



Argonne
NATIONAL
LABORATORY

... for a brighter future



U.S. Department
of Energy

UChicago ►
Argonne_{LLC}

A U.S. Department of Energy laboratory
managed by UChicago Argonne, LLC

Demonstration of GREET 2.7

I. Vehicle-Cycle Simulations through the Excel Spreadsheet

***Andrew Burnham
Center for Transportation Research
Argonne National Laboratory***

***GREET User Workshop
Argonne, IL, June 25-26, 2007***

Two Cases Will be Demoed through the GREET Excel Spreadsheet Model

- Hybrid Electric Vehicle (Demo 1)
 - Vehicle Selection: HEV
 - Material Selection: Lightweight
 - Battery Selection: Ni-MH vs. Li-Ion
 - Motive Battery Replacement: 0 vs. 1 per lifetime
- Fuel Cell Vehicle (Demo 2)
 - Vehicle Selection: FCV
 - Material Selection: Conventional
 - Battery Selection: Li-Ion
 - Stack vs. Battery Size: 70 kW stack/30 kW Li-Ion vs. 100 kW stack/no battery
 - Platinum Allocation Method: Weight-based vs. market-based

Browse the Overview Sheet prior to the Specific GREET Simulation

The screenshot shows a Microsoft Excel window titled "greet2_7.xls". The active sheet is "Overview". The content is as follows:

Sheet	Description
Vehi_Inputs	Key input parameters of vehicle and vehicle components that users can specify for GREET simulations.
Mat_Inputs	Key input parameters of vehicle materials that users can specify for GREET simulations.
Steel	Calculations of energy use and emissions for steel production.
C.Iron	Calculations of energy use and emissions for cast iron production.
W.Al	Calculations of energy use and emissions for wrought aluminum production.
C.Al	Calculations of energy use and emissions for cast aluminum production.
Lead	Calculations of energy use and emissions for lead production.
Nickel	Calculations of energy use and emissions for nickel production.
KOH	Calculations of energy use and emissions for KOH production.
Cobalt	Calculations of energy use and emissions for cobalt oxide production.
Copper	Calculations of energy use and emissions for copper production.
Zinc	Calculations of energy use and emissions for zinc production.
Magnesium	Calculations of energy use and emissions for magnesium production.
S.Acids	Calculations of energy use and emissions for sulfuric acid production.
Glass	Calculations of energy use and emissions for glass production.
Plastic	Calculations of energy use and emissions for plastic production.
Rubber	Calculations of energy use and emissions for rubber production.
Platinum	Calculations of energy use and emissions for platinum production.
Vanadium	Calculations of energy use and emissions for vanadium production.
Zirconium	Calculations of energy use and emissions for zirconium production.
Titanium	Calculations of energy use and emissions for titanium production.
Chromium	Calculations of energy use and emissions for chromium production.
Rare Earth	Calculations of energy use and emissions for rare earth production.
Manganese	Calculations of energy use and emissions for manganese production.
FC Materials	Calculations of energy use and emissions for fuel cell materials production.
Mat_Sum	Summary of energy use and emissions results for vehicle materials production (per pound of material).
Vehi_Fluids	Calculations of energy use and emissions for fluids production, fluids use and fluids disposal.
Battery Assembly	Calculations of energy use and emissions for battery assembly.

Input Weights (Vehicle, Lead-Acid Battery, and Fluids) in the Veh Inputs Sheet

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

1. Specification of Total Vehicle Weight, pounds

	ICEV: Conventional Material	ICEV: Lightweight Material	HEV: Conventional Material	HEV: Lightweight Material	FCV: Conventional Material	FCV: Lightweight Material
	3,330	1,970	2,810	2,000	3,020	2,280

2. Vehicle Battery and Fluids Weight, pounds per vehicle

2.1) Battery Weight

	ICEV: Conventional Material	ICEV: Lightweight Material	HEV: Conventional Material	HEV: Lightweight Material	FCV: Conventional Material	FCV: Lightweight Material
Lead-Acid	36.0	23.4	22.1	14.4	22.1	14.4
Ni-MH			84.3	51.3	110.0	69.7
Li-Ion			33.7	20.5	44.0	27.9

2.2) Fluids Weight

	Engine Oil	Power Steering Fluid	Brake Fluid	Transmission Fluid	Powertrain Coolant	Windshield Fluid	Adhesives
ICEV	8.5	0.0	2.0	24.0	23.0	6.0	30.0
HEV	8.5	0.0	2.0	1.8	23.0	6.0	30.0
FCV	0.0	0.0	2.0	1.8	15.8	6.0	30.0

3. Key Input Parameters for Vehicle Components: Body, Powertrain System, Transmission System, Chassis, Traction Motor, Generator, Electronic Control

3.1) Vehicle Components Weight, pounds (excluding battery, fluids, and misc)

	ICEV: Conventional Material	ICEV: Lightweight Material	HEV: Conventional Material	HEV: Lightweight Material	FCV: Conventional Material	FCV: Lightweight Material
	3201	1853	2632	1863	2832	2140

3.2.a) Fuel Cell Stack Size, kW

421 Fuel Cell Auxiliary System: Lightweight Material

Ready Calculate NUM

Note: You can change in GREET 2.7 any value but if you stray to far from the default you may have unrealistic results

Select Key Input Parameters for the Vehicle Components in the Veh_Inputs Sheet

Microsoft Excel - greet2_7.xls

Type a question for help

File Edit View Insert Format Tools Data Window Help

100%

Arial 8

B28

16		HEV	8.5	0.0	2.0	1.8	23.0	6.0	30.0
17		FCV	0.0	0.0	2.0	1.8	15.8	6.0	30.0

3. Key Input Parameters for Vehicle Components: Body, Powertrain System, Transmission System, Chassis, Traction Motor, Generator, Electronic Controller

3.1) Vehicle Components Weight, pounds (excluding battery, fluids, and fuel)

	ICEV: Conventional Material	ICEV: Lightweight Material	HEV: Conventional Material	HEV: Lightweight Material	FCV: Conventional Material	FCV: Lightweight Material
	3201	1853	2632	1863	2832	2140

3.2.a) Fuel Cell Stack Size, kW

70	Conventional Material
54	Lightweight Material

3.2.b) Weight of Fuel Cell Stack and Auxiliary System, pounds

226	Fuel Cell Stack (Powertrain System): Conventional Material
546	Fuel Cell Auxiliary System: Conventional Material
174	Fuel Cell Stack (Powertrain System): Lightweight Material
421	Fuel Cell Auxiliary System: Lightweight Material

3.3) Vehicle Components Composition, % by wt

	ICEV: Conventional Material	ICEV: Lightweight Material	HEV: Conventional Material	HEV: Lightweight Material	FCV: Conventional Material	FCV: Lightweight Material
Powertrain System	25.7%	30.7%	17.0%	21.6%	8.0%	8.1%
Transmission System	6.3%	6.7%	7.2%	7.8%	2.6%	2.8%
Chassis (w/o battery)	23.9%	23.0%	24.5%	24.5%	23.0%	23.8%
Traction Motor	0.0%	0.0%	2.1%	2.0%	3.8%	3.8%
Generator	0.0%	0.0%	2.1%	2.0%	0.0%	0.0%
Electronic Controller	0.0%	0.0%	1.8%	1.8%	3.4%	3.3%
Fuel Cell Auxiliary System	0.0%	0.0%	0.0%	0.0%	19.3%	19.7%
Body: including BIW, interior, exterio	44.1%	39.6%	45.3%	40.3%	39.9%	38.5%

3.4) Tire Replacements During Lifetime of Vehicle

3

4. Key Input Parameters for Batteries

4.1) Battery Type for Hybrid Electric Vehicles

1	Ni-MH
---	-------

Overview \ Vehi_Inputs \ Mat_Inputs \ Steel \ C.Iron \ W.Al \ C.Al \ Lead \ Nickel \ KOH \ Cobalt \ Copper \ Zinc \ Magnesium \ S.Acid \ Glass \ Plasti

Ready Calculate NUM

Select Key Input Parameters for Battery and Fluids in the Veh_Inputs Sheet

Microsoft Excel - greet2_7.xls

File Edit View Insert Format Tools Data Window Help

Type a question for help

B28

A B C D E F G H I J K

47

48 **4. Key Input Parameters for Batteries**

49 **4.1) Battery Type for Hybrid Electric Vehicles**

50 1 -- Ni-MH

51 2 -- Li-Ion

52

53 **4.2) Battery Type for Fuel Cell Vehicles**

54 1 -- Ni-MH

55 2 -- Li-Ion

56

57 **4.3) Battery Size in Peak Battery Power, kW**

	Ni-MH	Li-Ion
HEV: Conventional Material	23	23
HEV: Lightweight Material	14	14
FCV: Conventional Material	30	30
FCV: Lightweight Material	19	19

63

64 **4.4) Battery Replacements During Lifetime of Vehicle**

	Lead-Acid	Ni-MH	Li-Ion
ICEV	2		
HEV	2	1	1
FCV	2	1	1

69

70 **4.5) Battery Specific Power**

	W/kg	W/lb
Ni-MH	600	272
Li-Ion	1500	680

73

74 **5. Key Input Parameters for Fluids**

75 **5.1) Fluids Replacements During Lifetime of Vehicle**

Engine Oil	Power Steering Fluid	Brake Fluid	Transmission Fluid	Powertrain Coolant	Windshield Fluid	Adhesives
40	0	3	1	3	20	0

78

79 **5.2) 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%

82

Overview Vehi_Inputs Mat_Inputs Steel C.Iron W.Al C.Al Lead Nickel KOH Cobalt Copper Zinc Magnesium S.Acid Glass Plasti

Ready Calculate NUM

Select Key Assumptions for ADR and Vehicle Lifetime in the Veh_Inputs Sheet

Microsoft Excel - greet2_7.xls

File Edit View Insert Format Tools Data Window Help

Type a question for help

100%

Arial B B I U

D101 $=1+(0.0012*((G4-H4)/G4*100)^2)+0.6877*((G4-H4)/G4*100)+0.0351/100$

81		66.7%	66.7%	66.7%	66.7%	66.7%	0.0%	66.7%
82								
83	6. GREET Default Key Assumptions for Vehicle and Vehicle Component Production							
84	6.1) Energy Use of Battery Assembly: mmBtu per ton of battery							
85		27.470	Lead-Acid					
86		35.230	Ni-MH					
87		30.690	Li-Ion					
88								
89	6.2) Energy Use of Vehicle Assembling, Disposal and Recycling: mmBtu per vehicle							
90		0.234	Paint Production					
91		0.956	Vehicle Painting					
92		3.874	Vehicle Assembly					
93		1.420	Vehicle Disposal					
94								
95	7. Lifetime VMT of a Vehicle, miles							
96		ICEV: Conventional Material	ICEV: Lightweight Material	HEV: Conventional Material	HEV: Lightweight Material	FCV: Conventional Material	FCV: Lightweight Material	
97		160,000	160,000	160,000	160,000	160,000	160,000	
98								
99	8. Ratios of Fuel Economy of Lightweight Material Vehicles Relative to Their Conventional Material Vehicles Counterpart							
100		ICEV: Lightweight Material	HEV: Lightweight Material	FCV: Lightweight Material				
101		132%	119%	118%				
102								
103								
104								
105								
106								
107								
108								
109								
110								
111								
112								
113								
114								
115								

Select Material Composition for Each Vehicle Component in the Mat Inputs Sheet

Microsoft Excel - greet2_7.xls

File Edit View Insert Format Tools Data Window Help

Type a question for help

B320 29.654

Scenario Control Variables and Input Assumptions Related to Vehicle Materials

1. Material Composition for Vehicle Components

1.1) Material Composition for Each Component, % by wt

	ICEV: Conventional Material	ICEV: Lightweight Material	HEV: Conventional Material	HEV: Lightweight Material	FCV: Conventional Material	FCV: Lightweight Material
Body						
Steel	68.3%	11.1%	68.3%	10.8%	68.3%	10.3%
Wrought Aluminum	0.7%	9.1%	0.7%	8.9%	0.7%	8.5%
Copper/Brass	1.9%	3.6%	1.9%	3.5%	1.9%	3.3%
Magnesium	0.04%	0.9%	0.04%	0.9%	0.04%	0.9%
Glass	6.5%	7.7%	6.5%	7.5%	6.5%	7.2%
Carbon Fiber-Reinforced Plastic	0.0%	38.1%	0.0%	39.7%	0.0%	42.3%
Average Plastic	18.1%	23.6%	18.1%	22.9%	18.1%	22.0%
Rubber	0.5%	0.9%	0.5%	0.8%	0.5%	0.8%
Others	4.0%	5.0%	4.0%	5.0%	4.0%	4.7%
Powertrain System						
Steel	39.5%	54.8%	48.4%	59.6%	1.5%	1.5%
Stainless Steel	0.0%	3.6%	0.0%	3.2%	0.0%	0.0%
Cast iron	28.6%	5.3%	24.0%	4.7%	0.0%	0.0%
Wrought Aluminum	0.0%	1.8%	0.0%	2.5%	23.2%	23.2%
Cast Aluminum	17.1%	17.8%	14.4%	15.8%	0.0%	0.0%
Copper/Brass	2.9%	3.8%	2.6%	3.2%	0.0%	0.0%
Average Plastic	9.3%	11.1%	8.4%	9.4%	0.0%	0.0%
Rubber	2.6%	1.8%	2.2%	1.6%	0.0%	0.0%
Carbon Fiber-Reinforced Plastic	0.0%	0.0%	0.0%	0.0%	62.7%	62.7%
PFSA	0.0%	0.0%	0.0%	0.0%	5.4%	5.4%
Carbon Paper	0.0%	0.0%	0.0%	0.0%	5.1%	5.1%
PTFE	0.0%	0.0%	0.0%	0.0%	1.4%	1.4%
Carbon & PFSA Suspension	0.0%	0.0%	0.0%	0.0%	0.6%	0.6%
Platinum	0.002%	0.003%	0.002%	0.002%	0.09%	0.09%
Others	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Transmission System/Gearbox						
Steel	30.0%	30.0%	60.5%	60.5%	60.5%	60.5%
Copper	0.0%	0.0%	18.9%	18.9%	18.9%	18.9%
Cast Iron	30.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Wrought Aluminum	30.0%	30.0%	20.0%	20.0%	20.0%	20.0%

Overview Vehi_Inputs **Mat_Inputs** Steel C.Iron W.Al C.Al Lead Nickel KOH Cobalt Copper Zinc Magnesium S.Acid Glass Plasti

Ready Calculate NUM

Aggregated Material Composition for Components Will be Displayed in the Mat_Inputs Sheet

Summary Table (Rows 70-76):

Row	Material	Column G (%)	Column H (%)
70	Carbon Fiber-Reinforced Plastic	25.7%	25.7%
71	Wrought Aluminum	16.7%	16.7%
72	Copper	9.6%	9.6%
73	Average Plastics	8.7%	8.7%
74	Rubber	1.5%	1.5%
75	Nickel	0.5%	0.5%
76	Others	0.5%	0.5%

1.2) Vehicle Material Composition Aggregated by Each Component: % by wt

Material	ICEV: Conventional Material	ICEV: Lightweight Material	HEV: Conventional Material	HEV: Lightweight Material	FCV: Conventional Material	FCV: Lightweight Material
Steel	61.7%	30.5%	65.2%	30.9%	56.4%	21.4%
Stainless Steel	0.0%	1.1%	0.0%	0.7%	0.0%	0.0%
Cast Iron	11.1%	4.2%	6.0%	3.7%	1.8%	2.6%
Wrought Aluminum	2.2%	6.9%	1.8%	6.3%	5.9%	10.3%
Cast Aluminum	4.7%	14.7%	5.1%	14.1%	3.2%	11.2%
Copper/Brass	1.9%	3.2%	4.3%	5.4%	4.8%	5.5%
Magnesium	0.02%	0.4%	0.02%	0.4%	0.02%	0.3%
Glass	2.9%	3.0%	2.9%	3.0%	2.6%	2.8%
Average Plastic	11.2%	14.0%	10.6%	12.6%	10.2%	11.7%
Rubber	2.4%	2.6%	1.9%	2.0%	1.8%	1.8%
Carbon Fiber-Reinforced Plastic	0.0%	15.1%	0.0%	16.0%	10.0%	26.4%
Glass Fiber-Reinforced Plastic	0.0%	2.3%	0.0%	2.4%	0.0%	2.3%
Nickel	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%
PFSA	0.0%	0.0%	0.0%	0.0%	0.4%	0.4%
Carbon Paper	0.0%	0.0%	0.0%	0.0%	0.4%	0.4%
PTFE	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%
Carbon & PFSA Suspension	0.0%	0.0%	0.0%	0.0%	0.05%	0.05%
Platinum	0.0005%	0.0009%	0.0003%	0.0004%	0.007%	0.007%
Others	1.9%	2.2%	2.2%	2.5%	2.2%	2.5%

1.3) Material Composition of Tire, % by wt

Material	Percentage (%)
Rubber	66.7%
Steel	0.0%

2. Battery Material Composition, % by wt

Navigation: Overview / Vehi_Inputs / **Mat_Inputs** / Steel / C.Iron / W.Al / C.Al / Lead / Nickel / KOH / Cobalt / Copper / Zinc / Magnesium / S.Acid / Glass / Plasti

Aggregated Material Composition for Components Will be Displayed in the Mat_Inputs Sheet

Microsoft Excel - greet2_7.xls

Type a question for help

100%

B77

	A	B	C	D	E	F	G	H	I	J	K
70		Carbon Fiber-Reinforced Plastic					25.7%	25.7%			
71		Wrought Aluminum					16.7%	16.7%			
72		Copper					9.6%	9.6%			
73		Average Plastics					8.7%	8.7%			
74		Rubber					1.5%	1.5%			
75		Nickel					0.5%	0.5%			
76		Others					0.5%	0.5%			
77											
78		1.2) Vehicle Material Composition Aggregated by Each Component: % by wt									
79			ICEV: Conventional Material	ICEV: Lightweight Material	HEV: Conventional Material	HEV: Lightweight Material	FCV: Conventional Material	FCV: Lightweight Material			
80		Steel	61.7%	30.5%	65.2%	30.9%	56.4%	21.4%			
81		Stainless Steel	0.0%	1.1%	0.0%	0.7%	0.0%	0.0%			
82		Cast Iron	11.1%	4.2%	6.0%	3.7%	1.8%	2.6%			
83		Wrought Aluminum	2.2%	6.9%	1.8%	6.3%	5.9%	10.3%			
84		Cast Aluminum	4.7%	14.7%	5.1%	14.1%	3.2%	11.2%			
85		Copper/Brass	1.9%	3.2%	4.3%	5.4%	4.8%	5.5%			
86		Magnesium	0.02%	0.4%	0.02%	0.4%	0.02%	0.3%			
87		Glass	2.9%	3.0%	2.9%	3.0%	2.6%	2.8%			
88		Average Plastic	11.2%	14.0%	10.6%	12.6%	10.2%	11.7%			
89		Rubber	2.4%	2.6%	1.9%	2.0%	1.8%	1.8%			
90		Carbon Fiber-Reinforced Plastic	0.0%	15.1%	0.0%	16.0%	10.0%	26.4%			
91		Glass Fiber-Reinforced Plastic	0.0%	2.3%	0.0%	2.4%	0.0%	2.3%			
92		Nickel	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%			
93		PFSA	0.0%	0.0%	0.0%	0.0%	0.4%	0.4%			
94		Carbon Paper	0.0%	0.0%	0.0%	0.0%	0.4%	0.4%			
95		PTFE	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%			
96		Carbon & PFSA Suspension	0.0%	0.0%	0.0%	0.0%	0.05%	0.05%			
97		Platinum	0.0005%	0.0009%	0.0003%	0.0004%	0.007%	0.007%			
98		Others	1.9%	2.2%	2.2%	2.5%	2.2%	2.5%			
99											
100		1.3) Material Composition of Tire, % by wt									
101			Rubber	Steel							
102			66.7%	0.0%							
103											
104		2. Battery Material Composition, % by wt									
		Overview / Vehi_Inputs / <u>Mat_Inputs</u> / Steel / C.Iron / W.Al / C.Al / Lead / Nickel / KOH / Cobalt / Copper / Zinc / Magnesium / S.Acid / Glass / Plasti									

Ready Calculate NUM

Select Material Composition for Battery in the Mat Inputs Sheet

Microsoft Excel - greet2_7.xls

File Edit View Insert Format Tools Data Window Help

Type a question for help

B77

2. Battery Material Composition, % by wt

	ICEV: Conventional Material	ICEV: Lightweight Material	HEV: Conventional Material	HEV: Lightweight Material	FCV: Conventional Material	FCV: Lightweight Material
Lead-Acid						
Plastic: Polypropylene	6.1%	6.1%	6.1%	6.1%	6.1%	6.1%
Lead	69.0%	69.0%	69.0%	69.0%	69.0%	69.0%
Sulfuric Acid	7.9%	7.9%	7.9%	7.9%	7.9%	7.9%
Fiberglass	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%
Water	14.1%	14.1%	14.1%	14.1%	14.1%	14.1%
Others	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%
Ni-MH						
Iron			12.0%	12.0%	12.0%	12.0%
Steel			23.7%	23.7%	23.7%	23.7%
Aluminum			0.5%	0.5%	0.5%	0.5%
Copper			3.9%	3.9%	3.9%	3.9%
Magnesium			1.0%	1.0%	1.0%	1.0%
Cobalt			1.8%	1.8%	1.8%	1.8%
Nickel			28.2%	28.2%	28.2%	28.2%
Rare Earth Metals			6.3%	6.3%	6.3%	6.3%
Average Plastic			22.5%	22.5%	22.5%	22.5%
Rubber			0.1%	0.1%	0.1%	0.1%
Li-Ion						
Lithium Oxide (LiO2)			5.3%	5.3%	5.3%	5.3%
Nickel			2.6%	2.6%	2.6%	2.6%
Cobalt			2.7%	2.7%	2.7%	2.7%
Manganese			2.5%	2.5%	2.5%	2.5%
Graphite/Carbon			10.6%	10.6%	10.6%	10.6%
Binder			2.1%	2.1%	2.1%	2.1%
Copper			24.5%	24.5%	24.5%	24.5%
Wrought Aluminum			18.6%	18.6%	18.6%	18.6%
Cast Aluminum			10.6%	10.6%	10.6%	10.6%
Electrolyte			8.7%	8.7%	8.7%	8.7%
Plastic: Polypropylene			8.1%	8.1%	8.1%	8.1%
Plastic: Polyethylene			2.9%	2.9%	2.9%	2.9%
Steel			0.2%	0.2%	0.2%	0.2%
Thermal Insulation			0.5%	0.5%	0.5%	0.5%

Ready Calculate NUM

Select Key Input Parameters for Material Use in the Mat_Inputs Sheet

Microsoft Excel - greet2_7.xls

File Edit View Insert Format Tools Data Window Help

Type a question for help

100%

Arial 8 B I U

B152 Nickel

4. Key Input Parameters for Material Use			
4.1) Share of Virgin and Recycled Materials Used in Vehicle, % by wt			
	Virgin Material	Recycled Material	
Steel	30.0%	70.0%	
Wrought Aluminum	89.0%	11.0%	
Cast Aluminum	41.0%	59.0%	
Lead	27.0%	73.0%	
Nickel	56.0%	44.0%	

4.2) Tons of Intermediate Material Needed per Ton of Final Steel Product								
	Ore Recovery	Ore Pelletizing & Sintering	Coke Production	Blast Furnace	Basic O2 Processing	Electric Arc Furnace	Sheet Production & Rolling	Stamping
Virgin Steel	5.200	1.860	0.531	1.180	1.420	0.220	1.340	1.000
Recycled Steel					0.090	1.530	1.340	1.000
Stainless Steel						1.610	1.340	1.000

4.3) Tons of Intermediate Material Needed per Ton of Final Wrought Aluminum Product								
	Bauxite Mining	Bauxite Refining	Alumina Reduction	Scrap Preparation	Reverb Melt and Ingot Cast	Al Melting and Production & Casting	Sheet Production & Rolling	Stamping
Virgin Wrought Aluminum	4.800	1.900	1.000			1.000	1.380	1.000
Recycled Wrought Aluminum				1.060	1.000	1.000	1.380	1.000

4.4) Tons of Intermediate Material Needed per Ton of Final Cast Aluminum Product						
	Bauxite Mining	Bauxite Refining	Alumina Reduction	Al Melting and Casting	Al Casting	Al Recycling
Cast Aluminum	4.800	1.900	1.000	1.000		
Recycled Cast Aluminum					1.000	1.000

4.5) Tons of Nickel Needed per Ton of Nickel Hydroxide Product

0.633

4.6) Composition of Fiberglass, % by wt		
	Glass	Glass Fiber
	0.0%	100.0%

4.7 a) Shares of Individual Plastic in a Vehicle for Average Plastic Calculation, % by wt

Overview \ Vehi_Inputs \ Mat_Inputs \ Steel \ C.Iron \ W.Al \ C.Al \ Lead \ Nickel \ KOH \ Cobalt \ Copper \ Zinc \ Magnesium \ S.AcId \ Glass \ Plasti

Ready Calculate NUM

Select Key Energy Use Assumptions for Material Production in the Mat_Inputs Sheet

Microsoft Excel - greet2_7.xls

Type a question for help

File Edit View Insert Format Tools Data Window Help

100%

Arial 8

B152 Nickel

	A	B	C	D	E	F	G	H	I	J	K	
196		5. GREET Default Key Assumptions for Material Production										
197		5.1) Energy Use of Steel Production: mmBtu per ton of material product										
198		0.054	Taconite Mining									
199		1.391	Ore Pelletizing & Sintering									
200		5.580	Coke Production									
201		15.886	Blast Furnace									
202		1.627	Basic O2 Processing									
203		4.240	Electric Arc Furnace (for virgin steel and recycled steel)									
204		4.819	Electric Arc Furnace (for stainless steel)									
205		6.108	Sheet Production & Rolling									
206		5.453	Stamping									
207												
208		5.2) Energy Use of Cast Iron Production: mmBtu per ton of material product										
209		1.339	Iron Recycling									
210		20.664	Iron Casting									
211												
212		5.3) Energy Use of Wrought Aluminum Production: mmBtu per ton of material product										
213		0.563	Bauxite Mining									
214		9.527	Bauxite Refining: Bayer Process									
215		65.843	Alumina Reduction: Hall-Heroult Process									
216		4.146	Al Melting and Casting									
217		8.344	Sheet Production & Rolling									
218		5.453	Stamping									
219		0.623	Scrap Preparation (Recycled Al)									
220		9.500	Reverb Melt and Ingot Cast (Recycled Al)									
221												
222		5.4) Energy Use of Cast Aluminum Production: mmBtu per ton of material product										
223		0.563	Bauxite Mining									
224		9.527	Bauxite Refining: Bayer Process									
225		65.843	Alumina Reduction: Hall-Heroult Process									
226		4.146	Al Melting and Casting									
227		34.650	Al Casting (Recycled Al)									
228		1.450	Al Recycling (Recycled Al)									
229												
230		5.5) Energy Use of Lead Production: mmBtu per ton of lead										
231		2.590	Lead Ore Mining									

Ready Calculate NUM

Overview Vehi_Inputs **Mat_Inputs** Steel C.Iron W.Al C.Al Lead Nickel KOH Cobalt Copper Zinc Magnesium S.Acid Glass Plasti

Select Key Input Parameters in the Vehi_Inputs Sheet: Hybrid Electric Vehicle (Demo 1)

4. Key Input Parameters for Batteries

4.1) Battery Type for Hybrid Electric Vehicles

1	1 -- Ni-MH
2	2 -- Li-Ion

4.2) Battery Type for Fuel Cell Vehicles

1	1 -- Ni-MH
2	2 -- Li-Ion

4.3) Battery Size in Peak Battery Power, kW

	Ni-MH	Li-Ion
HEV: Conventional Material	23	23
HEV: Lightweight Material	14	14
FCV: Conventional Material	30	30
FCV: Lightweight Material	19	19

4.4) Battery Replacements During Lifetime of Vehicle

	Lead-Acid	Ni-MH	Li-Ion
ICEV	2	1	1
HEV	2		
FCV	2		

4.5) Battery Specific Power

	W/kg	W/lb
Ni-MH	600	272
Li-Ion	1500	680

5. Key Input Parameters for Fluids

5.1) Fluids Replacements During Lifetime of Vehicle

Engine Oil	Power Steering Fluid	Brake Fluid	Transmission Fluid	Powertrain Coolant	Windshield Fluid	Adhesives
40	0	3	1	3	20	0

5.2) 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%

Callouts:

- Specify which motive battery type will be used (points to cell B50)
- Specify number of battery replacements during lifetime of vehicle (points to cell D67)

Select Key Input Parameters in the Vehi Inputs and Mat Inputs Sheet: Fuel Cell Vehicle (Demo 2)

Microsoft Excel - greet2_7.xls

2.2.a) Fuel Cell Stack Size, kW

70	Conventional Material
54	Lightweight Material

3.2.b) Weight of Fuel Cell Stack and Auxiliary System, pounds

226	Fuel Cell Stack (Powertrain System): Conventional Material
546	Fuel Cell Auxiliary System: Conventional Material
174	Fuel Cell Stack (Powertrain System): Lightweight Material
421	Fuel Cell Auxiliary System: Lightweight Material

3.3) Vehicle Components Composition, % by wt

	ICEV: Conventional Material	ICEV: Lightweight Material	HEV: Conventional Material	HEV: Lightweight Material	FCV: Conventional Material	FCV: Lightweight Material
Powertrain System	25.7%	30.7%	17.0%	21.6%	8.0%	8.1%
Transmission System	6.3%	6.7%	7.2%	7.8%	2.6%	2.8%
Chassis (w/o battery)	23.9%	23.0%	24.5%	24.5%	23.0%	23.8%
Traction Motor	0.0%	0.0%	2.1%	2.0%	3.8%	3.8%
Generator	0.0%	0.0%	2.1%	2.0%	0.0%	0.0%
Electronic Controller	0.0%	0.0%	1.8%	1.8%	3.4%	3.3%
Fuel Cell Auxiliary System	0.0%	0.0%	0.0%	0.0%	19.3%	19.3%
Body, including BW, interior, exterio	44.1%	39.6%	45.3%	40.3%	39.9%	38.5%

3.4) Tire Replacements During Lifetime of Vehicle

3

4. Key Input Parameters for Batteries

4.1) Battery Type for Hybrid Electric Vehicles

1 -- Ni-MH
2 -- Li-Ion

4.2) Battery Type for Fuel Cell Vehicles

1 -- Ni-MH
2 -- Li-Ion

4.3) Battery Size in Peak Battery Power, kW

	Ni-MH	Li-Ion
HEV: Conventional Material	23	23
HEV: Lightweight Material	14	14
FCV: Conventional Material	30	30
FCV: Lightweight Material	19	19

Overview / Vehi Inputs / Mat Inputs / Steel / C.Iron / W.Al / C.Al / Lead / Nickel / KOH / Cobalt / Copper / Zinc / Mg

Specify fuel cell stack and Li-Ion battery power

Microsoft Excel - greet2_7.xls

4.8) Selection of Method for Estimating Energy Use for Platinum Production

2

1 -- NA mine - weight based energy allocation
2 -- South African mine based
3 -- NA mine - market value based energy allocation

5. GREET Default Key Assumptions for Material Production

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

0.054	Taconite Mining
1.391	Ore Pelletizing & Sintering
5.500	Coke Production
15.898	Blast Furnace
1.627	Basic O2 Processing
4.240	Electric Arc Furnace (for virgin steel and recycled steel)
4.819	Electric Arc Furnace (for stainless steel)
6.108	Sheet Production & Rolling
5.453	Stamping

5.2) Energy Use of Cast Iron Production: mmBtu per ton of material product

1.339	Iron Recycling
20.664	Iron Casting

5.3) Energy Use of Wrought Aluminum Production: mmBtu per ton of material product

0.563	Bauxite Mining
9.527	Bauxite Refining: Bayer Process
65.843	Alumina Reduction: Hall-Heroult Process
4.148	Al Melting and Casting
8.344	Sheet Production & Rolling
5.453	Stamping
0.629	Scrap Preparation (Recycled Al)
9.500	Reverb Melt and Ingot Cast (Recycled Al)

5.4) Energy Use of Cast Aluminum Production: mmBtu per ton of material product

0.563	Bauxite Mining
9.527	Bauxite Refining: Bayer Process
65.843	Alumina Reduction: Hall-Heroult Process

Overview / Vehi Inputs / Mat Inputs / Steel / C.Iron / W.Al / C.Al / Lead / Nickel / KOH / Cobalt / Copper / Zinc / Magnesium / S.Ac / Glass / Plasti

Specify platinum allocation method

The Vehi Sum Sheet Summarizes the Vehicle-Cycle Results

Demo 1: HEV with Ni-MH battery

Demo 1: HEV with Li-Ion battery

Microsoft Excel - greet2_7.xls

File Edit View Insert Format Tools Data Window Help

F65 =SUM(B65:E65)

	A	B	C	D	E	F
48	CO: Urban	254.459	43.323	11.785	94.879	404.447
49	NOx: Urban	811.995	154.617	42.071	452.452	1461.135
50	PM10: Urban	141.503	9.388	2.696	169.982	323.570
51	PM2.5: Urban	63.041	5.609	1.578	109.961	180.189
52	SOx: Urban	1201.095	344.651	93.417	631.009	2270.172
53						
54	1.3) HEV: Conventional Material					
55		mmBtu or grams per vehicle lifetime				
56		Components	ADR	Batteries	Fluids	Total
57	Total energy	61.4	12.7	16.9	10.7	101.7
58	Fossil fuels	58.6	11.5	15.1	10.6	95.8
59	Coal	21.5	6.3	9.6	0.5	37.9
60	Natural gas	27.5	4.7	4.0	2.0	38.3
61	Petroleum	9.6	0.4	1.4	8.2	19.6
62	CO2	4,880,685	1,039,264	1,374,092	659,420	7,953,461
63	CH4	8,526	1,624	1,976	1,073	13,198
64	N2O	57	15	19	5	95
65	GHGs	5,093,561	1,080,979	1,425,120	685,612	8,285,271
66	VOC: Total	1,327	2,230	136	29,211	32,904
67	CO: Total	34,014	767	1,089	226	36,096
68	NOx: Total	5,595	4,041	1,562	1,146	12,344
69	PM10: Total	8,261	2,261	1,873	431	12,826
70	PM2.5: Total	2,710	871	519	250	4,349
71	SOx: Total	17,580	5,673	12,100	1,349	36,702

Microsoft Excel - greet2_7.xls

File Edit View Insert Format Tools Data Window Help

F65 =SUM(B65:E65)

	A	B	C	D	E	F
48	CO: Urban	254.459	43.323	11.785	94.879	404.447
49	NOx: Urban	811.995	154.617	42.071	452.452	1461.135
50	PM10: Urban	141.503	9.388	2.696	169.982	323.570
51	PM2.5: Urban	63.041	5.609	1.578	109.961	180.189
52	SOx: Urban	1201.095	344.651	93.417	631.009	2270.172
53						
54	1.3) HEV: Conventional Material					
55		mmBtu or grams per vehicle lifetime				
56		Components	ADR	Batteries	Fluids	Total
57	Total energy	62.5	12.7	9.0	10.7	94.9
58	Fossil fuels	59.6	11.5	8.1	10.6	89.8
59	Coal	21.9	6.3	4.5	0.5	33.2
60	Natural gas	28.0	4.7	2.5	2.0	37.2
61	Petroleum	9.7	0.4	1.1	8.2	19.4
62	CO2	4,964,938	1,039,264	721,159	659,420	7,384,781
63	CH4	8,672	1,624	1,092	1,073	12,461
64	N2O	58	15	10	5	87
65	GHGs	5,181,482	1,080,979	740,200	685,612	7,697,281
66	VOC: Total	1,340	2,230	69	29,211	32,850
67	CO: Total	34,625	767	213	226	36,830
68	NOx: Total	5,690	4,041	863	1,146	11,740
69	PM10: Total	8,411	2,261	1,029	431	12,132
70	PM2.5: Total	2,759	871	325	250	4,204
71	SOx: Total	17,905	5,673	4,325	1,349	29,252