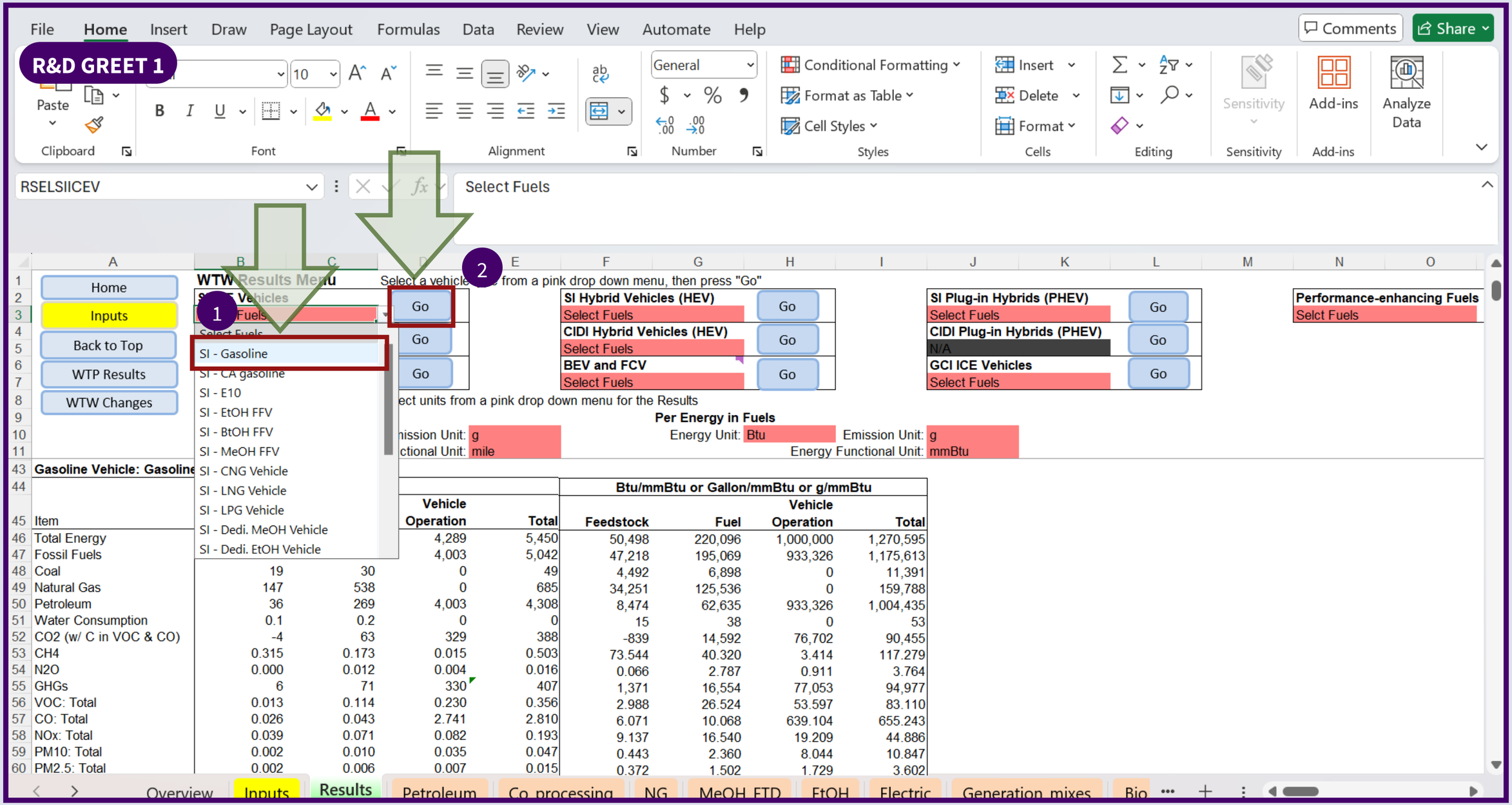

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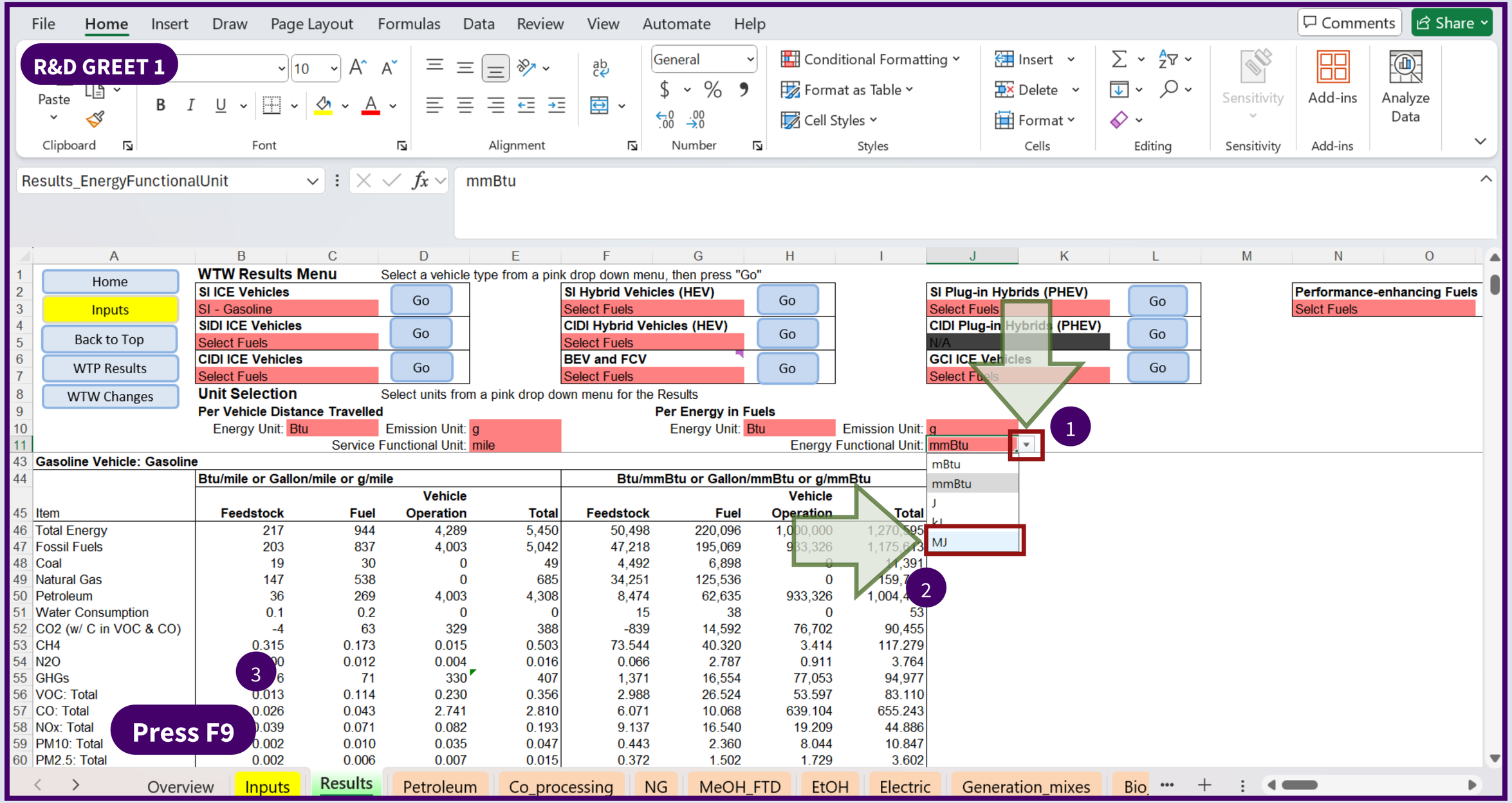

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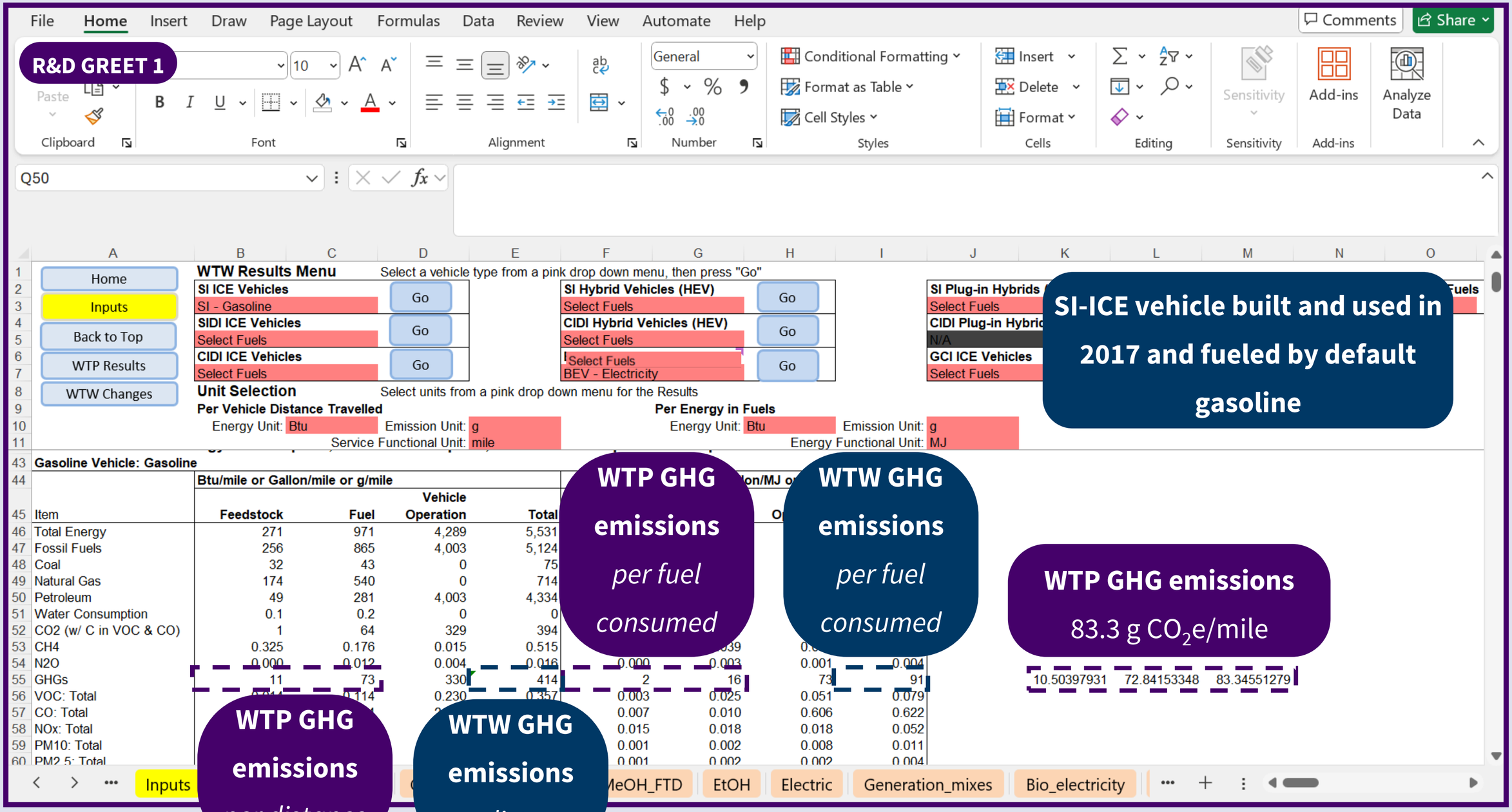

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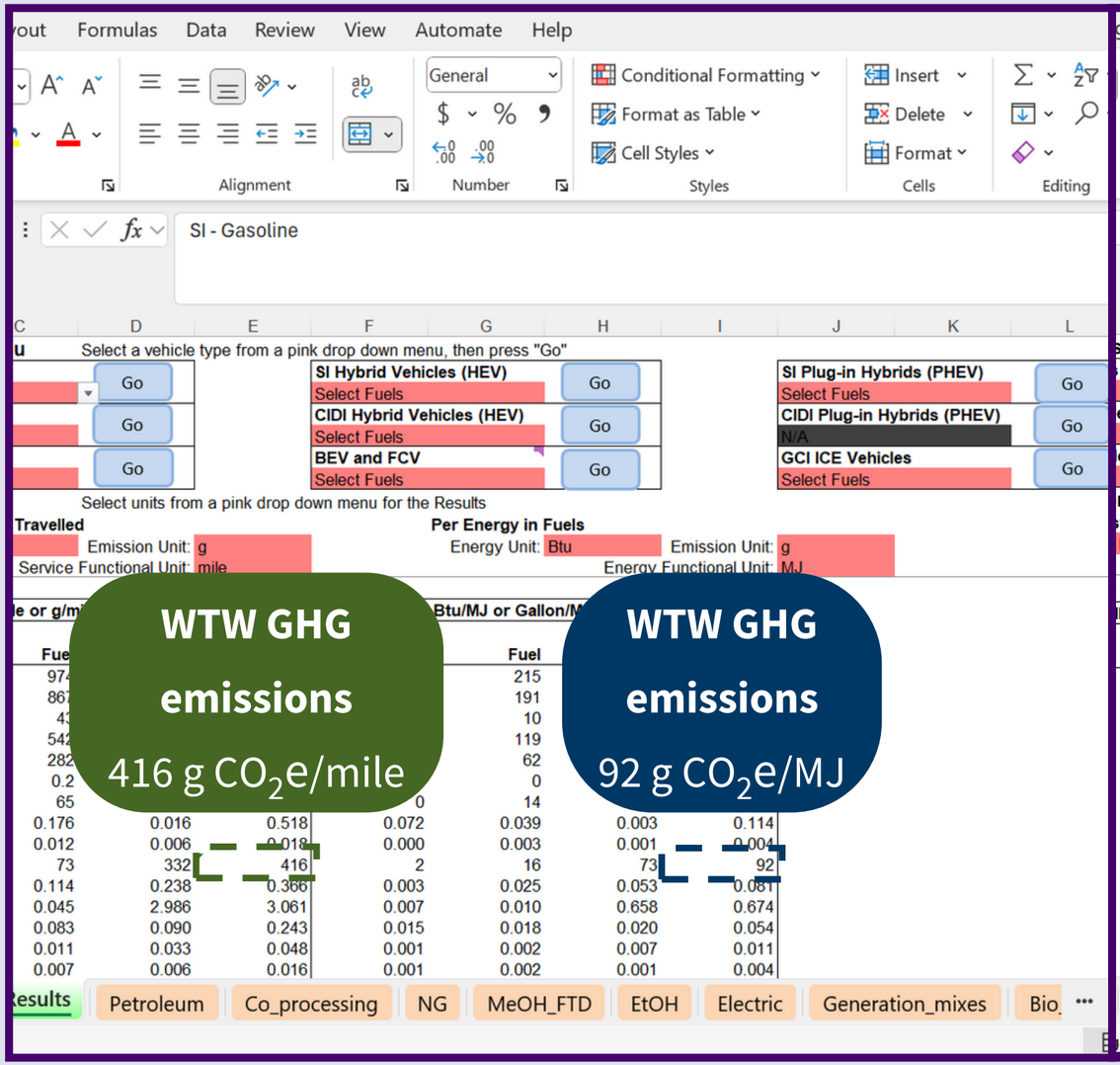
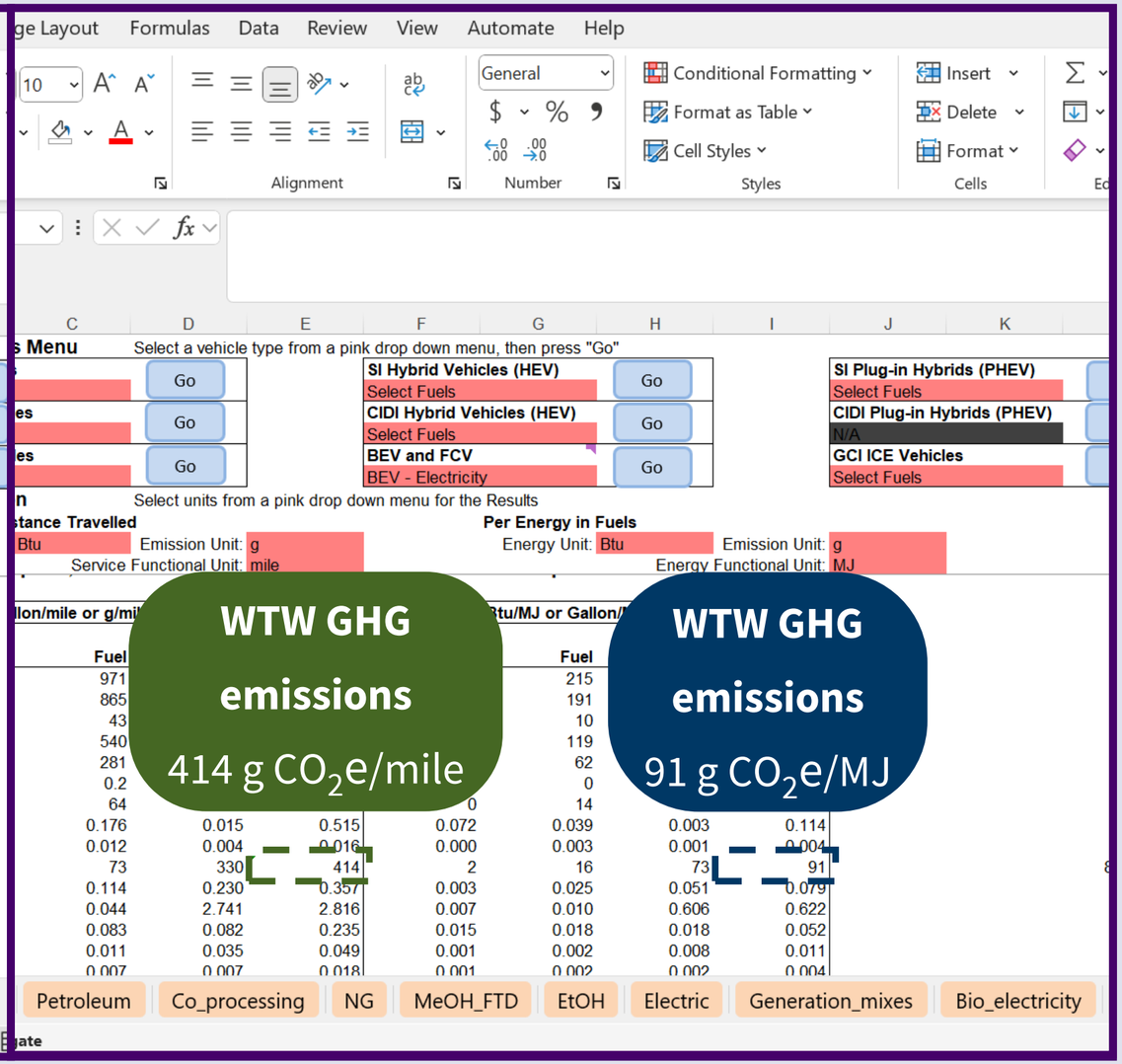
SI-ICE LDV vehicle on the road in 2017



SI-ICE LDV built in 2017



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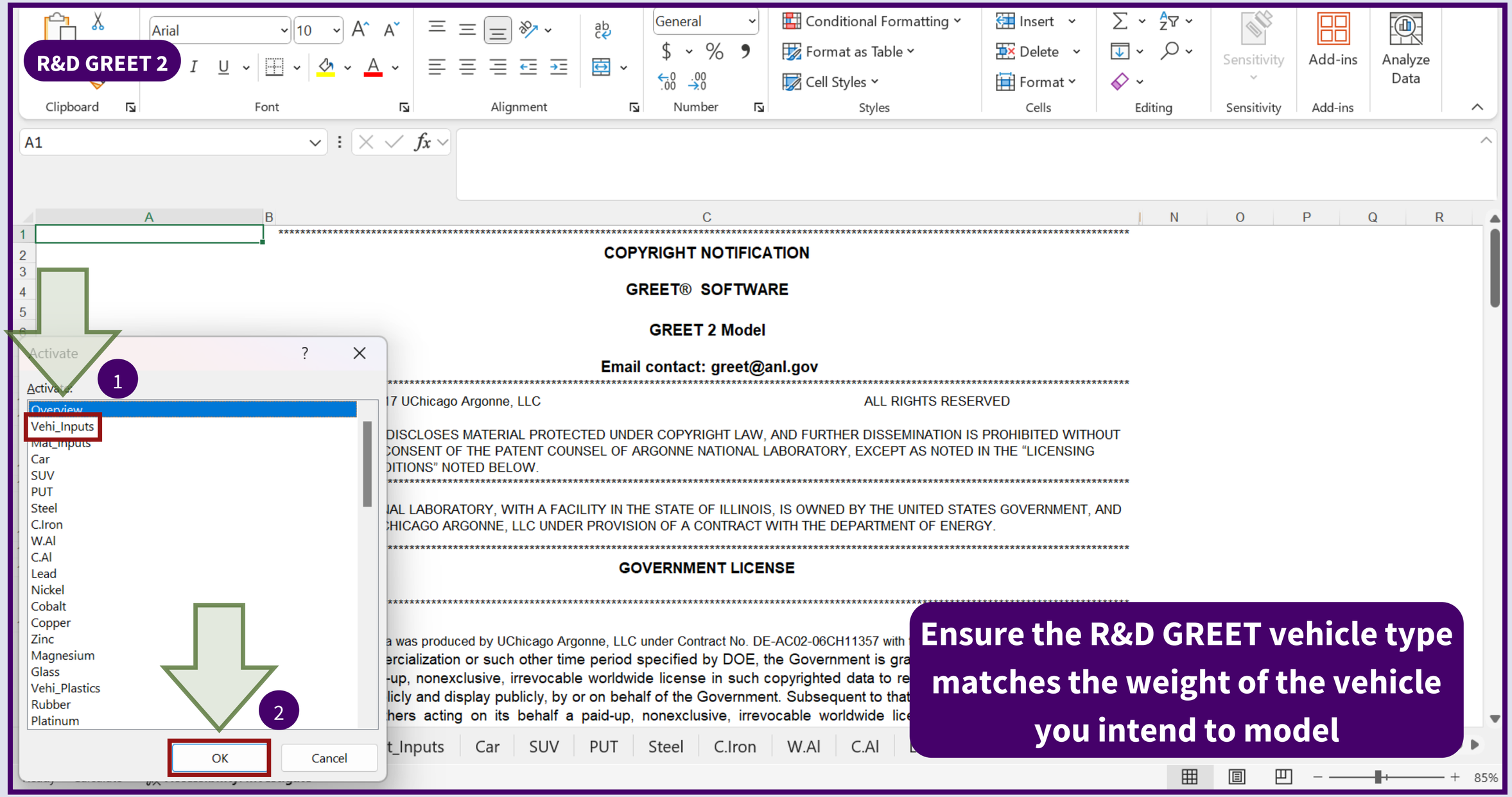

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R&D GREET 2

J102

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

1. Selection of Vehicle Types for Simulation

1

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

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

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

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	PHEV: Lightweight Material	EV: Conventional Material	EV: Lightweight Material	FCV: Conventional Material	FCV: Lightweight Material
3,183	2,692	3,429	2,839	3,713	3,007	4,026	3,193	3,644	2,930

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	36.0	23.4	22.1	14.4	22.1	14.4	22.1	14.4	22.1	14.4
Ni-MH			89.1	75.3	635.3	495.8	2,853.2	2,162.3	105.6	94.1
Li-Ion			30.0	25.3	196.6	153.4	1,049.7	795.5	31.2	27.8

Overview | Vehi_Inputs | Mat_Inputs | Car | SUV | PUT | Steel | C.Iron | W.Al | C.Al | Lead | Nickel | Cobalt | Copper | Zinc | M

Ready Calculate Accessibility: Investigate 85%

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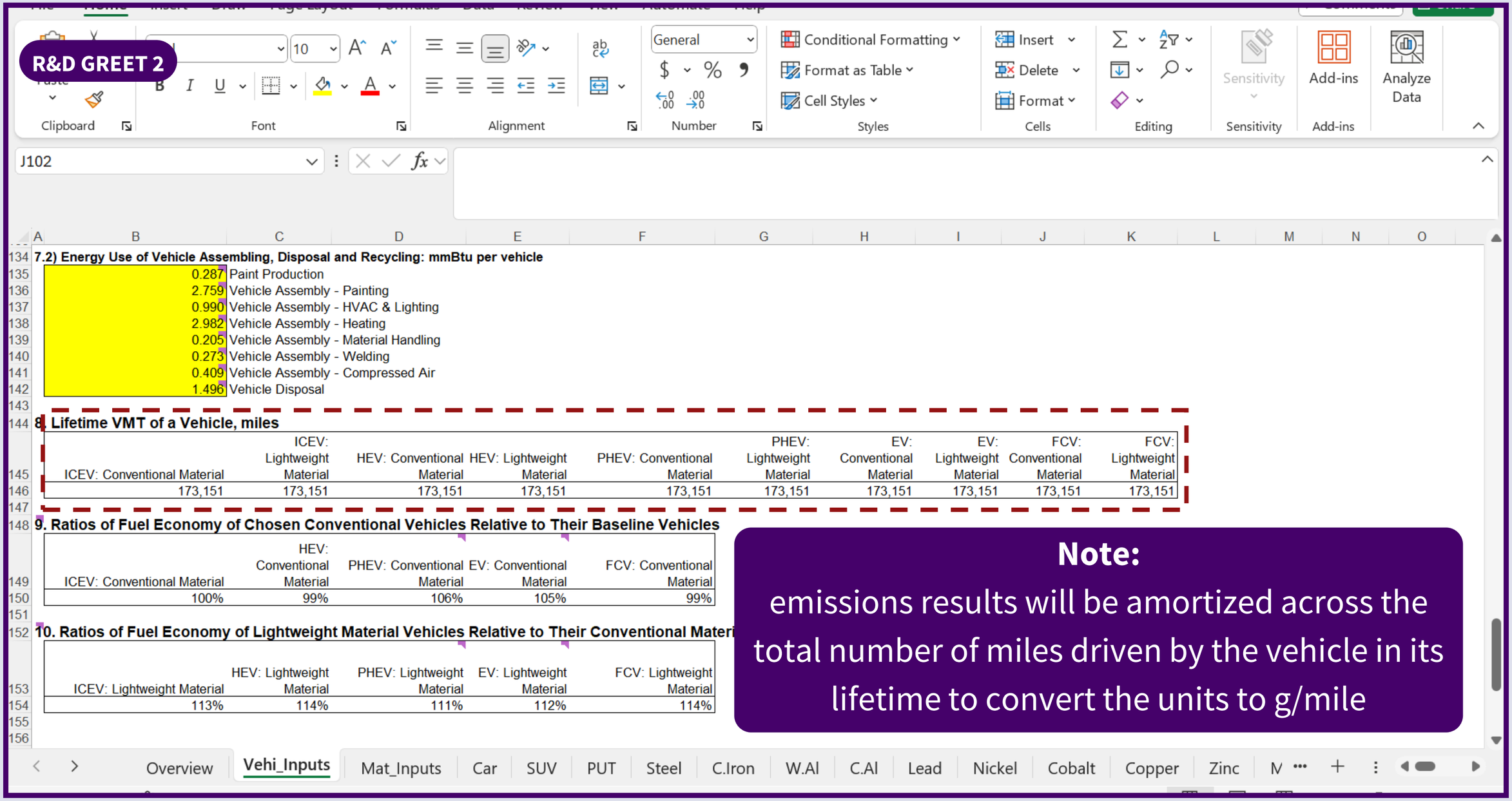

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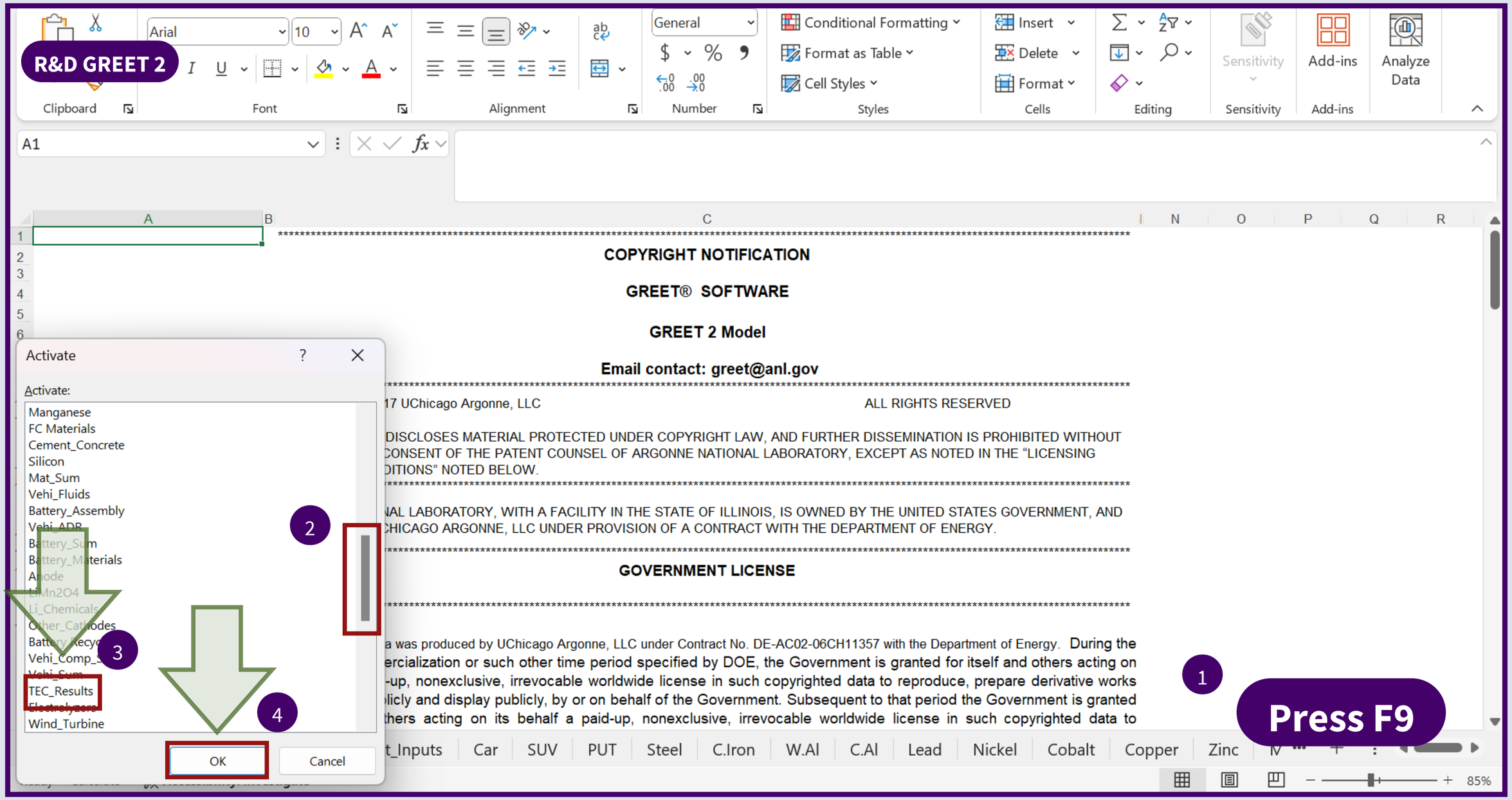

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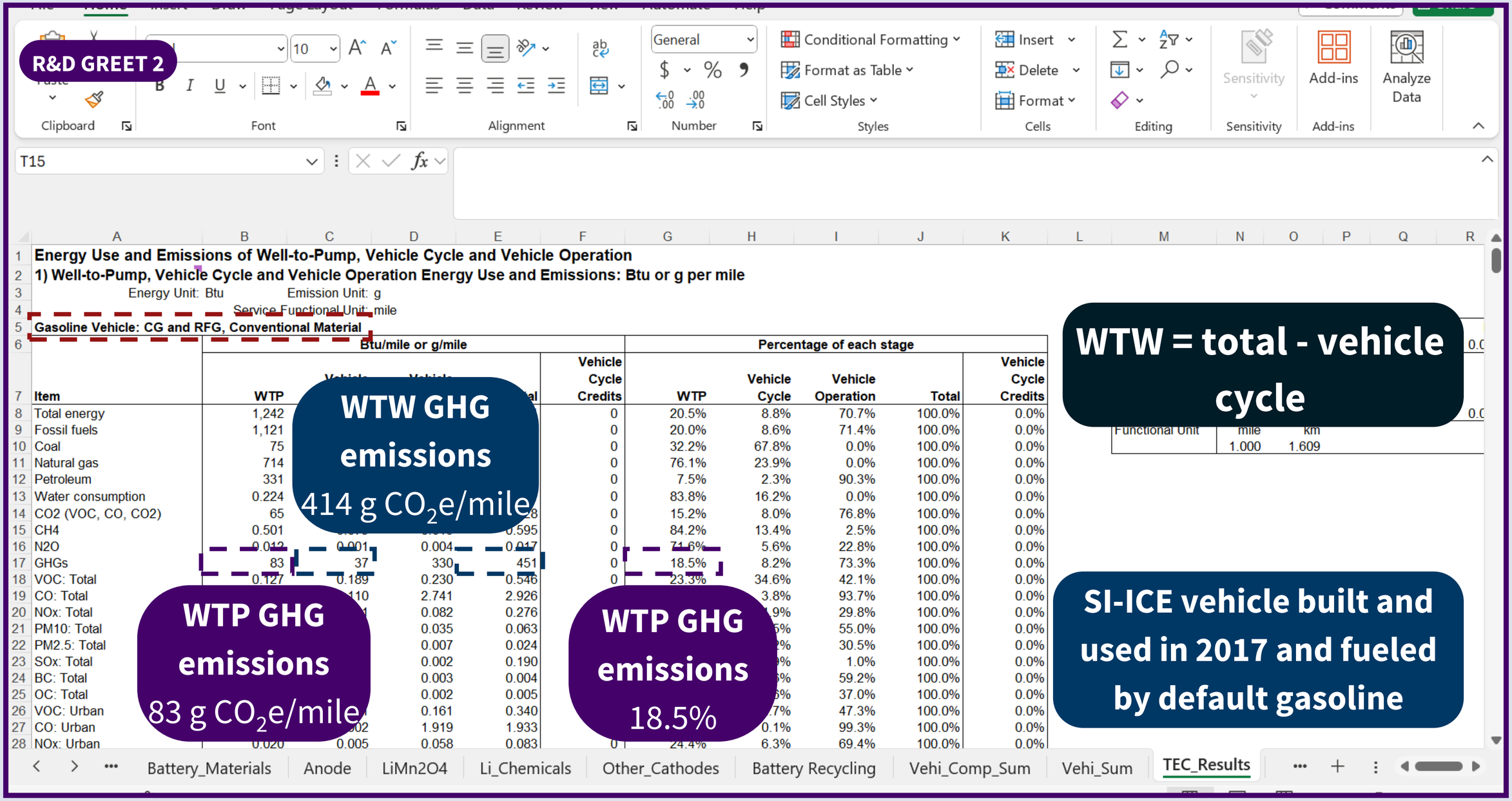
R&D GREET 2



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

	Btu/mile or g/mile					Percentage of each stage				
Item	WTP	Vehicle	Vehicle	Total	Vehicle Cycle Credits	WTP	Vehicle Cycle	Vehicle Operation	Total	Vehicle Cycle Credits
Total energy	1,242				0	20.5%	8.8%	70.7%	100.0%	0.0%
Fossil fuels	1,121				0	20.0%	8.6%	71.4%	100.0%	0.0%
Coal	75				0	32.2%	67.8%	0.0%	100.0%	0.0%
Natural gas	714				0	76.1%	23.9%	0.0%	100.0%	0.0%
Petroleum	331				0	7.5%	2.3%	90.3%	100.0%	0.0%
Water consumption	0.224				0	83.8%	16.2%	0.0%	100.0%	0.0%
CO2 (VOC, CO, CO2)	65			28	0	15.2%	8.0%	76.8%	100.0%	0.0%
CH4	0.501			0.595	0	84.2%	13.4%	2.5%	100.0%	0.0%
N2O	0.012	0.001	0.004	0.017	0	71.6%	5.6%	22.8%	100.0%	0.0%
GHGs	83	37	330	451	0	18.5%	8.2%	73.3%	100.0%	0.0%
VOC: Total	0.127	0.189	0.230	0.546	0	23.3%	34.6%	42.1%	100.0%	0.0%
CO: Total		110	2.741	2.926			3.8%	93.7%	100.0%	0.0%
NOx: Total		1	0.082	0.276			9%	29.8%	100.0%	0.0%
PM10: Total			0.035	0.063			5%	55.0%	100.0%	0.0%
PM2.5: Total			0.007	0.024			2%	30.5%	100.0%	0.0%
SOx: Total			0.002	0.190			9%	1.0%	100.0%	0.0%
BC: Total			0.003	0.004			5%	59.2%	100.0%	0.0%
OC: Total			0.002	0.005			6%	37.0%	100.0%	0.0%
VOC: Urban			0.161	0.340			7%	47.3%	100.0%	0.0%
CO: Urban		02	1.919	1.933			0.1%	99.3%	100.0%	0.0%
NOx: Urban	0.020	0.005	0.058	0.083	0	24.4%	6.3%	69.4%	100.0%	0.0%

Functional Unit	mile	km
	1.000	1.609

WTW GHG emissions
414 g CO_2e/mile

WTP GHG emissions
83 g CO_2e/mile

WTP GHG emissions
18.5%

WTW = total - vehicle cycle

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

Battery_Materials | Anode | LiMn2O4 | Li_Chemicals | Other_Cathodes | Battery Recycling | Vehi_Comp_Sum | Vehi_Sum | TEC_Results

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How Do Battery Electric Vehicles (BEVs) Compare to Internal Combustion Engine Vehicles (ICEVs) on a Vehicle Cycle Perspective?

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SUV BEV

Model a 2022 Sport Utility Vehicle (SUV) Battery Electric Vehicle (BEV) Using an NMC622 Battery in R&D GREET

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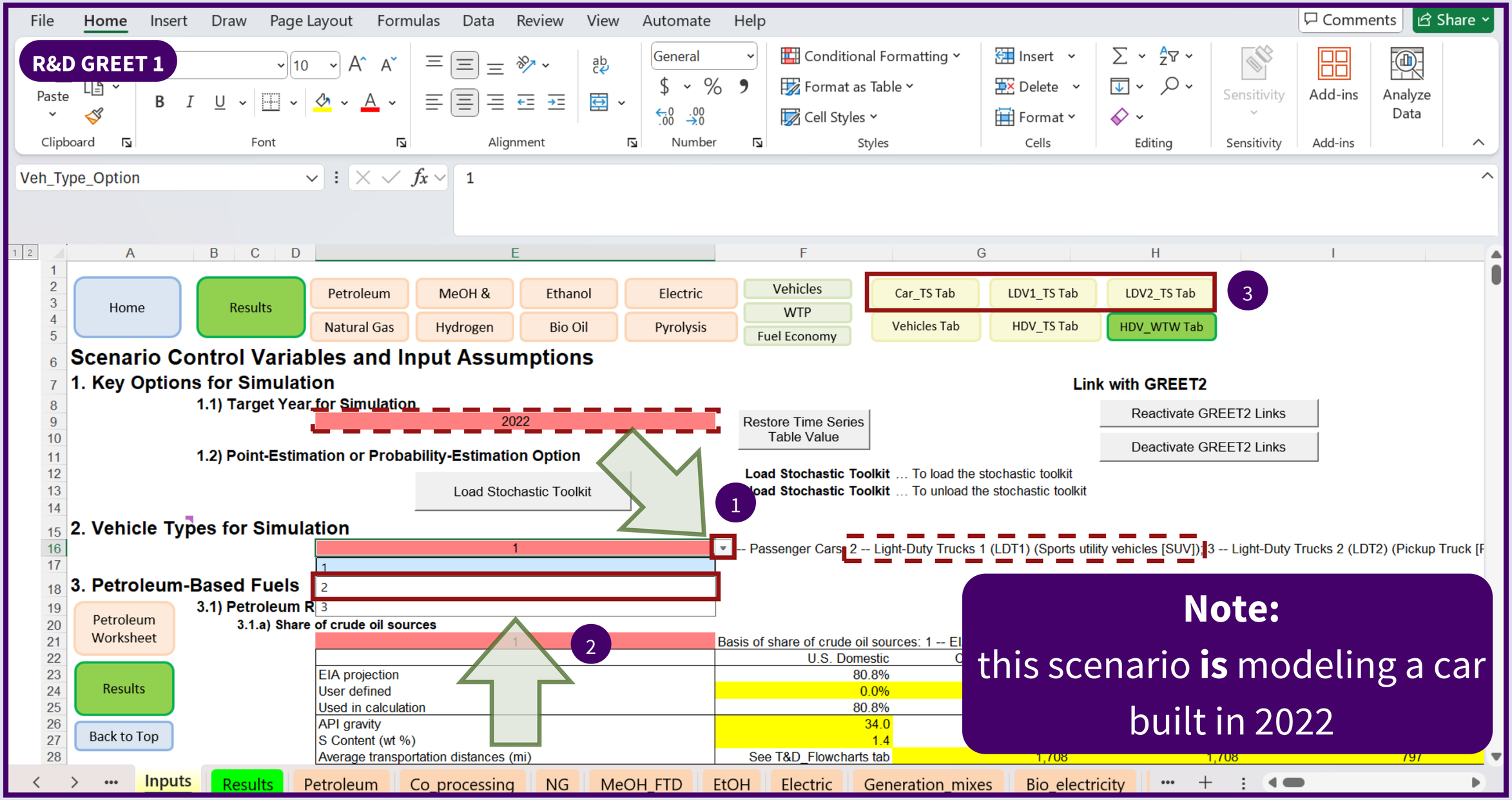

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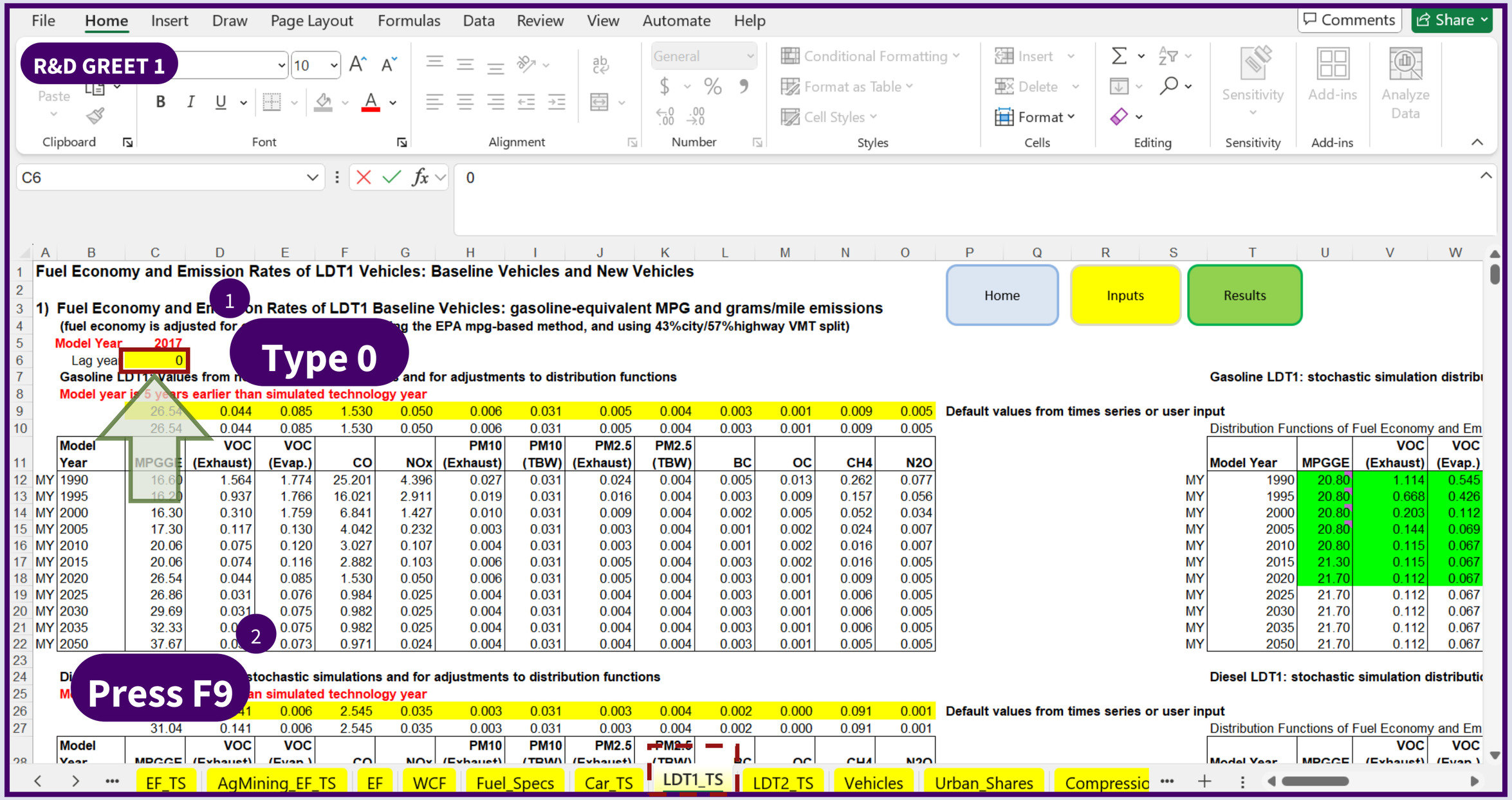

Model Year	MPGGE	VOC (Exhaust)	VOC (Evap.)	CO	NOx	PM10 (Exhaust)	PM10 (TBW)	PM2.5 (Exhaust)	PM2.5 (TBW)	BC	OC	CH4	N2O
MY 1990	16.60	1.564	1.774	25.201	4.396	0.027	0.031	0.024	0.004	0.005	0.013	0.262	0.077
MY 1995	16.20	0.937	1.766	16.021	2.911	0.019	0.031	0.016	0.004	0.003	0.009	0.157	0.056
MY 2000	16.30	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	0.0	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	0.0	0.073	0.971	0.024	0.004	0.031	0.004	0.004	0.003	0.001	0.005	0.005

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

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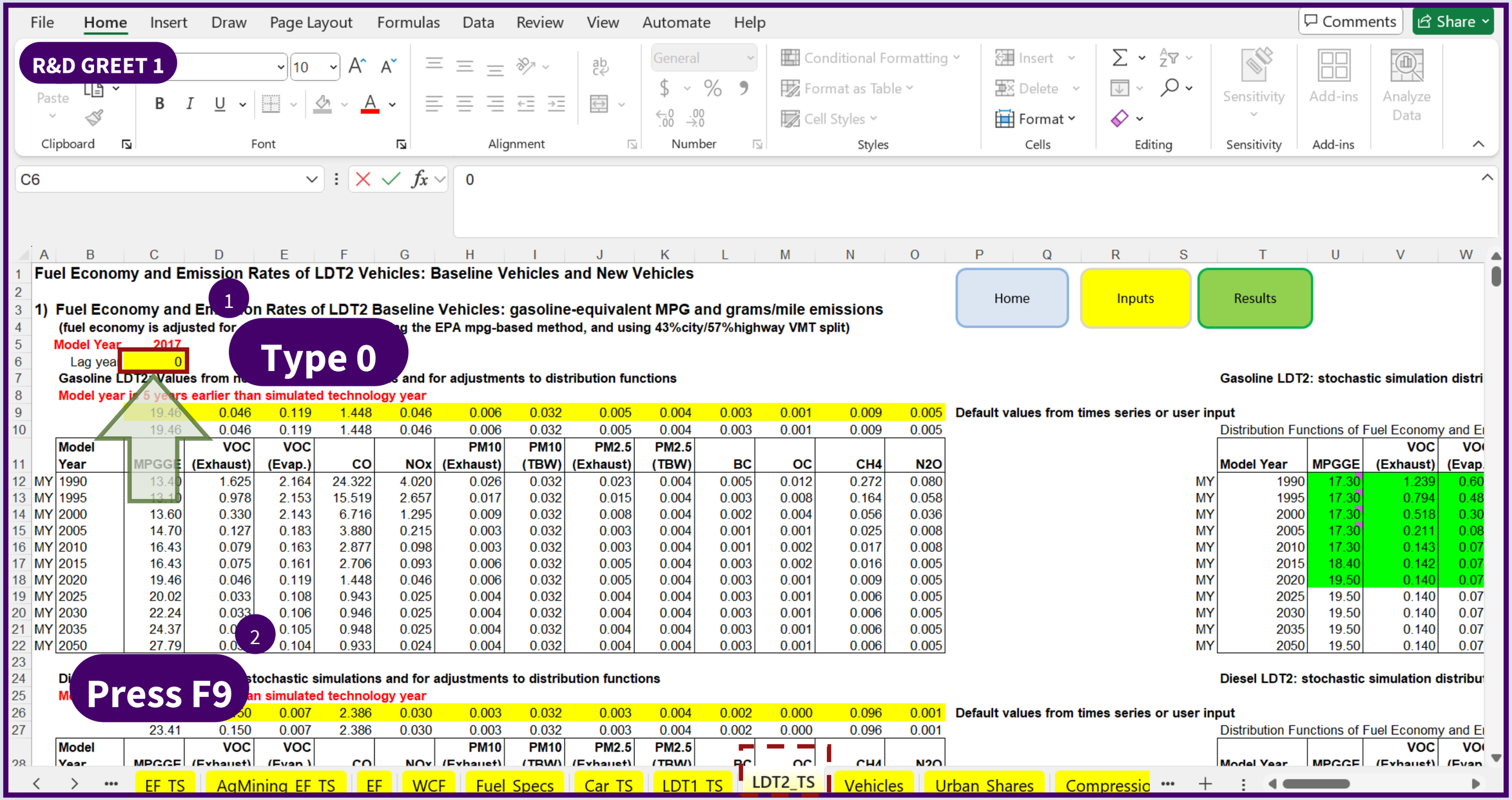

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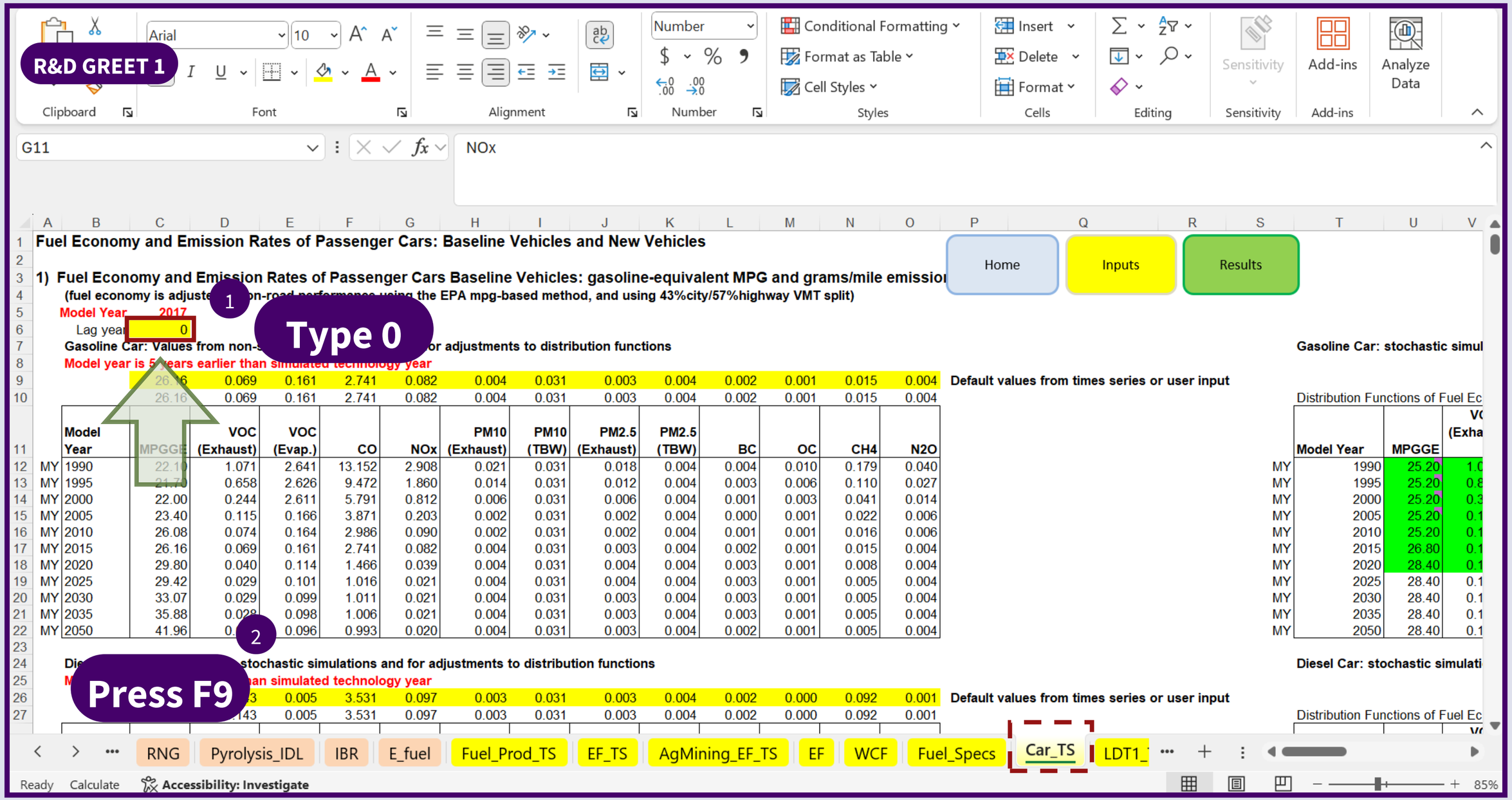

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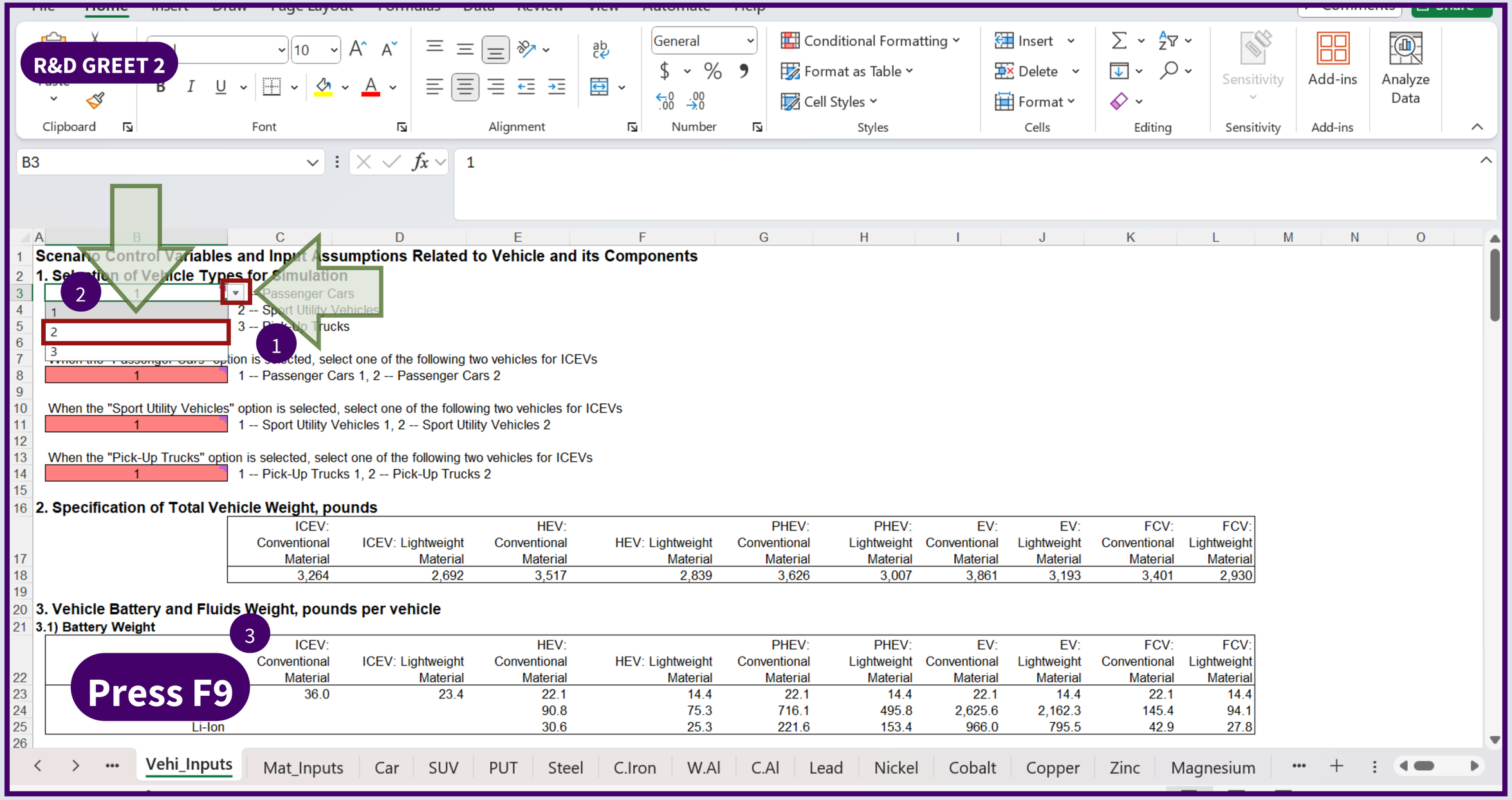

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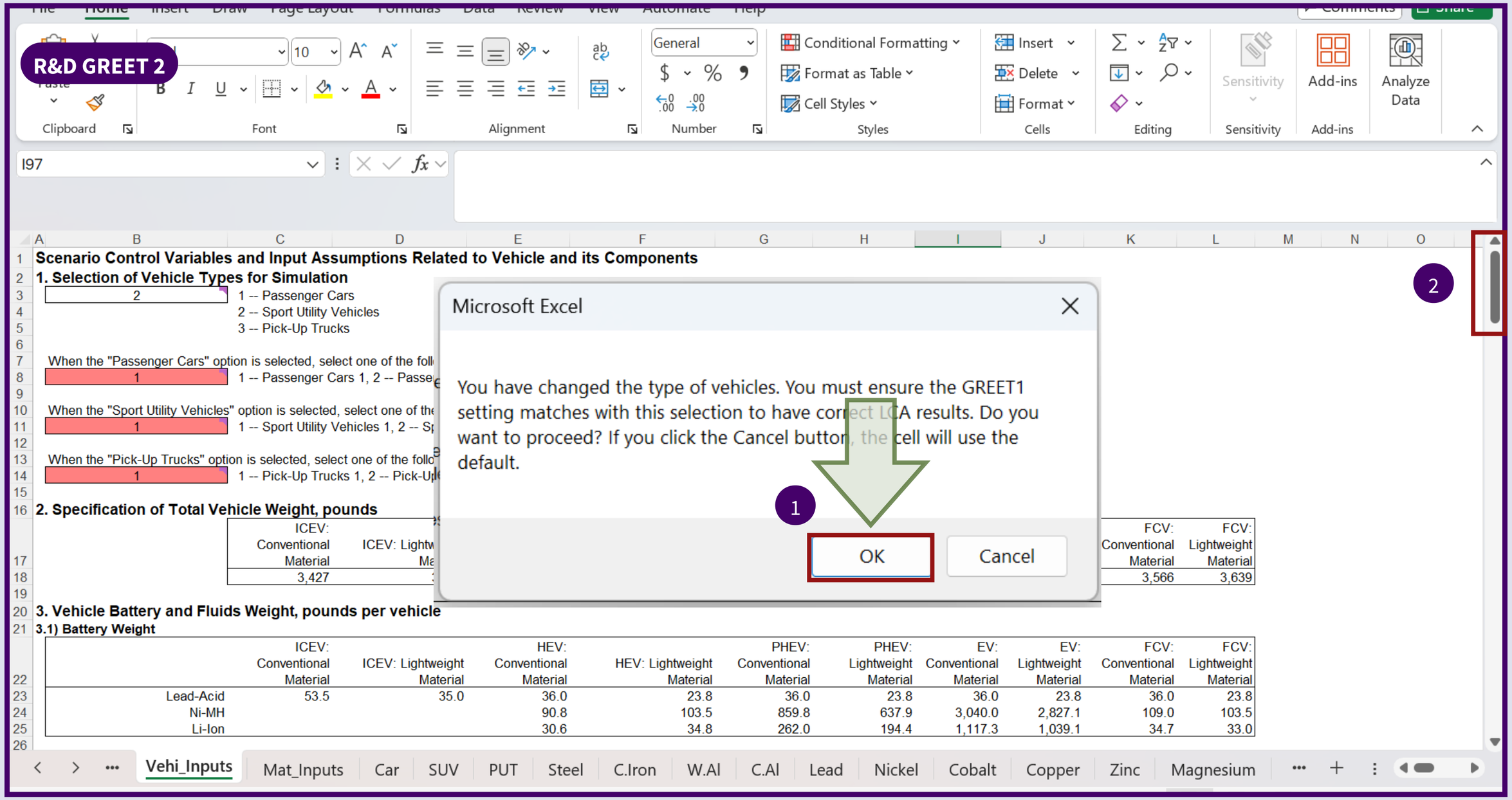

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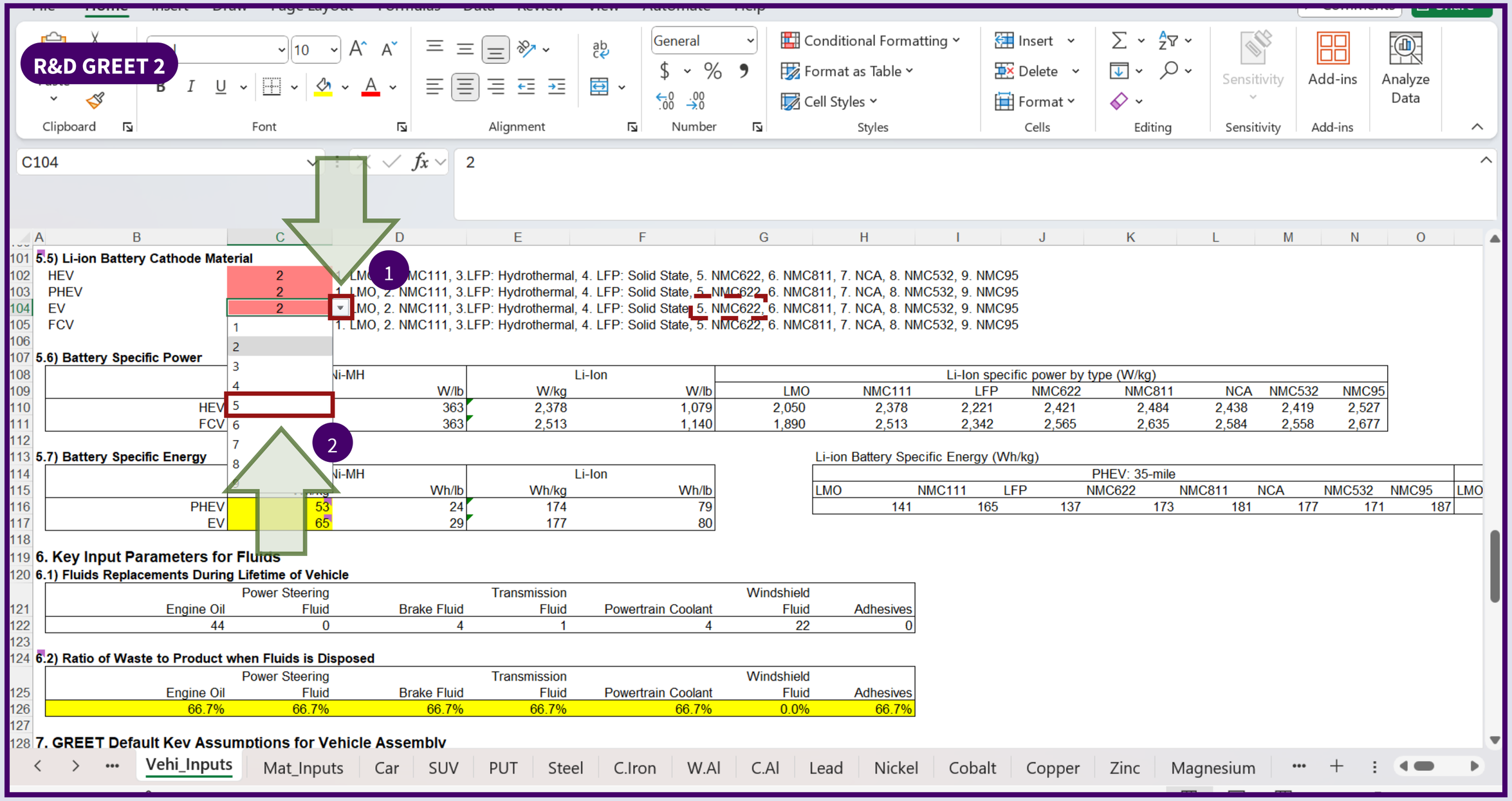

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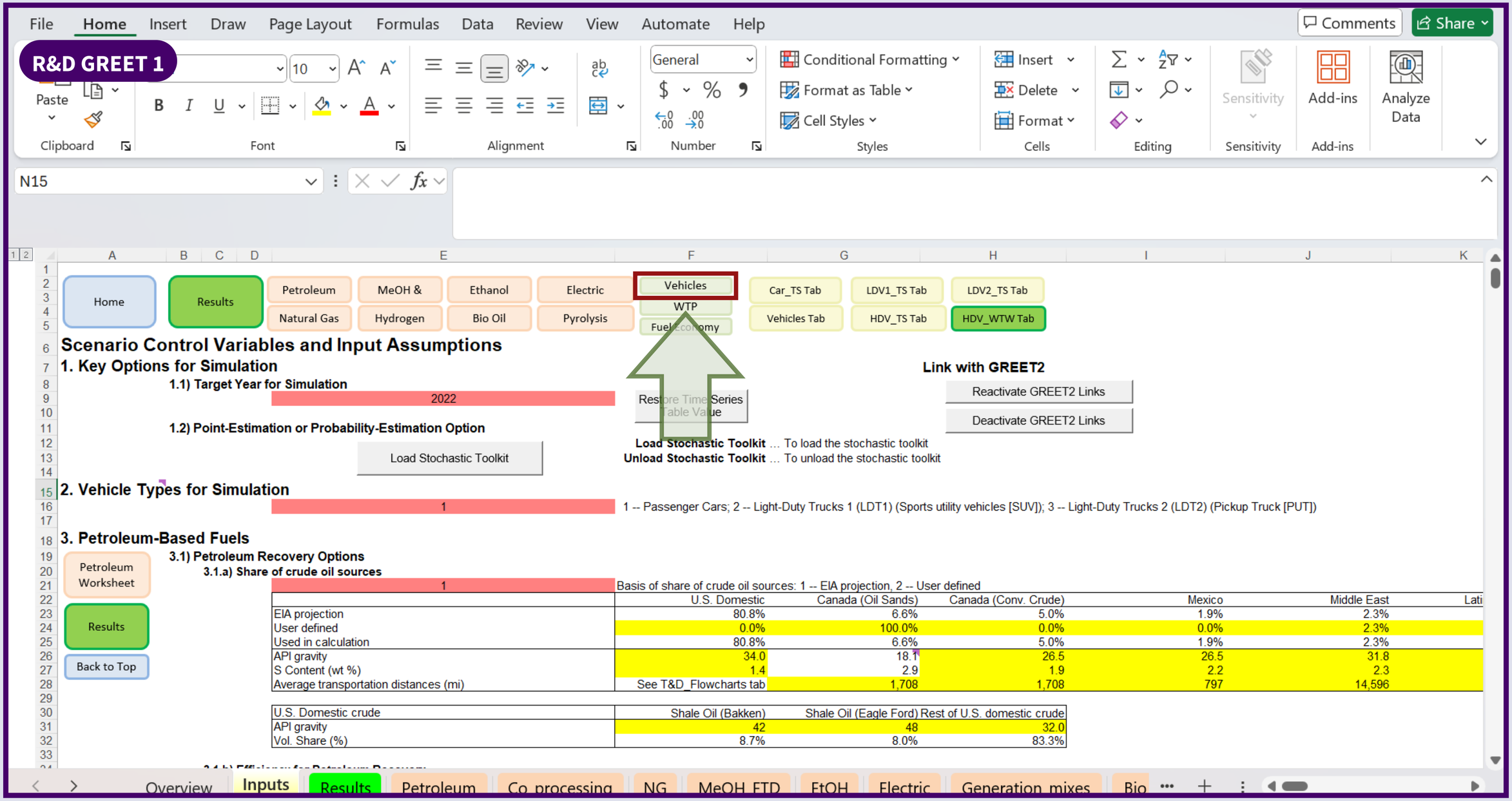
Default Range for a BEV



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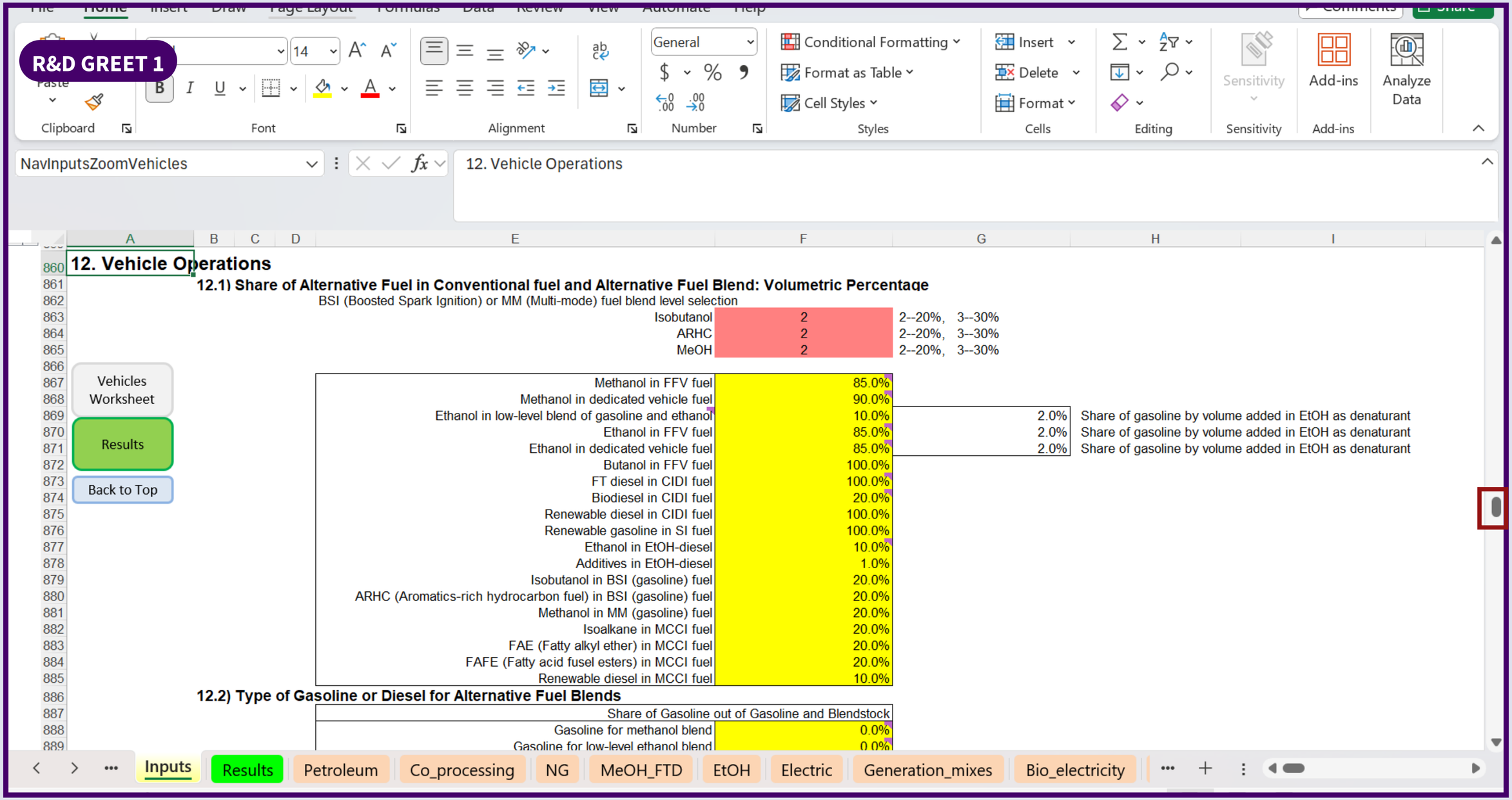

12. Vehicle Operations

12.1) Share of Alternative Fuel in Conventional fuel and Alternative Fuel Blend: Volumetric Percentage

BSI (Boosted Spark Ignition) or MM (Multi-mode) fuel blend level selection

Isobutanol	2	2--20%, 3--30%
ARHC	2	2--20%, 3--30%
MeOH	2	2--20%, 3--30%

Methanol in FFV fuel	85.0%		
Methanol in dedicated vehicle fuel	90.0%		
Ethanol in low-level blend of gasoline and ethanol	10.0%	2.0%	Share of gasoline by volume added in EtOH as denaturant
Ethanol in FFV fuel	85.0%	2.0%	Share of gasoline by volume added in EtOH as denaturant
Ethanol in dedicated vehicle fuel	85.0%	2.0%	Share of gasoline by volume added in EtOH as denaturant
Butanol in FFV fuel	100.0%		
FT diesel in CIDI fuel	100.0%		
Biodiesel in CIDI fuel	20.0%		
Renewable diesel in CIDI fuel	100.0%		
Renewable gasoline in SI fuel	100.0%		
Ethanol in EtOH-diesel	10.0%		
Additives in EtOH-diesel	1.0%		
Isobutanol in BSI (gasoline) fuel	20.0%		
ARHC (Aromatics-rich hydrocarbon fuel) in BSI (gasoline) fuel	20.0%		
Methanol in MM (gasoline) fuel	20.0%		
Isoalkane in MCCI fuel	20.0%		
FAE (Fatty alkyl ether) in MCCI fuel	20.0%		
FAFE (Fatty acid fusel esters) in MCCI fuel	20.0%		
Renewable diesel in MCCI fuel	10.0%		

12.2) Type of Gasoline or Diesel for Alternative Fuel Blends

	Share of Gasoline out of Gasoline and Blendstock
Gasoline for methanol blend	0.0%
Gasoline for low-level ethanol blend	0.0%

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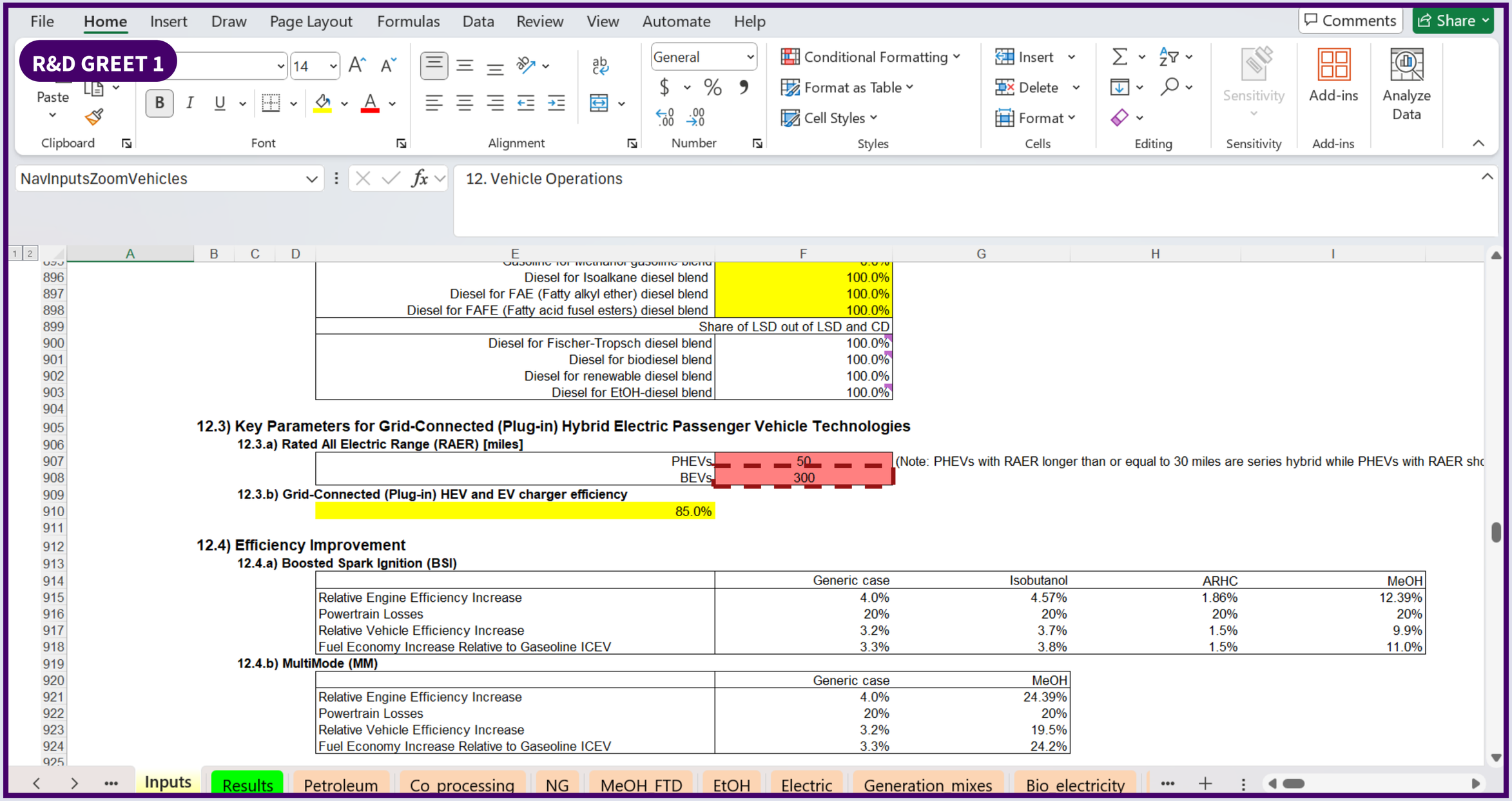

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Relative Fuel Economy for this SUV BEV Compared to a Baseline SI Vehicle Using Gasoline

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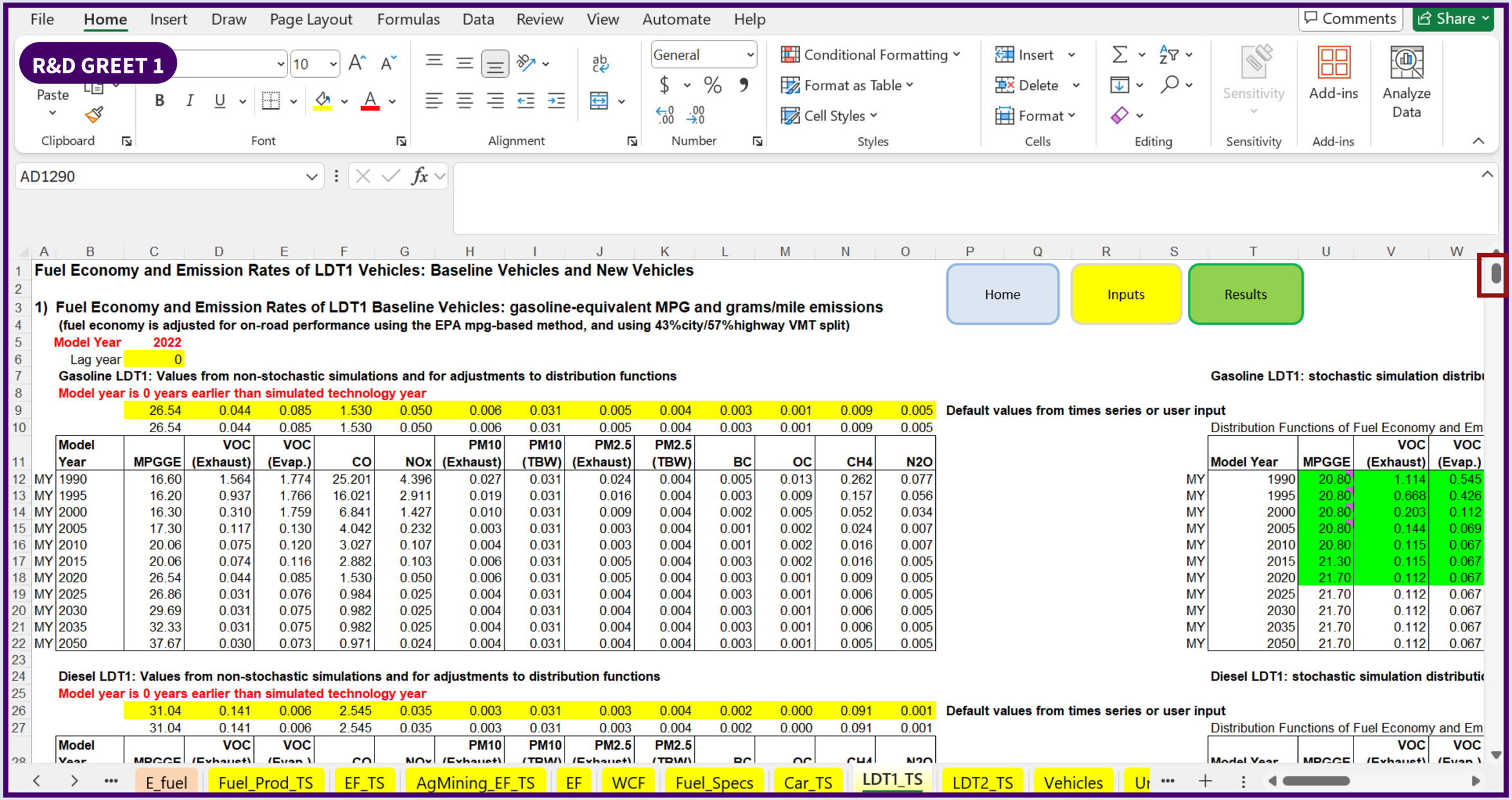

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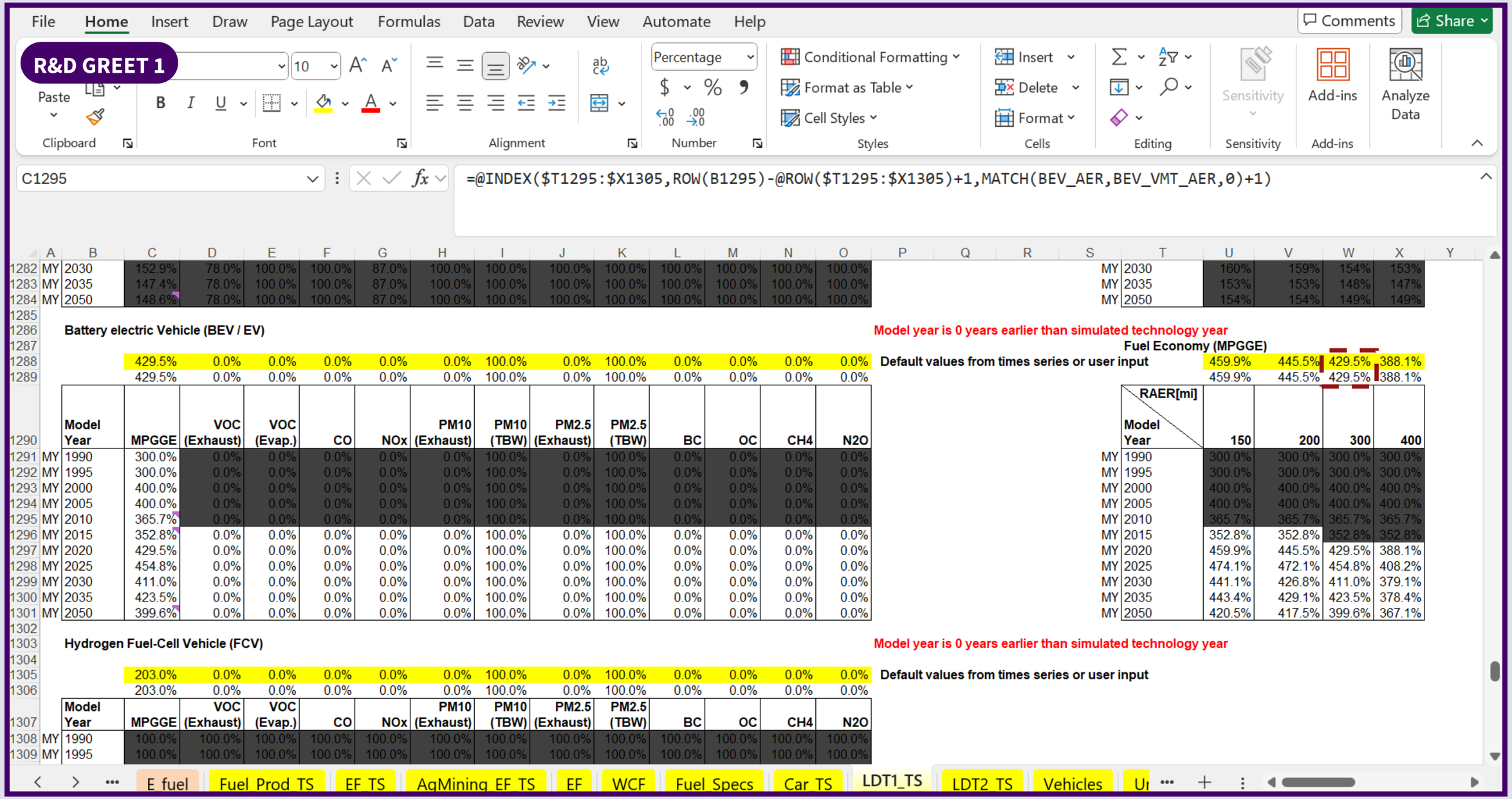

		Model Year	MPGGE	VOC (Exhaust)	VOC (Evap.)	CO	NOx	PM10 (Exhaust)	PM10 (TBW)	PM2.5 (Exhaust)	PM2.5 (TBW)	BC	OC	CH4	N2O
1282	MY	2030	152.9%	78.0%	100.0%	100.0%	87.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
1283	MY	2035	147.4%	78.0%	100.0%	100.0%	87.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
1284	MY	2050	148.6%	78.0%	100.0%	100.0%	87.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
1285															
1286		**Battery electric Vehicle (BEV / EV)**													
1287															
1288			429.5%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%
1289			429.5%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%
1290		**Model Year**	**MPGGE**	**VOC (Exhaust)**	**VOC (Evap.)**	**CO**	**NOx**	**PM10 (Exhaust)**	**PM10 (TBW)**	**PM2.5 (Exhaust)**	**PM2.5 (TBW)**	**BC**	**OC**	**CH4**	**N2O**
1291	MY	1990	300.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%
1292	MY	1995	300.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%
1293	MY	2000	400.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%
1294	MY	2005	400.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%
1295	MY	2010	365.7%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%
1296	MY	2015	352.8%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%
1297	MY	2020	429.5%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%
1298	MY	2025	454.8%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%
1299	MY	2030	411.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%
1300	MY	2035	423.5%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%
1301	MY	2050	399.6%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%
1302															
1303		**Hydrogen Fuel-Cell Vehicle (FCV)**													
1304															
1305			203.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%
1306			203.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%
1307		**Model Year**	**MPGGE**	**VOC (Exhaust)**	**VOC (Evap.)**	**CO**	**NOx**	**PM10 (Exhaust)**	**PM10 (TBW)**	**PM2.5 (Exhaust)**	**PM2.5 (TBW)**	**BC**	**OC**	**CH4**	**N2O**
1308	MY	1990	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
1309	MY	1995	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

		Model Year	RAER[mi] 150	200	300	400
	MY	2030	160%	159%	154%	153%
	MY	2035	153%	153%	148%	147%
	MY	2050	154%	154%	149%	149%
1288			459.9%	445.5%	429.5%	388.1%
1289			459.9%	445.5%	429.5%	388.1%
1290		**Model Year**	**RAER[mi] 150**	**200**	**300**	**400**
1291	MY	1990	300.0%	300.0%	300.0%	300.0%
1292	MY	1995	300.0%	300.0%	300.0%	300.0%
1293	MY	2000	400.0%	400.0%	400.0%	400.0%
1294	MY	2005	400.0%	400.0%	400.0%	400.0%
1295	MY	2010	365.7%	365.7%	365.7%	365.7%
1296	MY	2015	352.8%	352.8%	352.8%	352.8%
1297	MY	2020	459.9%	445.5%	429.5%	388.1%
1298	MY	2025	474.1%	472.1%	454.8%	408.2%
1299	MY	2030	441.1%	426.8%	411.0%	379.1%
1300	MY	2035	443.4%	429.1%	423.5%	378.4%
1301	MY	2050	420.5%	417.5%	399.6%	367.1%

Model year is 0 years earlier than simulated technology year

Default values from times series or user input

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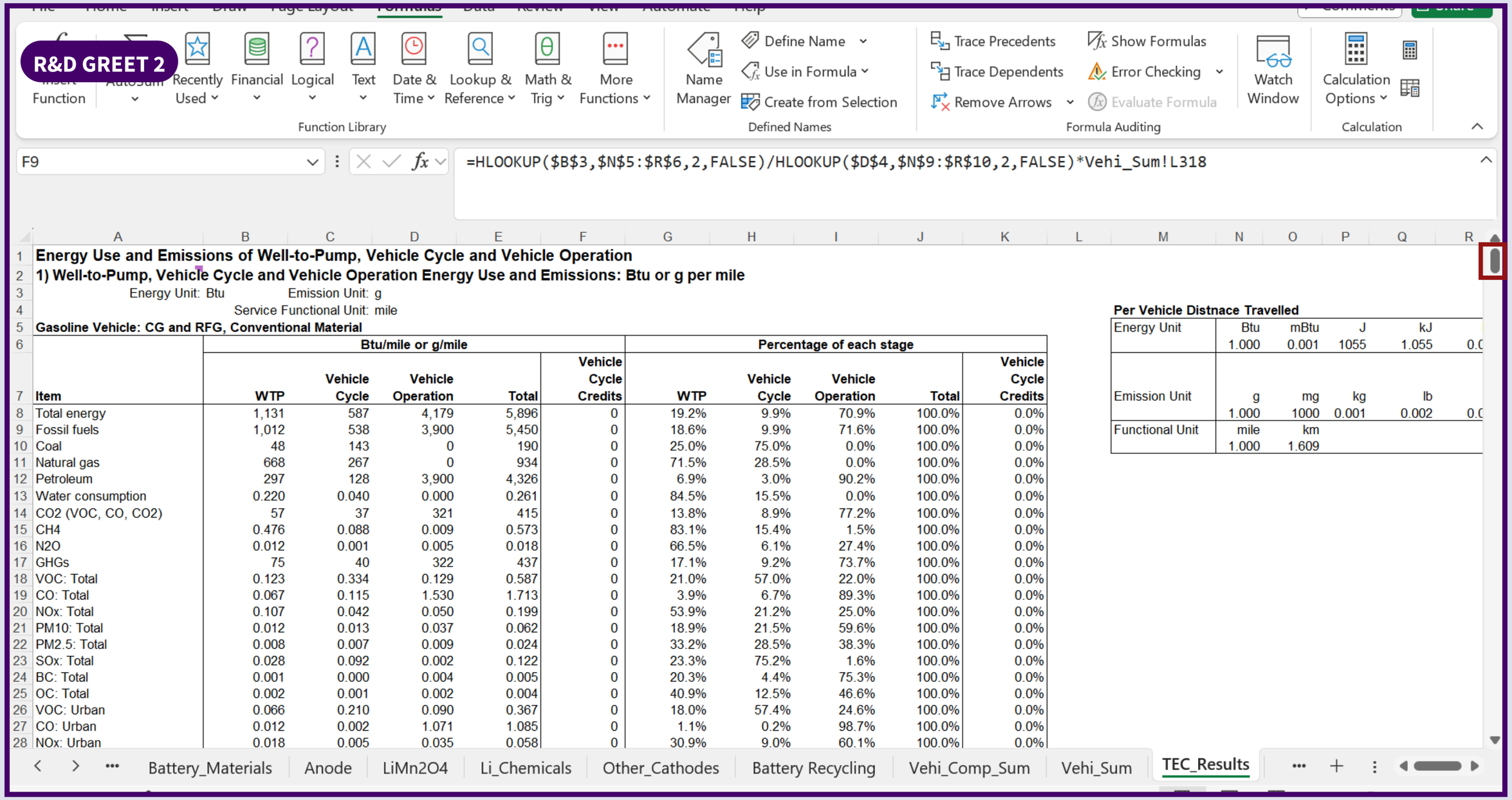
Cradle-to-Grave (C2G) GHG Emissions



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

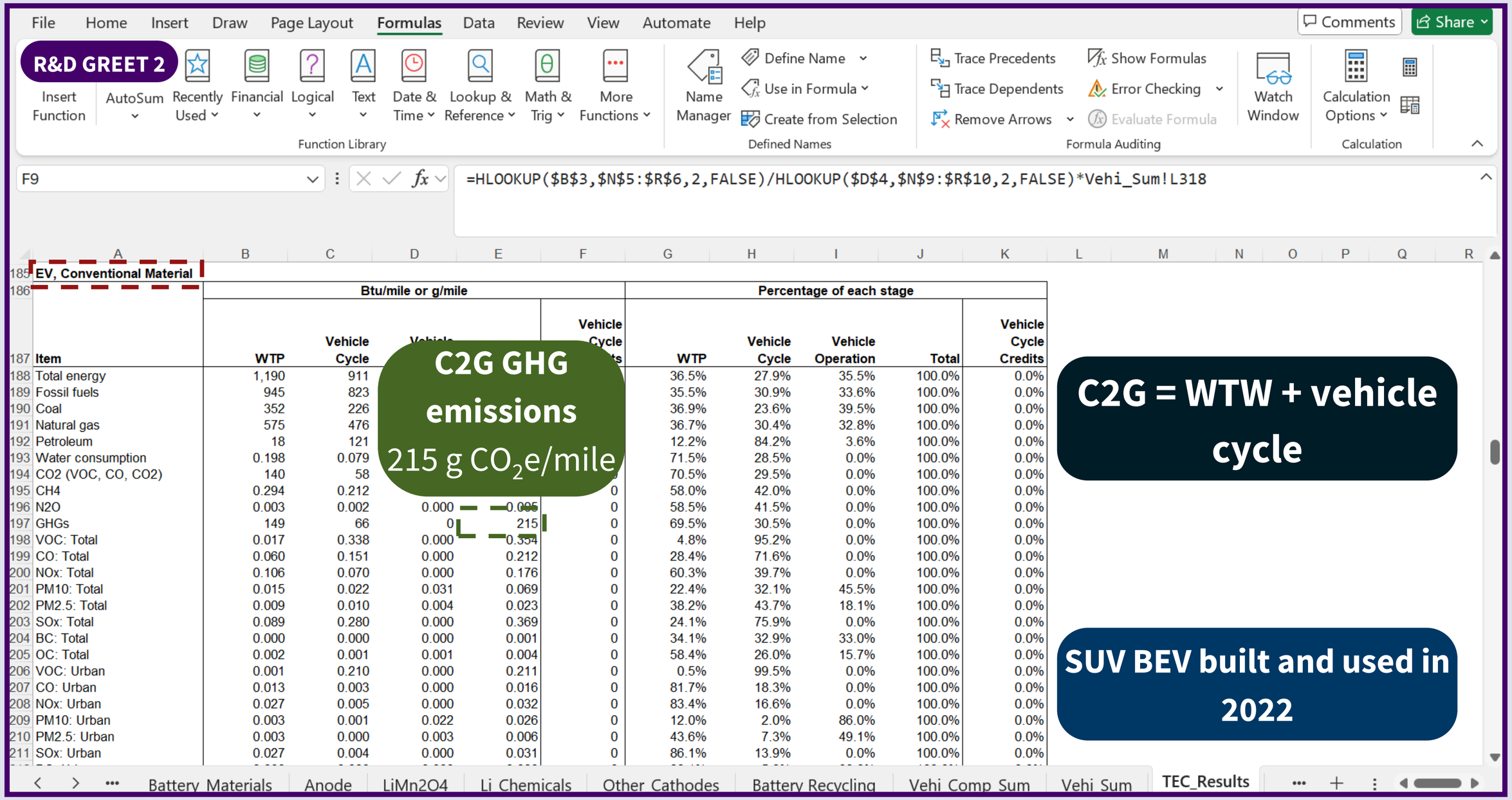
Service Functional Unit: mile

Gasoline Vehicle: CG and RFG, Conventional Material

	Btu/mile or g/mile					Percentage of each stage				
Item	WTP	Vehicle Cycle	Vehicle Operation	Total	Vehicle Cycle Credits	WTP	Vehicle Cycle	Vehicle Operation	Total	Vehicle Cycle Credits
Total energy	1,131	587	4,179	5,896	0	19.2%	9.9%	70.9%	100.0%	0.0%
Fossil fuels	1,012	538	3,900	5,450	0	18.6%	9.9%	71.6%	100.0%	0.0%
Coal	48	143	0	190	0	25.0%	75.0%	0.0%	100.0%	0.0%
Natural gas	668	267	0	934	0	71.5%	28.5%	0.0%	100.0%	0.0%
Petroleum	297	128	3,900	4,326	0	6.9%	3.0%	90.2%	100.0%	0.0%
Water consumption	0.220	0.040	0.000	0.261	0	84.5%	15.5%	0.0%	100.0%	0.0%
CO2 (VOC, CO, CO2)	57	37	321	415	0	13.8%	8.9%	77.2%	100.0%	0.0%
CH4	0.476	0.088	0.009	0.573	0	83.1%	15.4%	1.5%	100.0%	0.0%
N2O	0.012	0.001	0.005	0.018	0	66.5%	6.1%	27.4%	100.0%	0.0%
GHGs	75	40	322	437	0	17.1%	9.2%	73.7%	100.0%	0.0%
VOC: Total	0.123	0.334	0.129	0.587	0	21.0%	57.0%	22.0%	100.0%	0.0%
CO: Total	0.067	0.115	1.530	1.713	0	3.9%	6.7%	89.3%	100.0%	0.0%
NOx: Total	0.107	0.042	0.050	0.199	0	53.9%	21.2%	25.0%	100.0%	0.0%
PM10: Total	0.012	0.013	0.037	0.062	0	18.9%	21.5%	59.6%	100.0%	0.0%
PM2.5: Total	0.008	0.007	0.009	0.024	0	33.2%	28.5%	38.3%	100.0%	0.0%
SOx: Total	0.028	0.092	0.002	0.122	0	23.3%	75.2%	1.6%	100.0%	0.0%
BC: Total	0.001	0.000	0.004	0.005	0	20.3%	4.4%	75.3%	100.0%	0.0%
OC: Total	0.002	0.001	0.002	0.004	0	40.9%	12.5%	46.6%	100.0%	0.0%
VOC: Urban	0.066	0.210	0.090	0.367	0	18.0%	57.4%	24.6%	100.0%	0.0%
CO: Urban	0.012	0.002	1.071	1.085	0	1.1%	0.2%	98.7%	100.0%	0.0%
NOx: Urban	0.018	0.005	0.035	0.058	0	30.9%	9.0%	60.1%	100.0%	0.0%

Per Vehicle Distnace Travelled

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



EV, Conventional Material

Item	Btu/mile or g/mile: WTP	Vehicle Cycle	Vehicle Operation	Total	Vehicle Cycle Credits	Percentage of each stage: WTP	Vehicle Cycle	Vehicle Operation	Total	Vehicle Cycle Credits
Total energy	1,190	911				36.5%	27.9%	35.5%	100.0%	0.0%
Fossil fuels	945	823				35.5%	30.9%	33.6%	100.0%	0.0%
Coal	352	226				36.9%	23.6%	39.5%	100.0%	0.0%
Natural gas	575	476				36.7%	30.4%	32.8%	100.0%	0.0%
Petroleum	18	121				12.2%	84.2%	3.6%	100.0%	0.0%
Water consumption	0.198	0.079				71.5%	28.5%	0.0%	100.0%	0.0%
CO2 (VOC, CO, CO2)	140	58				70.5%	29.5%	0.0%	100.0%	0.0%
CH4	0.294	0.212			0	58.0%	42.0%	0.0%	100.0%	0.0%
N2O	0.003	0.002	0.000	0.005	0	58.5%	41.5%	0.0%	100.0%	0.0%
GHGs	149	66	0	215	0	69.5%	30.5%	0.0%	100.0%	0.0%
VOC: Total	0.017	0.338	0.000	0.354	0	4.8%	95.2%	0.0%	100.0%	0.0%
CO: Total	0.060	0.151	0.000	0.212	0	28.4%	71.6%	0.0%	100.0%	0.0%
NOx: Total	0.106	0.070	0.000	0.176	0	60.3%	39.7%	0.0%	100.0%	0.0%
PM10: Total	0.015	0.022	0.031	0.069	0	22.4%	32.1%	45.5%	100.0%	0.0%
PM2.5: Total	0.009	0.010	0.004	0.023	0	38.2%	43.7%	18.1%	100.0%	0.0%
SOx: Total	0.089	0.280	0.000	0.369	0	24.1%	75.9%	0.0%	100.0%	0.0%
BC: Total	0.000	0.000	0.000	0.001	0	34.1%	32.9%	33.0%	100.0%	0.0%
OC: Total	0.002	0.001	0.001	0.004	0	58.4%	26.0%	15.7%	100.0%	0.0%
VOC: Urban	0.001	0.210	0.000	0.211	0	0.5%	99.5%	0.0%	100.0%	0.0%
CO: Urban	0.013	0.003	0.000	0.016	0	81.7%	18.3%	0.0%	100.0%	0.0%
NOx: Urban	0.027	0.005	0.000	0.032	0	83.4%	16.6%	0.0%	100.0%	0.0%
PM10: Urban	0.003	0.001	0.022	0.026	0	12.0%	2.0%	86.0%	100.0%	0.0%
PM2.5: Urban	0.003	0.000	0.003	0.006	0	43.6%	7.3%	49.1%	100.0%	0.0%
SOx: Urban	0.027	0.004	0.000	0.031	0	86.1%	13.9%	0.0%	100.0%	0.0%

C2G GHG emissions

215 g CO_2e/mile

C2G = WTW + vehicle cycle

SUV BEV built and used in 2022

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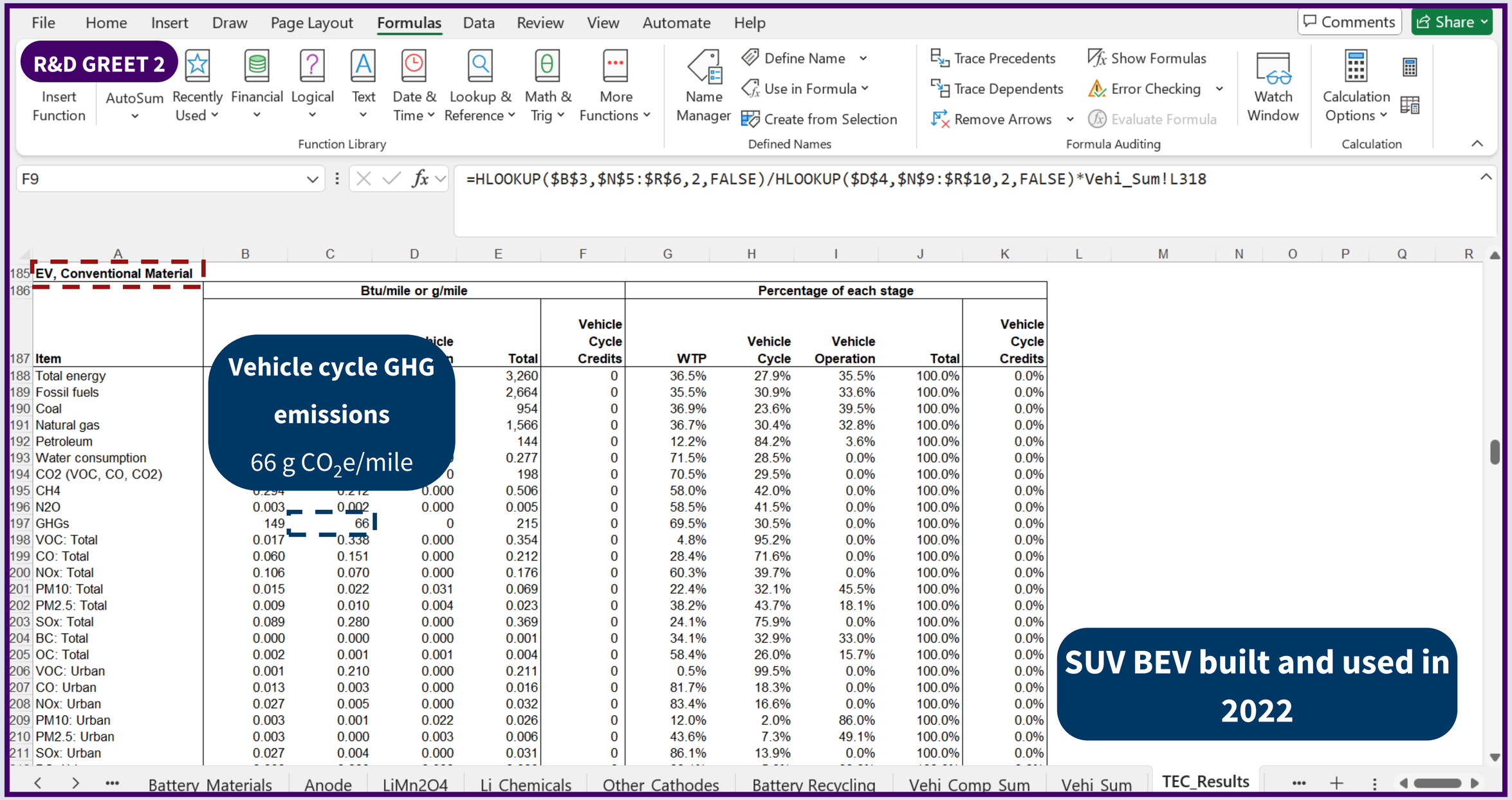
GHG Emissions from Producing the Vehicle



EV, Conventional Material

Item	Btu/mile or g/mile: Total	Btu/mile or g/mile: Vehicle Cycle Credits	Percentage of each stage: WTP	Percentage of each stage: Vehicle Cycle	Percentage of each stage: Vehicle Operation	Percentage of each stage: Total	Percentage of each stage: Vehicle Cycle Credits
Total energy	3,260	0	36.5%	27.9%	35.5%	100.0%	0.0%
Fossil fuels	2,664	0	35.5%	30.9%	33.6%	100.0%	0.0%
Coal	954	0	36.9%	23.6%	39.5%	100.0%	0.0%
Natural gas	1,566	0	36.7%	30.4%	32.8%	100.0%	0.0%
Petroleum	144	0	12.2%	84.2%	3.6%	100.0%	0.0%
Water consumption	0.277	0	71.5%	28.5%	0.0%	100.0%	0.0%
CO2 (VOC, CO, CO2)	198	0	70.5%	29.5%	0.0%	100.0%	0.0%
CH4	0.506	0	58.0%	42.0%	0.0%	100.0%	0.0%
N2O	0.005	0	58.5%	41.5%	0.0%	100.0%	0.0%
GHGs	215	0	69.5%	30.5%	0.0%	100.0%	0.0%
VOC: Total	0.354	0	4.8%	95.2%	0.0%	100.0%	0.0%
CO: Total	0.212	0	28.4%	71.6%	0.0%	100.0%	0.0%
NOx: Total	0.176	0	60.3%	39.7%	0.0%	100.0%	0.0%
PM10: Total	0.069	0	22.4%	32.1%	45.5%	100.0%	0.0%
PM2.5: Total	0.023	0	38.2%	43.7%	18.1%	100.0%	0.0%
SOx: Total	0.369	0	24.1%	75.9%	0.0%	100.0%	0.0%
BC: Total	0.001	0	34.1%	32.9%	33.0%	100.0%	0.0%
OC: Total	0.004	0	58.4%	26.0%	15.7%	100.0%	0.0%
VOC: Urban	0.211	0	0.5%	99.5%	0.0%	100.0%	0.0%
CO: Urban	0.016	0	81.7%	18.3%	0.0%	100.0%	0.0%
NOx: Urban	0.032	0	83.4%	16.6%	0.0%	100.0%	0.0%
PM10: Urban	0.026	0	12.0%	2.0%	86.0%	100.0%	0.0%
PM2.5: Urban	0.006	0	43.6%	7.3%	49.1%	100.0%	0.0%
SOx: Urban	0.031	0	86.1%	13.9%	0.0%	100.0%	0.0%

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SUV ICEV

Model a 2022 Sport Utility Vehicle (SUV) Internal Combustion Engine (ICEV) Using Gasoline in R&D GREET

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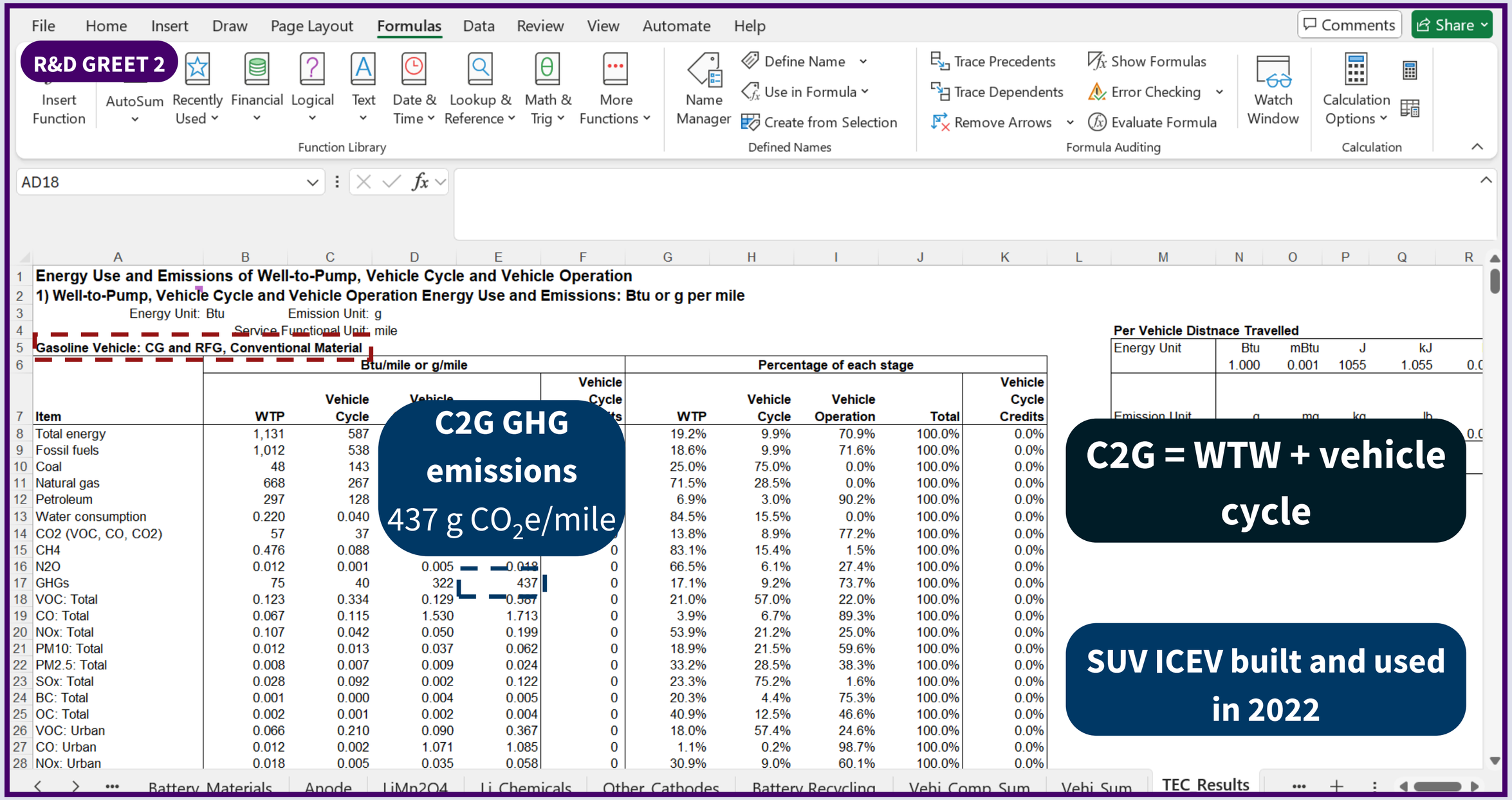
Cradle-to-Grave (C2G) GHG Emissions



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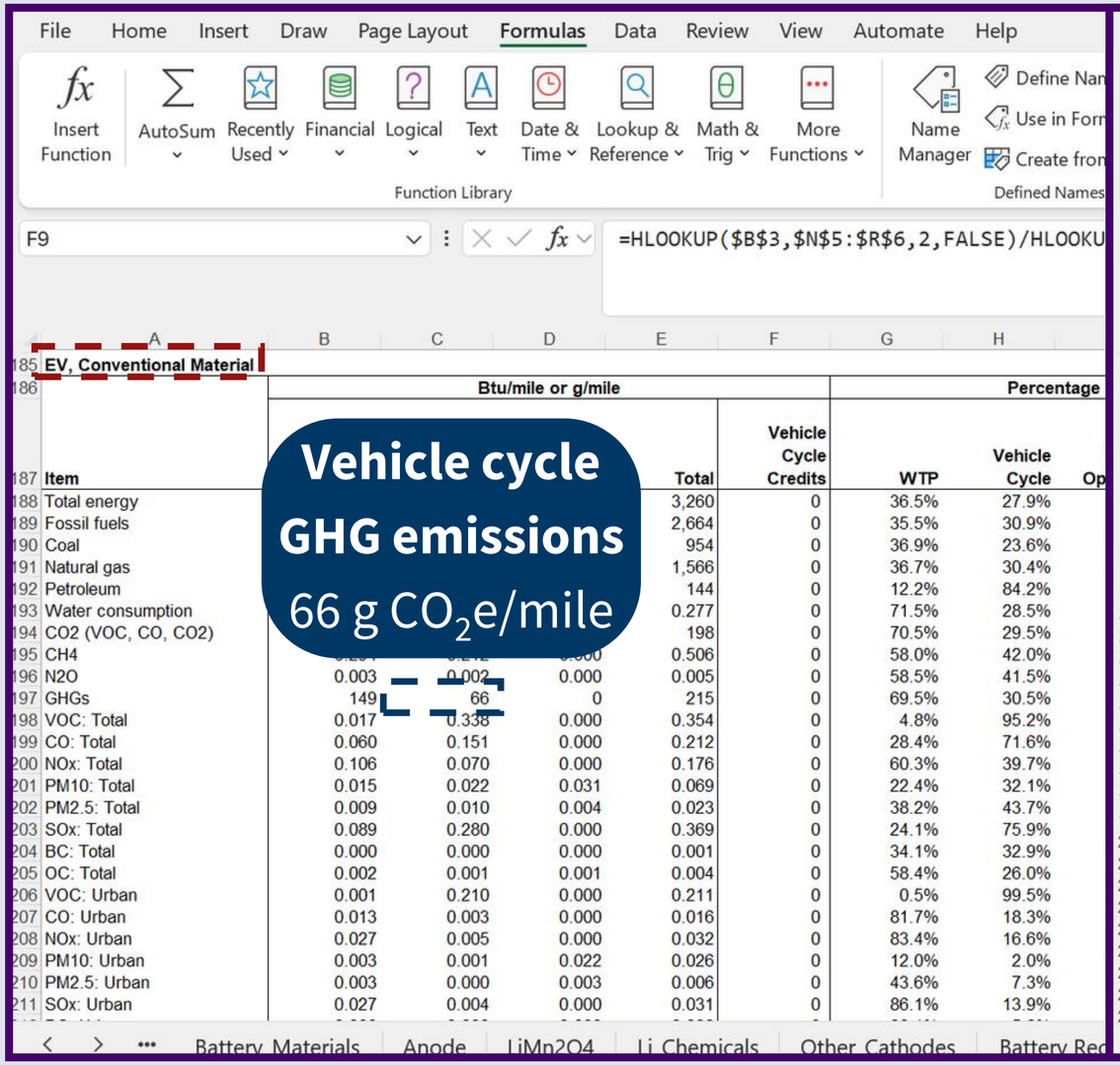
GHG Emissions from Producing the Vehicle

2022 SUV BEV

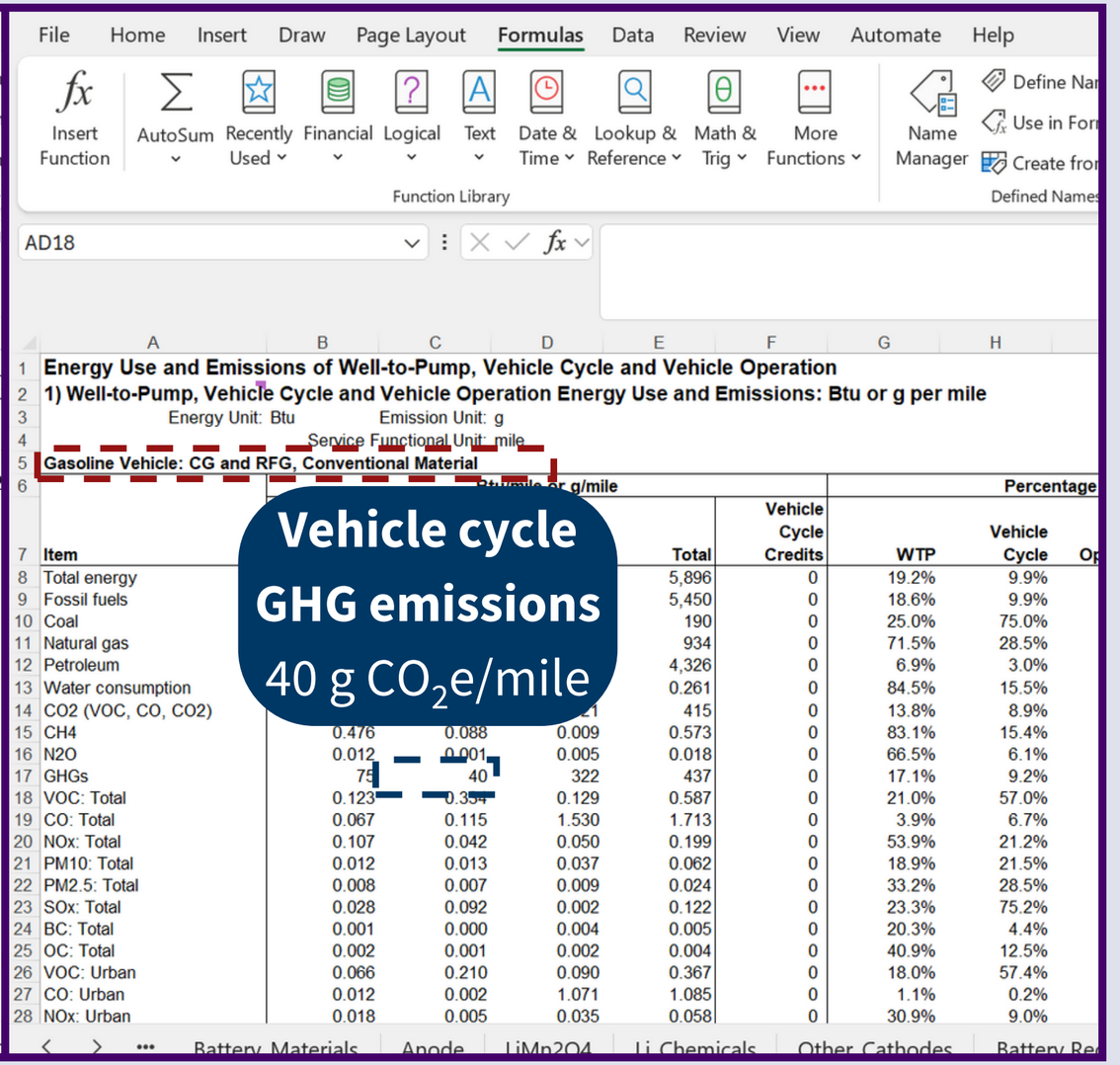


185 **EV, Conventional Material**

186		Btu/mile or g/mile					Percentage		
187	Item				Total	Vehicle Cycle Credits	WTP	Vehicle Cycle	Op
188	Total energy				3,260	0	36.5%	27.9%	
189	Fossil fuels				2,664	0	35.5%	30.9%	
190	Coal				954	0	36.9%	23.6%	
191	Natural gas				1,566	0	36.7%	30.4%	
192	Petroleum				144	0	12.2%	84.2%	
193	Water consumption				0.277	0	71.5%	28.5%	
194	CO2 (VOC, CO, CO2)				198	0	70.5%	29.5%	
195	CH4				0.506	0	58.0%	42.0%	
196	N2O	0.003	0.002	0.000	0.005	0	58.5%	41.5%	
197	GHGs	149	66	0	215	0	69.5%	30.5%	
198	VOC: Total	0.017	0.338	0.000	0.354	0	4.8%	95.2%	
199	CO: Total	0.060	0.151	0.000	0.212	0	28.4%	71.6%	
200	NOx: Total	0.106	0.070	0.000	0.176	0	60.3%	39.7%	
201	PM10: Total	0.015	0.022	0.031	0.069	0	22.4%	32.1%	
202	PM2.5: Total	0.009	0.010	0.004	0.023	0	38.2%	43.7%	
203	SOx: Total	0.089	0.280	0.000	0.369	0	24.1%	75.9%	
204	BC: Total	0.000	0.000	0.000	0.001	0	34.1%	32.9%	
205	OC: Total	0.002	0.001	0.001	0.004	0	58.4%	26.0%	
206	VOC: Urban	0.001	0.210	0.000	0.211	0	0.5%	99.5%	
207	CO: Urban	0.013	0.003	0.000	0.016	0	81.7%	18.3%	
208	NOx: Urban	0.027	0.005	0.000	0.032	0	83.4%	16.6%	
209	PM10: Urban	0.003	0.001	0.022	0.026	0	12.0%	2.0%	
210	PM2.5: Urban	0.003	0.000	0.003	0.006	0	43.6%	7.3%	
211	SOx: Urban	0.027	0.004	0.000	0.031	0	86.1%	13.9%	

Battery_Materials Anode LiMn2O4 Li_Chemicals Other_Cathodes Battery_Rec

2022 SUV ICEV



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

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

3 Energy Unit: Btu Emission Unit: g

4 Service Functional Unit: mile

5 **Gasoline Vehicle: CG and RFG, Conventional Material**

6		Btu/mile or g/mile				Percentage		
7	Item				Total	Vehicle Cycle Credits	WTP	Vehicle Cycle	Op
8	Total energy				5,896	0	19.2%	9.9%	
9	Fossil fuels				5,450	0	18.6%	9.9%	
10	Coal				190	0	25.0%	75.0%	
11	Natural gas				934	0	71.5%	28.5%	
12	Petroleum				4,326	0	6.9%	3.0%	
13	Water consumption				0.261	0	84.5%	15.5%	
14	CO2 (VOC, CO, CO2)				415	0	13.8%	8.9%	
15	CH4	0.476	0.088	0.009	0.573	0	83.1%	15.4%	
16	N2O	0.012	0.001	0.005	0.018	0	66.5%	6.1%	
17	GHGs	75	40	322	437	0	17.1%	9.2%	
18	VOC: Total	0.123	0.354	0.129	0.587	0	21.0%	57.0%	
19	CO: Total	0.067	0.115	1.530	1.713	0	3.9%	6.7%	
20	NOx: Total	0.107	0.042	0.050	0.199	0	53.9%	21.2%	
21	PM10: Total	0.012	0.013	0.037	0.062	0	18.9%	21.5%	
22	PM2.5: Total	0.008	0.007	0.009	0.024	0	33.2%	28.5%	
23	SOx: Total	0.028	0.092	0.002	0.122	0	23.3%	75.2%	
24	BC: Total	0.001	0.000	0.004	0.005	0	20.3%	4.4%	
25	OC: Total	0.002	0.001	0.002	0.004	0	40.9%	12.5%	
26	VOC: Urban	0.066	0.210	0.090	0.367	0	18.0%	57.4%	
27	CO: Urban	0.012	0.002	1.071	1.085	0	1.1%	0.2%	
28	NOx: Urban	0.018	0.005	0.035	0.058	0	30.9%	9.0%	

Battery_Materials Anode LiMn2O4 Li_Chemicals Other_Cathodes Battery_Rec

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How Do The Opportunities for Emission Mitigation for the Production of Major Vehicle Materials Affect the Vehicle Cycle Impacts of Vehicles?

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Increase the Share of Recycled Steel

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Scrap vs recycled materials

Scrap

Untreated material

Recycled

Obtained from the treatment of scrap

BEV Recycled Steel

Model a 2022 Sport Utility Vehicle (SUV) Battery Electric Vehicle (BEV) Made with 100% Recycled Steel and Virgin Aluminum Produced with 100% Hydropower Electricity

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Why replace a vehicle's steel with aluminum?

Pros of Replacing Steel with Aluminum

- Aluminum is lighter than steel
- Lighter vehicles have an improved fuel economy and consume less fuel over the vehicle's lifetime

Challenges/Cons of using Aluminum

- Virgin aluminum production is highly energy intensive
- Most energy comes from fossil sources - highly carbon intensive
- Most of the aluminum in vehicles is virgin

Therefore, renewable energy is needed to decarbonize virgin aluminum production

Aluminum background

Virgin Aluminum Production Involves

- Mining and extraction of bauxite ore
- Processing of bauxite to produce aluminum hydroxide
- Conversion of aluminum hydroxide to aluminum oxide (alumina)
- Hell-Heroult process, involving the reduction of alumina through electrolysis (with carbon anodes) to pure aluminum metal

80-90% of the life cycle GHG emissions of aluminum production come from the electrolysis process due to its high energy intensity

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Aluminum options and associated applications for vehicles in R&D GREET

Wrought Aluminum

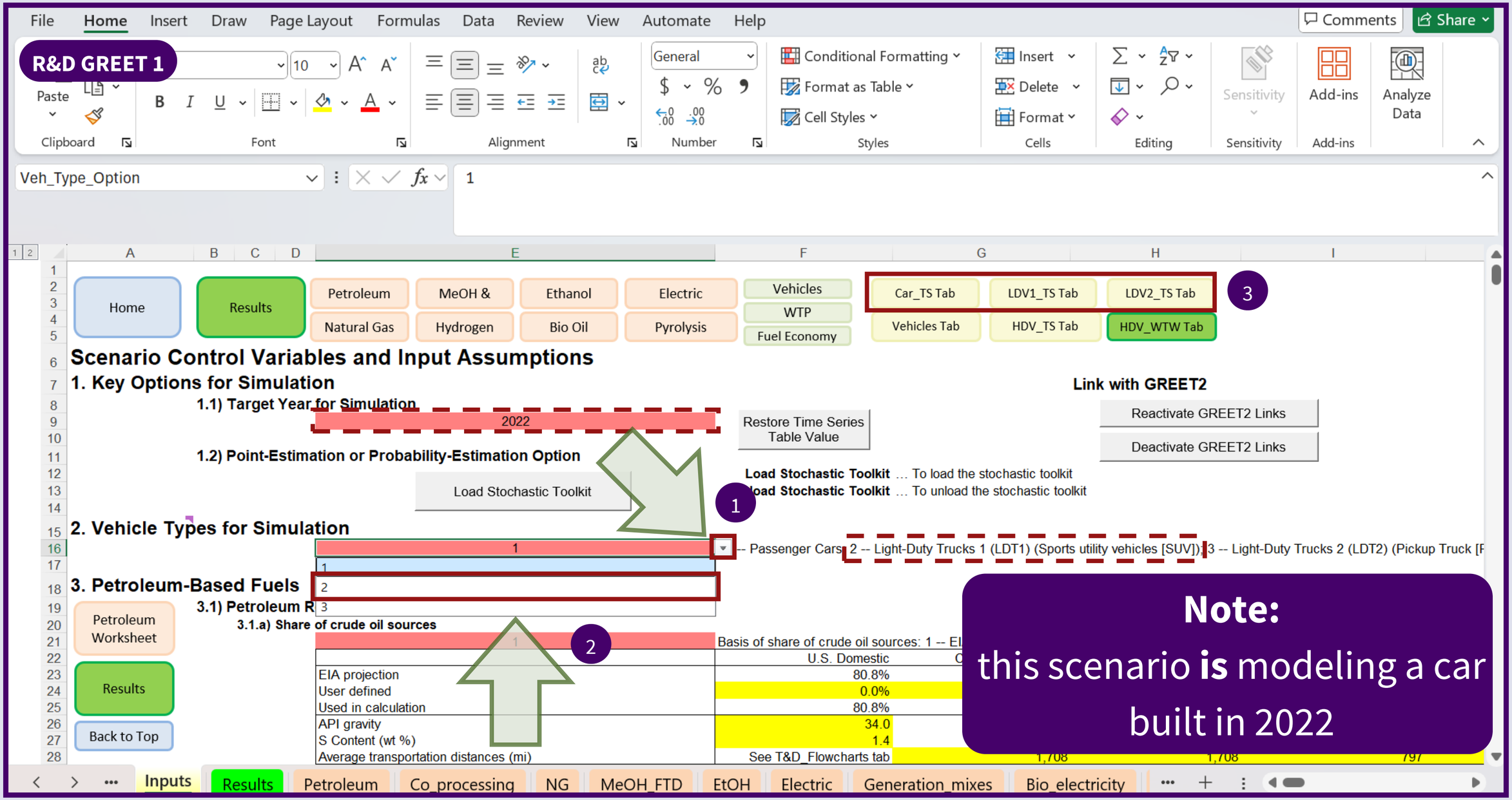
Used as an aluminum sheet, which could be stamped making the vehicle's body out of aluminum

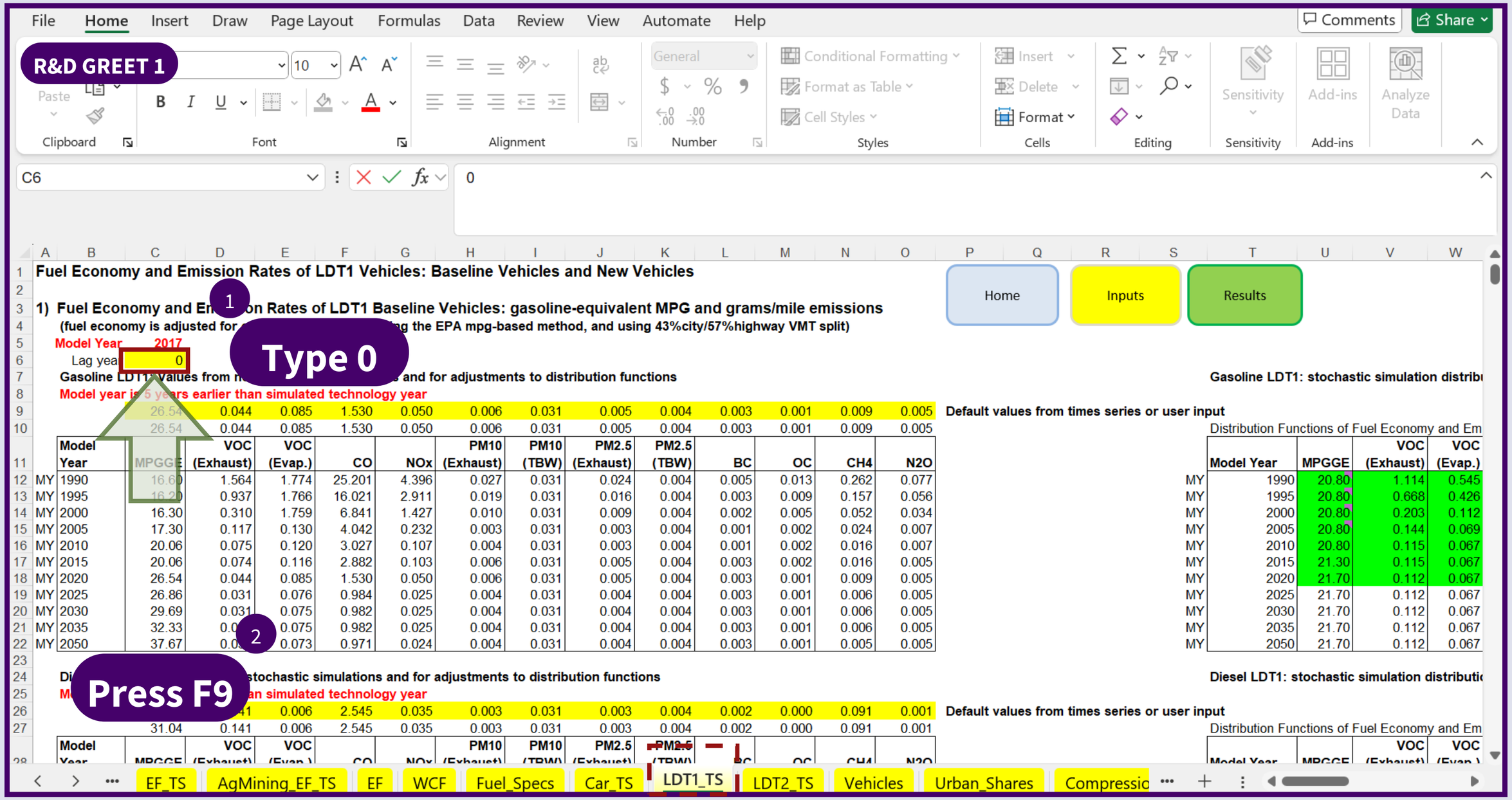
Extruded or Forced Aluminum Products

Used in the interior body

Cast Aluminum

Used primarily in engine blocks


R&D GREET 1
Veh_Type_Option
1
Home
Results
Petroleum
MeOH &
Ethanol
Electric
Natural Gas
Hydrogen
Bio Oil
Pyrolysis
Vehicles
WTP
Fuel Economy
Car_TS Tab
LDV1_TS Tab
LDV2_TS Tab
Vehicles Tab
HDV_TS Tab
HDV_WTW Tab
3
Scenario Control Variables and Input Assumptions
1. Key Options for Simulation
1.1) Target Year for Simulation
2022
Restore Time Series Table Value
Link with GREET2
Reactivate GREET2 Links
Deactivate GREET2 Links
1.2) Point-Estimation or Probability-Estimation Option
Load Stochastic Toolkit
Load Stochastic Toolkit ... To load the stochastic toolkit
Load Stochastic Toolkit ... To unload the stochastic toolkit
1
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 [P
3. Petroleum-Based Fuels
3.1) Petroleum R
3.1.a) Share of crude oil sources
Petroleum Worksheet
Results
Back to Top
2
Basis of share of crude oil sources: 1 -- El
U.S. Domestic
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
Note:
this scenario is modeling a car built in 2022
Inputs
Results
Petroleum
Co_processing
NG
MeOH_FTD
EtOH
Electric
Generation_mixes
Bio_electricity



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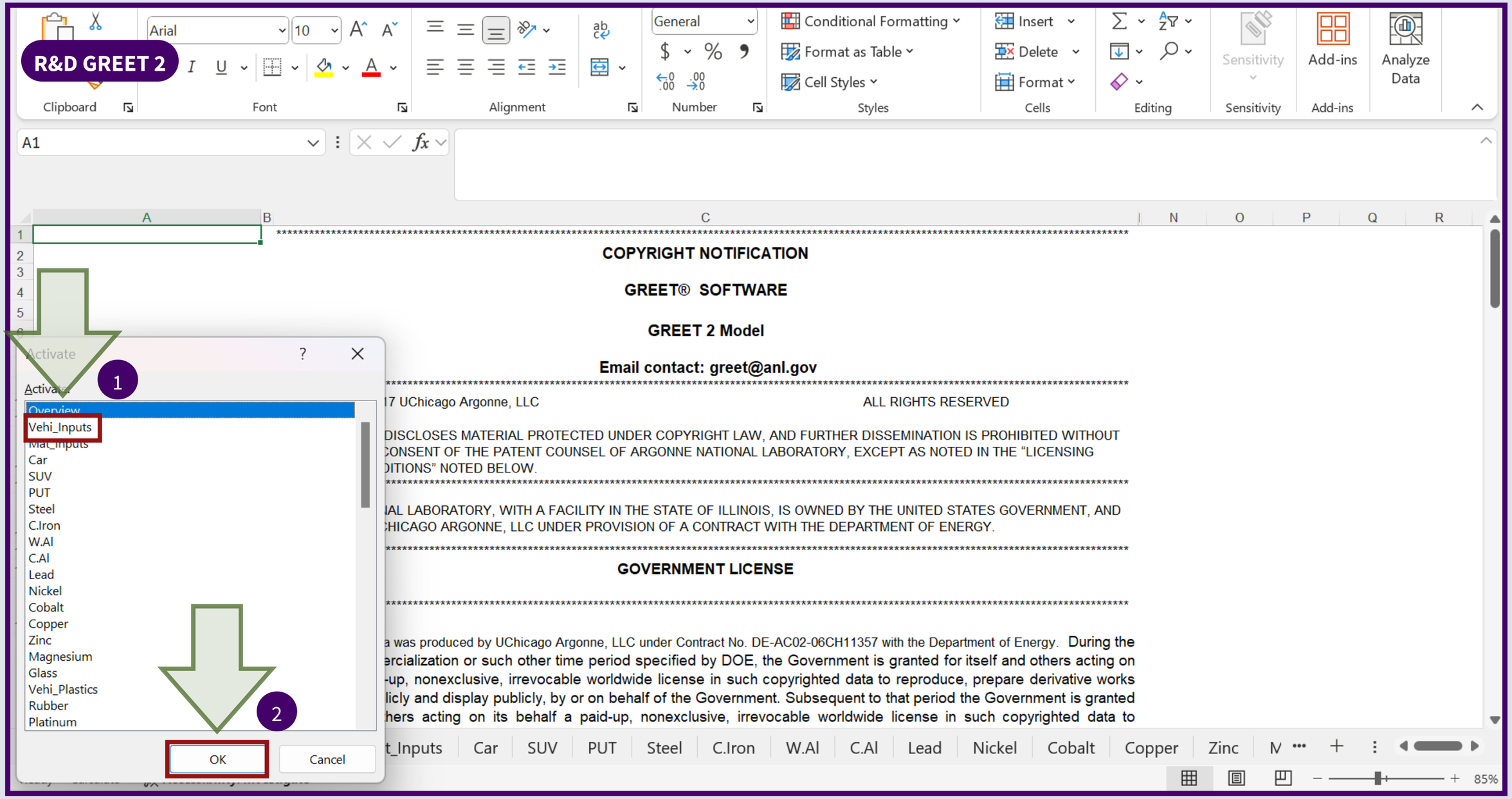

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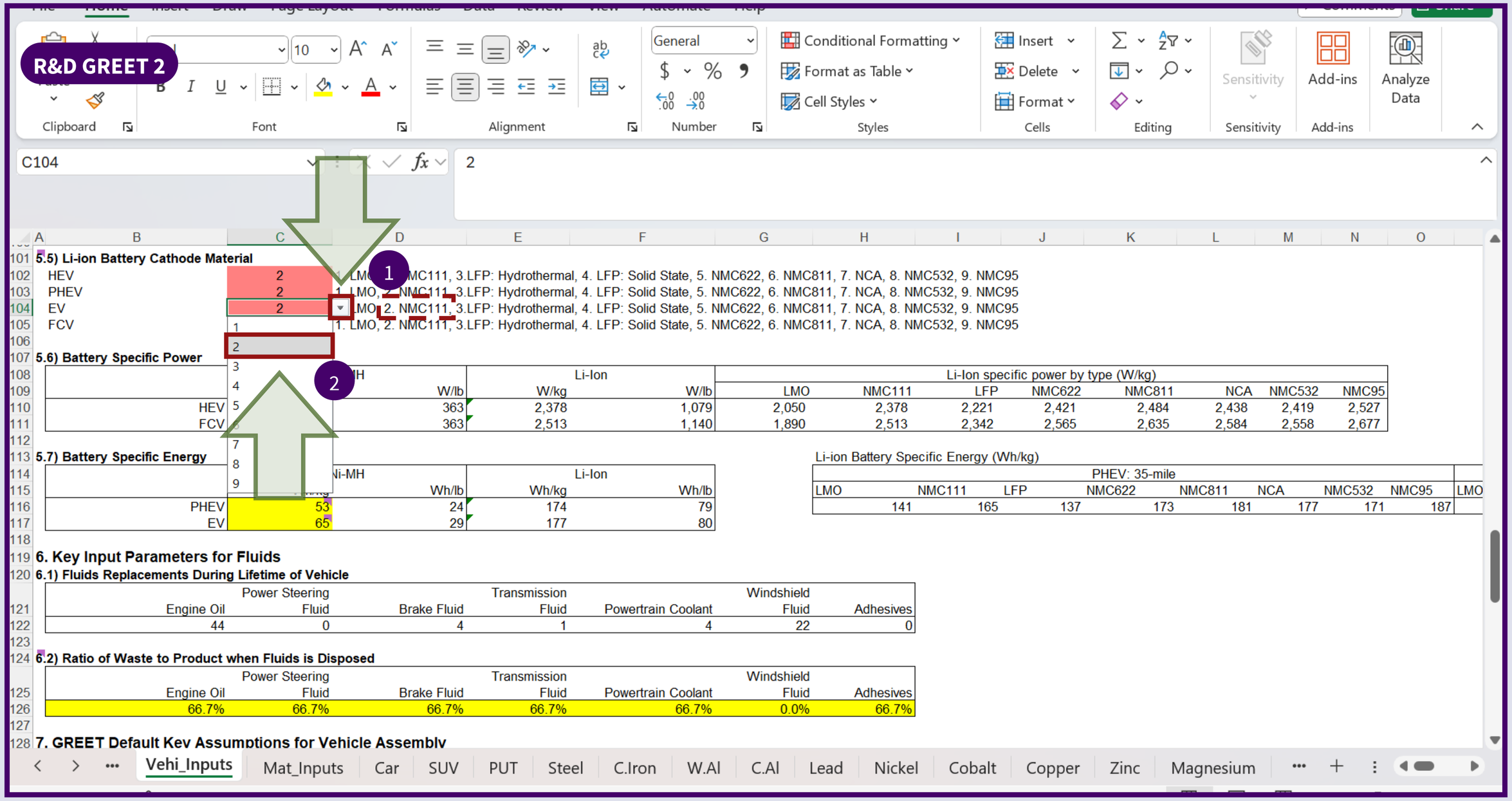

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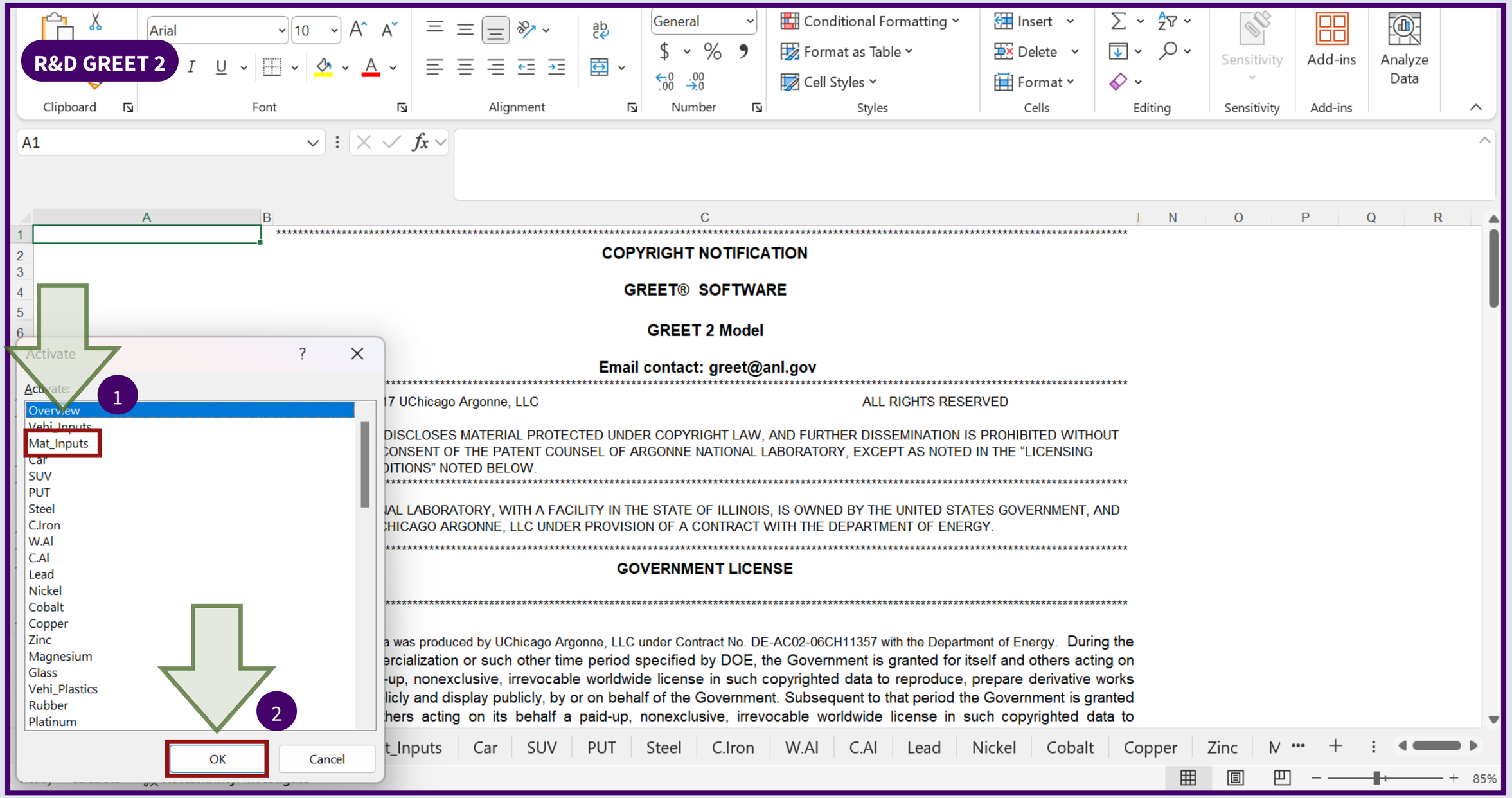

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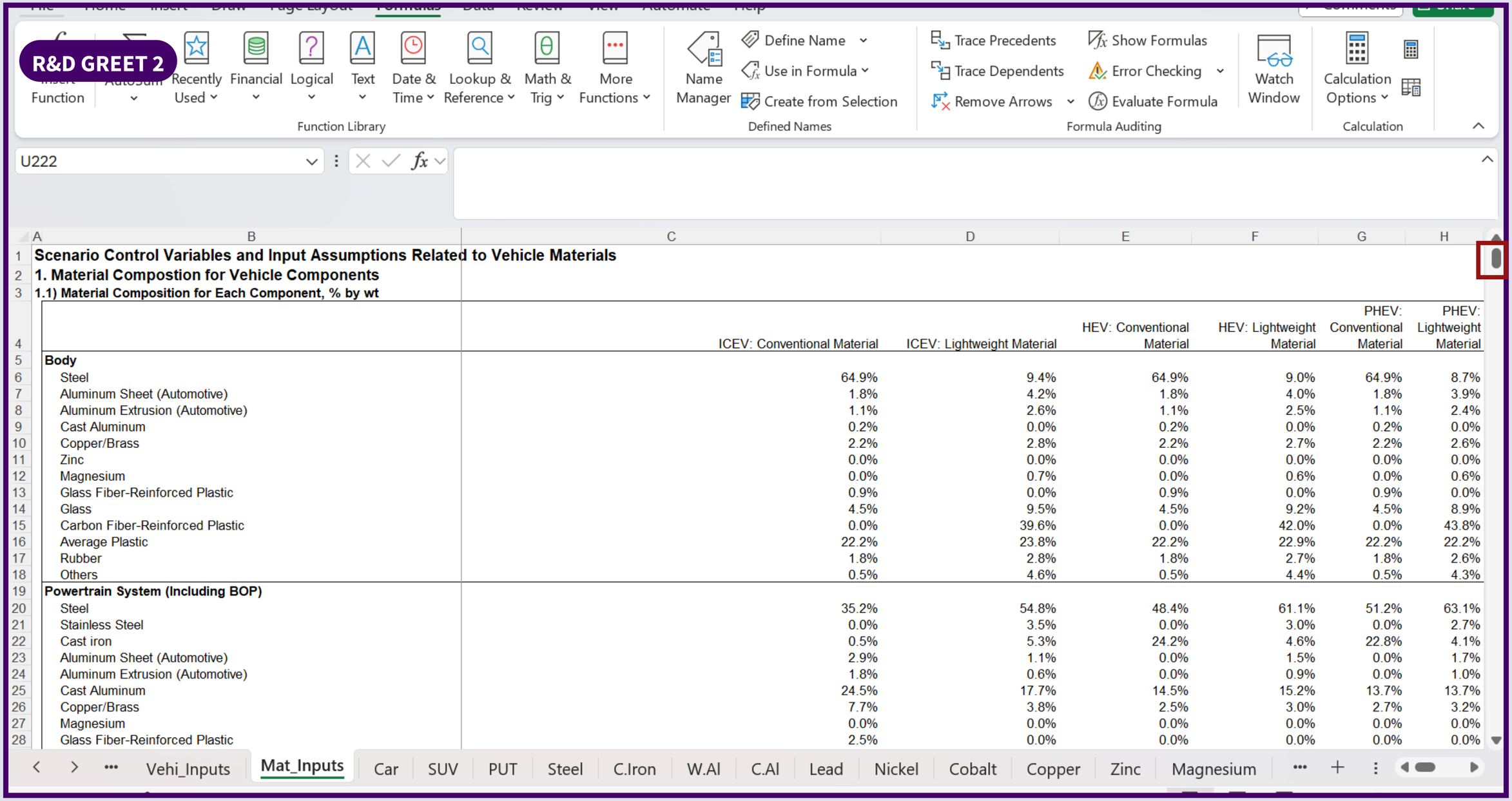

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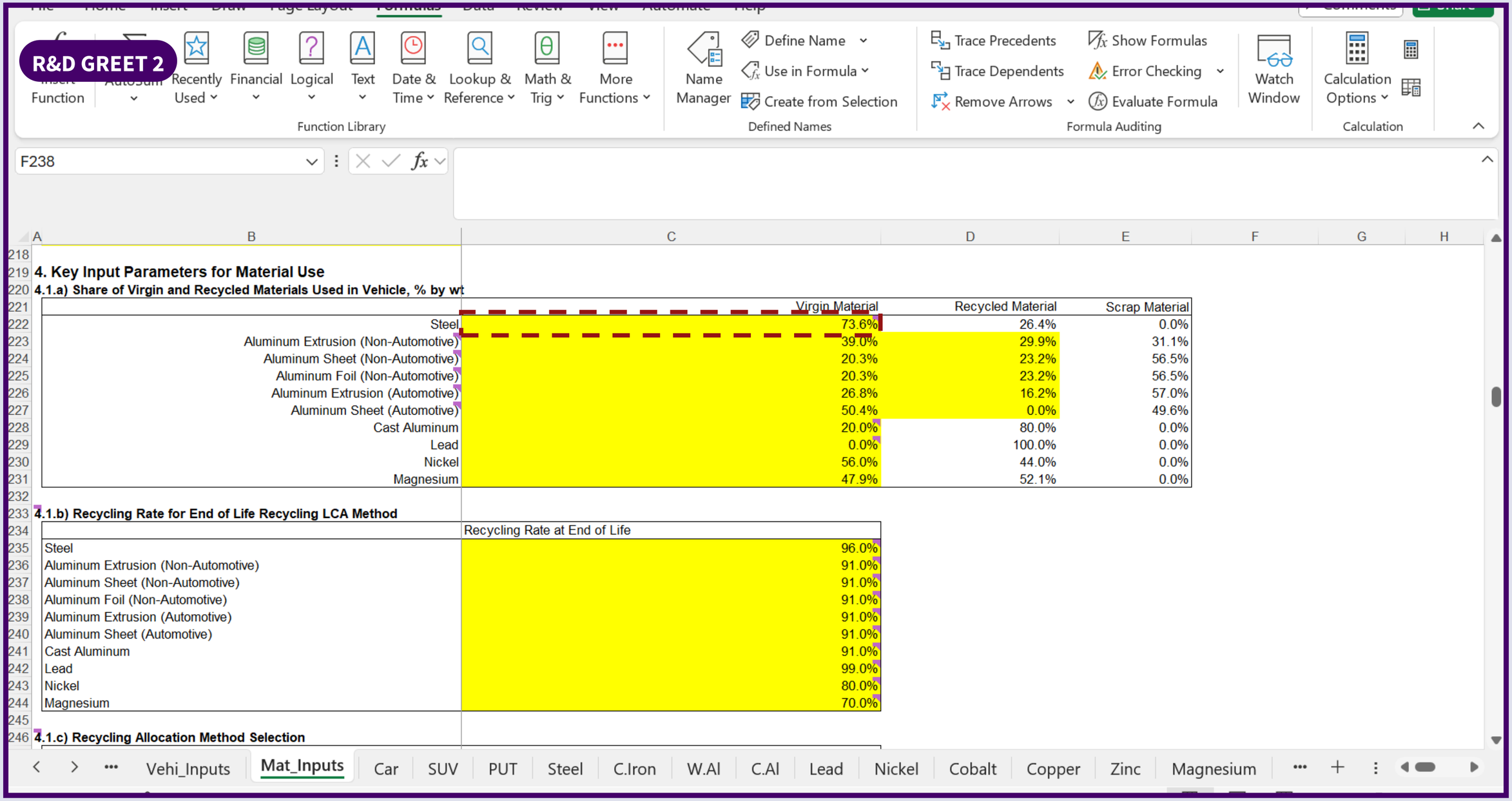
Default Share of Virgin Steel



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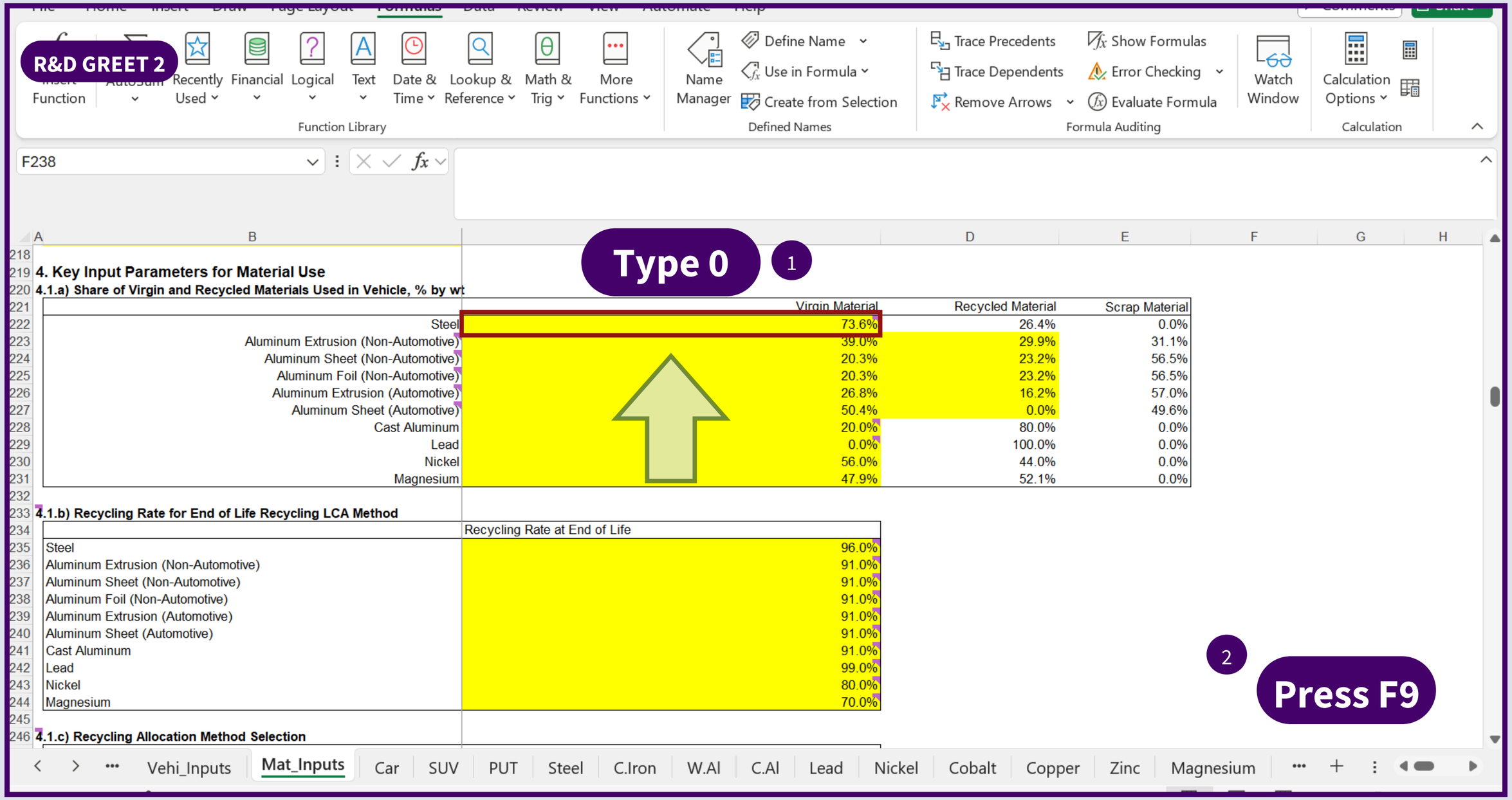

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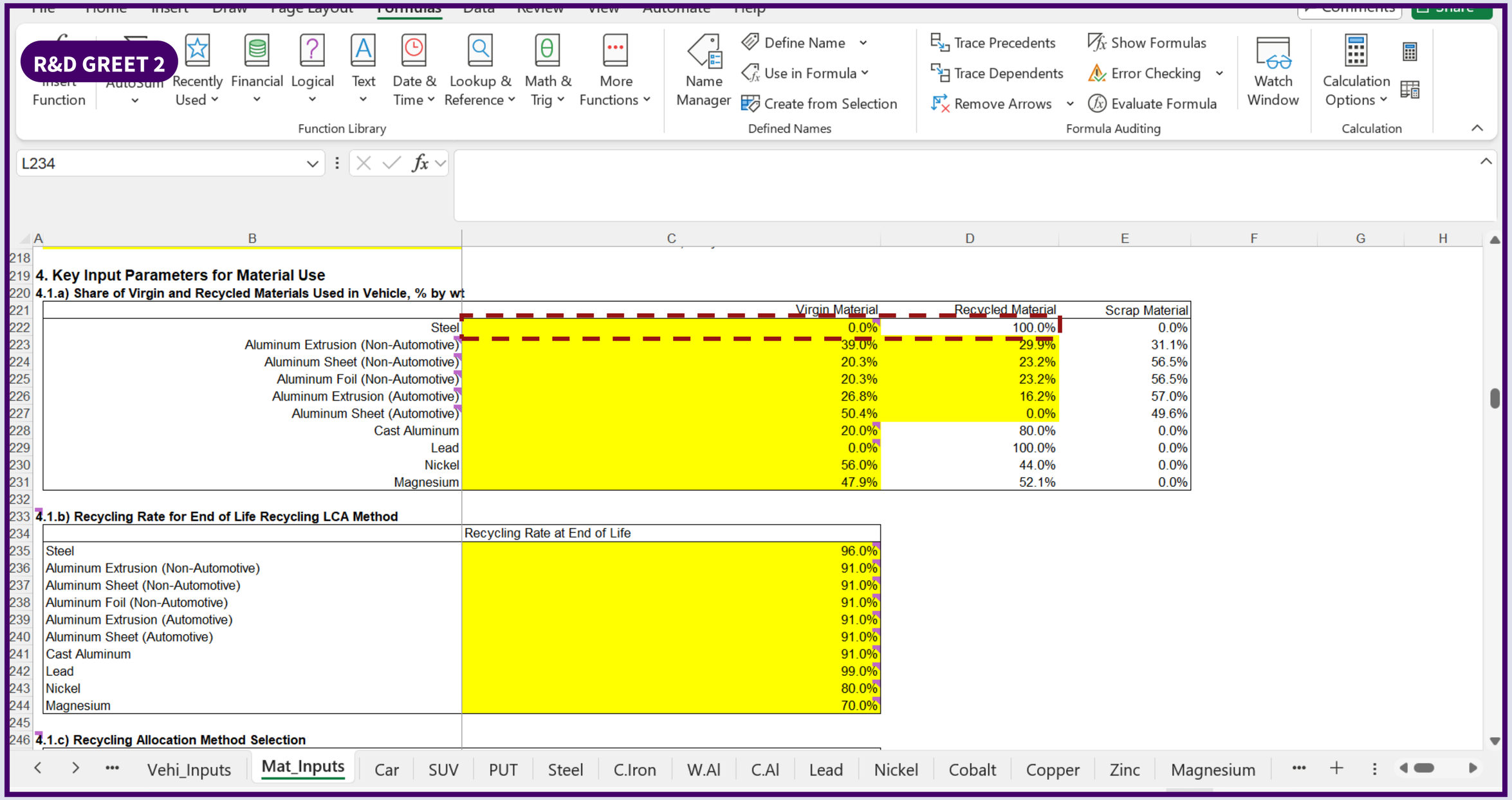

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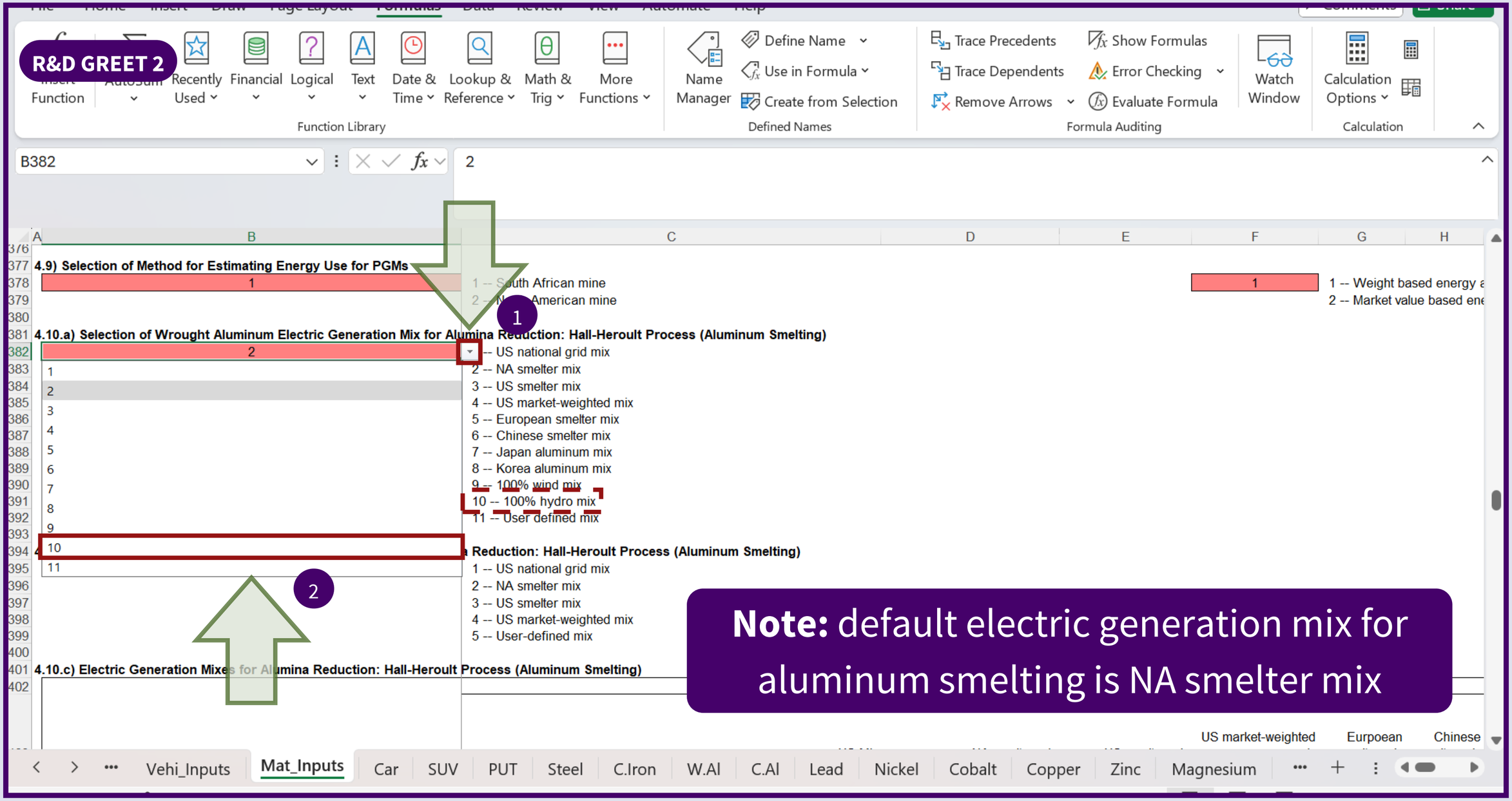

Note: default electric generation mix for aluminum smelting is NA smelter mix

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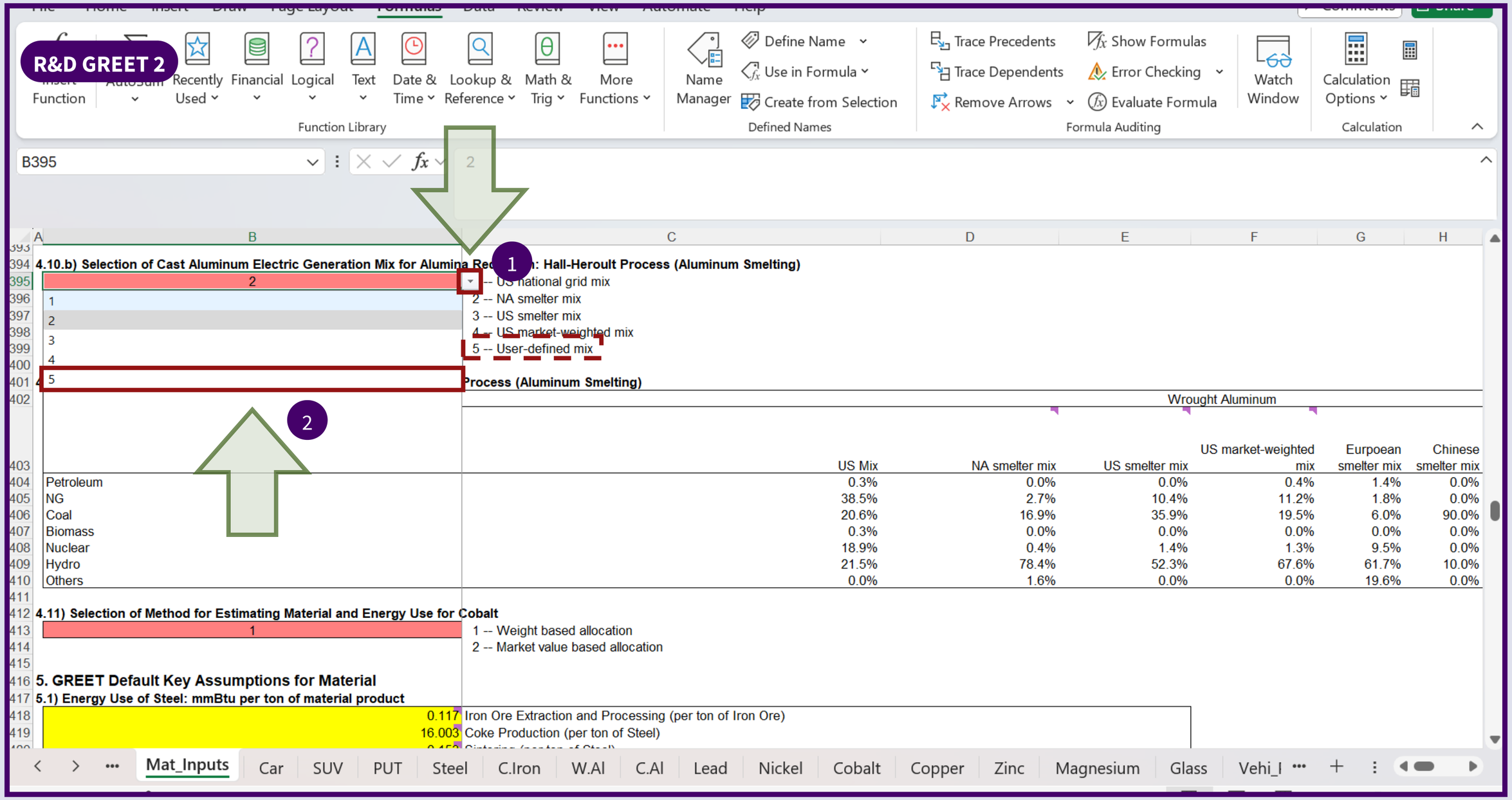

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R&D GREET 2

U416

4.10.c) Electric Generation Mixes for Alumina Reduction: Hall-Heroult

	Japan aluminum mix	Korea aluminum mix	100% renewable mix	100% hydro mix	User defined Mix	Cast Aluminum: US Mix	NA smelter mix	US smelter mix	US market-weighted mix	User defined Mix
Petroleum	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.0%	0.0%	0.4%	0.0%
NG	0.0%	9.5%	0.0%	0.0%	4.1%	38.5%	4.1%	10.4%	11.2%	0.0%
Coal	91.7%	61.9%	0.0%	0.0%	14.3%	20.6%	14.3%	35.9%	19.5%	0.0%
Biomass	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.0%	0.0%	0.0%	0.0%
Nuclear	0.0%	0.1%	0.0%	0.0%	0.5%	20.3%	0.5%	1.4%	1.3%	0.0%
Hydro	8.2%	25.3%	0.0%	100.0%	81.1%	20.0%	81.1%	52.3%	67.6%	100.0%
Others	0.0%	3.1%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

4.11) Selection of Method for Estimating Material and Energy Use for (

1

5. GREET Default Key Assumptions for Material

5.1) Energy Use of Steel: mmBtu per ton of material product

0.117
16.003
0.153
3.576
0.444
0.141
1.940
2.551
11.238

Fill out the user-defined mix as shown

Mat_Inputs | Car | SUV | PUT | Steel | C.Iron | W.Al | C.Al | Lead | Nickel | Cobalt | Copper | Zinc | Magnesium | Glass | Vehi_I

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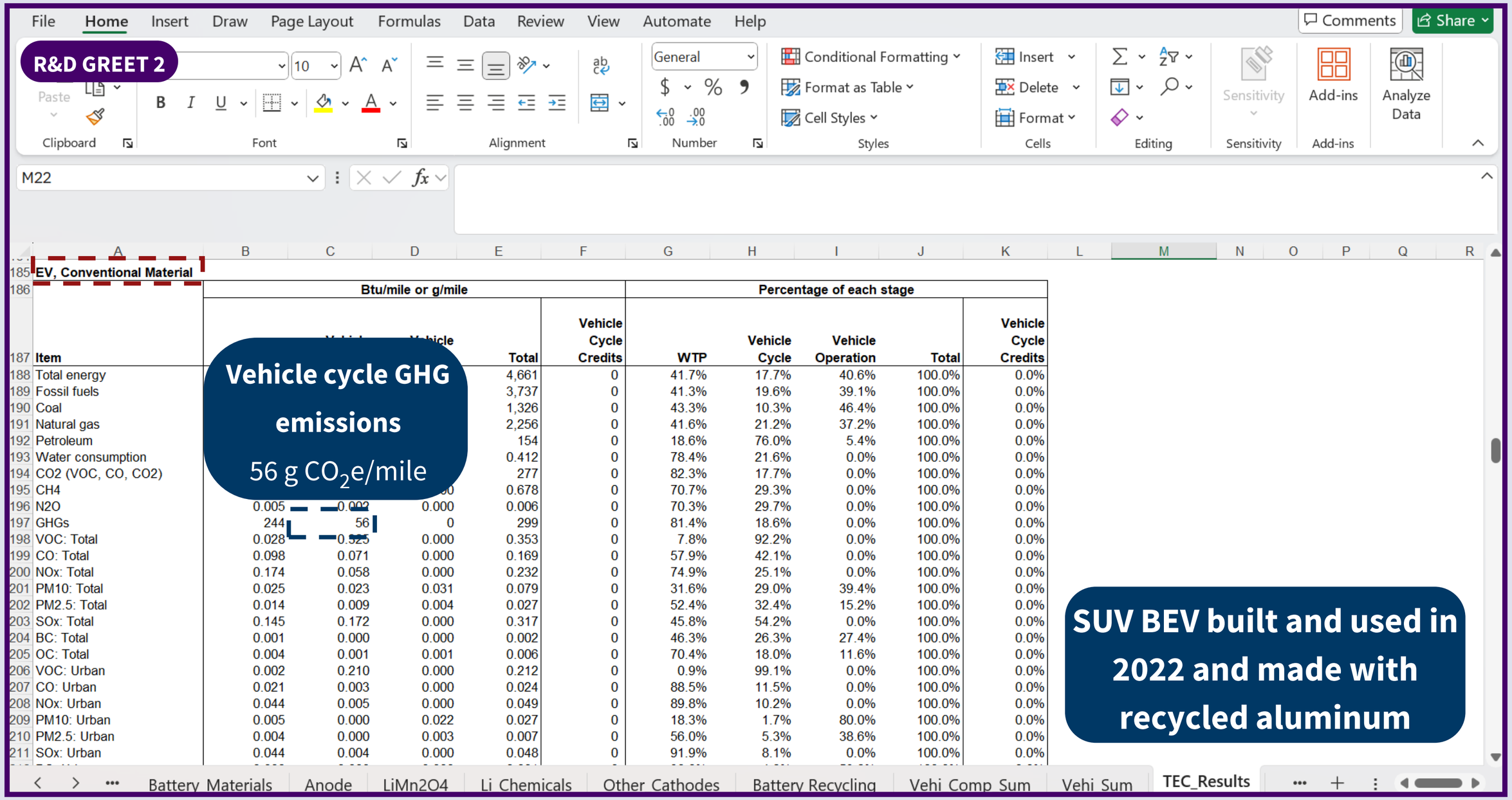
Vehicle Cycle GHG Emissions



Item	Btu/mile or g/mile					Percentage of each stage				
				Total	Vehicle Cycle Credits	WTP	Vehicle Cycle	Vehicle Operation	Total	Vehicle Cycle Credits
Total energy				4,661	0	41.7%	17.7%	40.6%	100.0%	0.0%
Fossil fuels				3,737	0	41.3%	19.6%	39.1%	100.0%	0.0%
Coal				1,326	0	43.3%	10.3%	46.4%	100.0%	0.0%
Natural gas				2,256	0	41.6%	21.2%	37.2%	100.0%	0.0%
Petroleum				154	0	18.6%	76.0%	5.4%	100.0%	0.0%
Water consumption				0.412	0	78.4%	21.6%	0.0%	100.0%	0.0%
CO2 (VOC, CO, CO2)				277	0	82.3%	17.7%	0.0%	100.0%	0.0%
CH4				0.678	0	70.7%	29.3%	0.0%	100.0%	0.0%
N2O	0.005	0.002	0.000	0.006	0	70.3%	29.7%	0.0%	100.0%	0.0%
GHGs	244	56	0	299	0	81.4%	18.6%	0.0%	100.0%	0.0%
VOC: Total	0.028	0.325	0.000	0.353	0	7.8%	92.2%	0.0%	100.0%	0.0%
CO: Total	0.098	0.071	0.000	0.169	0	57.9%	42.1%	0.0%	100.0%	0.0%
NOx: Total	0.174	0.058	0.000	0.232	0	74.9%	25.1%	0.0%	100.0%	0.0%
PM10: Total	0.025	0.023	0.031	0.079	0	31.6%	29.0%	39.4%	100.0%	0.0%
PM2.5: Total	0.014	0.009	0.004	0.027	0	52.4%	32.4%	15.2%	100.0%	0.0%
SOx: Total	0.145	0.172	0.000	0.317	0	45.8%	54.2%	0.0%	100.0%	0.0%
BC: Total	0.001	0.000	0.000	0.002	0	46.3%	26.3%	27.4%	100.0%	0.0%
OC: Total	0.004	0.001	0.001	0.006	0	70.4%	18.0%	11.6%	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	88.5%	11.5%	0.0%	100.0%	0.0%
NOx: Urban	0.044	0.005	0.000	0.049	0	89.8%	10.2%	0.0%	100.0%	0.0%
PM10: Urban	0.005	0.000	0.022	0.027	0	18.3%	1.7%	80.0%	100.0%	0.0%
PM2.5: Urban	0.004	0.000	0.003	0.007	0	56.0%	5.3%	38.6%	100.0%	0.0%
SOx: Urban	0.044	0.004	0.000	0.048	0	91.9%	8.1%	0.0%	100.0%	0.0%

ICEV Recycled Steel

Model a 2022 Sport Utility Vehicle (SUV) Internal Combustion Engine (ICEV) Using Gasoline Made with 100% Recycled Steel and Virgin Aluminum Produced with 100% Hydropower Electricity

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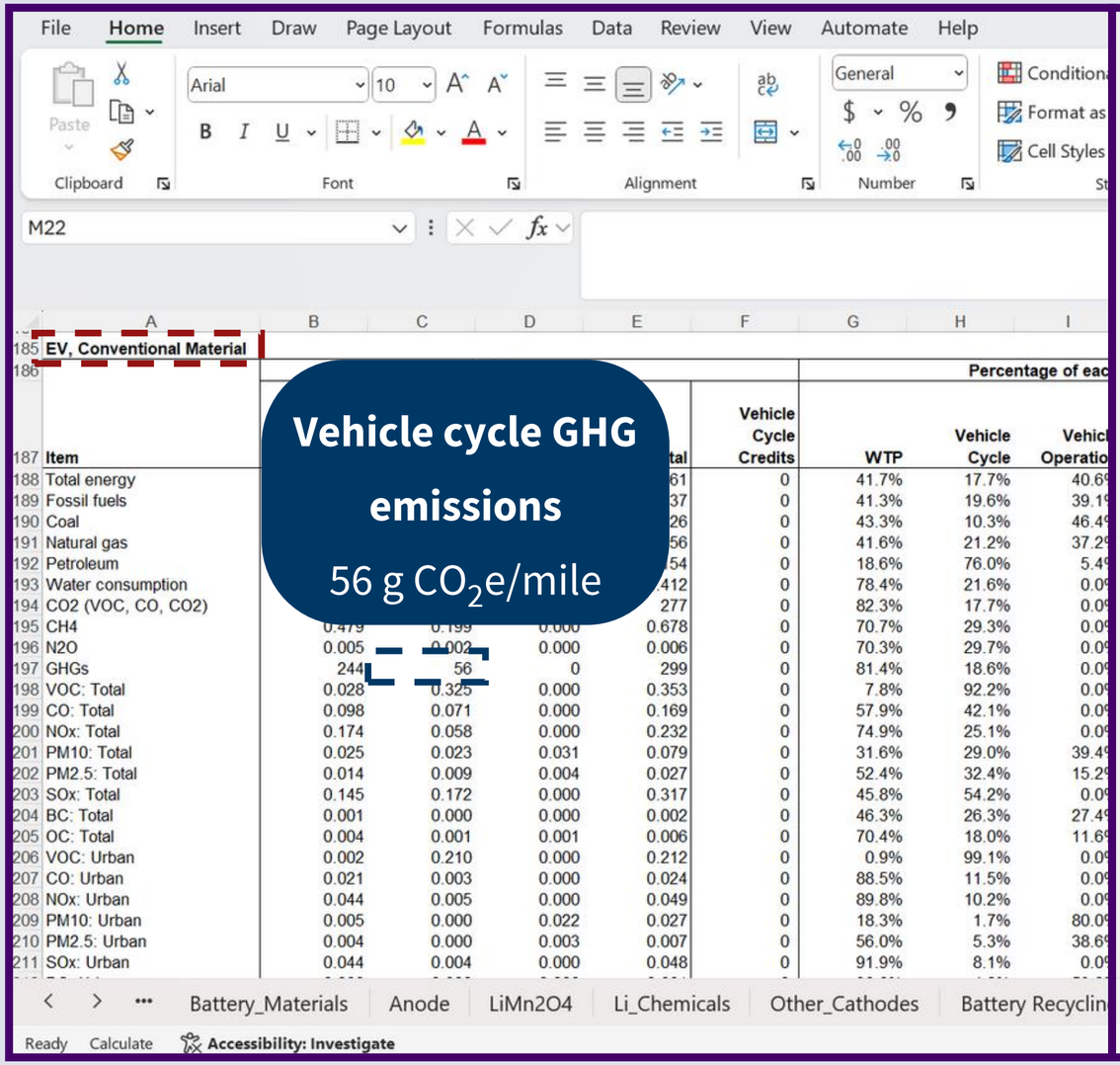
Vehicle Cycle GHG Emissions

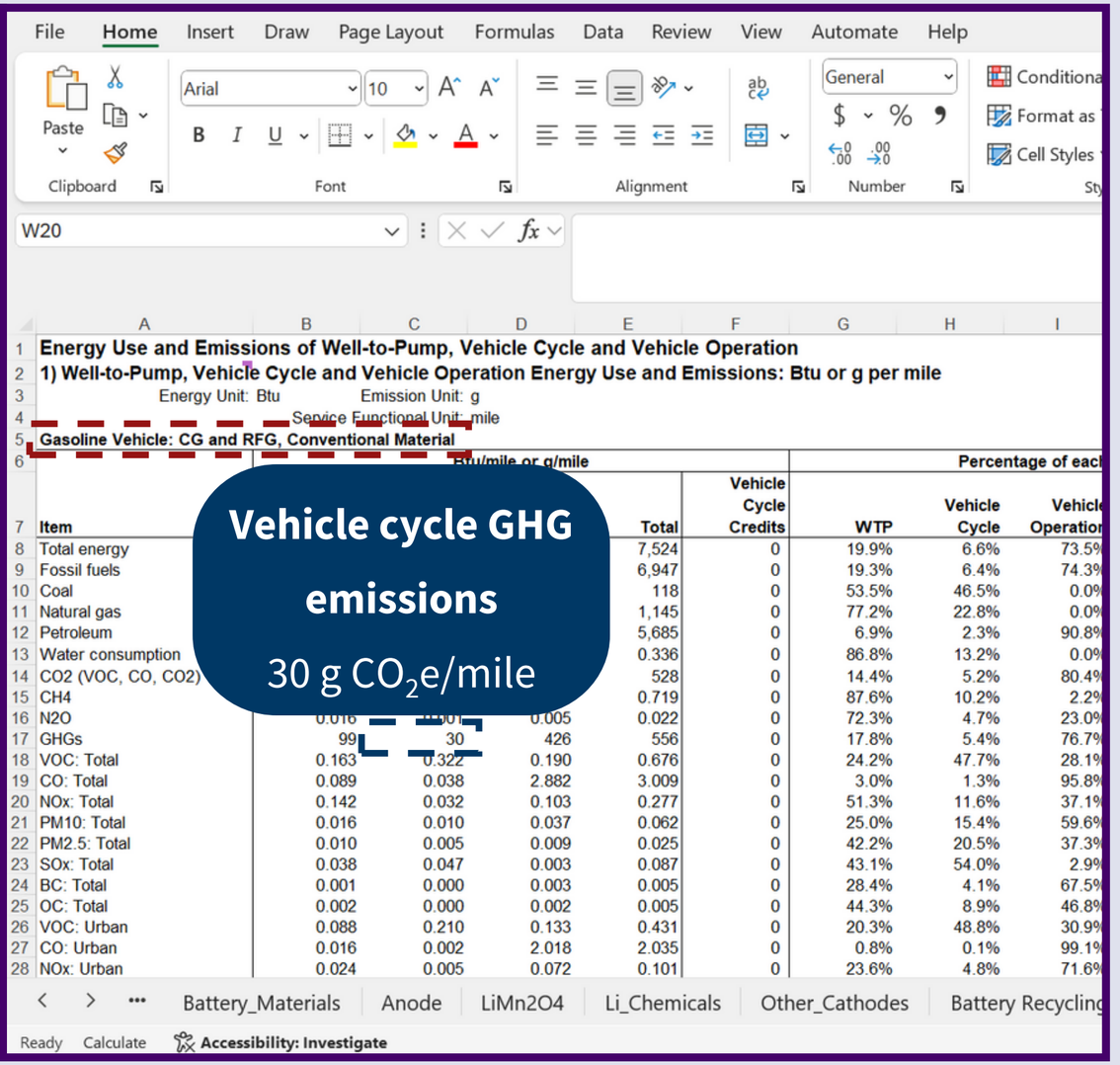
2022 SUV BEV



EV, Conventional Material

Item					Vehicle Cycle Credits	WTP	Vehicle Cycle	Vehicl Operatio
Total energy				61	0	41.7%	17.7%	40.6%
Fossil fuels				37	0	41.3%	19.6%	39.1%
Coal				26	0	43.3%	10.3%	46.4%
Natural gas				56	0	41.6%	21.2%	37.2%
Petroleum				54	0	18.6%	76.0%	5.4%
Water consumption				412	0	78.4%	21.6%	0.0%
CO2 (VOC, CO, CO2)				277	0	82.3%	17.7%	0.0%
CH4	0.479	0.199	0.000	0.678	0	70.7%	29.3%	0.0%
N2O	0.005	0.002	0.000	0.006	0	70.3%	29.7%	0.0%
GHGs	244	56	0	299	0	81.4%	18.6%	0.0%
VOC: Total	0.028	0.325	0.000	0.353	0	7.8%	92.2%	0.0%
CO: Total	0.098	0.071	0.000	0.169	0	57.9%	42.1%	0.0%
NOx: Total	0.174	0.058	0.000	0.232	0	74.9%	25.1%	0.0%
PM10: Total	0.025	0.023	0.031	0.079	0	31.6%	29.0%	39.4%
PM2.5: Total	0.014	0.009	0.004	0.027	0	52.4%	32.4%	15.2%
SOx: Total	0.145	0.172	0.000	0.317	0	45.8%	54.2%	0.0%
BC: Total	0.001	0.000	0.000	0.002	0	46.3%	26.3%	27.4%
OC: Total	0.004	0.001	0.001	0.006	0	70.4%	18.0%	11.6%
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	88.5%	11.5%	0.0%
NOx: Urban	0.044	0.005	0.000	0.049	0	89.8%	10.2%	0.0%
PM10: Urban	0.005	0.000	0.022	0.027	0	18.3%	1.7%	80.0%
PM2.5: Urban	0.004	0.000	0.003	0.007	0	56.0%	5.3%	38.6%
SOx: Urban	0.044	0.004	0.000	0.048	0	91.9%	8.1%	0.0%

2022 SUV ICEV



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				Total	Vehicle Cycle Credits	WTP	Vehicle Cycle	Vehicl Operatio
Total energy				7,524	0	19.9%	6.6%	73.5%
Fossil fuels				6,947	0	19.3%	6.4%	74.3%
Coal				118	0	53.5%	46.5%	0.0%
Natural gas				1,145	0	77.2%	22.8%	0.0%
Petroleum				5,685	0	6.9%	2.3%	90.8%
Water consumption				0.336	0	86.8%	13.2%	0.0%
CO2 (VOC, CO, CO2)				528	0	14.4%	5.2%	80.4%
CH4				0.719	0	87.6%	10.2%	2.2%
N2O	0.016	0.001	0.005	0.022	0	72.3%	4.7%	23.0%
GHGs	99	30	426	556	0	17.8%	5.4%	76.7%
VOC: Total	0.163	0.322	0.190	0.676	0	24.2%	47.7%	28.1%
CO: Total	0.089	0.038	2.882	3.009	0	3.0%	1.3%	95.8%
NOx: Total	0.142	0.032	0.103	0.277	0	51.3%	11.6%	37.1%
PM10: Total	0.016	0.010	0.037	0.062	0	25.0%	15.4%	59.6%
PM2.5: Total	0.010	0.005	0.009	0.025	0	42.2%	20.5%	37.3%
SOx: Total	0.038	0.047	0.003	0.087	0	43.1%	54.0%	2.9%
BC: Total	0.001	0.000	0.003	0.005	0	28.4%	4.1%	67.5%
OC: Total	0.002	0.000	0.002	0.005	0	44.3%	8.9%	46.8%
VOC: Urban	0.088	0.210	0.133	0.431	0	20.3%	48.8%	30.9%
CO: Urban	0.016	0.002	2.018	2.035	0	0.8%	0.1%	99.1%
NOx: Urban	0.024	0.005	0.072	0.101	0	23.6%	4.8%	71.6%

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