TERM PROJECT

H/EV Modeling and Simulation Exercise

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Advisor 2002 (or Advisor 2003) is a GUI software program that utilizes Matlab/Simulink to model and simulate vehicle (ICE vehicle, HEV, EV, and FCV) fuel economy, emission, and performance under various conditions including acceleration tests and various driving cycles. This exercise is to perform some introductory studies on electric vehicles. Please utilize this program to better understand H/EV system components and their interactions and effects on performance. Report on your results. The approach follows:

Four ready-made files for conventional and H/EV models are already available in Advisor 2002 (or Avisor 2003): Small_car_in (Default conventional small car) Focus_in (Ford Focus EV) gm_ev1_in (GM EV1) INSIGHT_defults_in (Honda Insight HEV)

Start with the "Small_car_in" file that represents the typically conventional small car. Answer questions 1 to 3 for all four vehicles (Small car, Ford Focus EV, GM-EV1, and Honda Insight).

Qestion1:Obtain and/or derive key input information in this file (available from main screen) including:

Vehicle weight Vehicle Cd and Af,

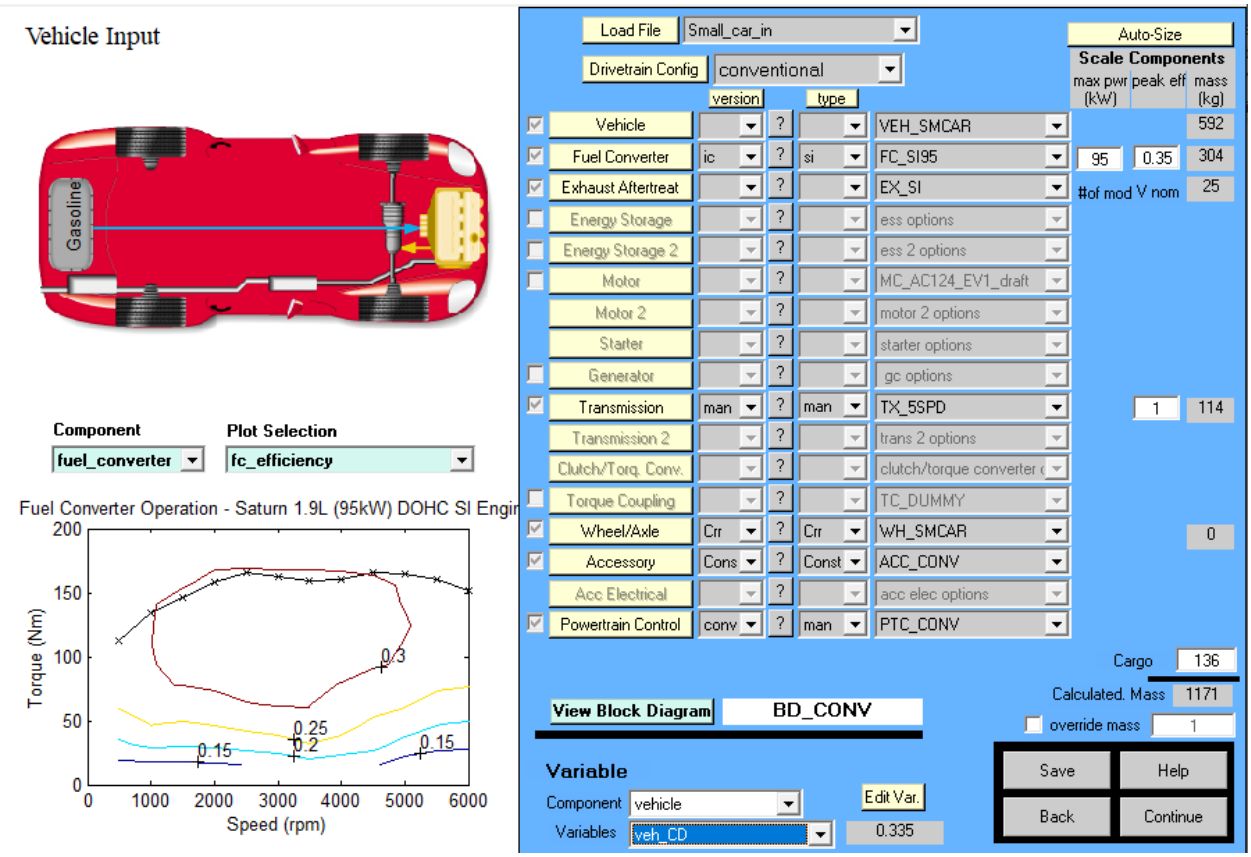
Motor-Controller type, base speed, peak torque, peak power, peak efficiency, mass.

Battery pack voltage and weight .

Battery module type and number of modules Battery OCV and resistance at 50% SOC

Answer:

Small_car_in



From the picture we can find these values as follow.

Vehicle weight: 1171kg Calculated. 1171

Vehicle Cd: 0.335 Variables veh_CD 0.335

Vehicle Af: 2m^2 Variables veh_FA 2

Motor-Controller type: not available

Motor base speed: not available

Motor peak torque: not available

Motor peak power: not available

Motor peak efficiency: not available

Motor mass: not available

Battery pack voltage: not available

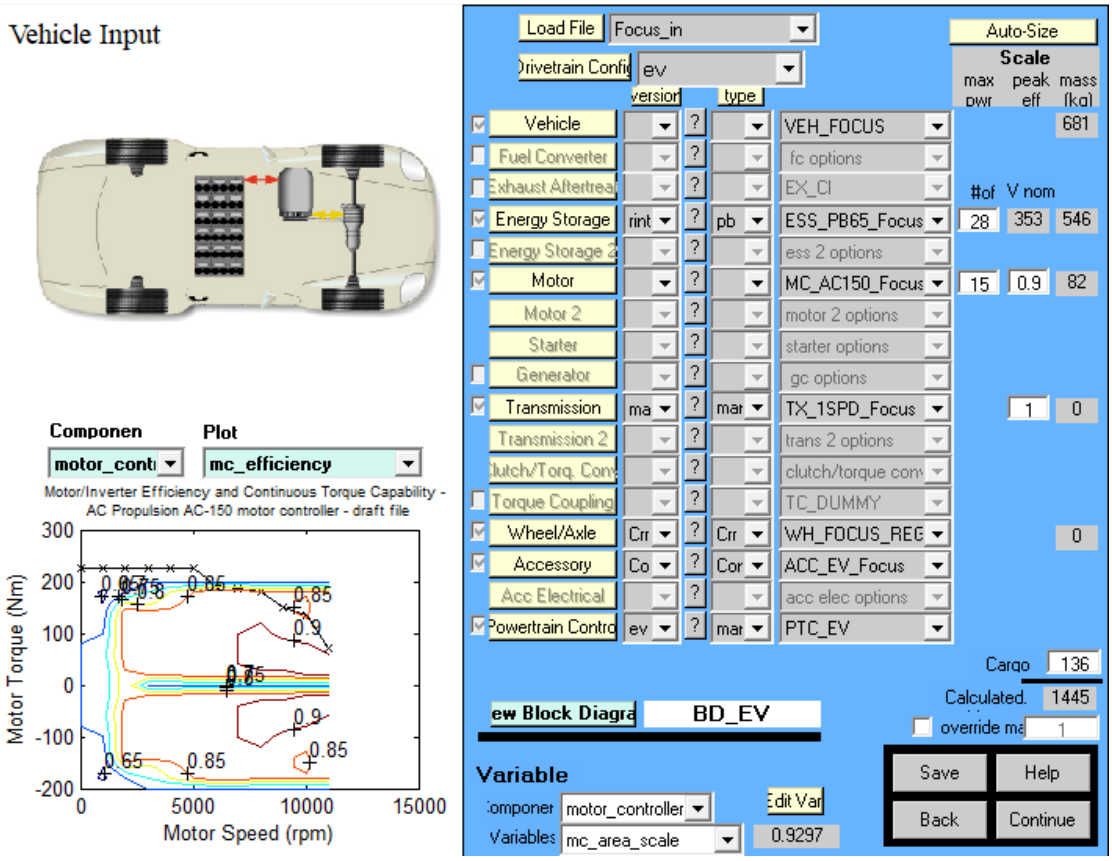
Battery pack weight: not available

Battery module type: not available

number of modules: not available

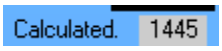
Battery OCV and resistance at 50% SOC: not available

Focus_in



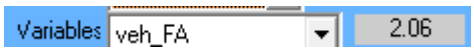
From the picture we can find these values as follow.

Vehicle weight: 1445kg



Vehicle Cd: 0.312

Vehicle Af: 2.06 m^2



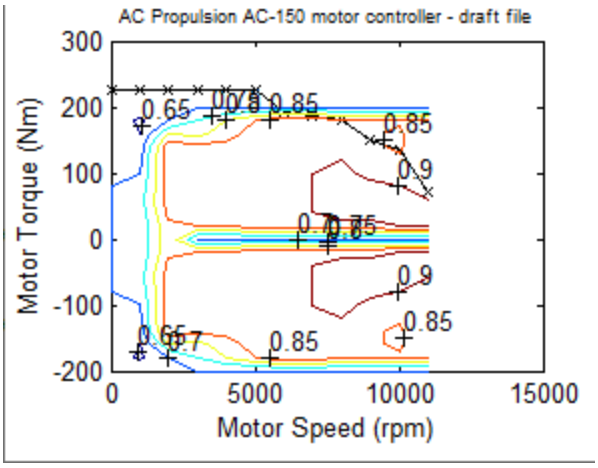
Motor-Controller type: AC propulsion AC-150 motor controller

```
Data loaded: MC_AC150_Focus_draft - AC Propulsion AC-150 motor controller - draft file

mc_description='AC Propulsion AC-150 motor controller - draft file';
```

We can get the information about the motor from the Matlab file.

Motor base speed: 5000rpm

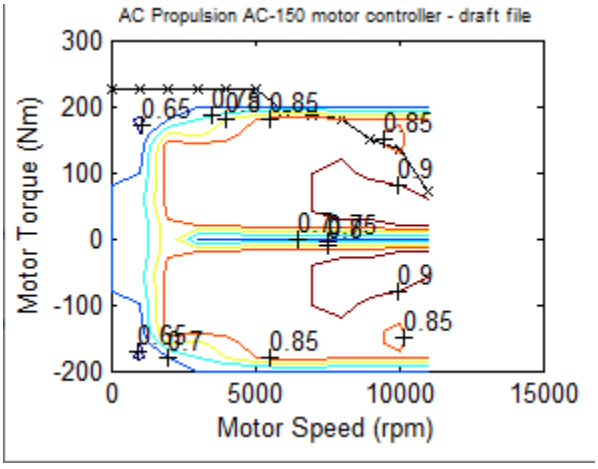
```
mc_max_trq=[225 225 225 225 225 225 190.98 185.1 179 150 133.7 70];% (N*m)

mc_map_spd=[0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000 11000]*(2*pi/60);
```



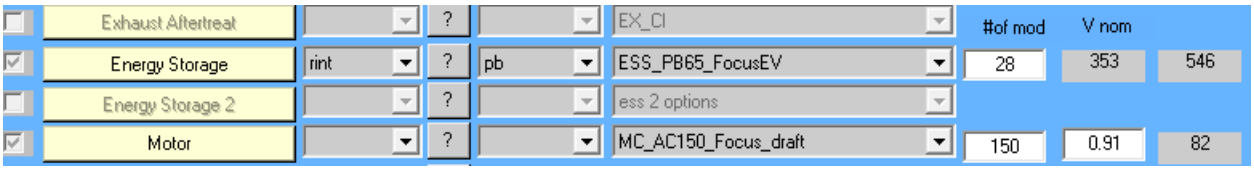
I get this data from the Matlab file of Motor. The motor torque could correspond to the motor speed underneath. So the point that motor toque changes could be when torque is 225Nm and speed is 5000rpm. In this case we can get motor base speed as 5000rpm. We could also get the base speed from the diagram directly.

Motor peak torque: 225N

```
mc_max_trq=[225 225 225 225 225 225 190.98 185.1 179 150 133.7 70];% (N*m)
```



Both from Matlab file of the diagram we can find that the max torque is 225Nm.



From this picture we can get the information about motor and battery.

Motor peak power: 150kW

From this picture we can find that the max power of the motor is 15kW.

Motor peak efficiency: 0.91

From the same picture above we can find that the motor peak efficiency is 0.91

Motor mass: 82kg

From the picture above we can find that the motor mass is 82kg.

Battery pack voltage: 353V

From the picture above we can find that the battery pack voltage is 353V.

Battery pack weight: 546kg

From the picture above we can find that the battery pack weight is 546kg.

Number of modules: 28

From the picture above we can find that the number of modules is 28.

Battery module type: Horizon 12N85 Lead-Acid battery

```
ess_description='Horizon 12N85 lead-acid battery';
ess_version=2002; % version of ADVISOR for which the file was generated
ess_proprietary=0; % 0=> non-proprietary, 1=> proprietary, do not distribute
ess_validation=0; % 0=> no validation, 1=> data agrees with source data,
% 2=> data matches source data and data collection methods have been verified
```

From the Matlab file data we can find that battery module type is Horizon 12N85 Lead-Acid battery.

Battery OCV at 50% SOC: 12.65V

```
% module's open-circuit (a.k.a. no-load) voltage, indexed by ess_soc and ess_tmp
ess_voc=[
   11.8 12.2 12.5 12.8 13.05 13.2
   11.8 12.2 12.5 12.8 13.05 13.2
   11.8 12.2 12.5 12.8 13.05 13.2
]; % (V)

ess_soc=[0:.2:1];  % (--)
```

From the picture above, six values of the OCV is corresponding to six values of SOC (0, 0.2, 0.4, 0.6, 0.8, 1). So, I use the average of the OCV When SOC is 0.4 and 0.6 to represent the OCV when SOC is 50%.

$OCV_{SOC50\%}$=(12.5+12.8)/2=12.65V

Battery resistance at 50% SOC: 0.015 Ohms(40C-discharge) ; 0.047 Ohms (40C-charge)

```
ess_r_dis=[
   0.090 0.030 0.020 0.010 0.005 0.0028
   0.090 0.030 0.020 0.010 0.005 0.0028
   0.090 0.030 0.020 0.010 0.005 0.0028
]; % (ohm)

% module's resistance to being charged, indexed by ess_soc and ess_tmp
% changed the high soc charge values to match results where good data unavailable
ess_r_chg=[
   0.018 0.025 0.044 0.050 0.100 0.250
   0.018 0.025 0.044 0.050 0.100 0.250
   0.018 0.025 0.044 0.050 0.100 0.250
]; % (ohm)

ess_soc=[0:.2:1];  % (--)
```

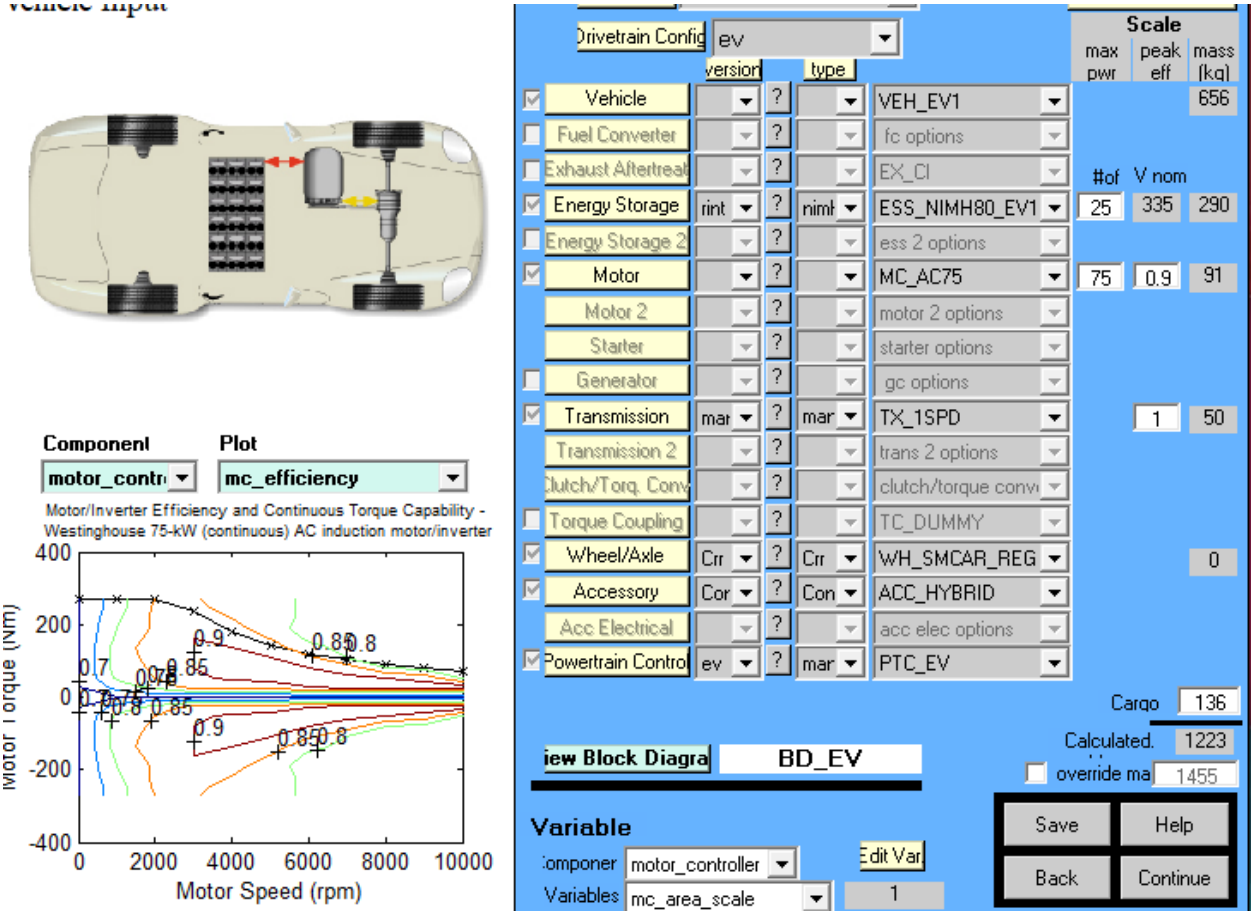
From the picture above, six values of the resistance(both discharge and charge) is corresponding to six values of SOC (0, 0.2, 0.4, 0.6, 0.8, 1)

So, I use the average of the resistance When SOC is 0.4 and 0.6 to represent the resistance when SOC is 50%.

40C-discharge resistance: (0.02+0.01)/2=0.015 Ohms

40C-charge resistance: (0.044+0.050)/2=0.047 Ohms

gm_ev1_in (Has two problem that motor parameter and battery parameter do not match the Matlab file, so I change the motor to AC75 and click the energy option “Ess_NIMH80_EV1” , it change to correct number.)



From the picture we can find these values as follow.

Vehicle weight: 1223g

Vehicle Cd: 0.19

Vehicle Af: 2.0379 m^2

Motor-Controller type: GM EV1 traction motor based on Westinghouse 75-KW (continuous) AC induction motor/converter

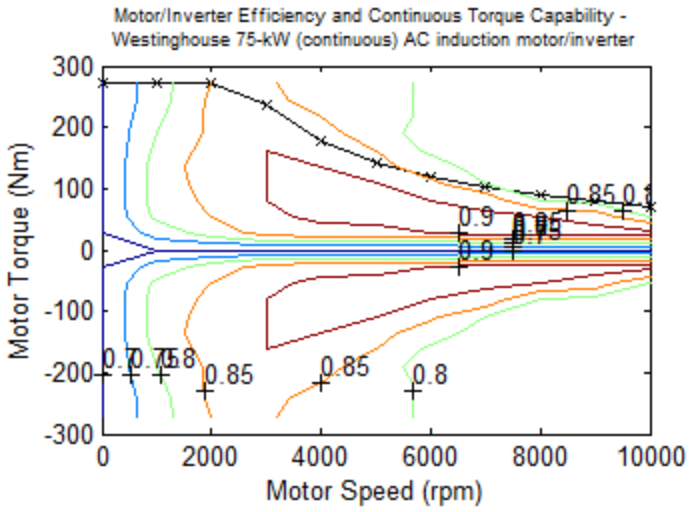
```
mc_description='GM EV1 traction motor based on Westinghouse 75-kW (continuous) AC induction motor/inverter';
```

We can get the information about the motor from the Matlab file.

Motor base speed: 2000rpm（I change the former motor which is AC124 because that the Matlab file shows that the motor should be AC75）

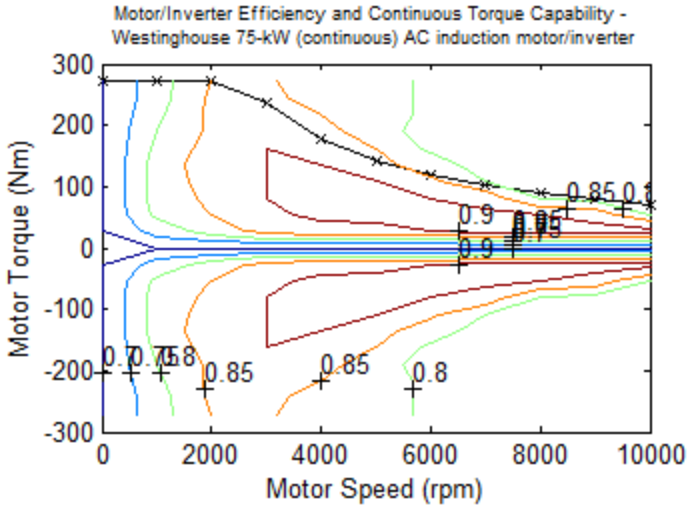
```
mc_max_trq=[200 200 200 175.2 131.4 105.1 87.6 75.1 65.7 58.4 52.5]*...
    4.448/3.281; % (N*m)

mc_map_spd=[0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000]*(2*pi/60);
```

I get this data from the Matlab file of Motor. The motor torque could correspond to the motor speed underneath. So the point that motor toque changes could be when torque is 200*4.448/3.281=271.14 Nm and speed is 2000rpm. In this case we can get motor base speed as 2000rpm. We could also get the base speed from the following diagram directly.

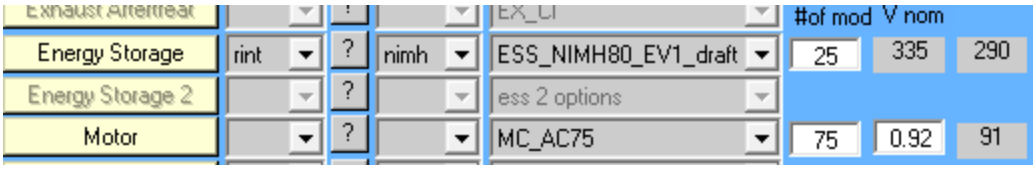


Motor peak torque: 271.14N

```
mc_max_trq=[200 200 200 175.2 131.4 105.1 87.6 75.1 65.7 58.4 52.5]*...
    4.448/3.281; % (N*m)
```



Both from Matlab file of the diagram we can find that the max torque is 271.14Nm(200*4.448/3.281=271.14 Nm).



From this picture we can get the information about motor and battery.

Motor peak power: 75kW

From this picture we can find that the max power of the motor is 75kW.

Motor peak efficiency: 0.92

From the same picture above we can find that the motor peak efficiency is 0.92

Motor mass: 91kg

From the picture above we can find that the motor mass is 91kg.

Battery pack voltage: 335V

From the picture above we can find that the battery pack voltage is 353V.

Battery pack weight: 290kg

From the picture above we can find that the battery pack weight is 546kg.

Number of modules: 25

From the picture above we can find that the number of modules is 25.

```
ess_module_num=25;  %a default value for number of modules
```

Battery module type: Horizon 12N85 Lead-Acid battery

```
ess_description='Horizon 12N85 lead-acid battery';
ess_version=2002; % version of ADVISOR for which the file was generated
ess_proprietary=0; % 0=> non-proprietary, 1=> proprietary, do not distribute
ess_validation=0; % 0=> no validation, 1=> data agrees with source data,
% 2=> data matches source data and data collection methods have been verified
```

From the Matlab file data we can find that battery module type is Horizon 12N85 Lead-Acid battery.

Battery OCV at 50% SOC: 13.4V

```
% module's open-circuit (a.k.a. no-load) voltage, indexed by ess_soc and ess_tmp
%ess_voc=[11.9 12.3 12.6 12.8 12.9 12.9 13 13.1 13.2 13.4 13.7;
%   11.9 12.3 12.6 12.8 12.9 12.9 13 13.1 13.2 13.4 13.7;
%   11.9 12.3 12.6 12.8 12.9 12.9 13 13.1 13.2 13.4 13.7]; % (V), Source: Ovonic Charge-decreasing
ess_voc=[12.5 12.8 13.1 13.3 13.4 13.4 13.5 13.6 13.7 13.9 14.2;
   12.5 12.8 13.1 13.3 13.4 13.4 13.5 13.6 13.7 13.9 14.2;
   12.5 12.8 13.1 13.3 13.4 13.4 13.5 13.6 13.7 13.9 14.2]; % (V), Source: Ovonic Charge-sustaining
%ess_voc=[12.8 13.2 13.5 13.7 13.8 13.8 13.9 14 14.1 14.3 14.6;
%   12.8 13.2 13.5 13.7 13.8 13.8 13.9 14 14.1 14.3 14.6;
%   12.8 13.2 13.5 13.7 13.8 13.8 13.9 14 14.1 14.3 14.6]; % (V), Source: Ovonic Charge-increasing

ess_soc=[0:.2:1];  % (--)
```

From the pictures above, 11 values of the OCV is corresponding to the values of SOC (0, 0.2, 0.4, 0.6, 0.8, 1). So, when SOC is 50% the OCV is 13.4V.

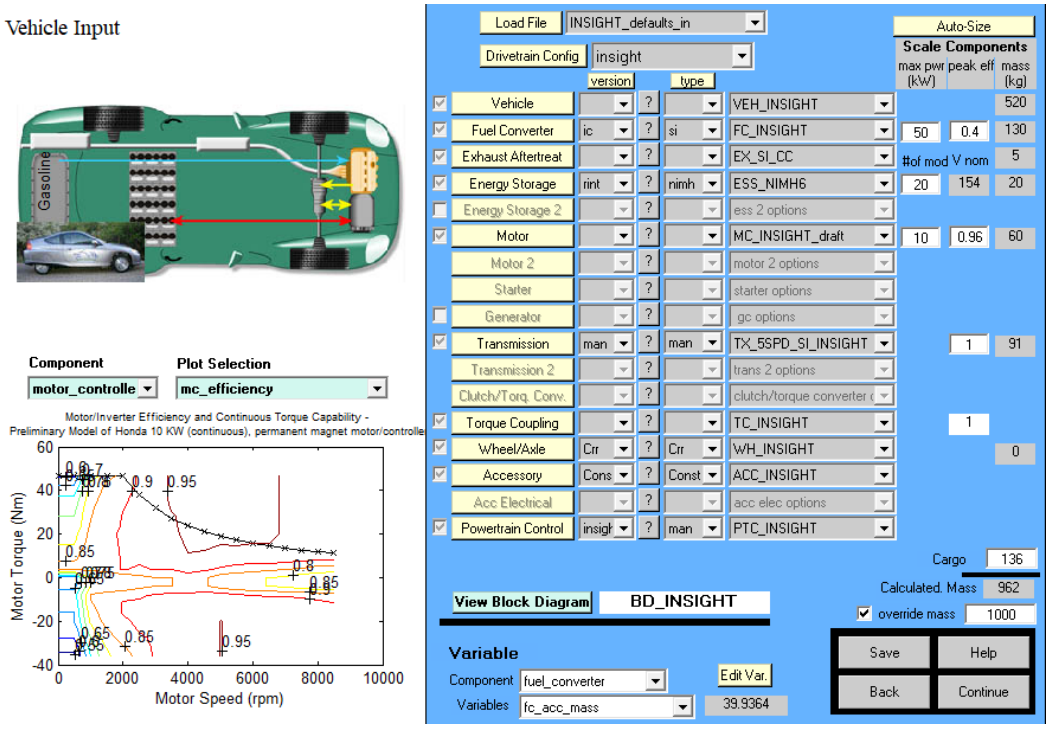
Battery resistance at 50% SOC: 0.0076 Ohms (40C-charge and 40C-discharge)

```
% module's resistance to being discharged, indexed by ess_soc and ess_tmp
ess_r_dis=[1.167 0.905  0.851   0.792   0.775   0.760   0.750   0.768   0.823   0.881   0.839
          1.167 0.905   0.851   0.792   0.775   0.760   0.750   0.768   0.823   0.881   0.839
           1.167 0.905  0.851   0.792   0.775   0.760   0.750   0.768   0.823   0.881   0.839
        ]*10/1000; % (ohm)

% module's resistance to being charged, indexed by ess_soc and ess_tmp
ess_r_chg=ess_r_dis;% (ohm), no other data available

ess_soc=[0:.2:1];  % (--)
```

From the pictures above, eleven values of the resistance is corresponding to the values of SOC (0, 0.2, 0.4, 0.6, 0.8, 1) and resistance when discharge and charge is same,

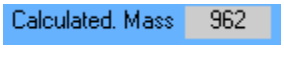
So, when SOC is 50% the resistance should be sixth value which equals 0.76*10/1000=0.0076 Ohms.

INSIGHT_defults_in

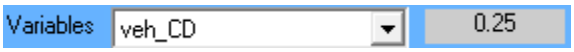


From this picture we can get the information about this vehicle.

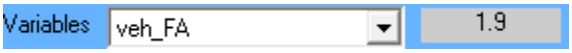
Vehicle weight: 962kg



Vehicle Cd: 0.25



Vehicle Af: 1.9m^2



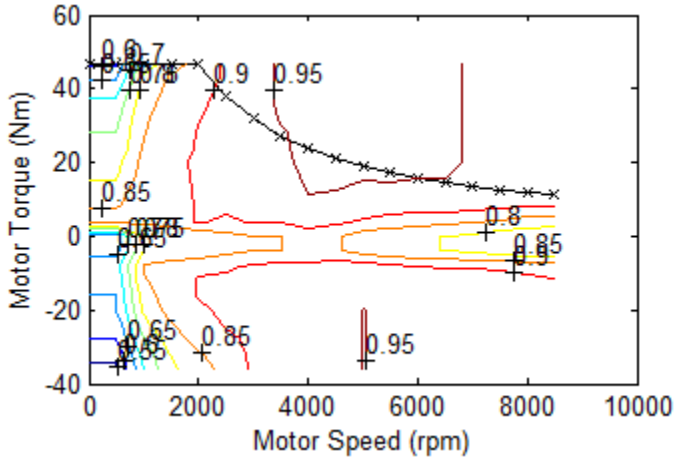
Motor-Controller type: Preliminary Model of Honda 10kW (continuous), permanent magnet motor/ controller.

```
mc_description='Preliminary Model of Honda 10 KW (continuous), permanent magnet motor/controller';
```

Motor base speed: 2000rpm

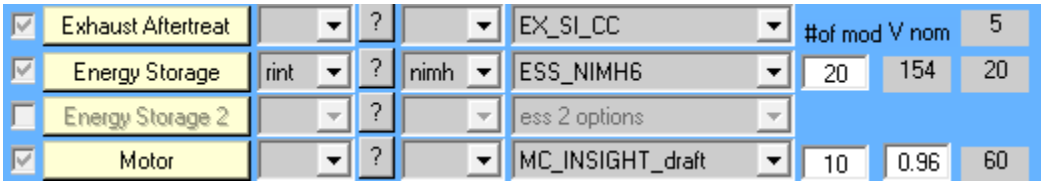
```
mc_max_trq=[46.5   46.5   46.5   46.5   46.5   38.2   31.8   27.3   23.9   21.2   19.1   17.4   15.9   14.7   13.6   12.7   11.9   11.2];% (N*m)
mc_max_gen_trq=-1*mc_max_trq;

% (rad/s), speed range of the motor
mc_map_spd=[0 500 1000 1500 2000 2500 3000 3500 4000 4500 5000 5500 6000 6500 7000 7500 8000 8500]*(2*pi)/60;
```

I get this data from the Matlab file of Motor. The motor torque could correspond to the motor speed underneath. So the point that motor toque changes could be when torque is 46.5Nm and speed is 2000rpm. In this case we can get motor base speed as 2000rpm. We could also get the base speed from the diagram directly.



Motor peak torque: 46.5Nm

```
mc_max_trq=[46.5    46.5    46.5    46.5    46.5    38.2    31.8    27.3    23.9    21.2    19.1    17.4    15.9    14.7    13.6    12.7    11.9    11.2];% (N*m)
mc_max_gen_trq=-1*mc_max_trq;
```



From this picture we can get the information about motor and battery.

Motor peak power: 10kW

Motor peak efficiency: 0.96

Motor mass: 60kg

Battery pack voltage: 154V

Battery pack weight: 20kg

Number of modules: 20

Battery module type: NiMH Spiral Wound

Nominal Cell Voltage:1.2V

Total Cells :120 (6 cells * 20 modules)

Nominal Voltage: 144V

Published Capacity: 6.5Ah

```
%
% Insight file created from NREL lab test data
%       NREL test data from testing entire Insight Battery Pack Jan.2001 (Insight Model Year 2000)
%
%       Insight pack is reported to be same technology as Japanese Prius (1998) with 20 modules instead of 40
%          Battery Type: NiMH Spiral Wound
%               Nominal Cell Voltage: 1.2V
%               Total Cells: 120 (6 cells x 20 modules)  (40 modules for Japanese Prius)
%               Nominal Voltage: 144 V (288 V for Japanese Prius)
%               Published Capacity: 6.5 Ah
```

Battery OCV at 50% SOC: 7.6909V(25C-charge)

```
% module's open-circuit (a.k.a. no-load) voltage, indexed by ess_soc and ess_tmp
ess_voc=[
    7.2370  7.4047  7.5106  7.5873  7.6459  7.6909  7.7294  7.7666  7.8078  7.9143  8.3645
    7.2370  7.4047  7.5106  7.5873  7.6459  7.6909  7.7294  7.7666  7.8078  7.9143  8.3645
];

%----------------------------------------
% SOC RANGE over which data is defined
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
ess_soc=[0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1];  % (--)
```

From the pictures above, 11 values of the OCV is corresponding to 11 values of SOC. So, when SOC is 50% the OCV is 7.6909V.

Battery resistance at 50% SOC: 0.0196 Ohms(25C-charge); 0.0268 Ohms(25C-discharge)

```
% module's resistance to being discharged, indexed by ess_soc and ess_tmp
% The discharge resistance is the average of 4 tests from 10 to 90% soc at the following
%  discharge currents: 6.5, 6.5, 18.5 and 32 Amps
%  The 0 and 100 % soc points were extrapolated
ess_r_dis=[
    0.0377  0.0338  0.0300  0.0280  0.0275  0.0268  0.0269  0.0273  0.0283  0.0298  0.0312
    0.0377  0.0338  0.0300  0.0280  0.0275  0.0268  0.0269  0.0273  0.0283  0.0298  0.0312
   ];


% module's resistance to being charged, indexed by ess_soc and ess_tmp
% The discharge resistance is the average of 4 tests from 10 to 90% soc at the following
%  discharge currents: 5.2, 5.2, 15 and 26 Amps
%  The 0 and 100 % soc points were extrapolated
ess_r_chg=[
   0.0235   0.0220  0.0205  0.0198  0.0198  0.0196  0.0198  0.0197  0.0203  0.0204  0.0204
    0.0235  0.0220  0.0205  0.0198  0.0198  0.0196  0.0198  0.0197  0.0203  0.0204  0.0204
   ];
%----------------------------------------
% SOC RANGE over which data is defined
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
ess_soc=[0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1];  % (--)
```

From the pictures above,11 values of the resistance is corresponding to 11 values of SOC (both discharge and charge).

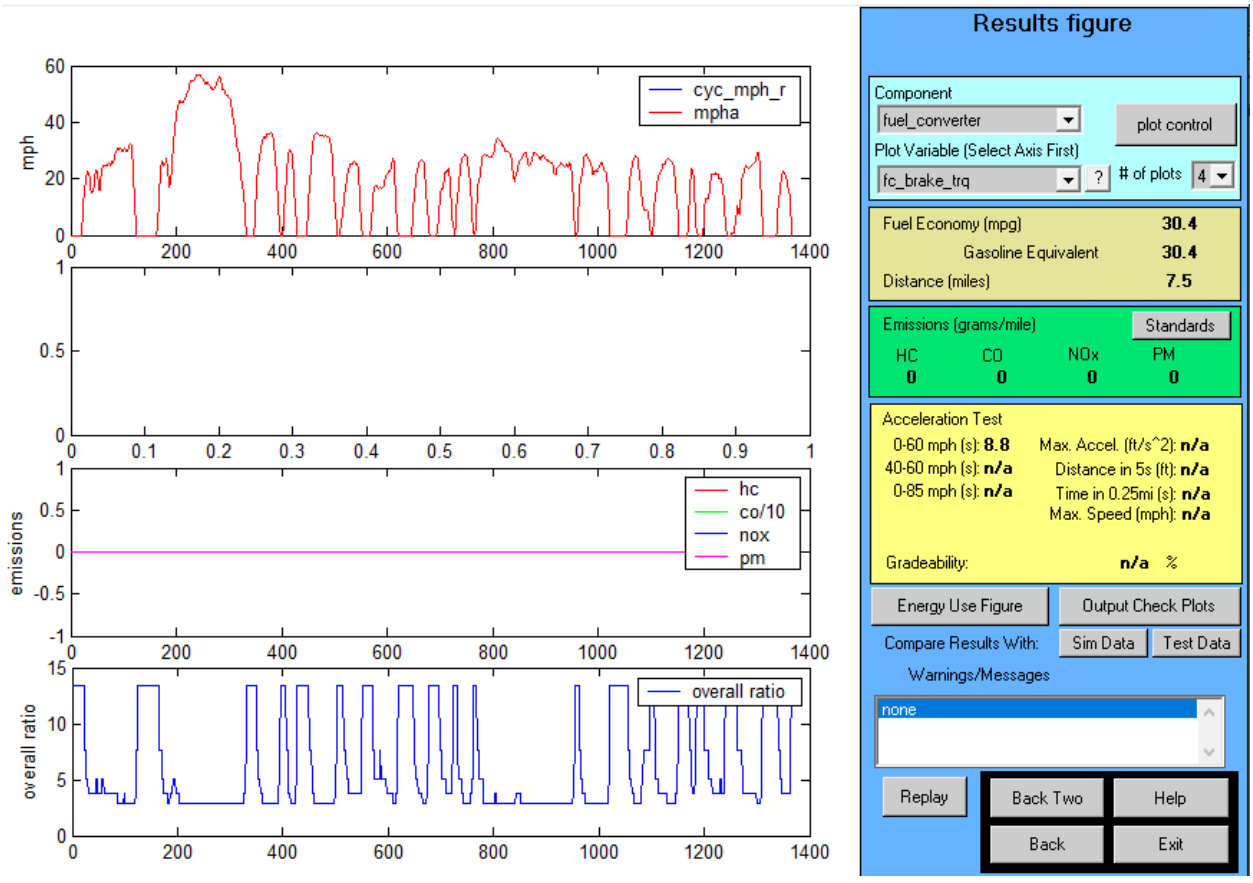
So, when SOC is 50% the resistance should be 0.0268 Ohms when discharge and 0.0196 Ohms when charge.

Question 2. Determine base vehicle performance by simulation (push “continue” on main screen to get to simulations page): 0 to 60 mph acceleration time by simulation Wh/mile energy consumption and fuel economy (mpg) on UDDS, HWFET, US06, and NEDC schedules. (Hint: energy consumption is negative “energy stored” under “energy use figure”) (Issue: depending on computer operation system, you might not be able to see this screen. If this problem occurs, try Advisor 2003).

Answer:

Small_car_in

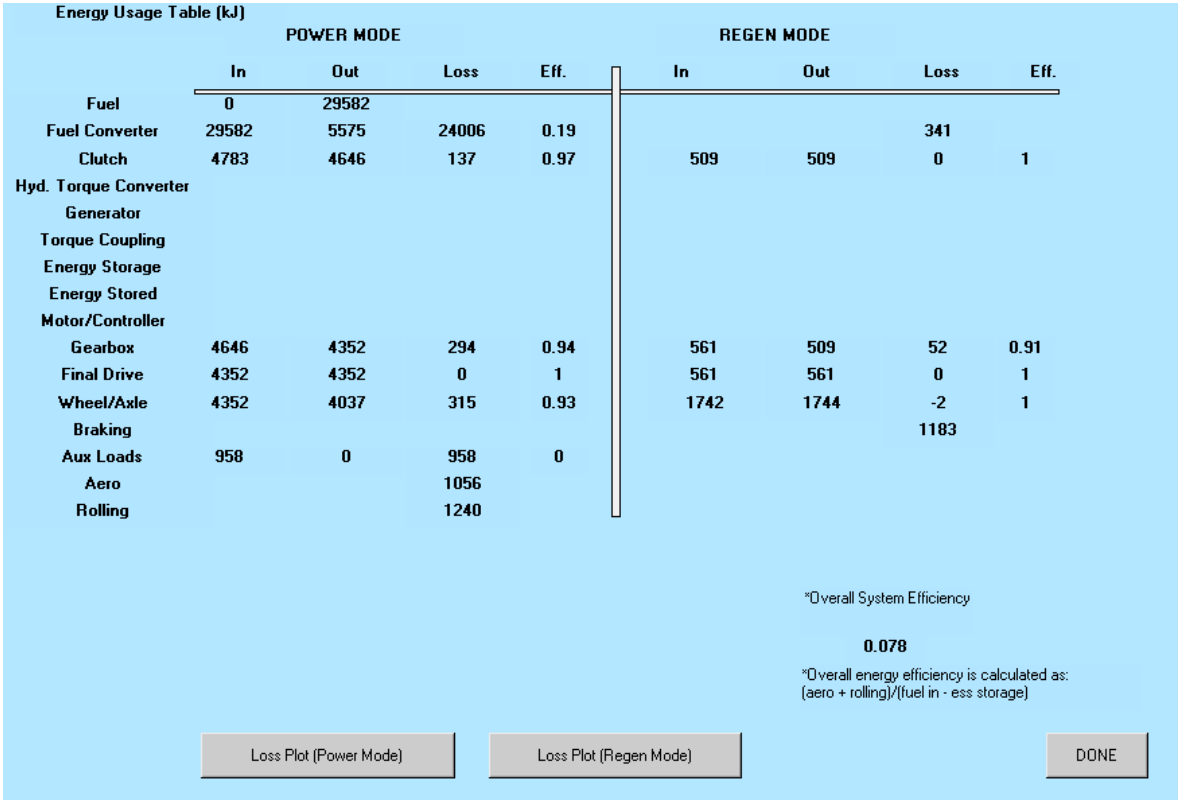
UDDS

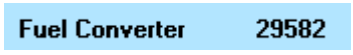


From this diagram we get that:

0 to 60 mph acceleration time: 8.8s

Wh/mile energy consumption:1095.63Wh/mile





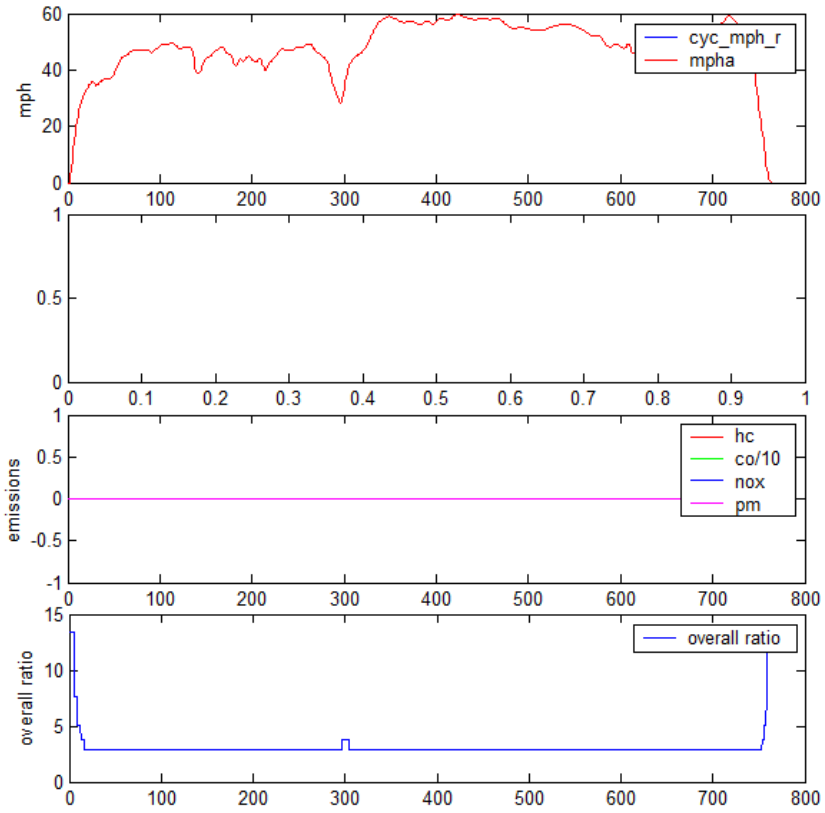
Open the energy use figure we can find that the total consumption of energy in this cycle. The consumption equals the input of fuel converter which is 29582kJ=8217.22Wh (1Watt hour (Wh) is equal to 3.6 kilojoules KJ). We also can find the distance of this cycle which is 7.5 mile from the diagram. 

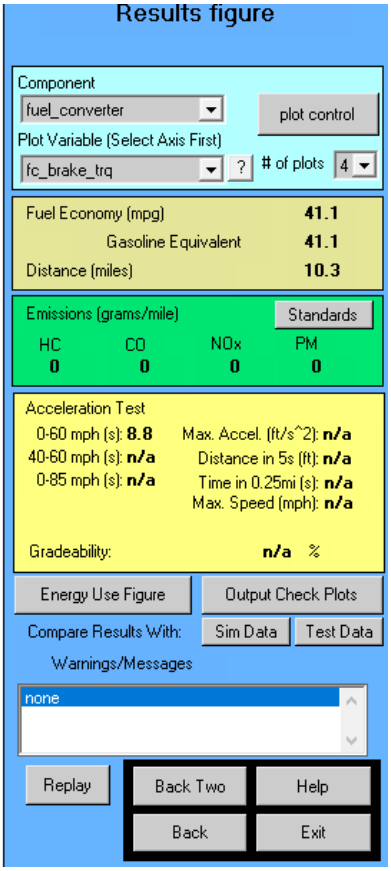
Then we can get Wh/mile consumption=8217.22Wh/7.5mile=1095.63Wh/mile

fuel economy (mpg): 30.4

Fuel Economy (mpg)	**30.4**
Gasoline Equivalent	**30.4**
Distance (miles)	**7.5**

HWFET:



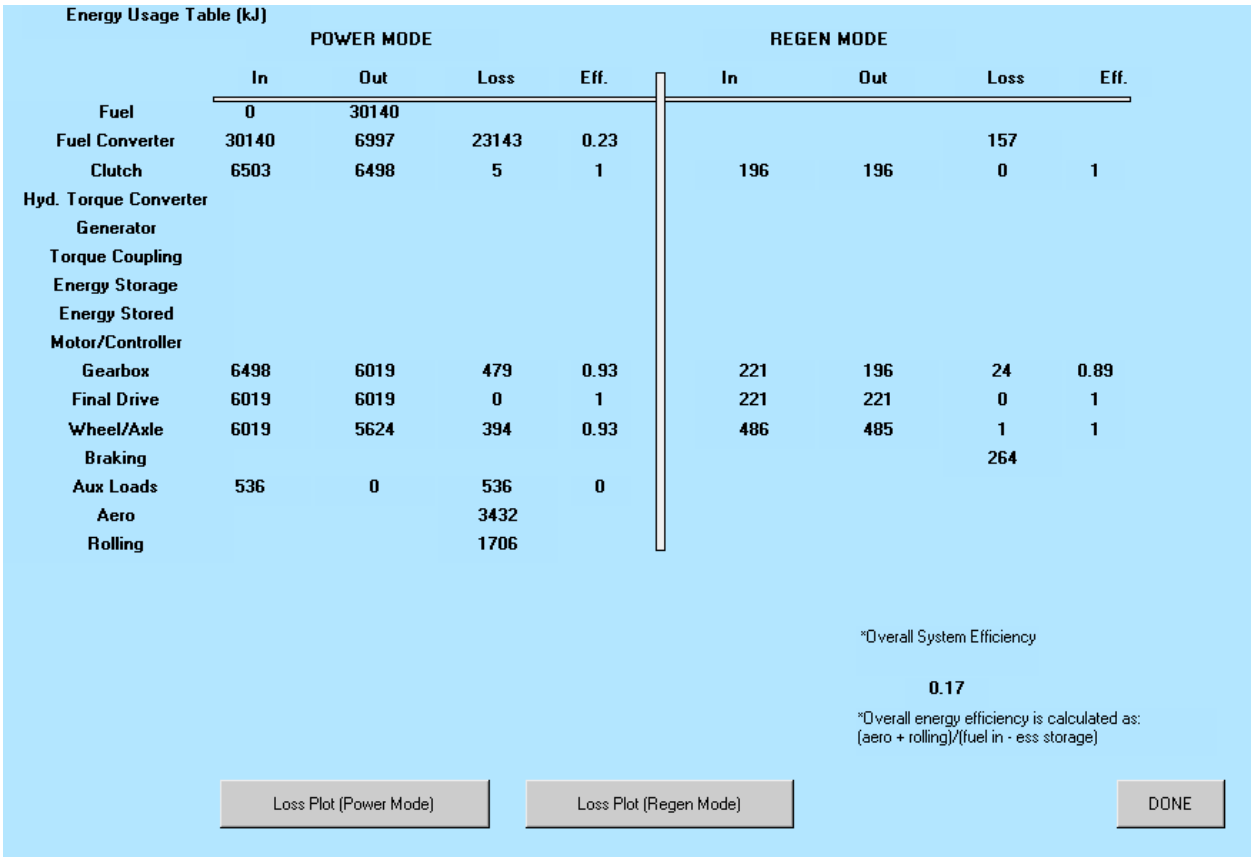


From this diagram we get that:

0 to 60 mph acceleration time: 8.8s

0-60 mph (s): **8.8**

Wh/mile energy consumption:812.84Wh/mile



Energy Usage Table (kJ)

	POWER MODE				REGEN MODE			
	In	Out	Loss	Eff.	In	Out	Loss	Eff.
Fuel	0	30140						
Fuel Converter	30140	6997	23143	0.23			157	
Clutch	6503	6498	5	1	196	196	0	1
Hyd. Torque Converter								
Generator								
Torque Coupling								
Energy Storage								
Energy Stored								
Motor/Controller								
Gearbox	6498	6019	479	0.93	221	196	24	0.89
Final Drive	6019	6019	0	1	221	221	0	1
Wheel/Axle	6019	5624	394	0.93	486	485	1	1
Braking							264	
Aux Loads	536	0	536	0				
Aero			3432					
Rolling			1706					

*Overall System Efficiency

0.17

*Overall energy efficiency is calculated as:
(aero + rolling)/(fuel in - ess storage)

Loss Plot (Power Mode) | Loss Plot (Regen Mode) | DONE

Fuel Converter	30140

Open the energy use figure we can find that the total consumption of energy in this cycle. The consumption equals the input of fuel converter which is 30140kJ=8372.22Wh (1Watt hour (Wh) is equal to 3.6 kilojoules KJ). We also can find the distance of this cycle which is 10.3 mile from the diagram.

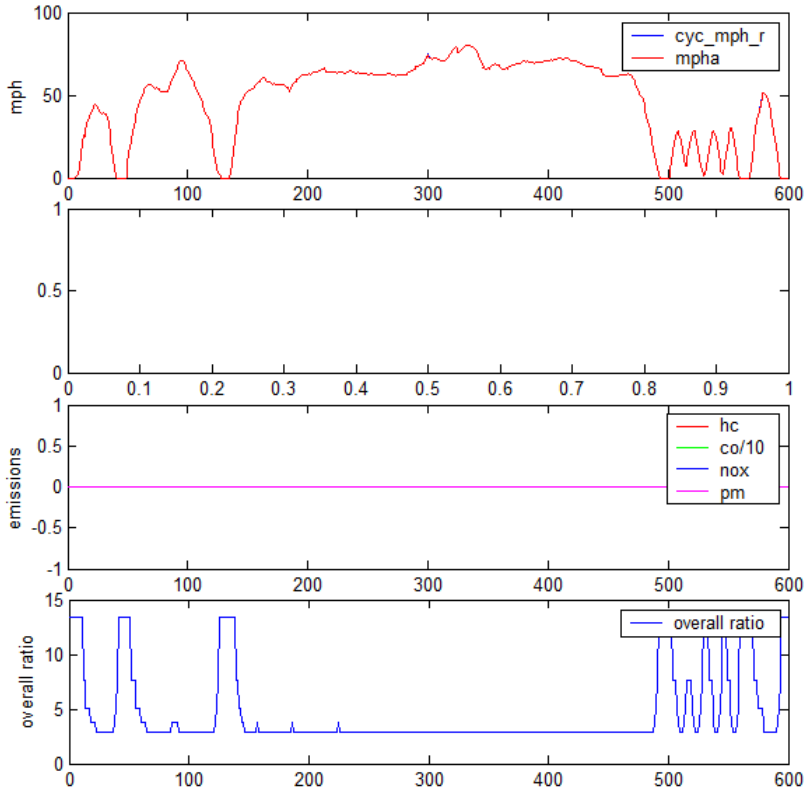
Distance (miles)	10.3

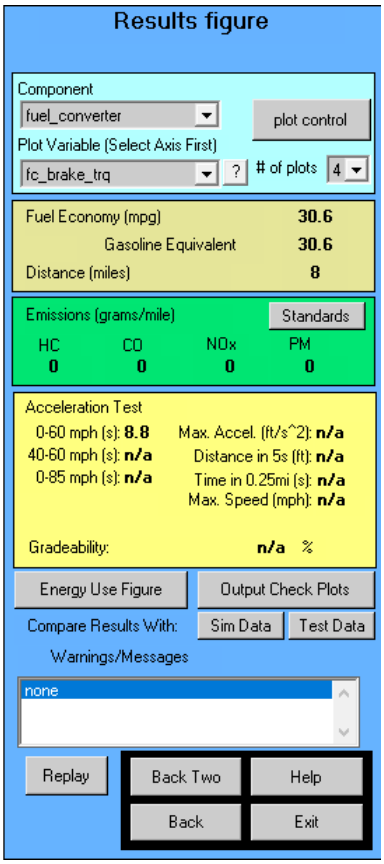
Then we can get Wh/mile consumption=8372.22Wh/10.3mile=812.84Wh/mile

fuel economy (mpg): 41.1

Fuel Economy (mpg)	41.1
Gasoline Equivalent	41.1
Distance (miles)	10.3

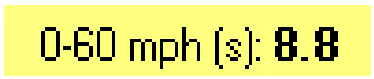
US06:



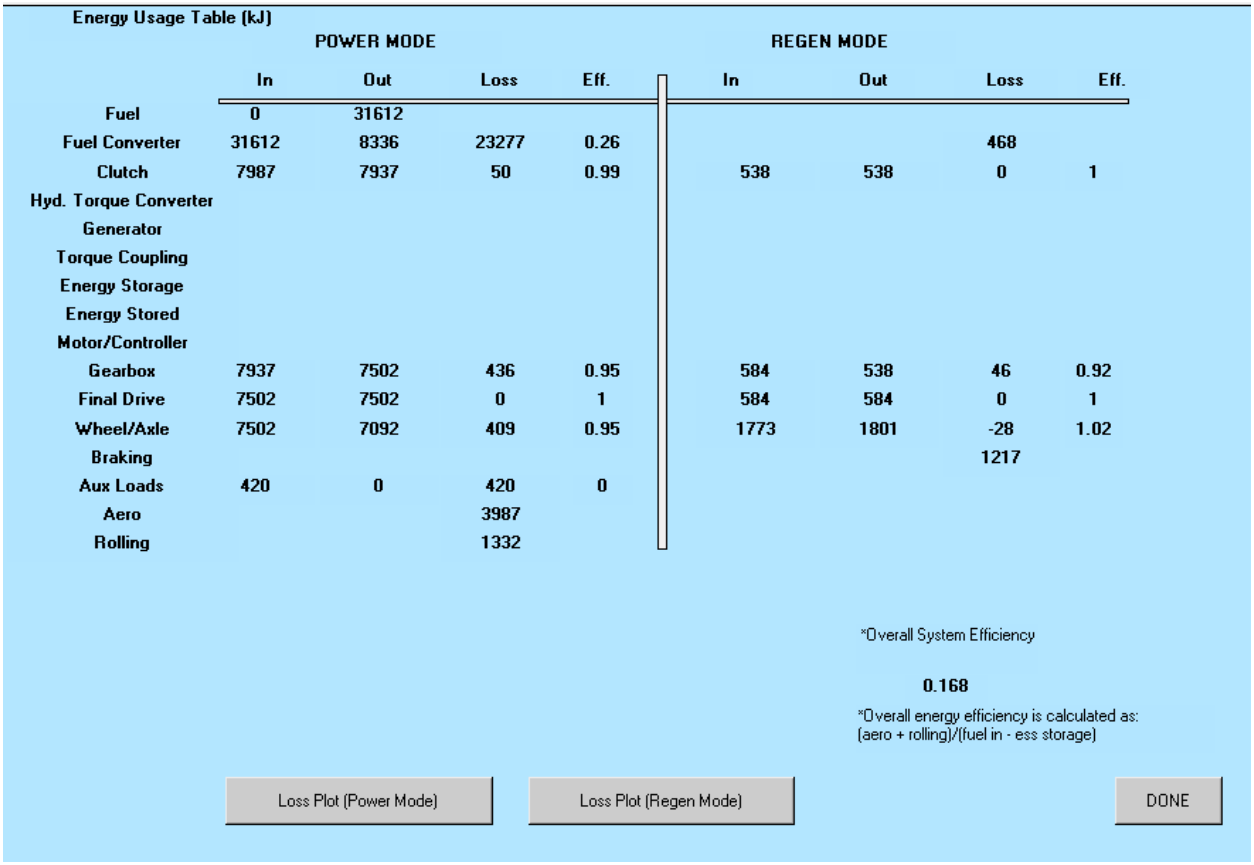


From this diagram we get that:

0 to 60 mph acceleration time: 8.8s



Wh/mile energy consumption:1097.64Wh/mile



Energy Usage Table (kJ)

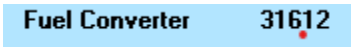
	POWER MODE				REGEN MODE			
	In	Out	Loss	Eff.	In	Out	Loss	Eff.
Fuel	0	31612						
Fuel Converter	31612	8336	23277	0.26			468	
Clutch	7987	7937	50	0.99	538	538	0	1
Hyd. Torque Converter								
Generator								
Torque Coupling								
Energy Storage								
Energy Stored								
Motor/Controller								
Gearbox	7937	7502	436	0.95	584	538	46	0.92
Final Drive	7502	7502	0	1	584	584	0	1
Wheel/Axle	7502	7092	409	0.95	1773	1801	-28	1.02
Braking							1217	
Aux Loads	420	0	420	0				
Aero			3987					
Rolling			1332					

*Overall System Efficiency

0.168

*Overall energy efficiency is calculated as:
(aero + rolling)/(fuel in - ess storage)

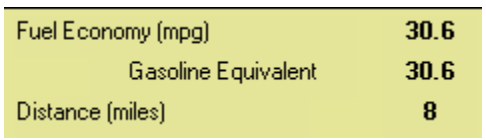
Loss Plot (Power Mode) | Loss Plot (Regen Mode) | DONE



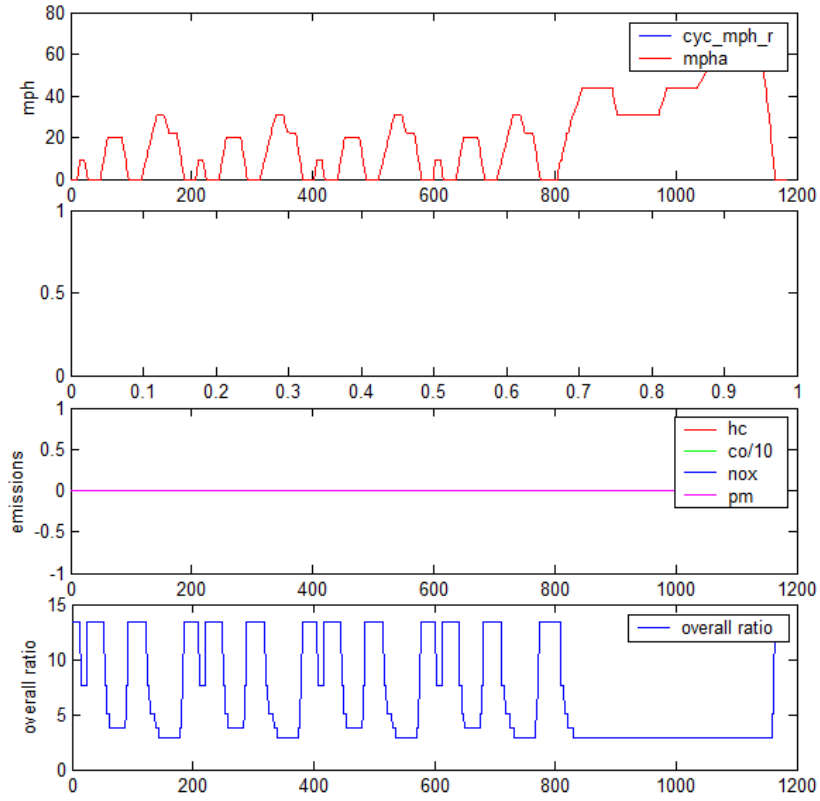
Open the energy use figure we can find that the total consumption of energy in this cycle. The consumption equals the input of fuel converter which is 31612kJ=8781.11Wh (1Watt hour (Wh) is equal to 3.6 kilojoules KJ). We also can find the distance of this cycle which is 8 mile from the diagram. 

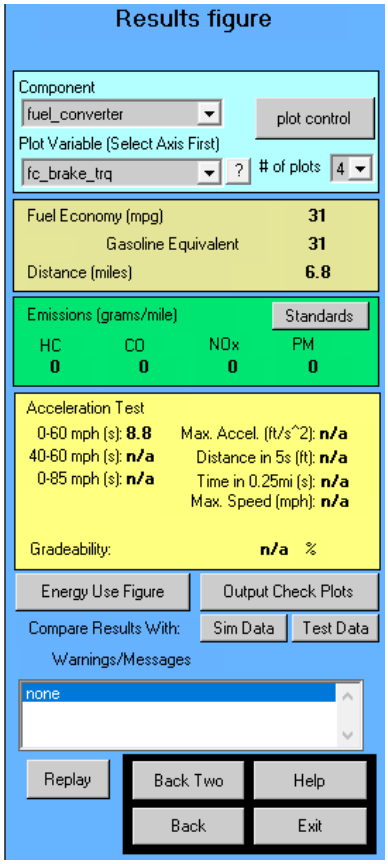
Then we can get Wh/mile consumption=8781.11Wh/8mile=1097.64Wh/mile

fuel economy (mpg): 30.6



NEDC:

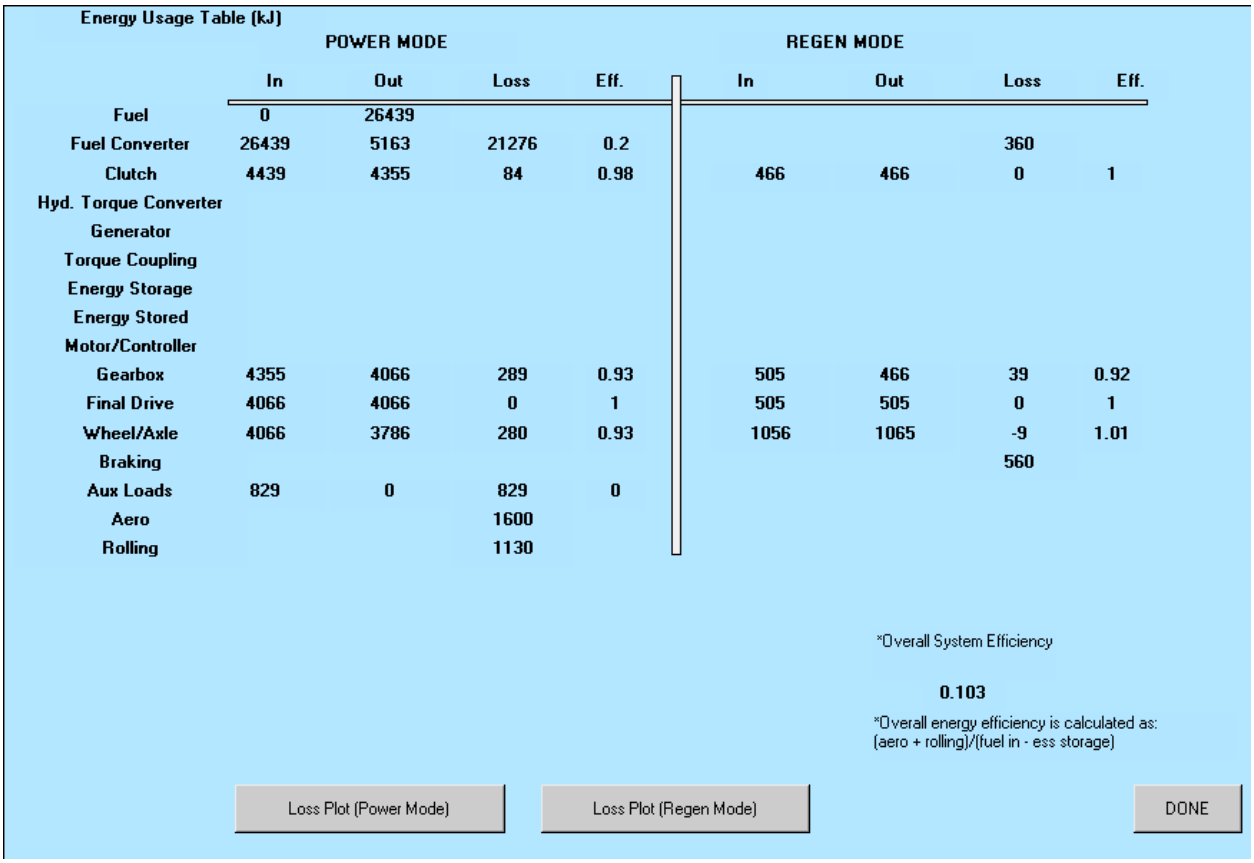




From this diagram we get that:

0 to 60 mph acceleration time: 8.8s

Wh/mile energy consumption:1080.03Wh/mile



Energy Usage Table (kJ)

	POWER MODE				REGEN MODE			
	In	Out	Loss	Eff.	In	Out	Loss	Eff.
Fuel	0	26439						
Fuel Converter	26439	5163	21276	0.2			360	
Clutch	4439	4355	84	0.98	466	466	0	1
Hyd. Torque Converter								
Generator								
Torque Coupling								
Energy Storage								
Energy Stored								
Motor/Controller								
Gearbox	4355	4066	289	0.93	505	466	39	0.92
Final Drive	4066	4066	0	1	505	505	0	1
Wheel/Axle	4066	3786	280	0.93	1056	1065	-9	1.01
Braking							560	
Aux Loads	829	0	829	0				
Aero			1600					
Rolling			1130					

*Overall System Efficiency

0.103

*Overall energy efficiency is calculated as:
(aero + rolling)/(fuel in - ess storage)

Loss Plot (Power Mode) | Loss Plot (Regen Mode) | DONE

Fuel Converter 26439

Open the energy use figure we can find that the total consumption of energy in this cycle. The consumption equals the input of fuel converter which is 26439kJ=7344.17Wh (1Watt hour (Wh) is equal to 3.6 kilojoules KJ). We also can find the distance of this cycle which is 6.8 mile from the diagram. Distance (miles) 6.8 Then we can get Wh/mile consumption=7344.17Wh/6.8mile=1080.03Wh/mile

fuel economy (mpg): 31

Fuel Economy (mpg)	31
Gasoline Equivalent	31
Distance (miles)	6.8

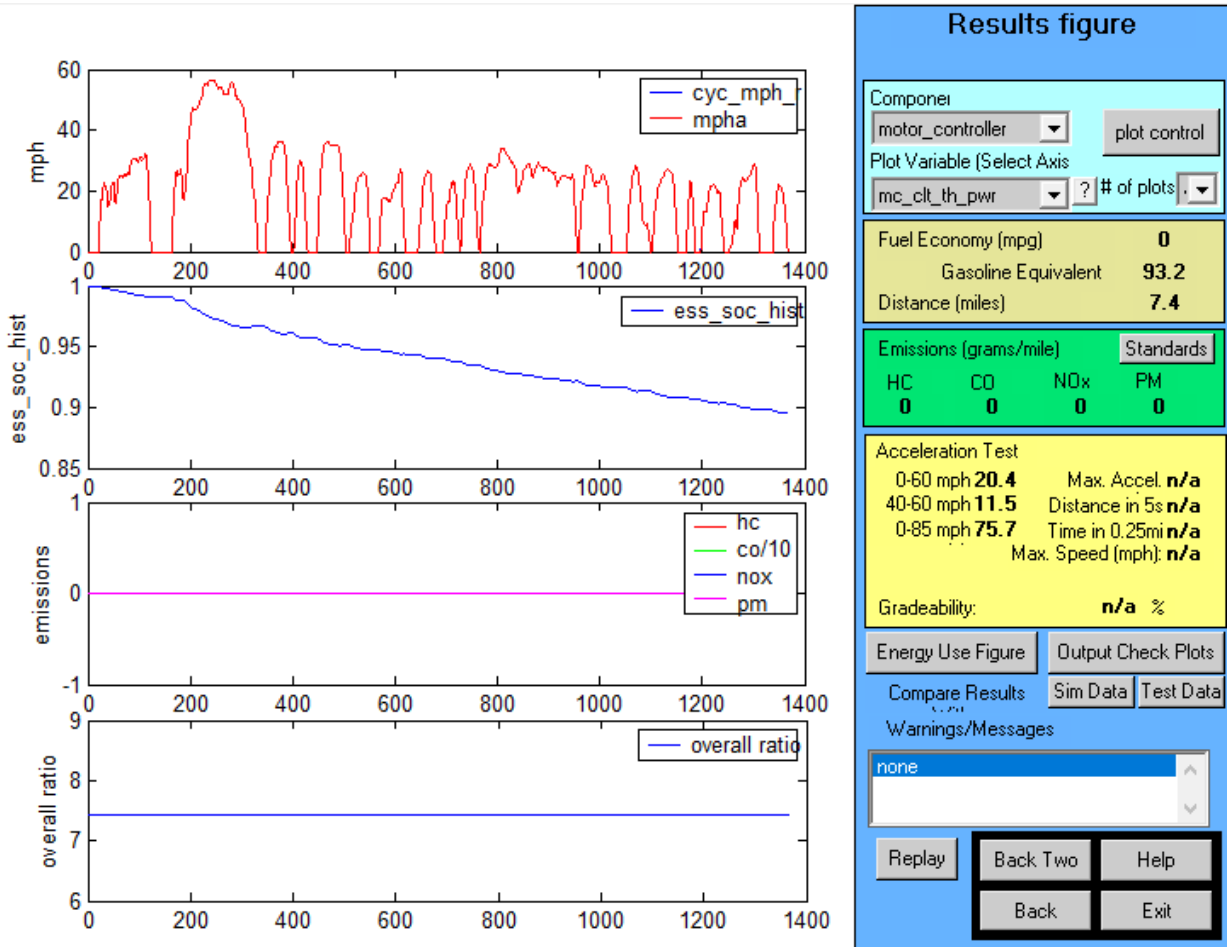
Focus_in

UDDS

0 to 60 mph acceleration time:20.4s

Wh/mile energy consumption:286Wh/mile

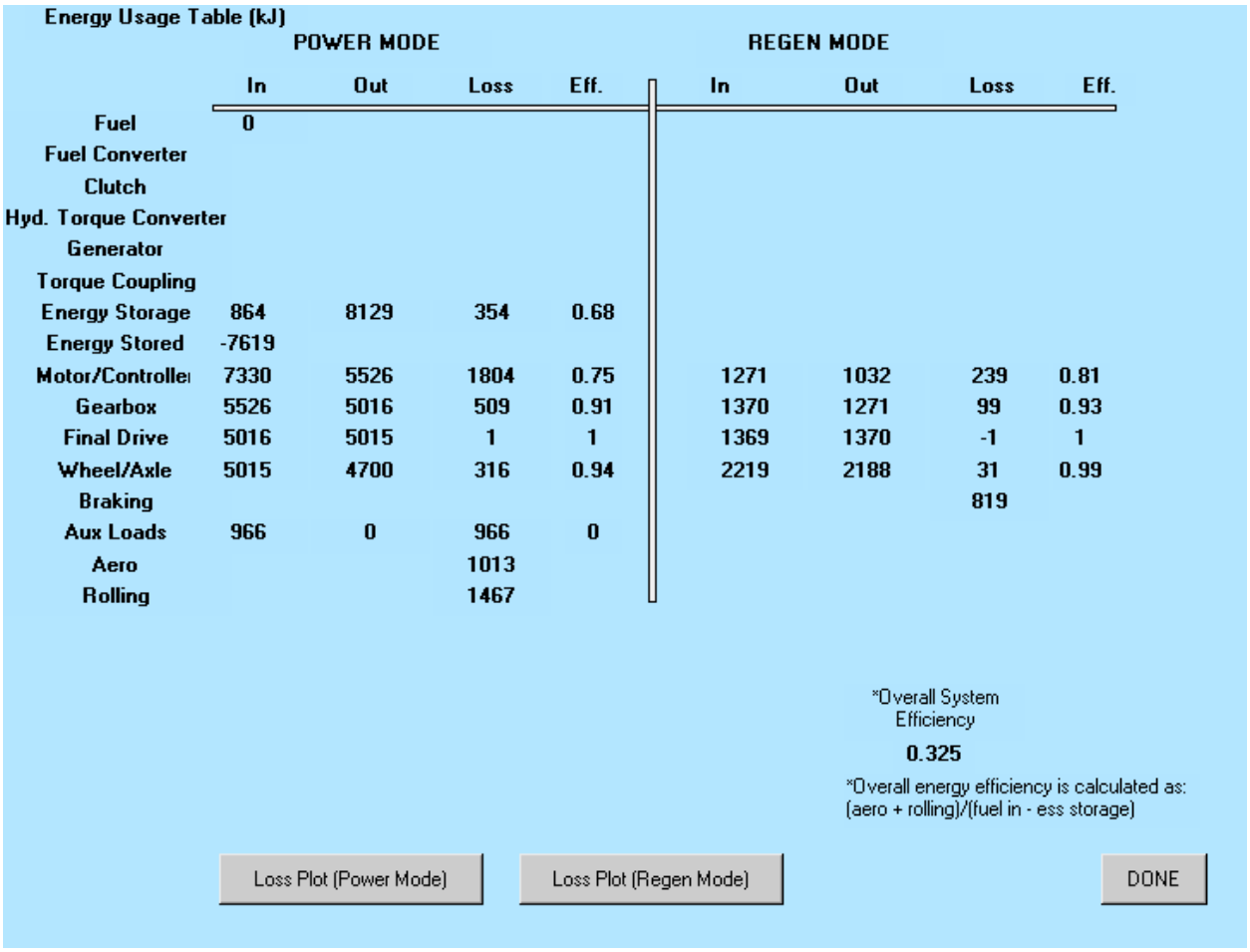
fuel economy (mpg):93.2

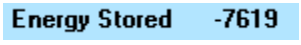


From this diagram we can get that:

0 to 60 mph acceleration time: 20.4 S

Wh/mile energy consumption:286Wh/mile





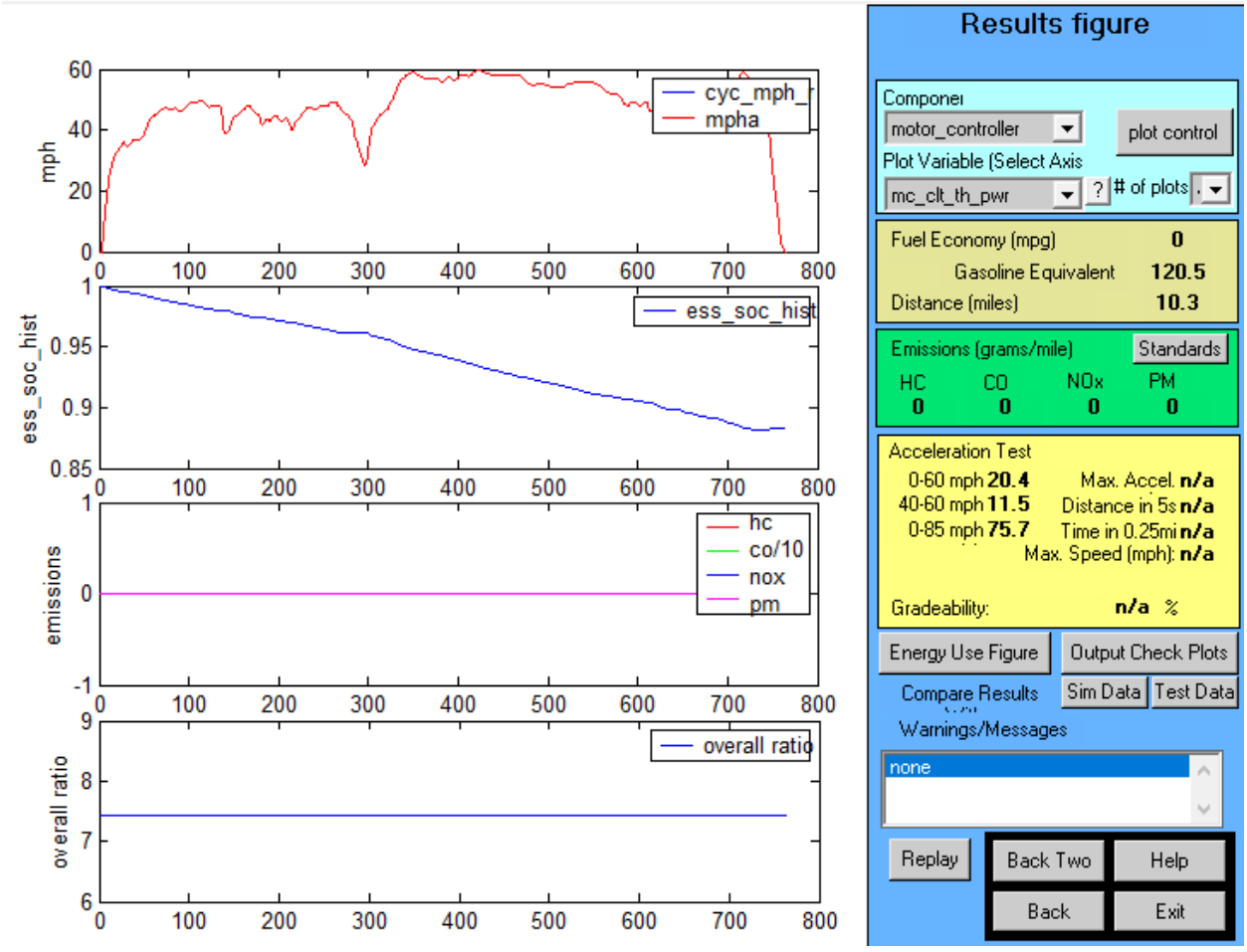
Open the energy use figure we can find that the total consumption of energy in this cycle. The consumption equals energy stored which is 7619kJ=2116.39Wh (1Watt hour (Wh) is equal to 3.6 kilojoules KJ). We

also can find the distance of this cycle which is 7.4 mile from the diagram. Distance (miles) 7.4 Then we can get Wh/mile consumption=2116.39Wh/7.4mile=286Wh/mile

fuel economy (mpg): 93.2(Gasoline Equivalent)

Fuel Economy (mpg)	0
Gasoline Equivalent	93.2
Distance (miles)	7.4

HWFET:



From this diagram we can get that:

0 to 60 mph acceleration time: 20.4 S

0-60 mph **20.4**

Wh/mile energy consumption:230.56Wh/mile

Energy Usage Table (kJ)

	POWER MODE				REGEN MODE			
	In	Out	Loss	Eff.	In	Out	Loss	Eff.
Fuel	0							
Fuel Converter								
Clutch								
Hyd. Torque Converter								
Generator								
Torque Coupling								
Energy Storage	272	8643	178	0.68				
Energy Stored	-8549							
Motor/Controller	8146	6984	1161	0.86	364	315	49	0.87
Gearbox	6984	6380	605	0.91	406	364	43	0.89
Final Drive	6380	6379	0	1	406	406	0	1
Wheel/Axle	6379	5975	404	0.94	664	650	14	0.98
Braking							244	
Aux Loads	540	0	540	0				
Aero			3292					
Rolling			2019					

*Overall System Efficiency

0.621

*Overall energy efficiency is calculated as: (aero + rolling)/(fuel in - ess storage)

Loss Plot (Power Mode) Loss Plot (Regen Mode) DONE

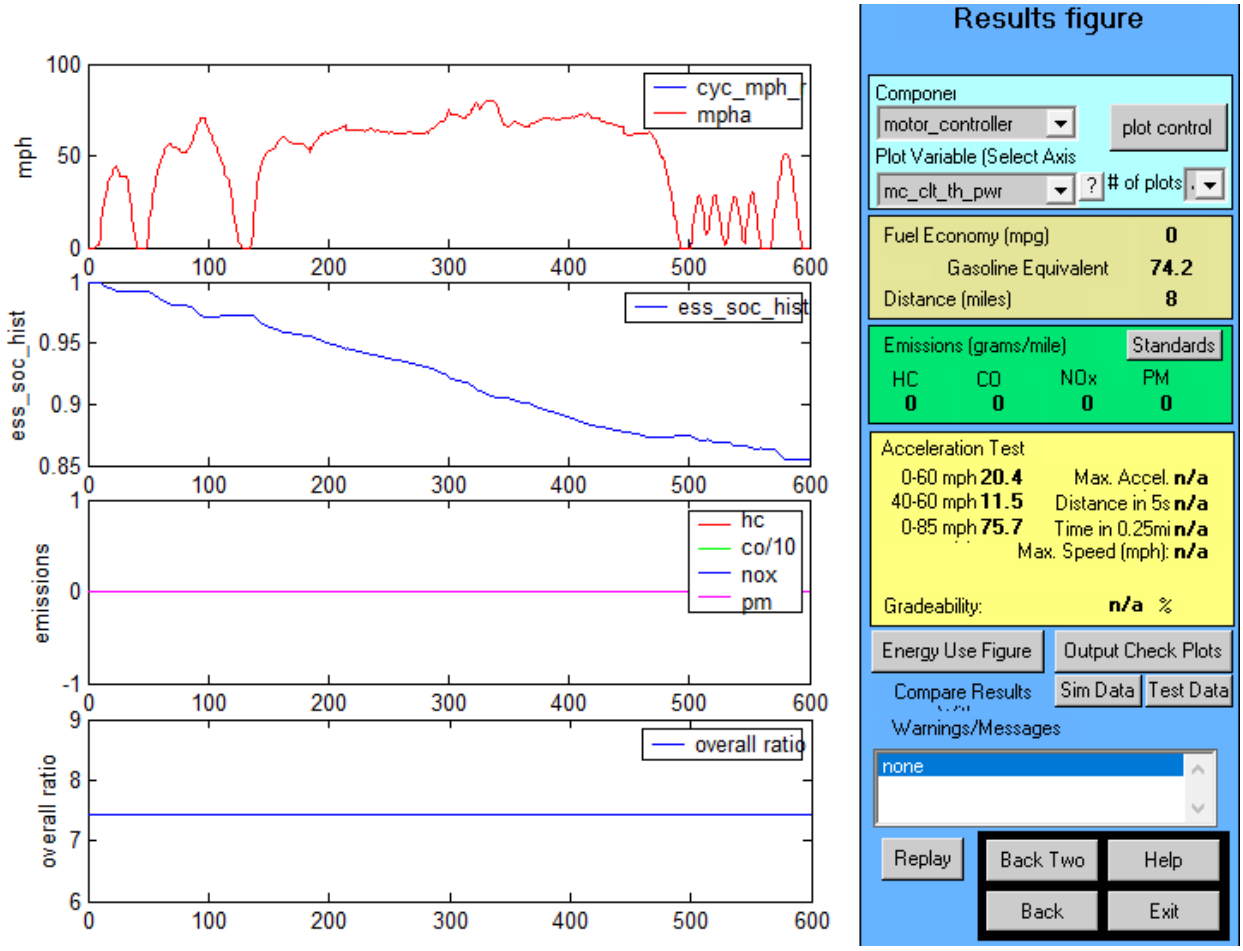
Energy Stored -8549

Open the energy use figure we can find that the total consumption of energy in this cycle. The consumption equals energy stored which is 8549kJ=2374.72Wh (1Watt hour (Wh) is equal to 3.6 kilojoules KJ). We also can find the distance of this cycle which is 10.3 mile from the diagram. Distance (miles) 10.3 Then we can get Wh/mile consumption=2374.72Wh/10.3mile=230.56Wh/mile

fuel economy (mpg): 120.5(Gasoline Equivalent)

Fuel Economy (mpg)	0
Gasoline Equivalent	120.5
Distance (miles)	10.3

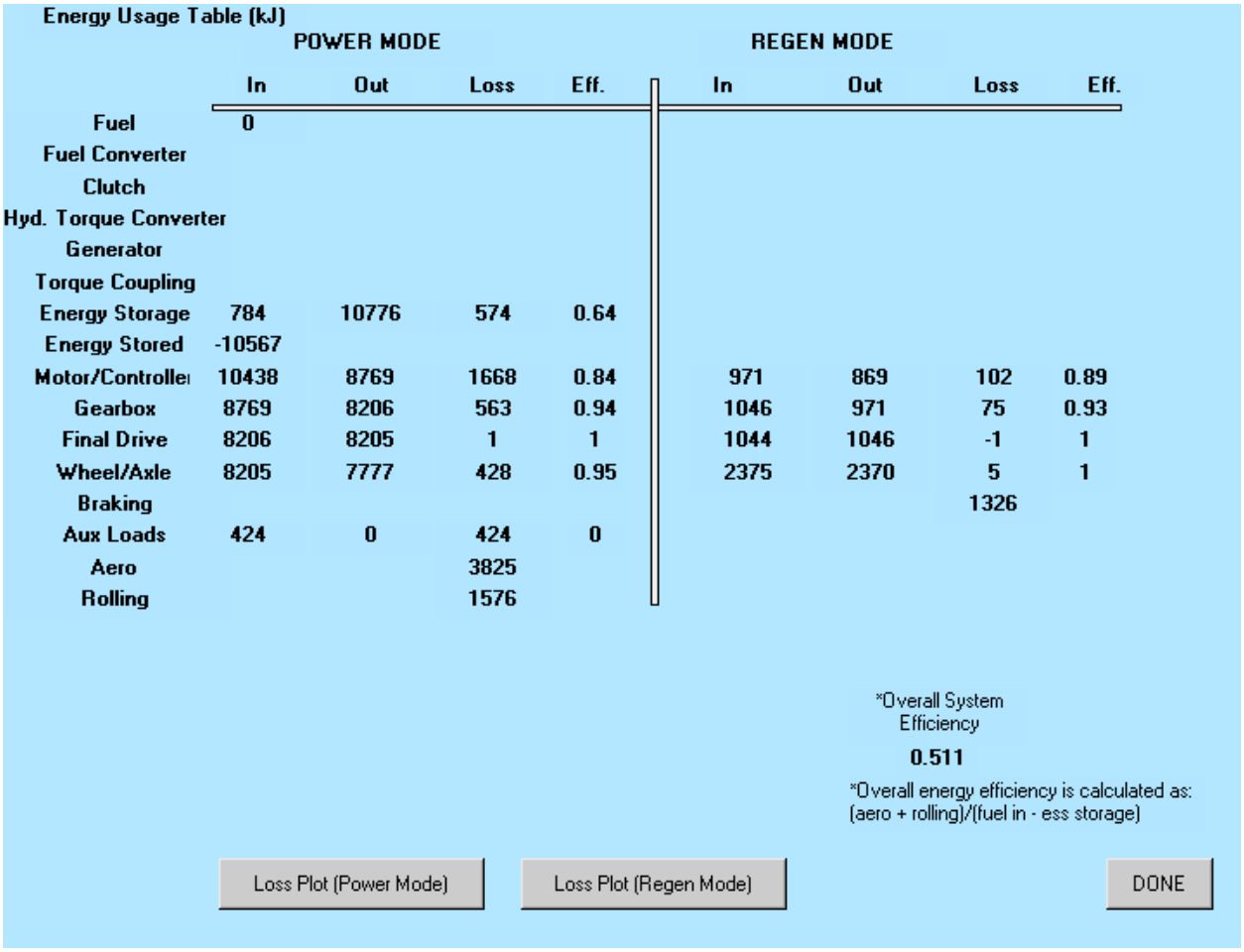
US06:



From this diagram we can get that:

0 to 60 mph acceleration time: 20.4 S

Wh/mile energy consumption:366.91Wh/mile



Energy Usage Table (kJ)

	POWER MODE				REGEN MODE			
	In	Out	Loss	Eff.	In	Out	Loss	Eff.
Fuel	0							
Fuel Converter								
Clutch								
Hyd. Torque Converter								
Generator								
Torque Coupling								
Energy Storage	784	10776	574	0.64				
Energy Stored	-10567							
Motor/Controller	10438	8769	1668	0.84	971	869	102	0.89
Gearbox	8769	8206	563	0.94	1046	971	75	0.93
Final Drive	8206	8205	1	1	1044	1046	-1	1
Wheel/Axle	8205	7777	428	0.95	2375	2370	5	1
Braking							1326	
Aux Loads	424	0	424	0				
Aero			3825					
Rolling			1576					

*Overall System Efficiency

0.511

*Overall energy efficiency is calculated as: (aero + rolling)/(fuel in - ess storage)

Loss Plot (Power Mode) Loss Plot (Regen Mode) DONE

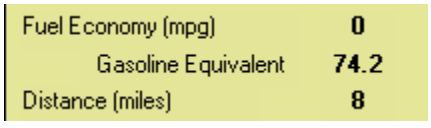
Energy Stored -10567

Open the energy use figure we can find that the total consumption of energy in this cycle. The consumption equals energy stored which is 10567kJ=2935.28Wh (1Watt hour (Wh) is equal to 3.6 kilojoules KJ). We also can find the distance of this cycle which is 8 mile from the diagram.

Distance (miles) 8

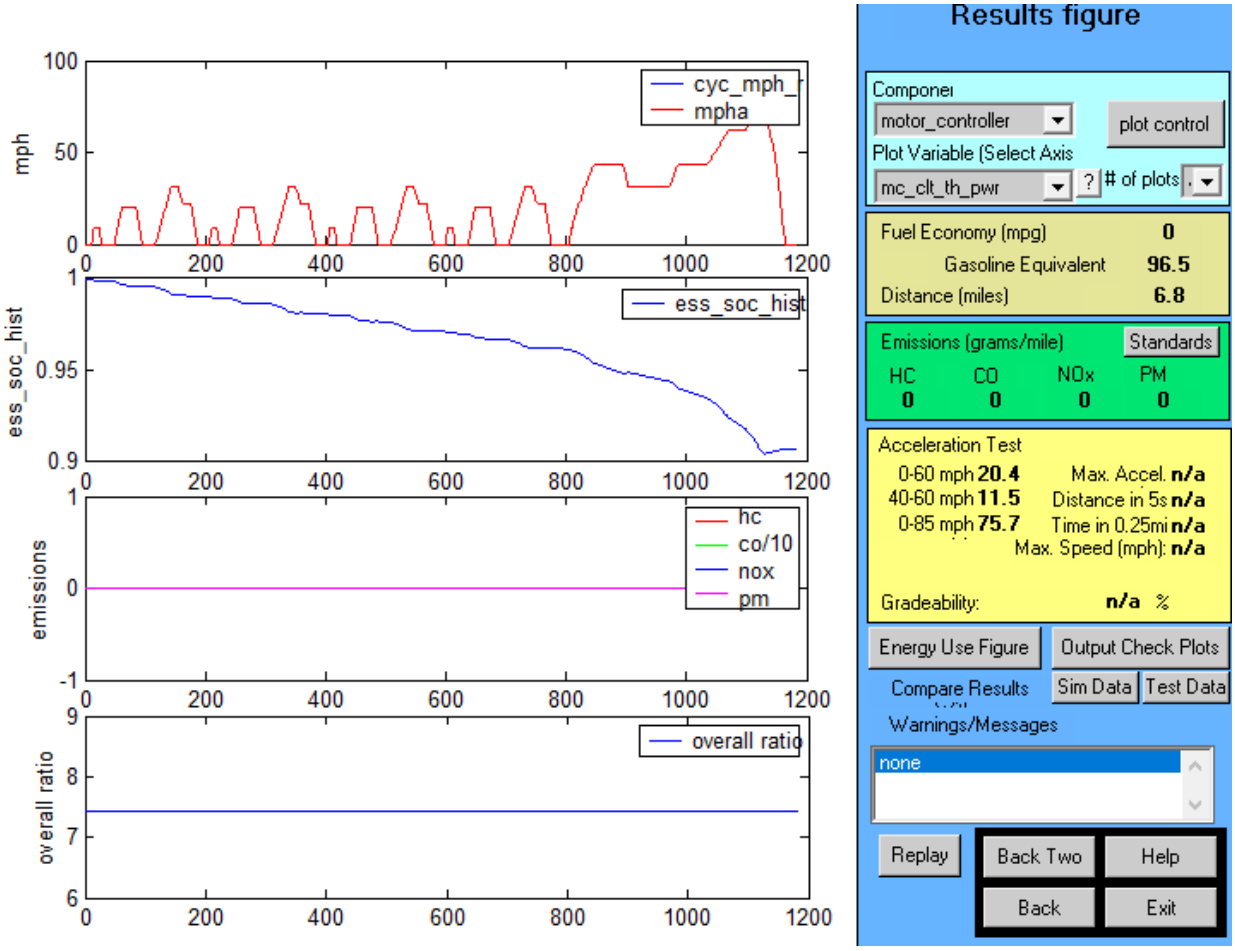
Then we can get Wh/mile consumption=2935.28Wh/8mile=366.91Wh/mile

fuel economy (mpg): 74.2(Gasoline Equivalent)



Fuel Economy (mpg)	0
Gasoline Equivalent	74.2
Distance (miles)	8

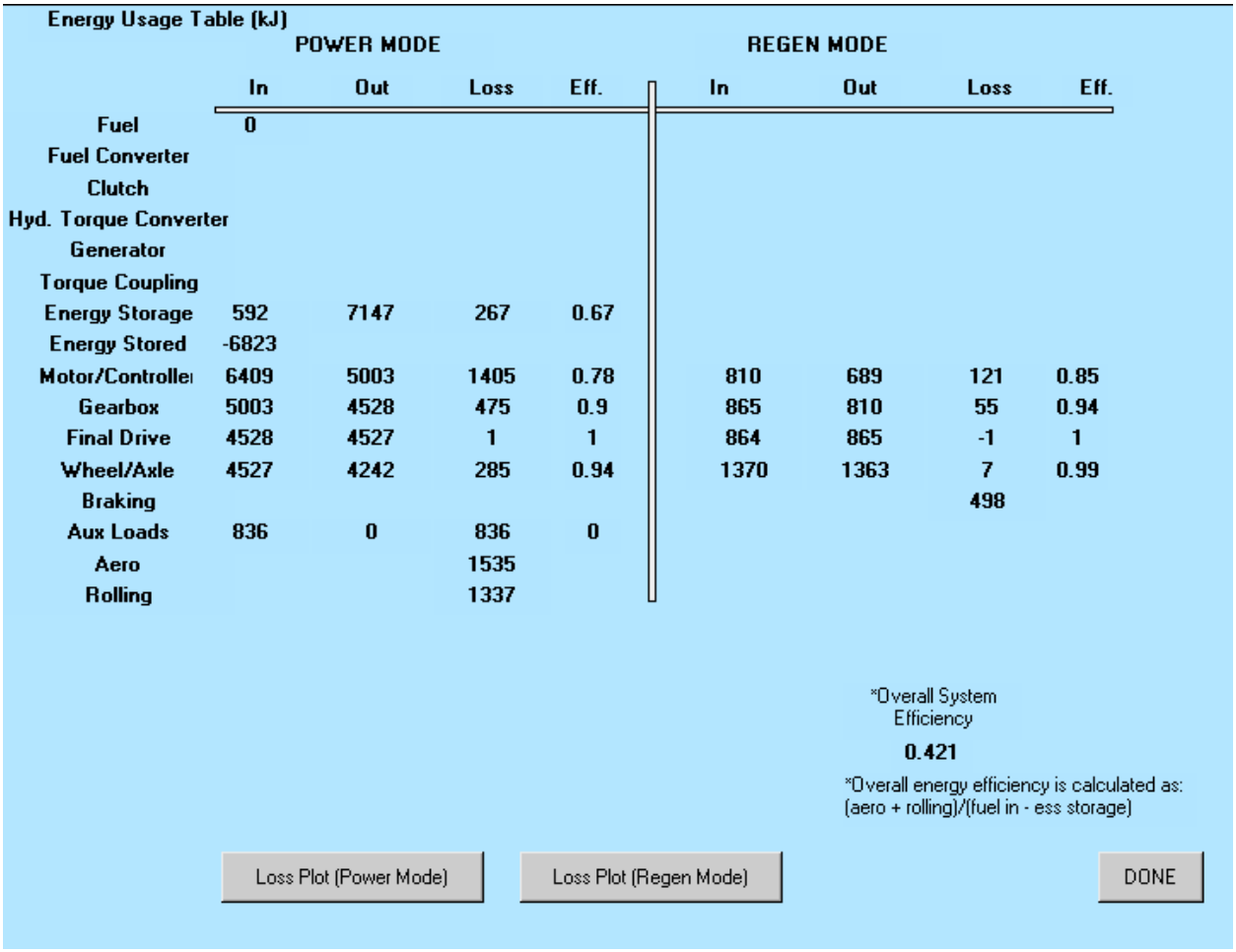
NEDC:



From this diagram we can get that:

0 to 60 mph acceleration time: 20.4 S

Wh/mile energy consumption:278.72Wh/mile



Energy Usage Table (kJ)

	POWER MODE In	Out	Loss	Eff.	REGEN MODE In	Out	Loss	Eff.
Fuel	0							
Fuel Converter								
Clutch								
Hyd. Torque Converter								
Generator								
Torque Coupling								
Energy Storage	592	7147	267	0.67				
Energy Stored	-6823							
Motor/Controller	6409	5003	1405	0.78	810	689	121	0.85
Gearbox	5003	4528	475	0.9	865	810	55	0.94
Final Drive	4528	4527	1	1	864	865	-1	1
Wheel/Axle	4527	4242	285	0.94	1370	1363	7	0.99
Braking							498	
Aux Loads	836	0	836	0				
Aero			1535					
Rolling			1337					

*Overall System Efficiency

0.421

*Overall energy efficiency is calculated as: (aero + rolling)/(fuel in - ess storage)

Loss Plot (Power Mode) | Loss Plot (Regen Mode) | DONE

Energy Stored -6823

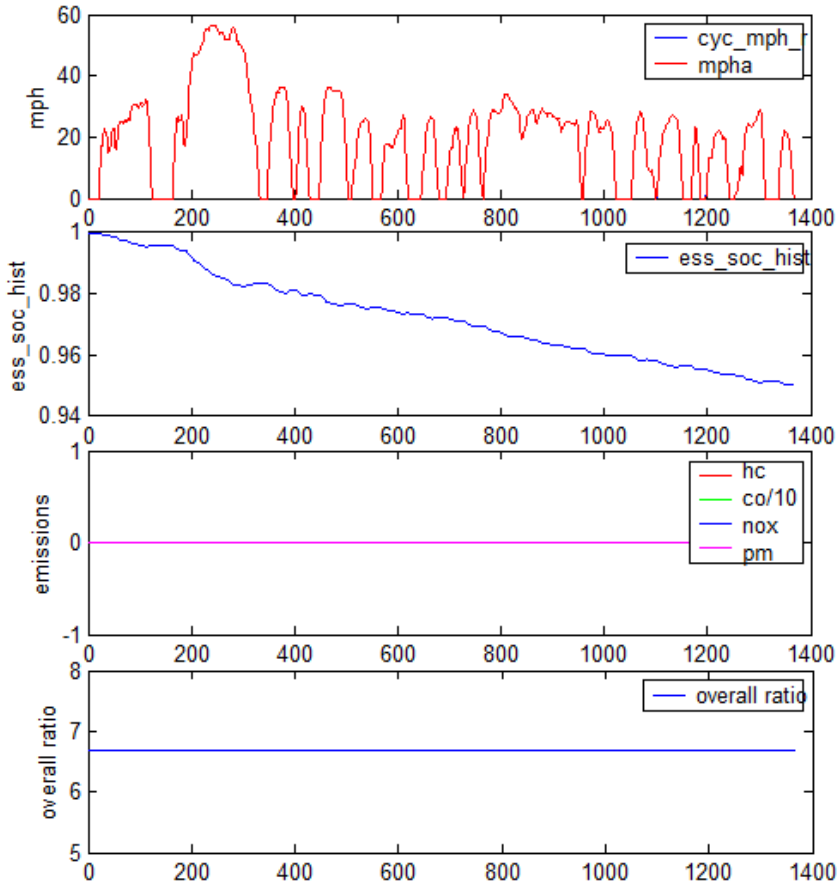
Open the energy use figure we can find that the total consumption of energy in this cycle. The consumption equals energy stored which is 6823kJ=1895.28Wh (1Watt hour (Wh) is equal to 3.6 kilojoules KJ). We also can find the distance of this cycle which is 6.8 mile from the diagram. Distance (miles) 6.8 Then we can get Wh/mile consumption=1895.28Wh/6.8mile=278.72Wh/mile

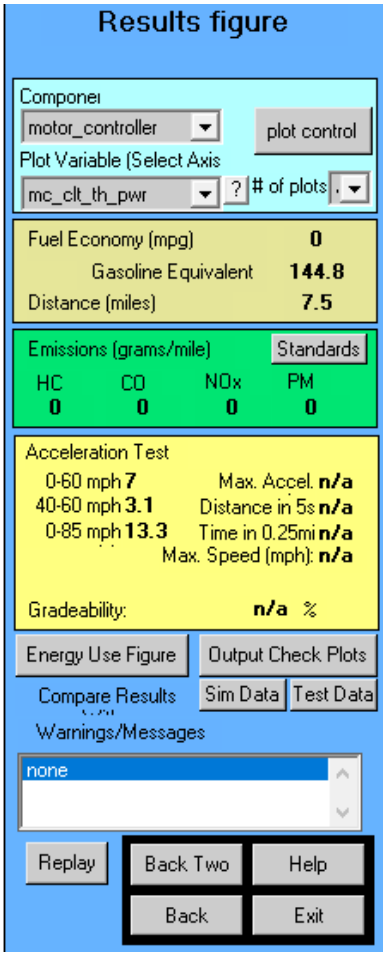
fuel economy (mpg): 96.5(Gasoline Equivalent)

Fuel Economy (mpg)	0
Gasoline Equivalent	96.5
Distance (miles)	6.8

gm_ev1_in

UDDS





From this diagram we can get that:

0 to 60 mph acceleration time:7 S

Wh/mile energy consumption:187.04Wh/mile

Energy Usage Table (kJ)

	POWER MODE				REGEN MODE			
	In	Out	Loss	Eff.	In	Out	Loss	Eff.
Fuel	0							
Fuel Converter								
Clutch								
Hyd. Torque Converter								
Generator								
Torque Coupling								
Energy Storage	1048	5949	149	0.94				
Energy Stored	-5050							
Motor/Controlle	5546	4260	1285	0.77	1518	1124	394	0.74
Gearbox	4260	3905	355	0.92	1649	1518	131	0.92
Final Drive	3905	3905	0	1	1649	1649	0	1
Wheel/Axle	3905	3594	311	0.92	2006	1985	21	0.99
Braking							336	
Aux Loads	479	0	479	0				
Aero			610					
Rolling			978					

*Overall System Efficiency

0.315

*Overall energy efficiency is calculated as: (aero + rolling)/(fuel in - ess storage)

Loss Plot (Power Mode) | Loss Plot (Regen Mode) | DONE

Energy Stored	-5050

Open the energy use figure we can find that the total consumption of energy in this cycle. The consumption equals energy stored which is 5050kJ=1402.78Wh (1Watt hour (Wh) is equal to 3.6 kilojoules KJ). We also can find the distance of this cycle which is 7.5 mile from the diagram.

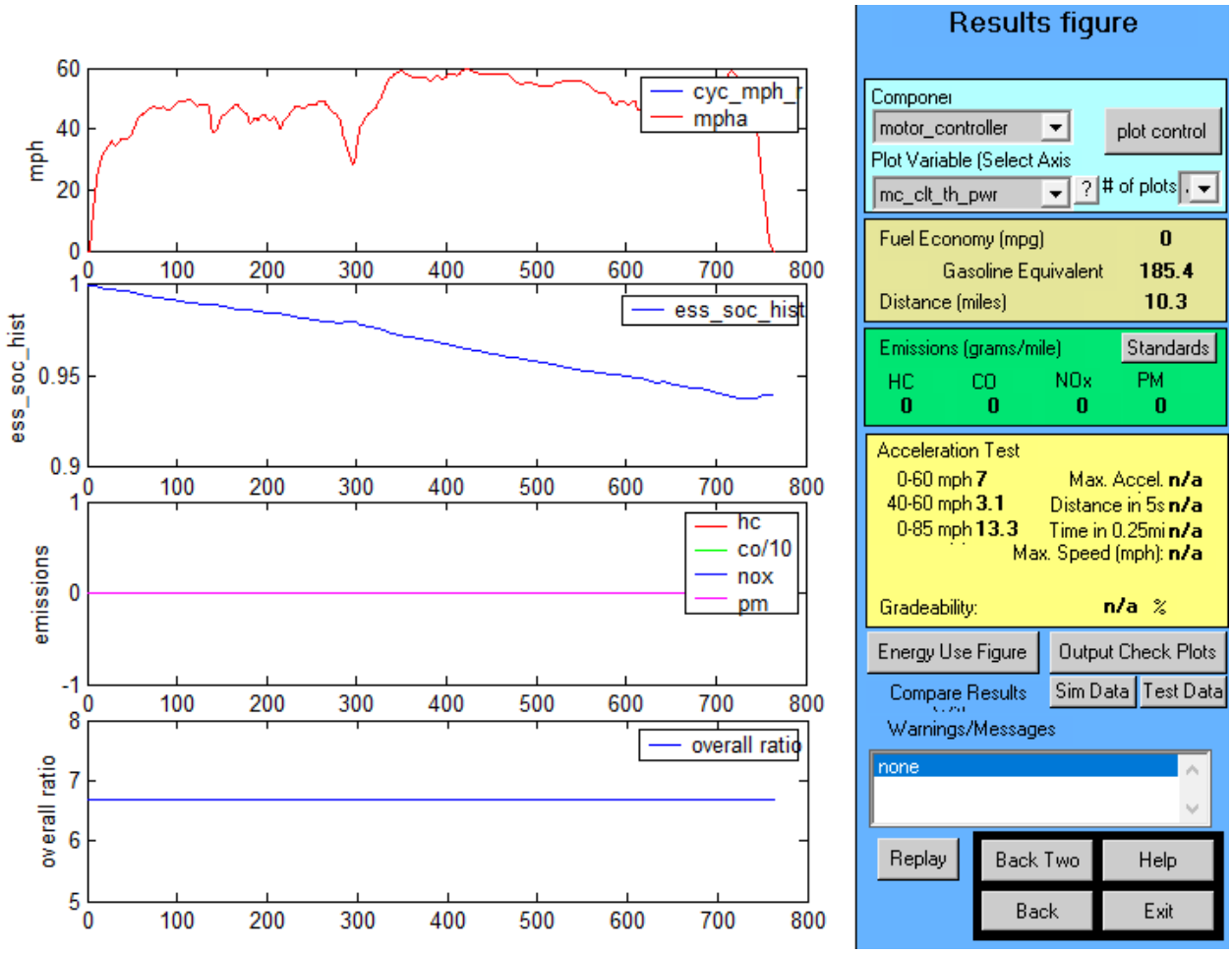
Distance (miles)	7.5

Then we can get Wh/mile consumption=1402.78Wh/7.5mile=187.04Wh/mile

fuel economy (mpg): 144.8(Gasoline Equivalent)

Fuel Economy (mpg)	0
Gasoline Equivalent	144.8
Distance (miles)	7.5

HWFET:



From this diagram we can get that:

0 to 60 mph acceleration time:7 S

Wh/mile energy consumption:165.56Wh/mile

Energy Usage Table (kJ)

	POWER MODE				REGEN MODE			
	In	Out	Loss	Eff.	In	Out	Loss	Eff.
Fuel	0							
Fuel Converter								
Clutch								
Hyd. Torque Converter								
Generator								
Torque Coupling								
Energy Storage	394	6390	143	0.94				
Energy Stored	-6139							
Motor/Controller	6144	4938	1207	0.8	542	416	126	0.77
Gearbox	4938	4378	559	0.89	607	542	65	0.89
Final Drive	4378	4378	0	1	607	607	0	1
Wheel/Axle	4378	3991	387	0.91	661	647	14	0.98
Braking							40	
Aux Loads	268	0	268	0				
Aero			1983					
Rolling			1347					

*Overall System Efficiency

0.542

*Overall energy efficiency is calculated as: (aero + rolling)/(fuel in - ess storage)

Loss Plot (Power Mode) | Loss Plot (Regen Mode) | DONE

Energy Stored	-6139

Open the energy use figure we can find that the total consumption of energy in this cycle. The consumption equals energy stored which is 6139kJ=1705.28Wh (1Watt hour (Wh) is equal to 3.6 kilojoules KJ). We also can find the distance of this cycle which is 10.3 mile from the diagram.

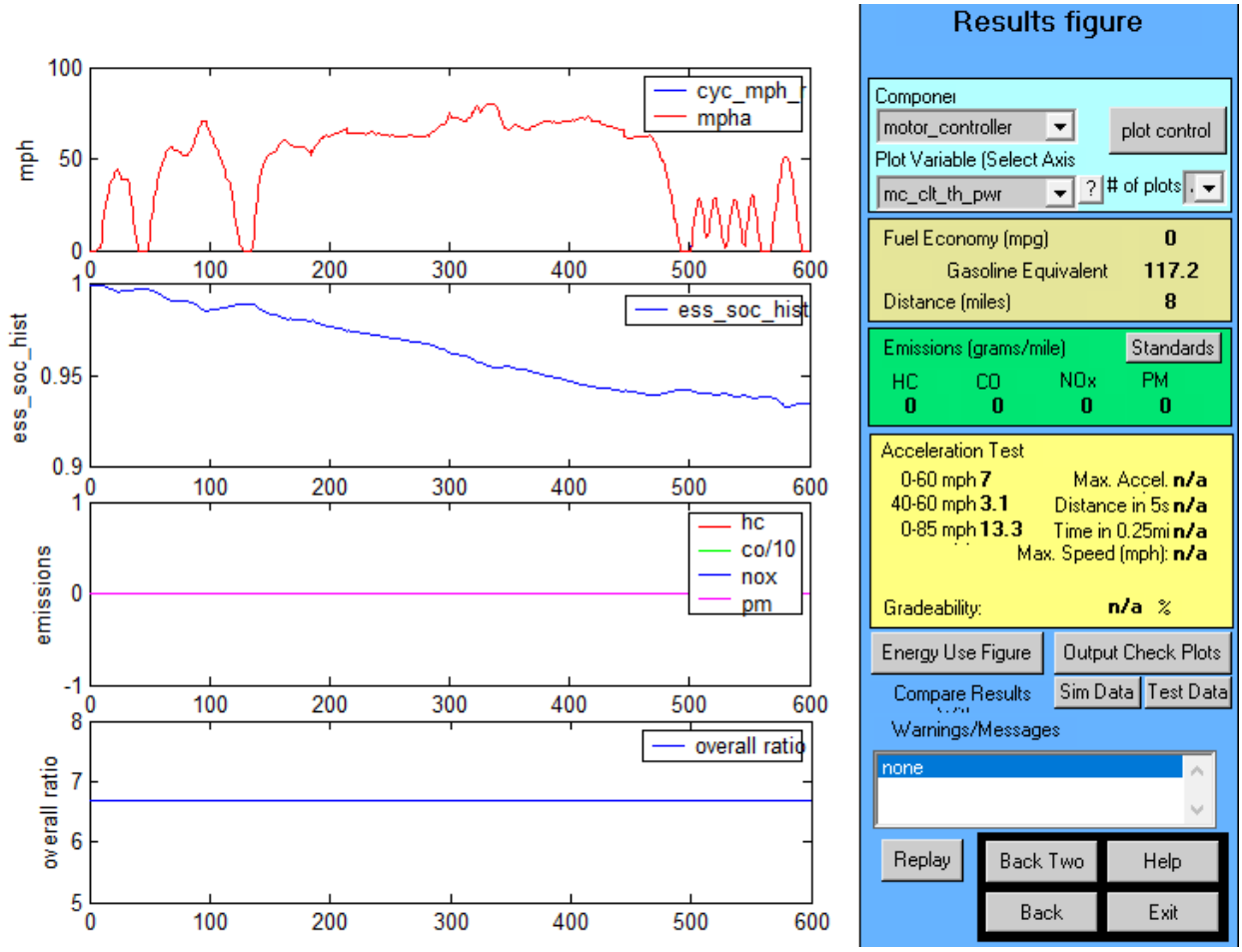
Distance (miles)	10.3

Then we can get Wh/mile consumption=1705.28Wh/10.3mile=165.56Wh/mile

fuel economy (mpg): 185.4(Gasoline Equivalent)

Fuel Economy (mpg)	0
Gasoline Equivalent	185.4
Distance (miles)	10.3

US06:



From this diagram we can get that:

0 to 60 mph acceleration time:7 S

0-60 mph 7

Wh/mile energy consumption:227.99Wh/mile

Energy Usage Table (kJ)

	POWER MODE In	Out	Loss	Eff.	REGEN MODE In	Out	Loss	Eff.
Fuel	0							
Fuel Converter								
Clutch								
Hyd. Torque Converter								
Generator								
Torque Coupling								
Energy Storage	1570	7642	494	0.9				
Energy Stored	-6566							
Motor/Controlle	7476	6455	1021	0.86	1910	1614	296	0.84
Gearbox	6455	5981	475	0.93	2046	1910	137	0.93
Final Drive	5981	5981	0	1	2046	2046	0	1
Wheel/Axle	5981	5583	397	0.93	2227	2221	7	1
Braking							175	
Aux Loads	210	0	210	0				
Aero			2304					
Rolling			1051					

*Overall System Efficiency

0.511

*Overall energy efficiency is calculated as: (aero + rolling)/(fuel in - ess storage)

Loss Plot (Power Mode) | Loss Plot (Regen Mode) | DONE

Energy Stored	-6566

Open the energy use figure we can find that the total consumption of energy in this cycle. The consumption equals energy stored which is 6566kJ=1823.89Wh (1Watt hour (Wh) is equal to 3.6 kilojoules KJ). We also can find the distance of this cycle which is 8 mile from the diagram.

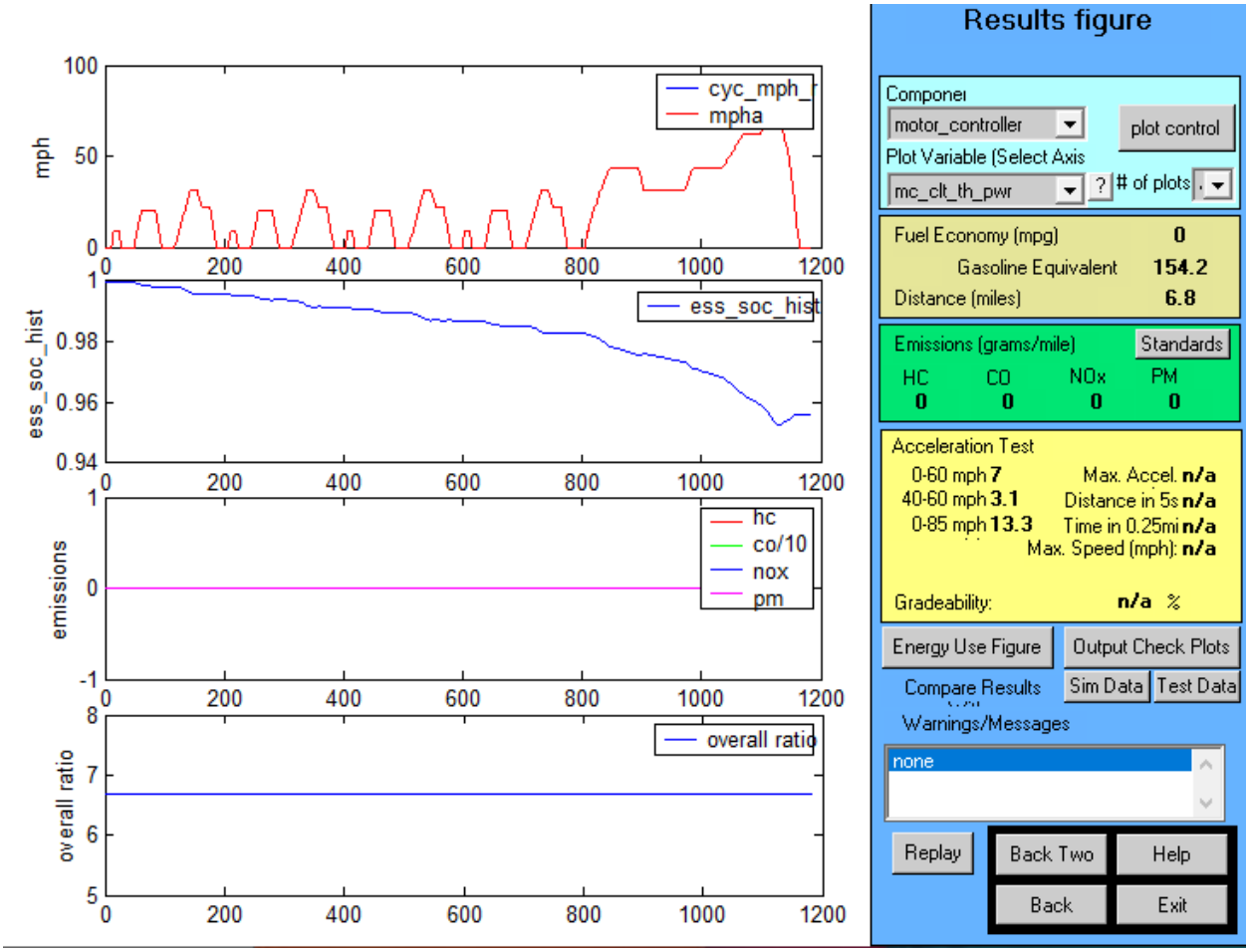
Distance (miles)	8

Then we can get Wh/mile consumption=1823.89Wh/8mile=227.99Wh/mile

fuel economy (mpg): 117.2(Gasoline Equivalent)

Fuel Economy (mpg)	0
Gasoline Equivalent	117.2
Distance (miles)	8

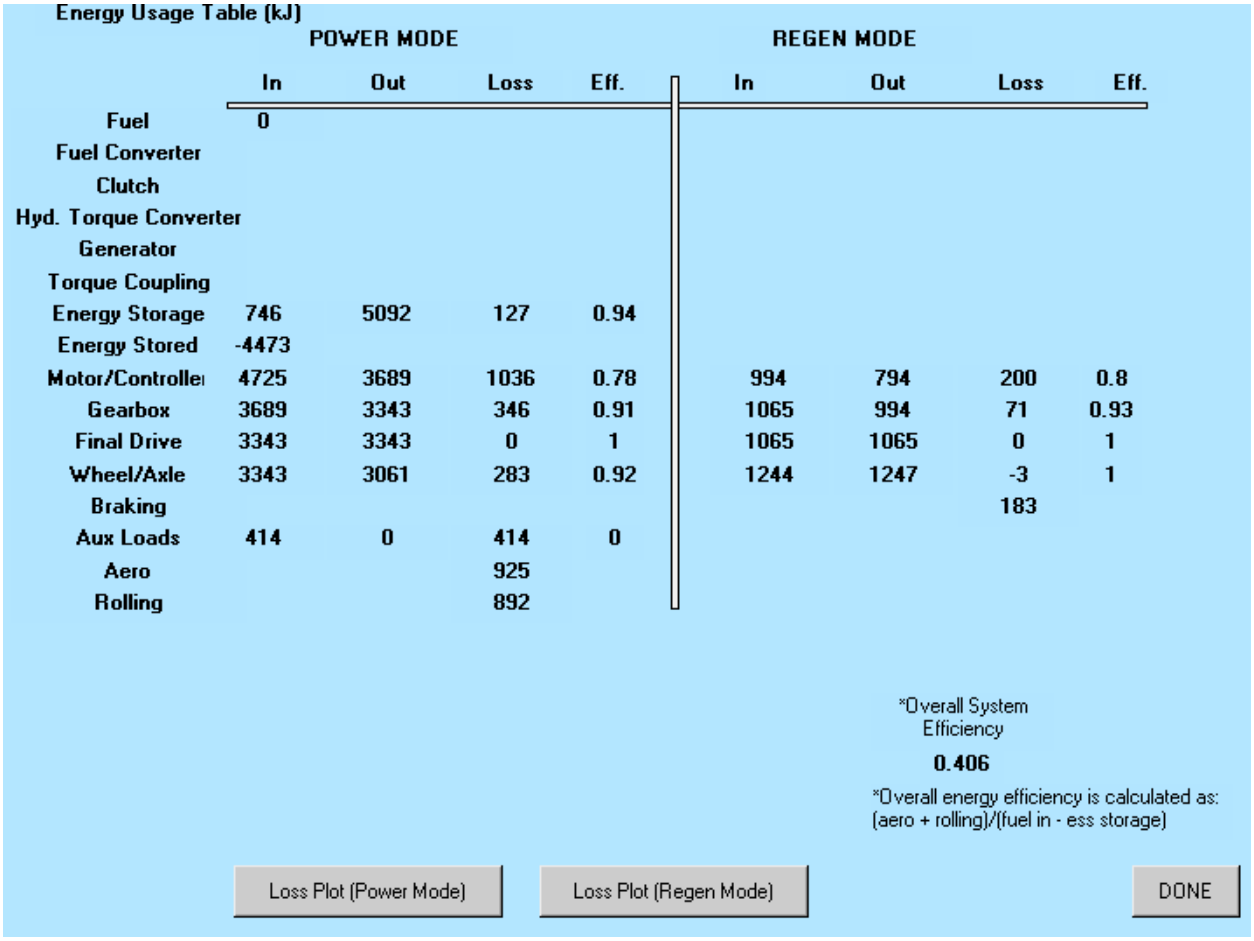
NEDC:



From this diagram we can get that:

0 to 60 mph acceleration time:7 S

Wh/mile energy consumption:182.72Wh/mile



Energy Usage Table (kJ)

	POWER MODE In	Out	Loss	Eff.	REGEN MODE In	Out	Loss	Eff.
Fuel	0							
Fuel Converter								
Clutch								
Hyd. Torque Converter								
Generator								
Torque Coupling								
Energy Storage	746	5092	127	0.94				
Energy Stored	-4473							
Motor/Controller	4725	3689	1036	0.78	994	794	200	0.8
Gearbox	3689	3343	346	0.91	1065	994	71	0.93
Final Drive	3343	3343	0	1	1065	1065	0	1
Wheel/Axle	3343	3061	283	0.92	1244	1247	-3	1
Braking							183	
Aux Loads	414	0	414	0				
Aero			925					
Rolling			892					

*Overall System Efficiency

0.406

*Overall energy efficiency is calculated as: (aero + rolling)/(fuel in - ess storage)

Loss Plot (Power Mode) | Loss Plot (Regen Mode) | DONE

Energy Stored -4473

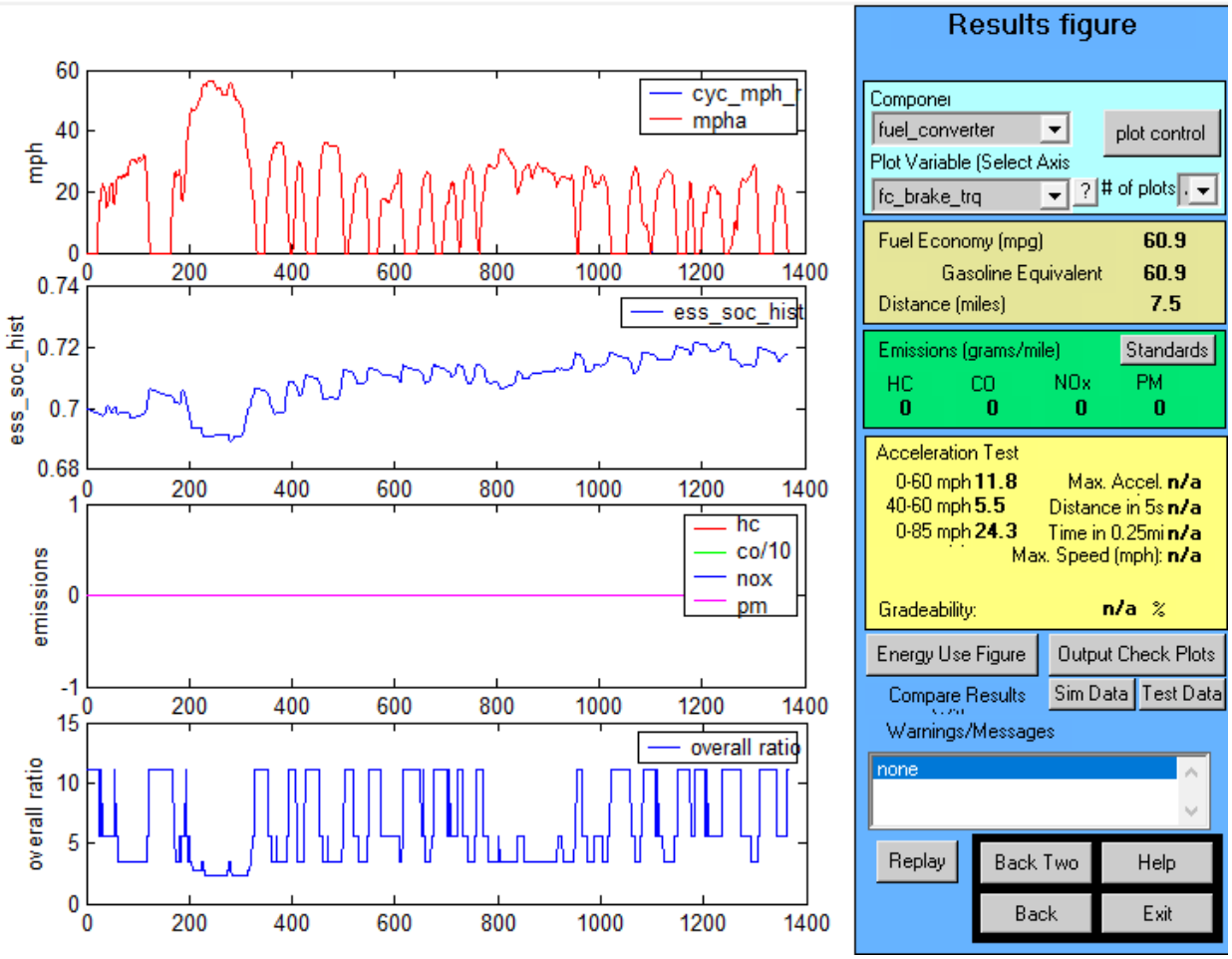
Open the energy use figure we can find that the total consumption of energy in this cycle. The consumption equals energy stored which is 4473kJ=1242.5Wh (1Watt hour (Wh) is equal to 3.6 kilojoules KJ). We also can find the distance of this cycle which is 6.8 mile from the diagram. Distance (miles) 6.8 Then we can get Wh/mile consumption=1242.5Wh/6.8mile=182.72Wh/mile

fuel economy (mpg): 154.2(Gasoline Equivalent)

Fuel Economy (mpg)	0
Gasoline Equivalent	154.2
Distance (miles)	6.8

INSIGHT_defults_in

UDDS

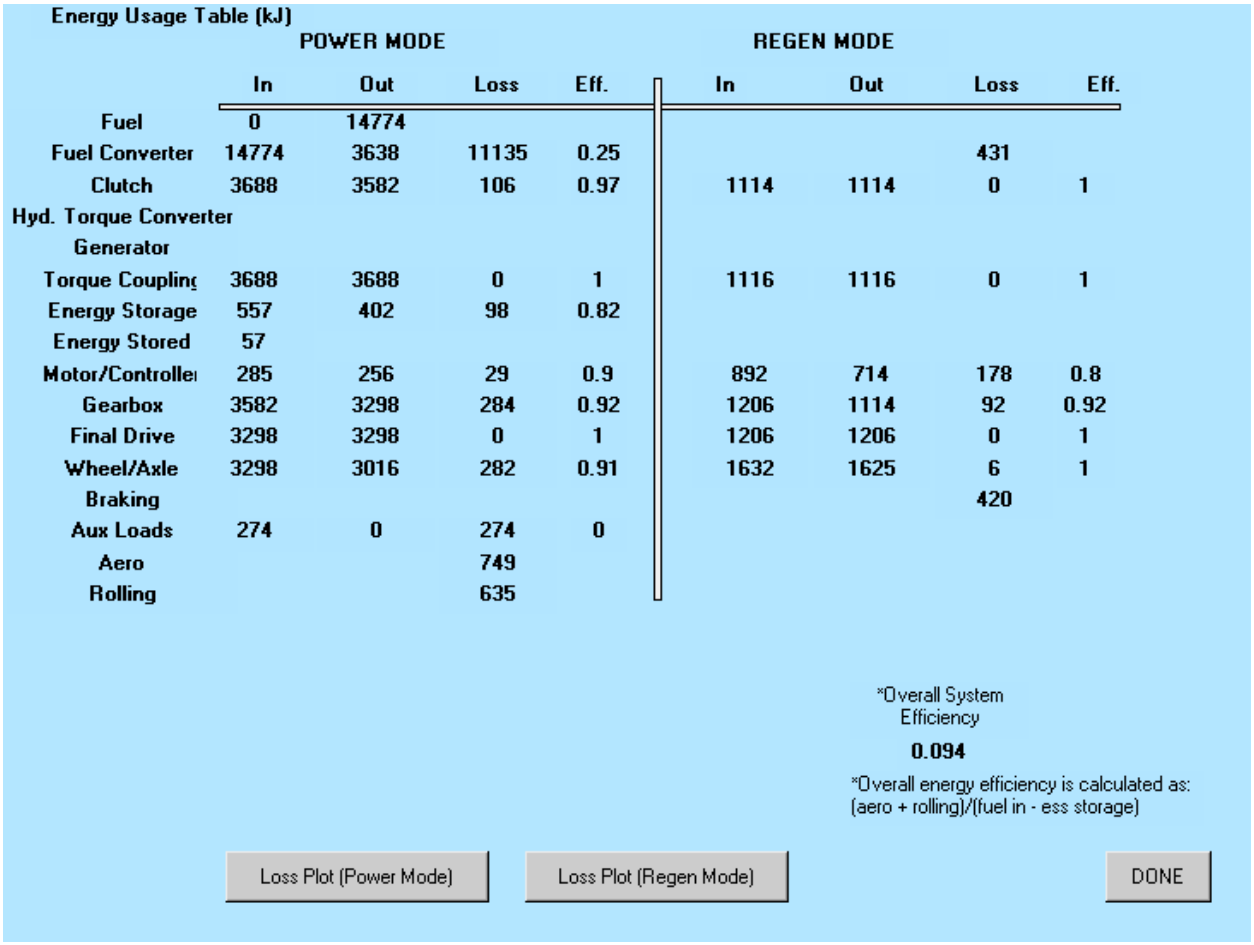


From this diagram we can get that:

0 to 60 mph acceleration time:11.8 S

0-60 mph 11.8

Wh/mile energy consumption:547.19Wh/mile



Energy Usage Table (kJ)

	POWER MODE In	Out	Loss	Eff.	REGEN MODE In	Out	Loss	Eff.
Fuel	0	14774						
Fuel Converter	14774	3638	11135	0.25			431	
Clutch	3688	3582	106	0.97	1114	1114	0	1
Hyd. Torque Converter								
Generator								
Torque Coupling	3688	3688	0	1	1116	1116	0	1
Energy Storage	557	402	98	0.82				
Energy Stored	57							
Motor/Controller	285	256	29	0.9	892	714	178	0.8
Gearbox	3582	3298	284	0.92	1206	1114	92	0.92
Final Drive	3298	3298	0	1	1206	1206	0	1
Wheel/Axle	3298	3016	282	0.91	1632	1625	6	1
Braking							420	
Aux Loads	274	0	274	0				
Aero			749					
Rolling			635					

*Overall System Efficiency

0.094

*Overall energy efficiency is calculated as: (aero + rolling)/(fuel in - ess storage)

Loss Plot (Power Mode) | Loss Plot (Regen Mode) | DONE

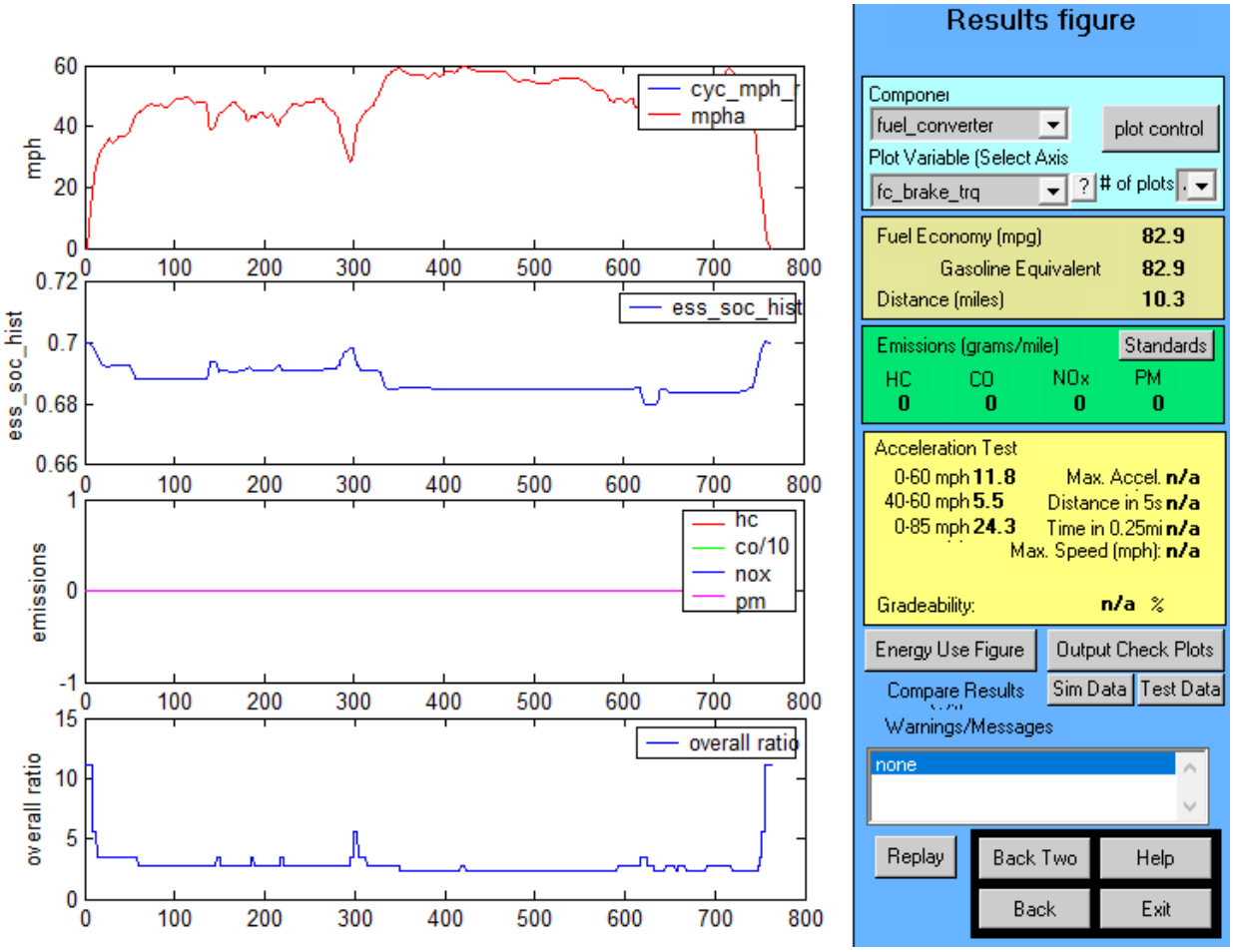
Fuel Converter 14774

Open the energy use figure we can find that the total consumption of energy in this cycle. The consumption equals the input of fuel converter which is 14774kJ=4103.89Wh (1Watt hour (Wh) is equal to 3.6 kilojoules KJ). We also can find the distance of this cycle which is 7.5 mile from the diagram. Distance (miles) 7.5 Then we can get Wh/mile consumption=14774Wh/7.5mile=547.19Wh/mile

fuel economy (mpg): 60.9

Fuel Economy (mpg)	60.9
Gasoline Equivalent	60.9
Distance (miles)	7.5

HWFET:

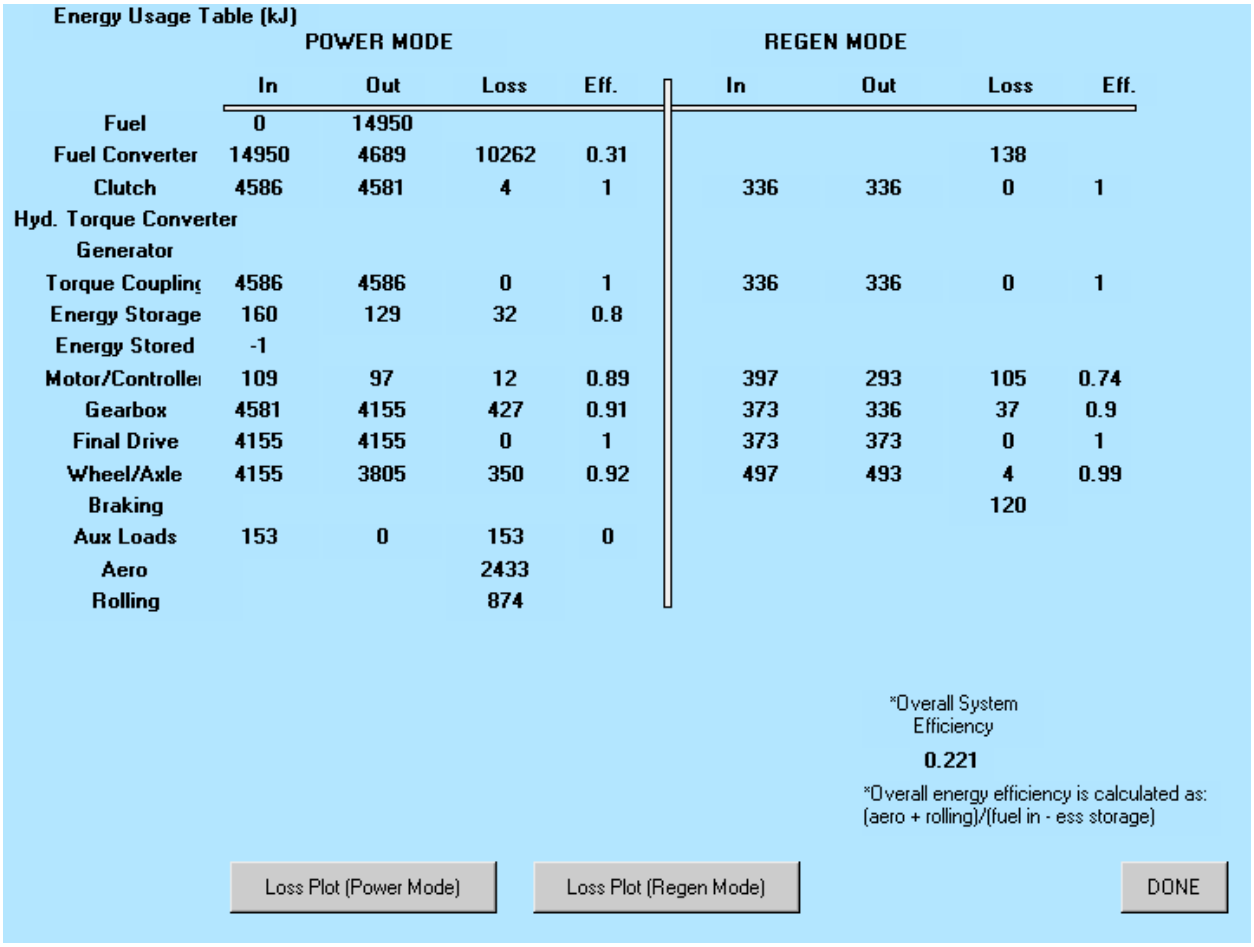


From this diagram we can get that:

0 to 60 mph acceleration time:11.8 S

0-60 mph **11.8**

Wh/mile energy consumption:403.18Wh/mile



Energy Usage Table (kJ)

	POWER MODE In	Out	Loss	Eff.	REGEN MODE In	Out	Loss	Eff.
Fuel	0	14950						
Fuel Converter	14950	4689	10262	0.31			138	
Clutch	4586	4581	4	1	336	336	0	1
Hyd. Torque Converter								
Generator								
Torque Coupling	4586	4586	0	1	336	336	0	1
Energy Storage	160	129	32	0.8				
Energy Stored	-1							
Motor/Controller	109	97	12	0.89	397	293	105	0.74
Gearbox	4581	4155	427	0.91	373	336	37	0.9
Final Drive	4155	4155	0	1	373	373	0	1
Wheel/Axle	4155	3805	350	0.92	497	493	4	0.99
Braking							120	
Aux Loads	153	0	153	0				
Aero			2433					
Rolling			874					

*Overall System Efficiency

0.221

*Overall energy efficiency is calculated as: (aero + rolling)/(fuel in - ess storage)

Loss Plot (Power Mode) | Loss Plot (Regen Mode) | DONE

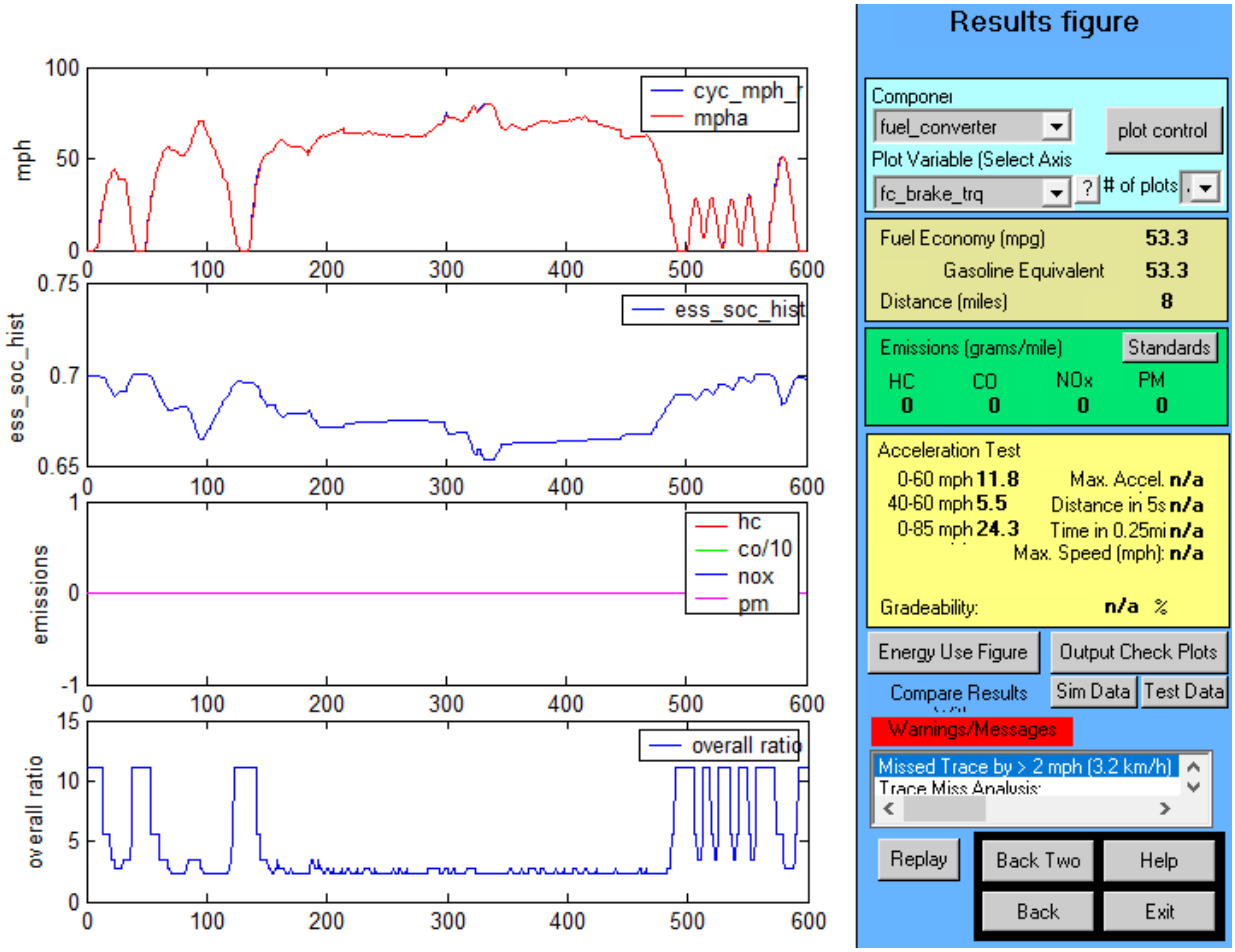
Fuel Converter 14950

Open the energy use figure we can find that the total consumption of energy in this cycle. The consumption equals the input of fuel converter which is 14950kJ=4152.78Wh (1Watt hour (Wh) is equal to 3.6 kilojoules KJ). We also can find the distance of this cycle which is 10.3 mile from the diagram. Distance (miles) 10.3 Then we can get Wh/mile consumption=4152.78Wh/10.3mile=403.18Wh/mile

fuel economy (mpg): 82.9

Fuel Economy (mpg)	82.9
Gasoline Equivalent	82.9
Distance (miles)	10.3

US06:



From this diagram we can get that:

0 to 60 mph acceleration time:11.8 S

Wh/mile energy consumption:629.17Wh/mile

Energy Usage Table (kJ)

	POWER MODE				REGEN MODE			
	In	Out	Loss	Eff.	In	Out	Loss	Eff.
Fuel	0	18120						
Fuel Converter	18120	5776	12344	0.32			333	
Clutch	5986	5951	35	0.99	958	958	0	1
Hyd. Torque Converter								
Generator								
Torque Coupling	5986	5986	0	1	960	960	0	1
Energy Storage	528	396	141	0.74				
Energy Stored	-9							
Motor/Controller	358	323	34	0.9	740	610	130	0.82
Gearbox	5951	5575	375	0.94	1042	958	84	0.92
Final Drive	5575	5575	0	1	1042	1042	0	1
Wheel/Axle	5575	5205	371	0.93	1682	1703	-21	1.01
Braking							661	
Aux Loads	120	0	120	0				
Aero			2824					
Rolling			682					

*Overall System Efficiency

0.193

*Overall energy efficiency is calculated as: (aero + rolling)/(fuel in - ess storage)

Loss Plot (Power Mode) | Loss Plot (Regen Mode) | DONE

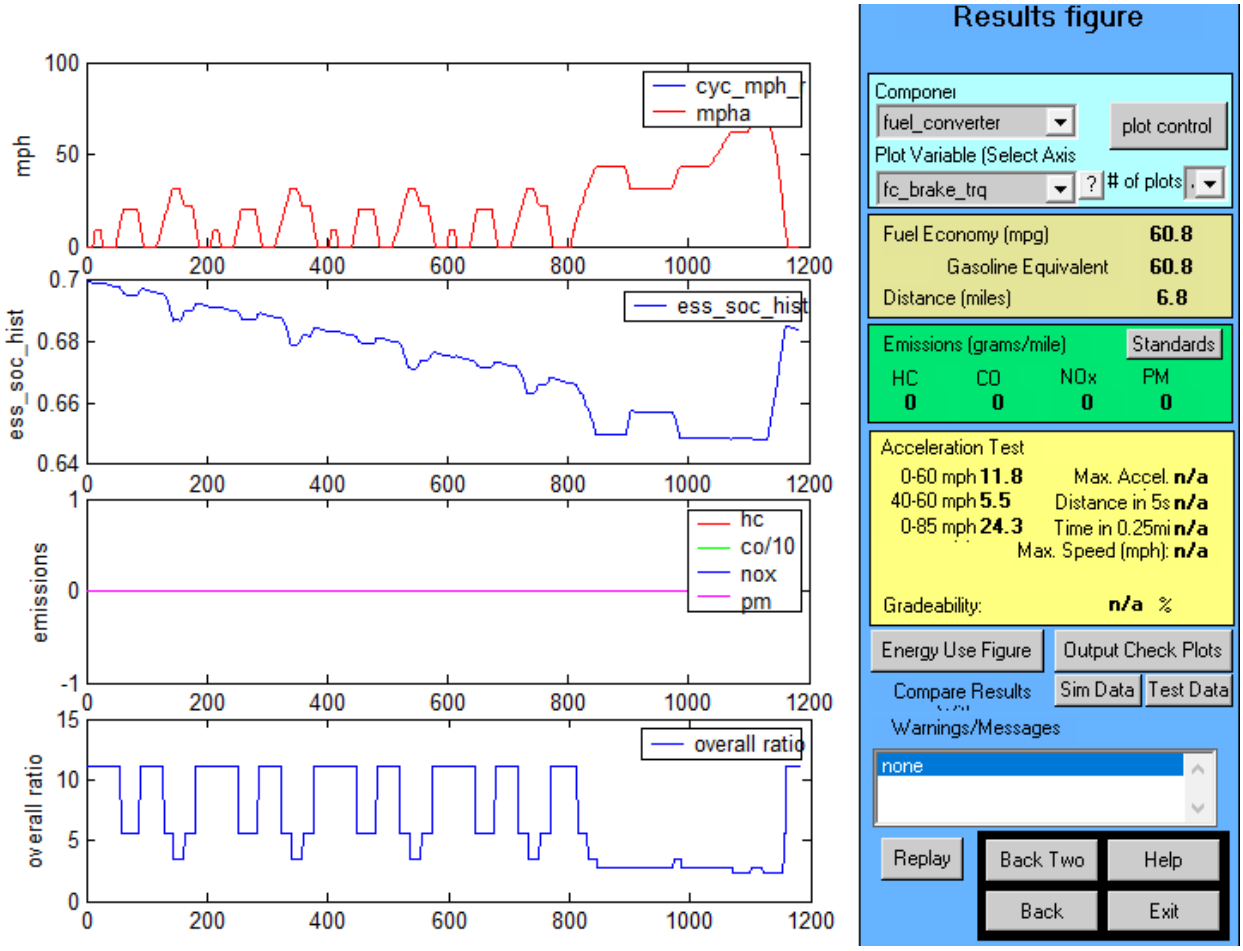
Fuel Converter 18120

Open the energy use figure we can find that the total consumption of energy in this cycle. The consumption equals the input of fuel converter which is 18120kJ=5033.33Wh (1Watt hour (Wh) is equal to 3.6 kilojoules KJ). We also can find the distance of this cycle which is 8mile from the diagram. Distance (miles) 8 Then we can get Wh/mile consumption=5033.33Wh/8mile=629.17Wh/mile

fuel economy (mpg): 53.3

Fuel Economy (mpg)	53.3
Gasoline Equivalent	53.3
Distance (miles)	8

NEDC:



From this diagram we can get that:

0 to 60 mph acceleration time:11.8 S

Wh/mile energy consumption:550.78Wh/mile

Energy Usage Table (kJ)

	POWER MODE				REGEN MODE			
	In	Out	Loss	Eff.	In	Out	Loss	Eff.
Fuel	0	13483						
Fuel Converter	13483	3308	10175	0.25			366	
Clutch	3297	3238	59	0.98	718	718	0	1
Hyd. Torque Converter								
Generator								
Torque Coupling	3297	3297	0	1	734	734	0	1
Energy Storage	297	297	54	0.82				
Energy Stored	-55							
Motor/Controller	200	172	28	0.86	551	436	114	0.79
Gearbox	3238	2959	279	0.91	767	718	49	0.94
Final Drive	2959	2959	0	1	767	767	0	1
Wheel/Axle	2959	2703	255	0.91	990	1000	-9	1.01
Braking							232	
Aux Loads	237	0	237	0				
Aero			1134					
Rolling			579					

*Overall System Efficiency

0.127

*Overall energy efficiency is calculated as: (aero + rolling)/(fuel in - ess storage)

Loss Plot (Power Mode) | Loss Plot (Regen Mode) | DONE

Fuel Converter 13483

Open the energy use figure we can find that the total consumption of energy in this cycle. The consumption equals the input of fuel converter which is 13483kJ=3745.28Wh (1Watt hour (Wh) is equal to 3.6 kilojoules KJ). We also can find the distance of this cycle which is 6.8 mile from the diagram. Distance (miles) 6.8 Then we can get Wh/mile consumption=3745.28Wh/6.8mile=550.78Wh/mile

fuel economy (mpg): 60.8

Fuel Economy (mpg)	60.8
Gasoline Equivalent	60.8
Distance (miles)	6.8

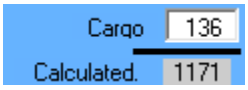
3. Determine effect of overall vehicle parameters such as **weight** and **aerodynamic drag** on acceleration, energy consumption performance, and range. You may input different values or do a parametric study using that option.

Answer: **In this question, I use tree values of weight and three values of Cd in UDDS cycle to find their impact on acceleration, energy consumption and range. Change the vehicle mass without changing Cd to see the impact of mass and change the Cd without changing vehicle mass to see the impact of Cd.**

Small_car_in

(Range is not available because the tank volume cannot be found in the data)

We can change vehicle weight by changing the weight of cargo. The former setting is



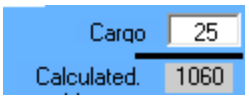
In this setting, running an UDDS cycle we can get the data from question2:

0 to 60 mph acceleration time: 8.8s

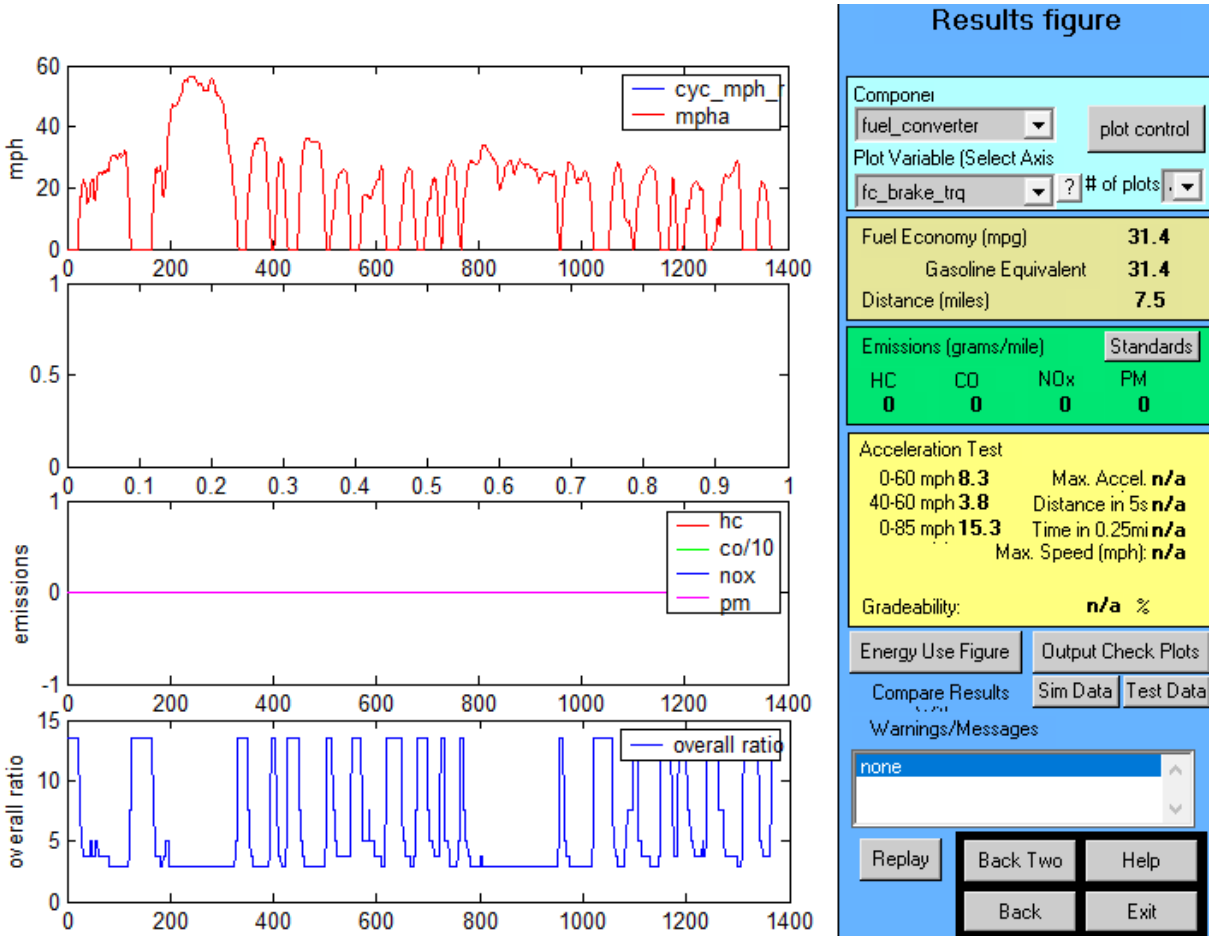
Wh/mile energy consumption:1095.63Wh/mile

fuel economy (mpg): 30.4

Now change cargo mass to 25kg and the vehicle weight will become 1060kg.



Running an UDDS cycle we can get:



From this diagram we can get that:

0 to 60 mph acceleration time:8.3 S

Wh/mile energy consumption:1061.7Wh/mile

Energy Usage Table (kJ)

	POWER MODE				REGEN MODE			
	In	Out	Loss	Eff.	In	Out	Loss	Eff.
Fuel	0	28666						
Fuel Converter	28666	5246	23420	0.18			319	
Clutch	4448	4322	126	0.97	482	482	0	1
Hyd. Torque Converter								
Generator								
Torque Coupling								
Energy Storage								
Energy Stored								
Motor/Controller								
Gearbox	4322	4037	285	0.93	533	482	51	0.9
Final Drive	4037	4037	0	1	533	533	0	1
Wheel/Axle	4037	3738	299	0.93	1560	1568	-8	1
Braking							1035	
Aux Loads	958	0	958	0				
Aero			1056					
Rolling			1122					

*Overall System Efficiency

0.076

*Overall energy efficiency is calculated as: (aero + rolling)/(fuel in - ess storage)

Loss Plot (Power Mode) | Loss Plot (Regen Mode) | DONE

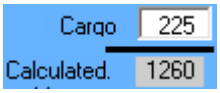
Fuel Converter	28666

Open the energy use figure we can find that the total consumption of energy in this cycle. The consumption equals the input of fuel converter which is 28666kJ=7962.78Wh (1Watt hour (Wh) is equal to 3.6 kilojoules KJ). We also can find the distance of this cycle which is 7.5mile from the diagram. Then we can get Wh/mile consumption=7962.78Wh/7.5mile=1061.7Wh/mile

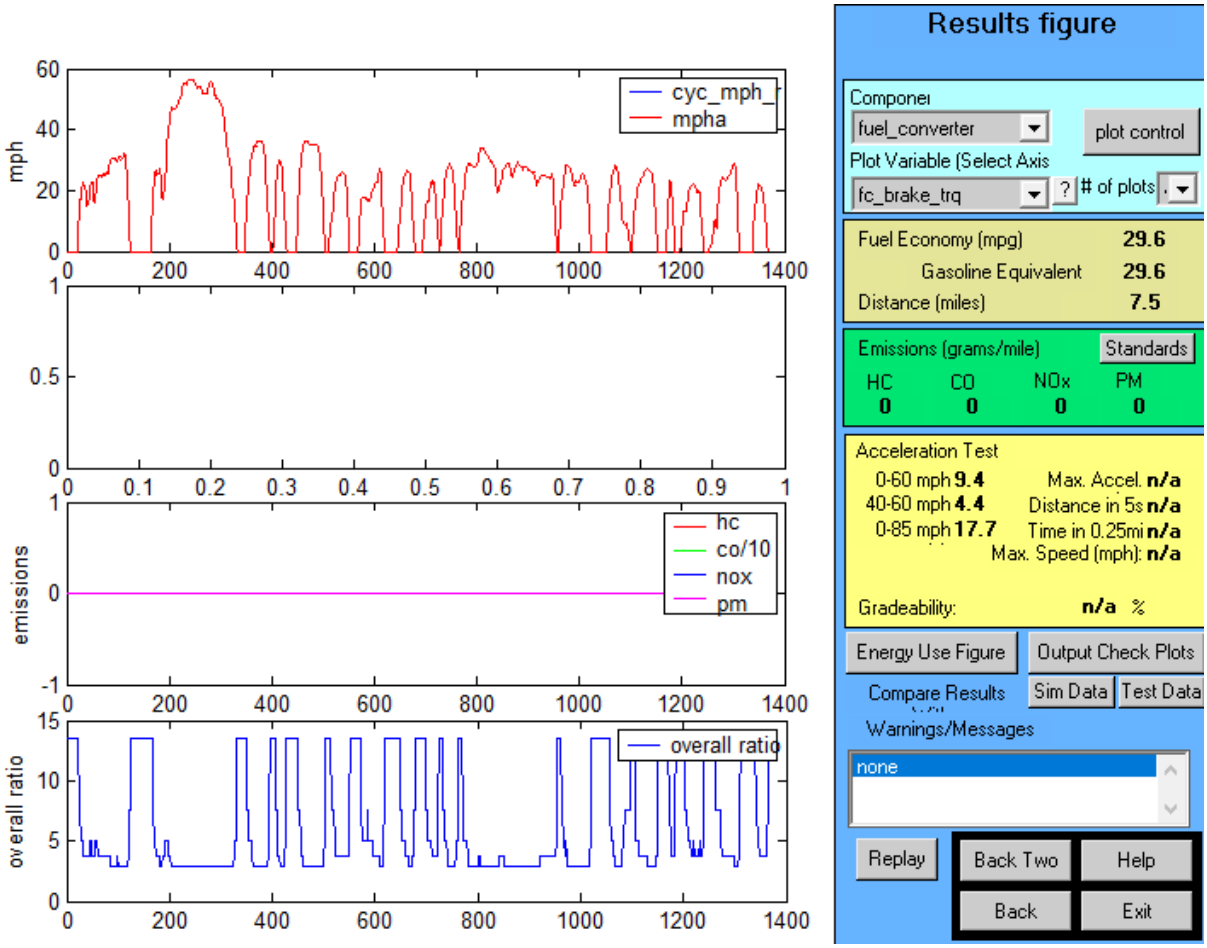
fuel economy (mpg): 31.4(Gasoline Equivalent)

Fuel Economy (mpg)	31.4
Gasoline Equivalent	31.4
Distance (miles)	7.5

Now change cargo mass to 225kg and the vehicle weight will become 1260kg.



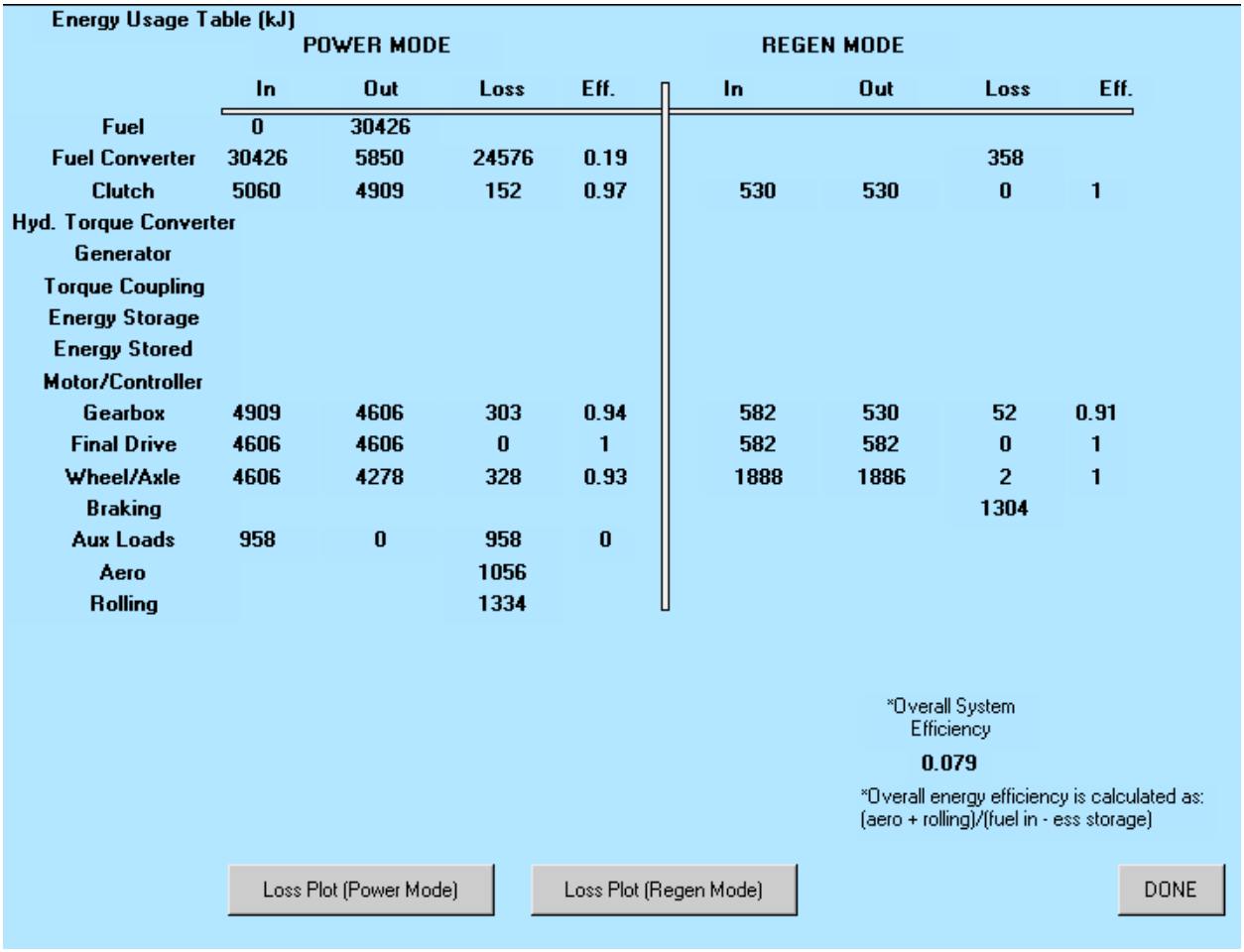
Running an UDDS cycle we can get:



From this diagram we can get that:

0 to 60 mph acceleration time:9.4S

Wh/mile energy consumption:1120.22Wh/mile



Energy Usage Table (kJ)

	POWER MODE				REGEN MODE			
	In	Out	Loss	Eff.	In	Out	Loss	Eff.
Fuel	0	30426						
Fuel Converter	30426	5850	24576	0.19			358	
Clutch	5060	4909	152	0.97	530	530	0	1
Hyd. Torque Converter								
Generator								
Torque Coupling								
Energy Storage								
Energy Stored								
Motor/Controller								
Gearbox	4909	4606	303	0.94	582	530	52	0.91
Final Drive	4606	4606	0	1	582	582	0	1
Wheel/Axle	4606	4278	328	0.93	1888	1886	2	1
Braking							1304	
Aux Loads	958	0	958	0				
Aero			1056					
Rolling			1334					

*Overall System Efficiency

0.079

*Overall energy efficiency is calculated as: (aero + rolling)/(fuel in - ess storage)

Loss Plot (Power Mode) | Loss Plot (Regen Mode) | DONE

Fuel Converter 30426

Open the energy use figure we can find that the total consumption of energy in this cycle. The consumption equals the input of fuel converter which is 30246kJ=8401.67Wh (1Watt hour (Wh) is equal to 3.6 kilojoules KJ). We also can find the distance of this cycle which is 7.5mile from the diagram. Then we can get Wh/mile consumption=8401.67Wh/7.5mile=1120.22Wh/mile

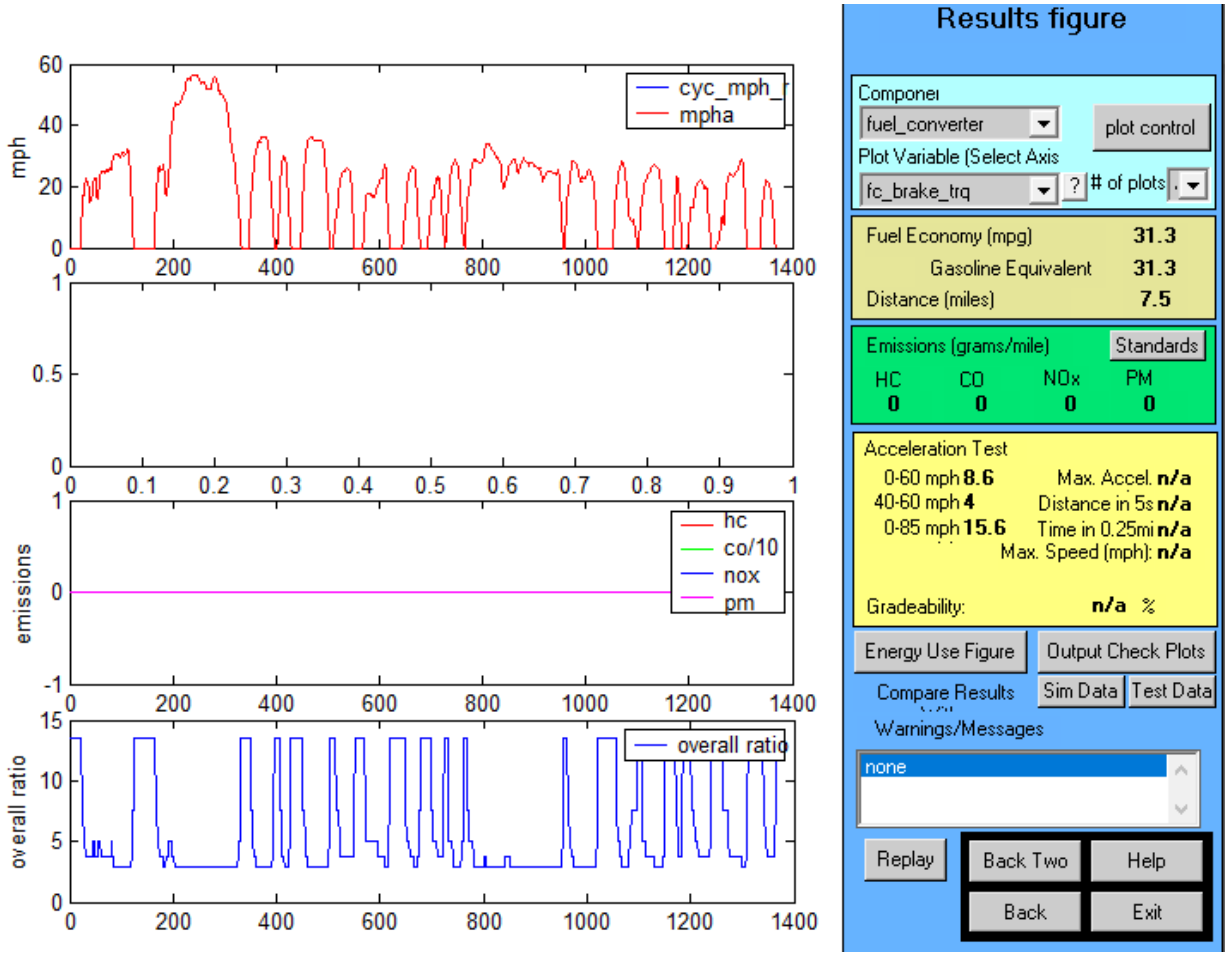
fuel economy (mpg): 29.6

Fuel Economy (mpg)	29.6
Gasoline Equivalent	29.6
Distance (miles)	7.5

The former setting of Cd is 0.335

Now change Cd to 0.2

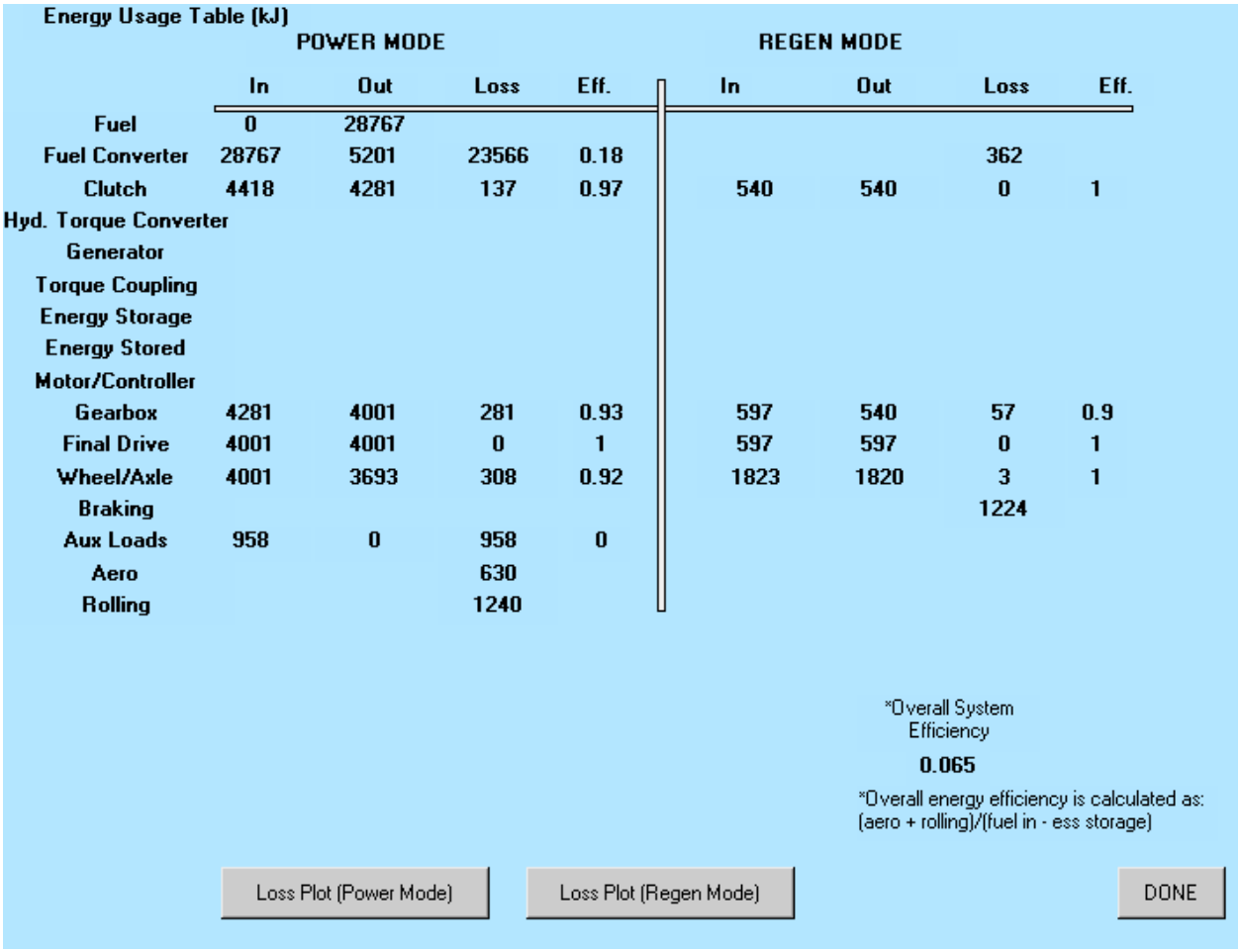
Running an UDDS cycle we can get:



From this diagram we can get that:

0 to o 60 mph acceleration time: 8.6S

Wh/mile energy consumption:1065.44Wh/mile



Energy Usage Table (kJ)

	POWER MODE				REGEN MODE			
	In	Out	Loss	Eff.	In	Out	Loss	Eff.
Fuel	0	28767						
Fuel Converter	28767	5201	23566	0.18			362	
Clutch	4418	4281	137	0.97	540	540	0	1
Hyd. Torque Converter								
Generator								
Torque Coupling								
Energy Storage								
Energy Stored								
Motor/Controller								
Gearbox	4281	4001	281	0.93	597	540	57	0.9
Final Drive	4001	4001	0	1	597	597	0	1
Wheel/Axle	4001	3693	308	0.92	1823	1820	3	1
Braking							1224	
Aux Loads	958	0	958	0				
Aero			630					
Rolling			1240					

*Overall System Efficiency

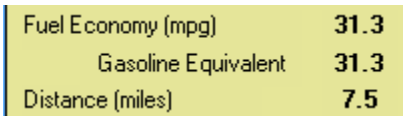
0.065

*Overall energy efficiency is calculated as: (aero + rolling)/(fuel in - ess storage)

Loss Plot (Power Mode) | Loss Plot (Regen Mode) | DONE

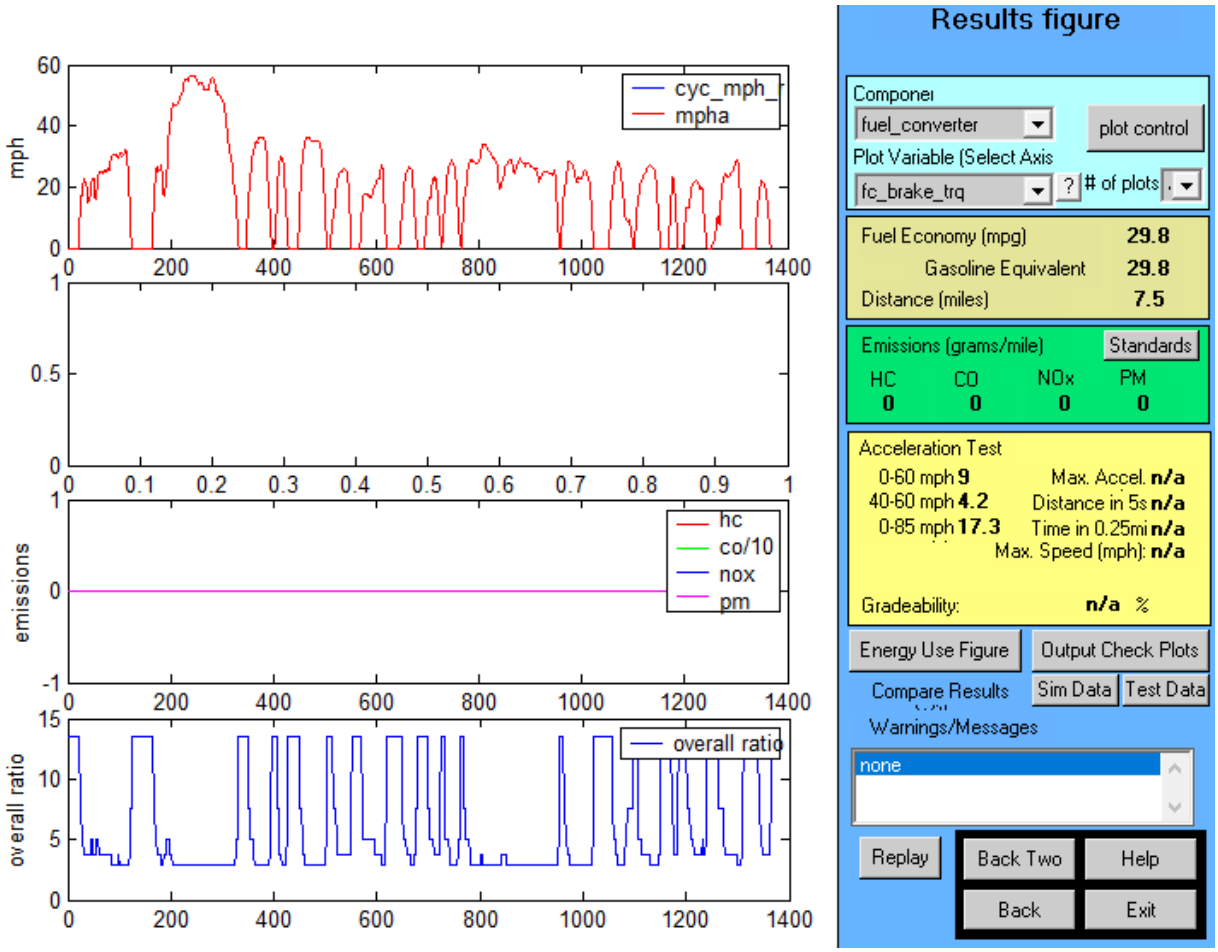
Open the energy use figure we can find that the total consumption of energy in this cycle. The consumption equals the input of fuel converter which is 28767kJ=7990.83Wh (1Watt hour (Wh) is equal to 3.6 kilojoules KJ). We also can find the distance of this cycle which is 7.5mile from the diagram. Then we can get Wh/mile consumption=7990.83Wh/7.5mile=1065.44Wh/mile

fuel economy (mpg): 31.3



Fuel Economy (mpg)	31.3
Gasoline Equivalent	31.3
Distance (miles)	7.5

Now change Cd to 0.44



From this diagram we can get that:

0 to 60 mph acceleration time:9 S

Wh/mile energy consumption:1119.85Wh/mile

Energy Usage Table (kJ)

	POWER MODE				REGEN MODE			
	In	Out	Loss	Eff.	In	Out	Loss	Eff.
Fuel	0	30236						
Fuel Converter	30236	5873	24363	0.19			326	
Clutch	5074	4937	137	0.97	488	488	0	1
Hyd. Torque Converter								
Generator								
Torque Coupling								
Energy Storage								
Energy Stored								
Motor/Controller								
Gearbox	4937	4634	303	0.94	537	488	49	0.91
Final Drive	4634	4634	0	1	537	537	0	1
Wheel/Axle	4634	4316	319	0.93	1689	1693	-4	1
Braking							1156	
Aux Loads	958	0	958	0				
Aero			1387					
Rolling			1240					

*Overall System Efficiency

0.087

*Overall energy efficiency is calculated as: (aero + rolling)/(fuel in - ess storage)

Loss Plot (Power Mode) | Loss Plot (Regen Mode) | DONE

Fuel Converter 30236

Open the energy use figure we can find that the total consumption of energy in this cycle. The consumption equals the input of fuel converter which is 30236kJ=8398.89Wh (1Watt hour (Wh) is equal to 3.6 kilojoules KJ). We also can find the distance of this cycle which is 7.5mile from the diagram. Then we can get Wh/mile consumption=8398.89Wh/7.5mile=1119.85Wh/mile

fuel economy (mpg): 29.8

Fuel Economy (mpg)	29.8
Gasoline Equivalent	29.8
Distance (miles)	7.5

In summary, we can get the information presented in this following table.

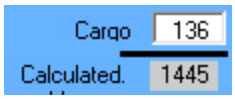
Vehicle Mass(kg)	1060	1171	1260
0 to 60 mph acceleration time(s)	8.3	8.8	9.4
energy consumption (Wh/mile)	1061.7	1095.63	1120.22
fuel economy (mpg)	31.4	30.4	29.6

Cd	0.2	0.335	0.44
0 to 60 mph acceleration time(s)	8.6	8.8	9
energy consumption (Wh/mile)	1065.44	1095.63	1119.85
fuel economy (mpg)	31.3	30.4	29.8

We can find that with increasing weight of vehicle or Cd, the acceleration time from 0 to 60mph, Wh/mile energy consumption will increase correspondingly, meanwhile the fuel economy will decrease.

Focus_in

We can change vehicle weight by changing the weight of cargo. The former setting is



In this setting, running an UDDS cycle we can get the data from question2:

0 to 60 mph acceleration time:20.4s

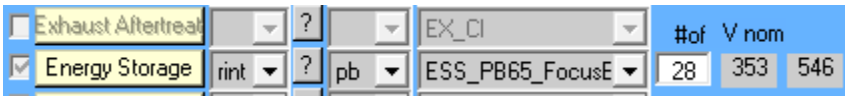
Wh/mile energy consumption:286Wh/mile

fuel economy (mpg):93.2(Gasoline Equivalent)

Range: **47.52 mile**

```
ess_max_ah_cap=[
    55
    55
    55
];  % (A*h), max. capacity at C/5 rate, indexed by ess_tmp
% average coulombic (a.k.a. amp-hour) efficiency below, indexed by ess_tmp
```

We can get the capacity of battery from the Matlab file, which is 55Ah(in C/5 rate). The nominal voltage of battery pack is 353V

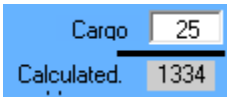


The energy of Battery=55Ah*353V=19415Wh

We set the DOD is 70% then we can get the range:

Range=19415Wh*70%/ (286Wh/mile)=47.52 mile

Now change cargo mass to 25kg and the vehicle weight will become 1334kg.



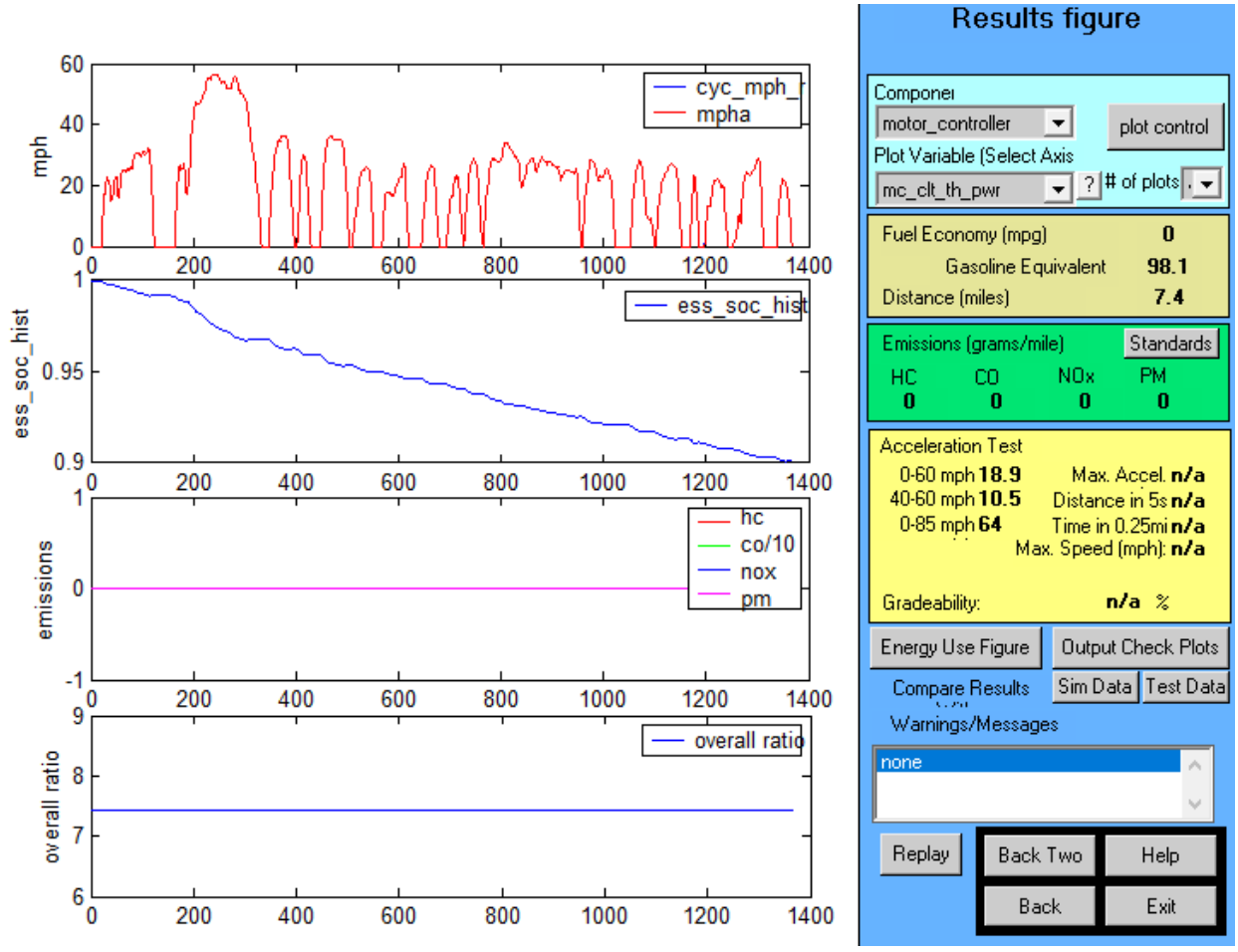
Running an UDDS cycle we can get:

0 to 60 mph acceleration time:18.9S

Wh/mile energy consumption:271.92Wh/mile

fuel economy (mpg): 98.1(Gasoline Equivalent)

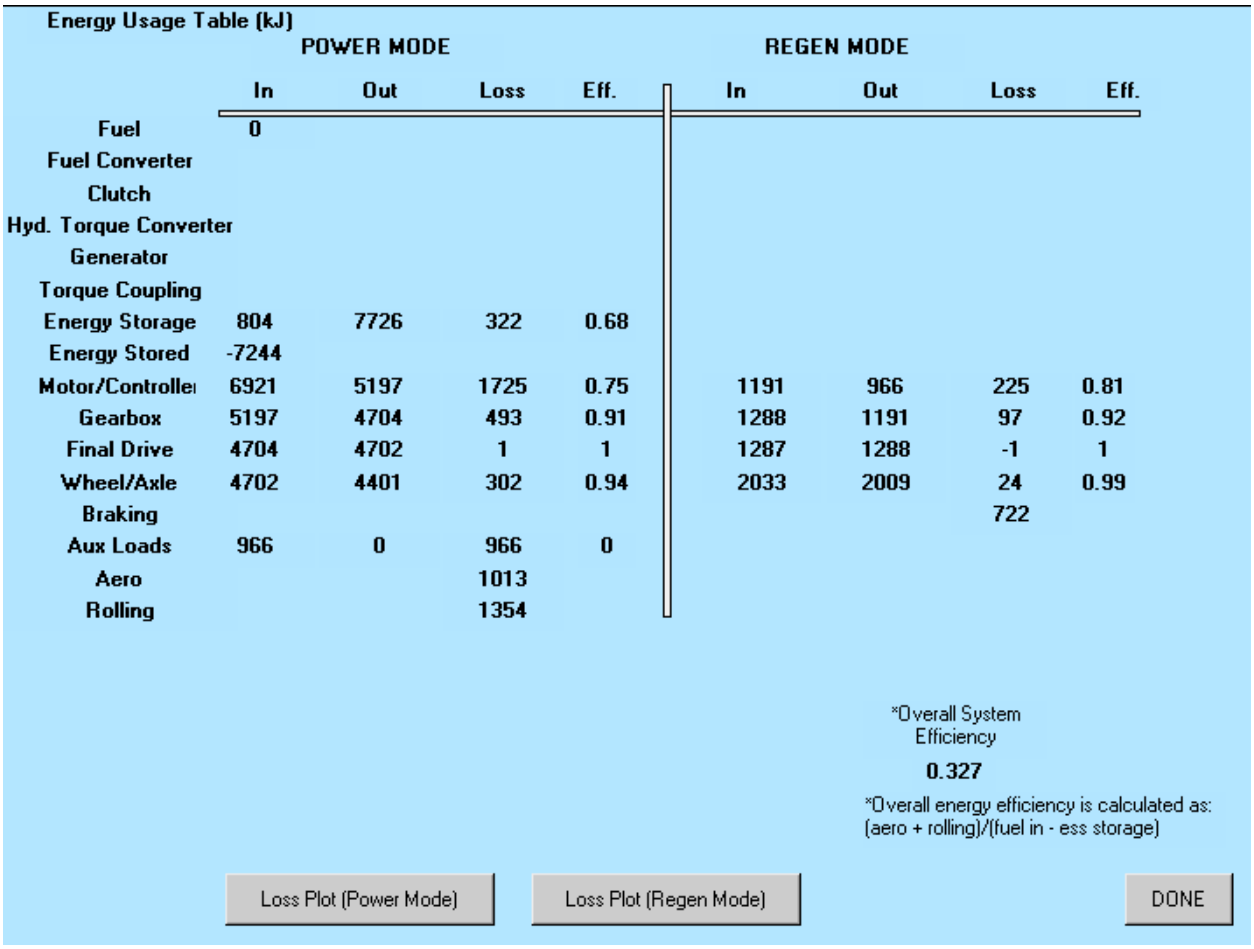
Range: 49.98 mile



From this diagram we can get that:

0 to 60 mph acceleration time:18.9S

Wh/mile energy consumption:271.92Wh/mile



Energy Usage Table (kJ)

	POWER MODE				REGEN MODE			
	In	Out	Loss	Eff.	In	Out	Loss	Eff.
Fuel	0							
Fuel Converter								
Clutch								
Hyd. Torque Converter								
Generator								
Torque Coupling								
Energy Storage	804	7726	322	0.68				
Energy Stored	-7244							
Motor/Controller	6921	5197	1725	0.75	1191	966	225	0.81
Gearbox	5197	4704	493	0.91	1288	1191	97	0.92
Final Drive	4704	4702	1	1	1287	1288	-1	1
Wheel/Axle	4702	4401	302	0.94	2033	2009	24	0.99
Braking							722	
Aux Loads	966	0	966	0				
Aero			1013					
Rolling			1354					

*Overall System Efficiency

0.327

*Overall energy efficiency is calculated as: (aero + rolling)/(fuel in - ess storage)

Loss Plot (Power Mode) | Loss Plot (Regen Mode) | DONE

Open the energy use figure we can find that the total consumption of energy in this cycle. The consumption equals the energy stored which is 7244kJ=2012.22Wh (1Watt hour (Wh) is equal to 3.6 kilojoules KJ). We also can find the distance of this cycle which is 7.4mile from the diagram. Then we can get Wh/mile consumption=2012.22Wh/7.4mile=271.92Wh/mile

fuel economy (mpg): 98.1(Gasoline Equivalent)

Fuel Economy (mpg)	**0**
Gasoline Equivalent	**98.1**
Distance (miles)	**7.4**

Range: 49.98 mile

```
ess_max_ah_cap=[
   55
   55
   55
];  % (A*h), max. capacity at C/5 rate, indexed by ess_tmp
% average coulombic (a.k.a. amp-hour) efficiency below, indexed by ess_tmp
```

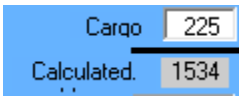
We can get the capacity of battery from the Matlab file, which is 55Ah(in C/5 rate). The nominal voltage of battery pack is 353V

The energy of Battery=55Ah*353V=19415Wh

We set the DOD is 70% then we can get the range:

Range=19415Wh*70%/ (271.92Wh/mile)=49.98 mile

Now change cargo mass to 225kg and the vehicle weight will become 1534kg.



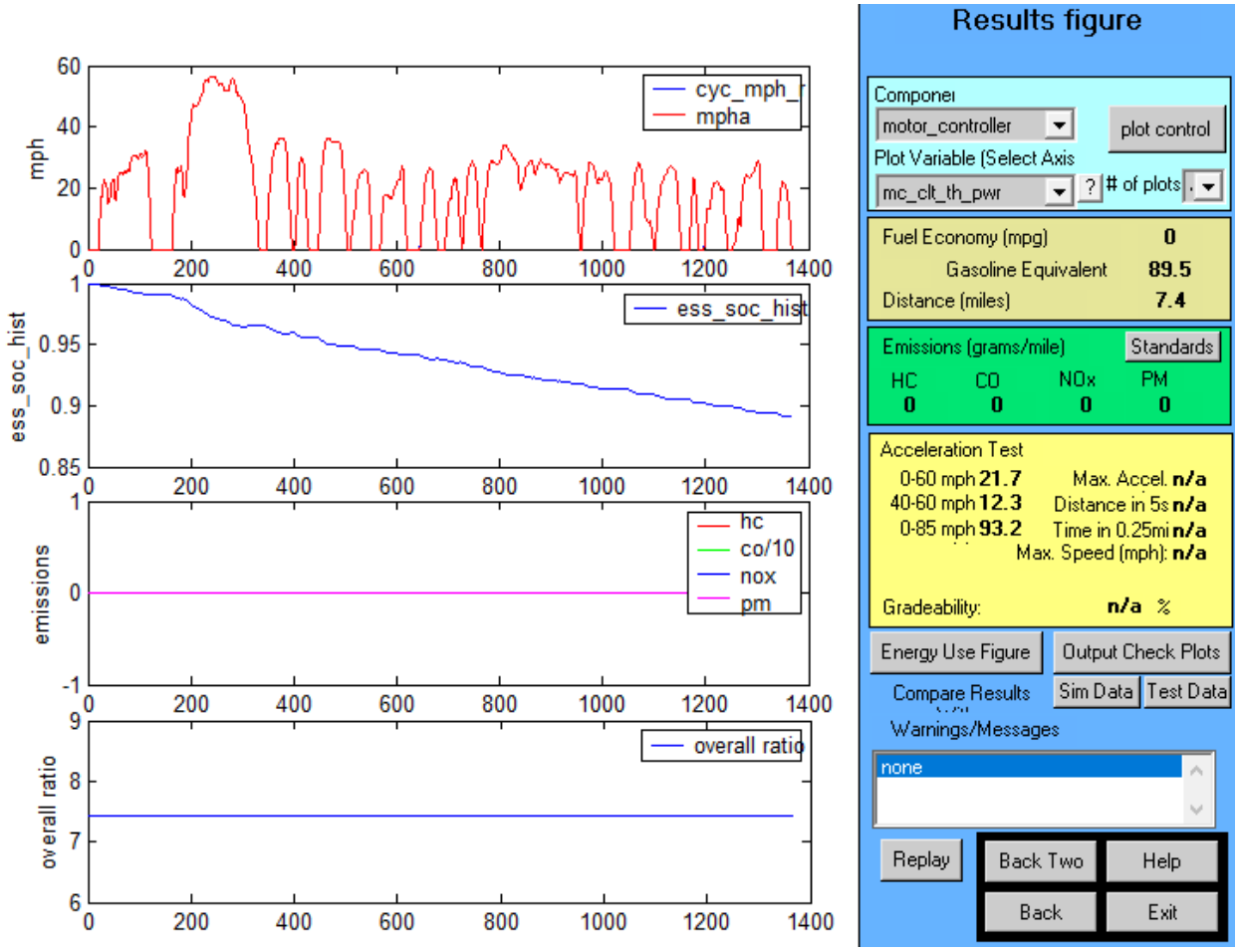
Running an UDD cycle we can get:

0 to 60 mph acceleration time:21.7S

Wh/mile energy consumption:297.48Wh/mile

fuel economy (mpg): 89.5(Gasoline Equivalent)

Range: 45.69 mile



From this diagram we can get that:

0 to 60 mph acceleration time:21.7S

Wh/mile energy consumption:297.48Wh/mile

Energy Usage Table (kJ)

	POWER MODE				REGEN MODE			
	In	Out	Loss	Eff.	In	Out	Loss	Eff.
Fuel	0							
Fuel Converter								
Clutch								
Hyd. Torque Converter								
Generator								
Torque Coupling								
Energy Storage	910	8457	378	0.67				
Energy Stored	-7925							
Motor/Controller	7662	5791	1871	0.76	1332	1082	250	0.81
Gearbox	5791	5268	523	0.91	1433	1332	101	0.93
Final Drive	5268	5267	1	1	1432	1433	-1	1
Wheel/Axle	5267	4940	327	0.94	2368	2332	36	0.98
Braking							900	
Aux Loads	966	0	966	0				
Aero			1013					
Rolling			1557					

*Overall System Efficiency

0.324

*Overall energy efficiency is calculated as: (aero + rolling)/(fuel in - ess storage)

Loss Plot (Power Mode) | Loss Plot (Regen Mode) | DONE

Energy Stored	-7925

Open the energy use figure we can find that the total consumption of energy in this cycle. The consumption equals the energy stored which is 7925kJ=2201.39Wh (1Watt hour (Wh) is equal to 3.6 kilojoules KJ). We also can find the distance of this cycle which is 7.4mile from the diagram. Then we can get Wh/mile consumption=2201.39Wh/7.4mile=297.48Wh/mile

fuel economy (mpg): 89.5(Gasoline Equivalent)

Fuel Economy (mpg)	0
Gasoline Equivalent	89.5
Distance (miles)	7.4

Range: 45.69 mile

```
ess_max_ah_cap=[
    55
    55
    55
];  % (A*h), max. capacity at C/5 rate, indexed by ess_tmp
% average coulombic (a.k.a. amp-hour) efficiency below, indexed by ess_tmp
```

We can get the capacity of battery from the Matlab file, which is 55Ah(in C/5 rate). The nominal voltage of battery pack is 353V

The energy of Battery=55Ah*353V=19415Wh

We set the DOD is 70% then we can get the range:

Range=19415Wh*70%/ (297.48Wh/mile)=45.69mile

The former setting of Cd is 0.312

Now change Cd to 0.2

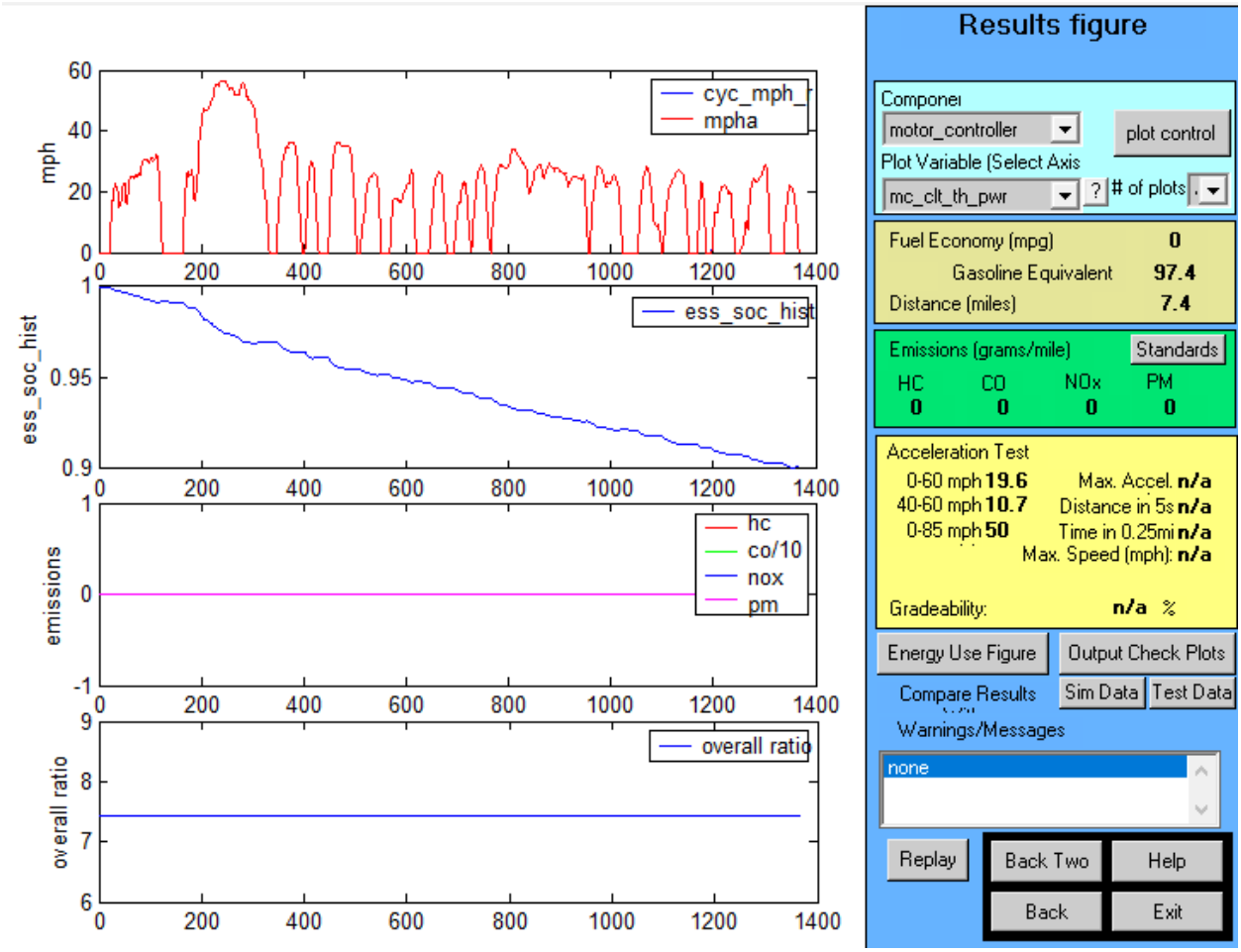
Running an UDDS cycle we can get:

0 to 60 mph acceleration time: 19.6S

Wh/mile energy consumption:272.07Wh/mile

fuel economy (mpg): 97.4 (Gasoline Equivalent)

Range: 49.95mile



From this diagram we can get that:

0 to 60 mph acceleration time: 19.6S

Wh/mile energy consumption:272.07Wh/mile

Energy Usage Table (kJ)

	POWER MODE				REGEN MODE			
	In	Out	Loss	Eff.	In	Out	Loss	Eff.
Fuel	0							
Fuel Converter								
Clutch								
Hyd. Torque Converter								
Generator								
Torque Coupling								
Energy Storage	887	7778	357	0.68				
Energy Stored	-7248							
Motor/Controller	6987	5218	1770	0.75	1310	1062	248	0.81
Gearbox	5218	4723	495	0.91	1415	1310	105	0.93
Final Drive	4723	4721	1	1	1413	1415	-1	1
Wheel/Axle	4721	4412	309	0.93	2295	2260	35	0.98
Braking							846	
Aux Loads	966	0	966	0				
Aero			649					
Rolling			1467					

*Overall System Efficiency

0.292

*Overall energy efficiency is calculated as: (aero + rolling)/(fuel in - ess storage)

Loss Plot (Power Mode) | Loss Plot (Regen Mode) | DONE

Energy Stored	-7248

Open the energy use figure we can find that the total consumption of energy in this cycle. The consumption equals the energy stored which is 7248kJ=2013.33Wh (1Watt hour (Wh) is equal to 3.6 kilojoules KJ). We also can find the distance of this cycle which is 7.4mile from the diagram. Then we can get Wh/mile consumption=2013.33Wh/7.4mile=272.07Wh/mile

fuel economy (mpg): 97.4 (Gasoline Equivalent)

Fuel Economy (mpg)	0
Gasoline Equivalent	97.4
Distance (miles)	7.4

Range: 49.95mile

```
ess_max_ah_cap=[
    55
    55
    55
];  % (A*h), max. capacity at C/5 rate, indexed by ess_tmp
% average coulombic (a.k.a. amp-hour) efficiency below, indexed by ess_tmp
```

We can get the capacity of battery from the Matlab file, which is 55Ah(in C/5 rate). The nominal voltage of battery pack is 353V

The energy of Battery=55Ah*353V=19415Wh

We set the DOD is 70% then we can get the range:

Range=19415Wh*70%/ (272.07Wh/mile)=49.95 mile

Now change Cd to 0.44

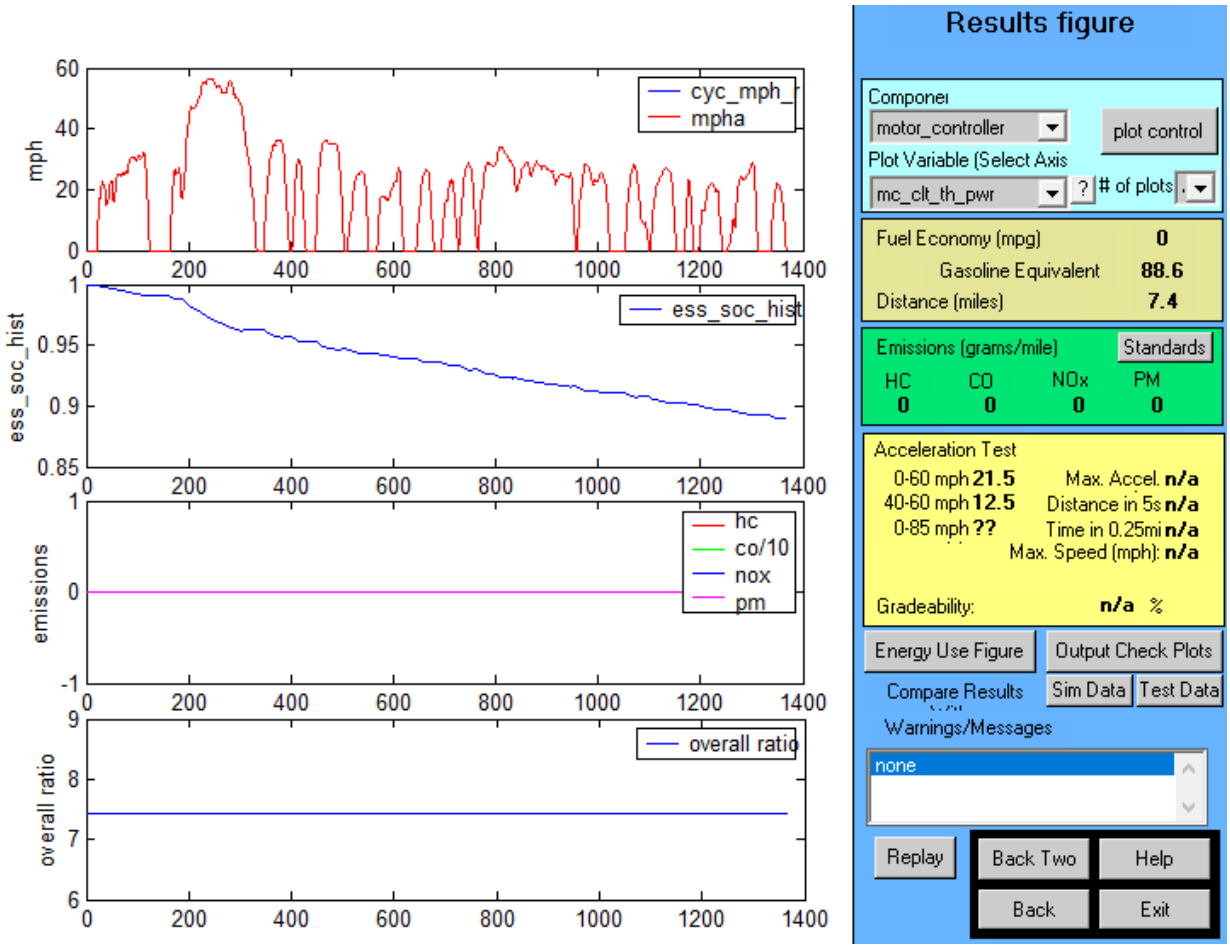
Running an UDDS cycle we can get:

0 to 60 mph acceleration time: 21.5S

Wh/mile energy consumption:302.21Wh/mile

fuel economy (mpg): 88.6 (Gasoline Equivalent)

Range: 44.97mile



From this diagram we can get that:

0 to 60 mph acceleration time: 21.5S

Wh/mile energy consumption:302.21Wh/mile

Energy Usage Table (kJ)

	POWER MODE				REGEN MODE			
	In	Out	Loss	Eff.	In	Out	Loss	Eff.
Fuel	0							
Fuel Converter								
Clutch								
Hyd. Torque Converter								
Generator								
Torque Coupling								
Energy Storage	841	8540	352	0.68				
Energy Stored	-8051							
Motor/Controller	7734	5889	1845	0.76	1233	1001	232	0.81
Gearbox	5889	5365	524	0.91	1328	1233	95	0.93
Final Drive	5365	5364	1	1	1327	1328	-1	1
Wheel/Axle	5364	5040	324	0.94	2144	2118	25	0.99
Braking							791	
Aux Loads	966	0	966	0				
Aero			1429					
Rolling			1467					

*Overall System Efficiency

0.36

*Overall energy efficiency is calculated as: (aero + rolling)/(fuel in - ess storage)

Loss Plot (Power Mode) | Loss Plot (Regen Mode) | DONE

Energy Stored	-8051

Open the energy use figure we can find that the total consumption of energy in this cycle. The consumption equals the energy stored which is 8051 kJ=2236.39Wh (1Watt hour (Wh) is equal to 3.6 kilojoules KJ). We also can find the distance of this cycle which is 7.4mile from the diagram. Then we can get Wh/mile consumption=2236.39Wh/7.4mile=302.21Wh/mile

fuel economy (mpg): 88.6 (Gasoline Equivalent)

Fuel Economy (mpg)	0
Gasoline Equivalent	88.6
Distance (miles)	7.4

Range: 44.97mile

```
ess_max_ah_cap=[
    55
    55
    55
];  % (A*h), max. capacity at C/5 rate, indexed by ess_tmp
% average coulombic (a.k.a. amp-hour) efficiency below, indexed by ess_tmp
```

We can get the capacity of battery from the Matlab file, which is 55Ah(in C/5 rate). The nominal voltage of battery pack is 353V

The energy of Battery=55Ah*353V=19415Wh

We set the DOD is 70% then we can get the range:

Range=19415Wh*70%/ (302.21Wh/mile)=44.97 mile

In summary, we can get the information presented in this following table.

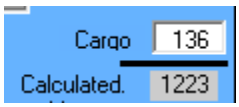
Vehicle Mass(kg)	**1334**	**1445**	**1534**
0 to 60 mph acceleration time(s)	**18.9**	**20.4**	**21.7**
energy consumption (Wh/mile)	**271.92**	**286**	**297.48**
fuel economy (mpg) (Gasoline Equivalent)	**98.1**	**93.2**	**89.5**
Range(mile)	**48.98**	**47.52**	**45.69**

Cd	0.2	0.315	0.44
0 to 60 mph acceleration time(s)	19.6	20.4	21.5
energy consumption (Wh/mile)	272.07	286	302.21
fuel economy (mpg) (Gasoline Equivalent)	97.4	93.2	88.6
Range(mile)	49.95	47.52	44.97

We can find that with increasing weight of vehicle or Cd, the acceleration time from 0 to 60mph, Wh/mile energy consumption will increase correspondingly, meanwhile the fuel economy and range will decrease.

gm_ev1_in

We can change vehicle weight by changing the weight of cargo. The former setting is



In this setting, running an UDDS cycle we can get the data from question2:

To 60 mph acceleration time:7S

Wh/mile energy consumption:187.04Wh/mile

fuel economy (mpg): 144.8(Gasoline Equivalent)

Range: **100.3 mile**

```
ess_max_ah_cap=[
    80
    80
    80
];  % (A*h), max. capacity at C/5 rate, indexed by ess_tmp
```

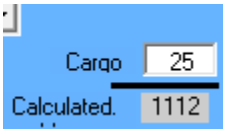
We can get the capacity of battery from the Matlab file, which is 80 Ah(in C/5 rate). The nominal voltage of battery pack is 335V

The energy of Battery=80Ah*335V=26800Wh

We set the DOD is 70% then we can get the range:

Range=26800Wh*70%/ (187.04Wh/mile)=100.3mile

Now change cargo mass to 10kg and the vehicle weight will become 1112kg.



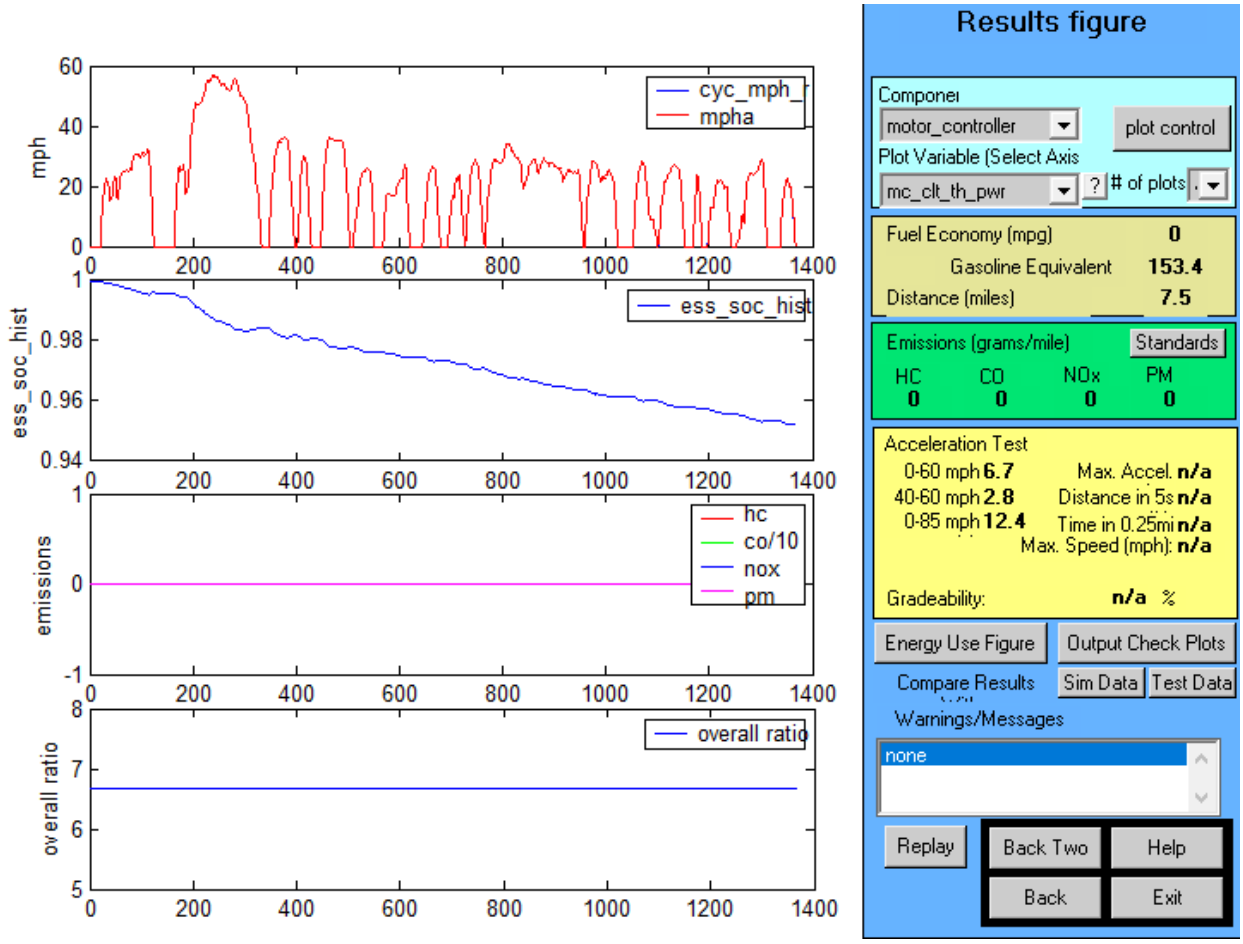
Running an UDDS cycle we can get:

To 60 mph acceleration time:6.7S

Wh/mile energy consumption:178.93Wh/mile

fuel economy (mpg): 153.4(Gasoline Equivalent)

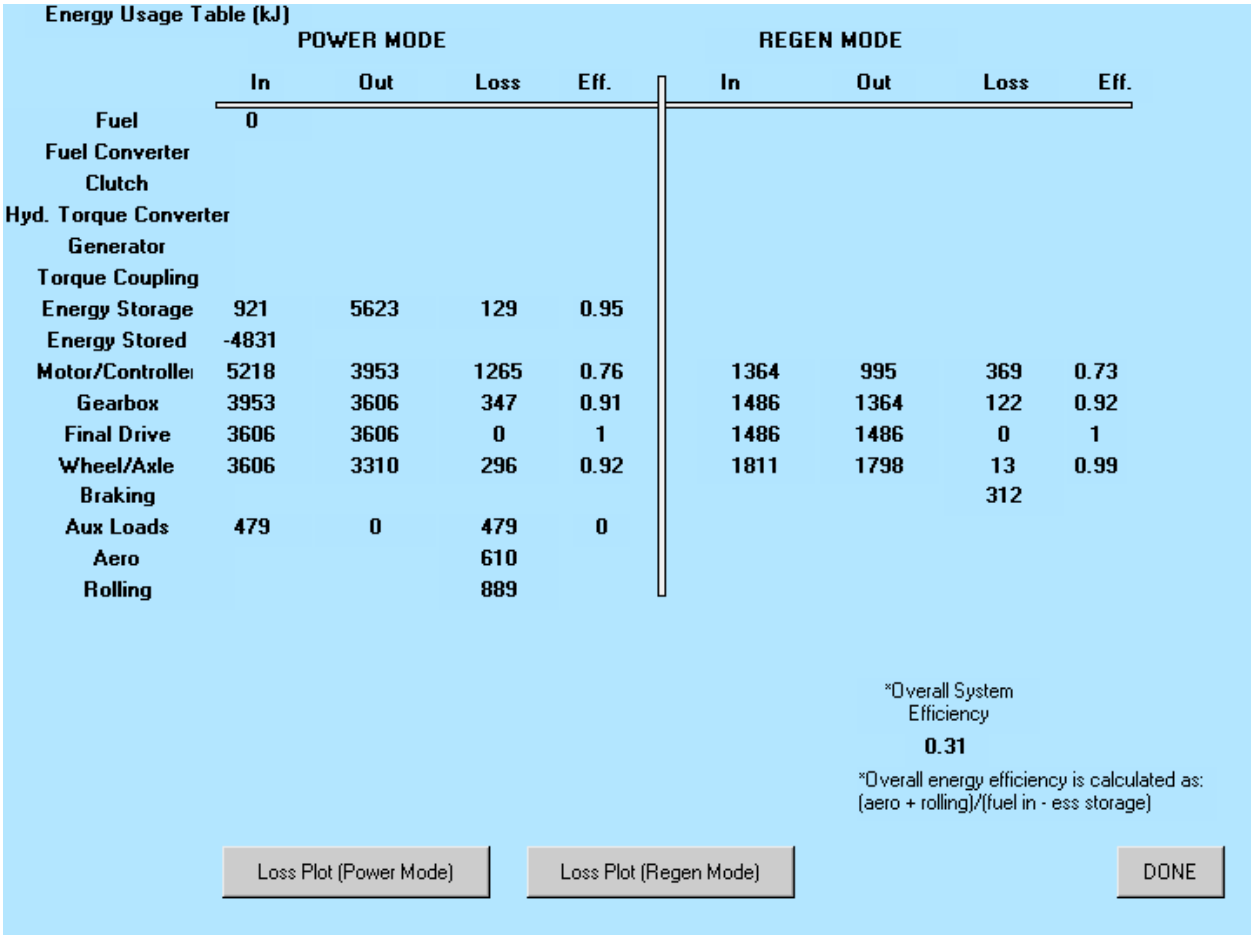
Range: 104.85 mile



From this diagram we can get that:

To 60 mph acceleration time:6.7S

Wh/mile energy consumption:178.93Wh/mile



Energy Usage Table (kJ)

	POWER MODE In	Out	Loss	Eff.	REGEN MODE In	Out	Loss	Eff.
Fuel	0							
Fuel Converter								
Clutch								
Hyd. Torque Converter								
Generator								
Torque Coupling								
Energy Storage	921	5623	129	0.95				
Energy Stored	-4831							
Motor/Controlle	5218	3953	1265	0.76	1364	995	369	0.73
Gearbox	3953	3606	347	0.91	1486	1364	122	0.92
Final Drive	3606	3606	0	1	1486	1486	0	1
Wheel/Axle	3606	3310	296	0.92	1811	1798	13	0.99
Braking							312	
Aux Loads	479	0	479	0				
Aero			610					
Rolling			889					

*Overall System Efficiency

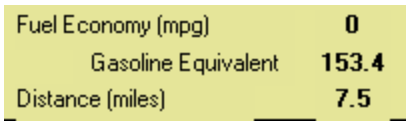
0.31

*Overall energy efficiency is calculated as: (aero + rolling)/(fuel in - ess storage)

Loss Plot (Power Mode) | Loss Plot (Regen Mode) | DONE

Open the energy use figure we can find that the total consumption of energy in this cycle. The consumption equals the energy stored which is 4831kJ=1341.94Wh (1Watt hour (Wh) is equal to 3.6 kilojoules KJ). We also can find the distance of this cycle which is 7.5mile from the diagram. Then we can get Wh/mile consumption=1341.94Wh/7.5mile=178.93Wh/mile

fuel economy (mpg): 153.4(Gasoline Equivalent)



Range: **104.85 mile**

```
ess_max_ah_cap=[
    80
    80
    80
];  % (A*h), max. capacity at C/5 rate, indexed by ess_tmp
```

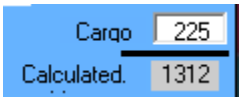
We can get the capacity of battery from the Matlab file, which is 80 Ah(in C/5 rate). The nominal voltage of battery pack is 335V

The energy of Battery=80Ah*335V=26800Wh

We set the DOD is 70% then we can get the range:

Range=26800Wh*70%/ (178.93Wh/mile)=104.85mile

Now change cargo mass to 225kg and the vehicle weight will become 1534kg.



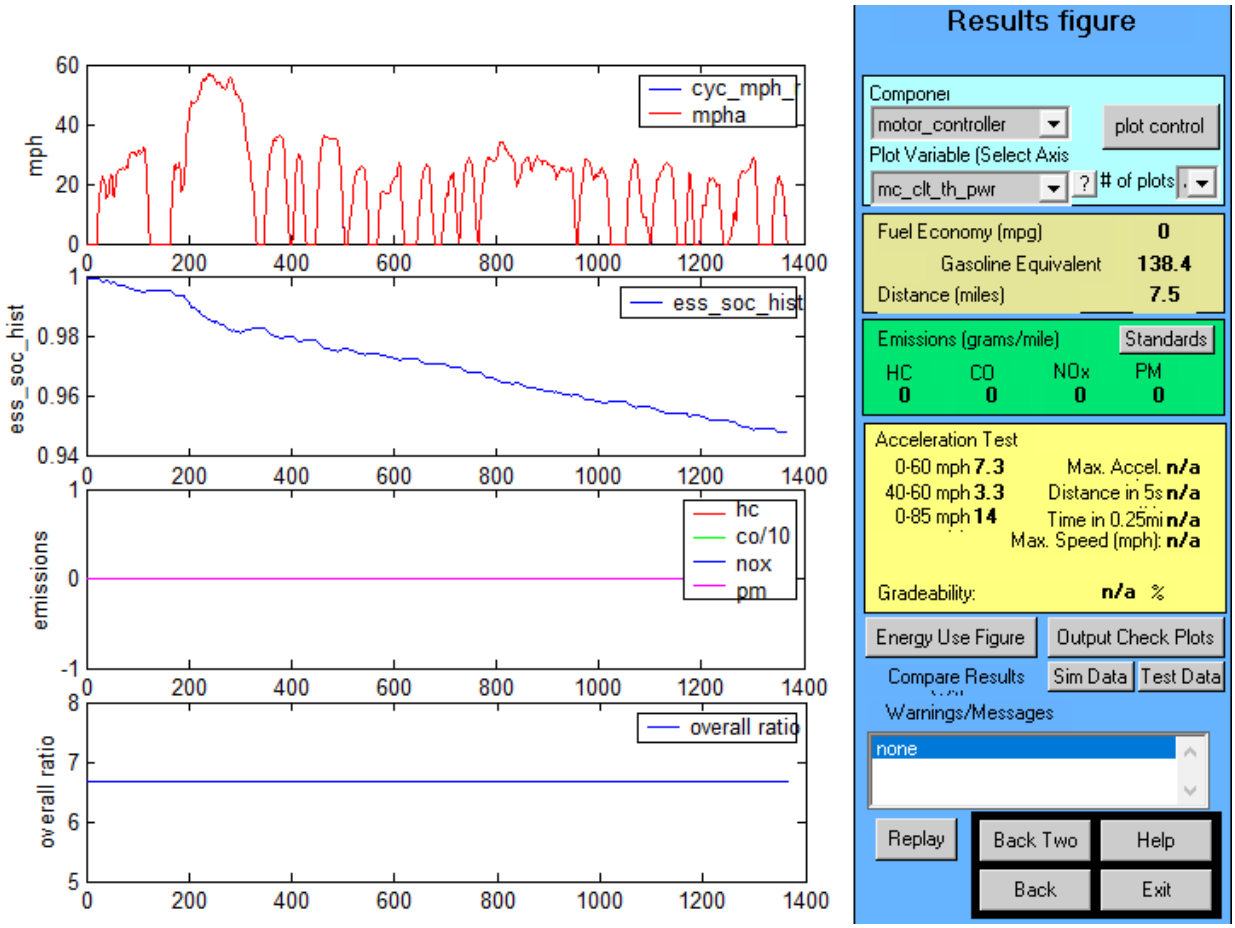
Running an UDDS cycle we can get:

To 60 mph acceleration time:7.3S

Wh/mile energy consumption:193.85Wh/mile

fuel economy (mpg): 138.4(Gasoline Equivalent)

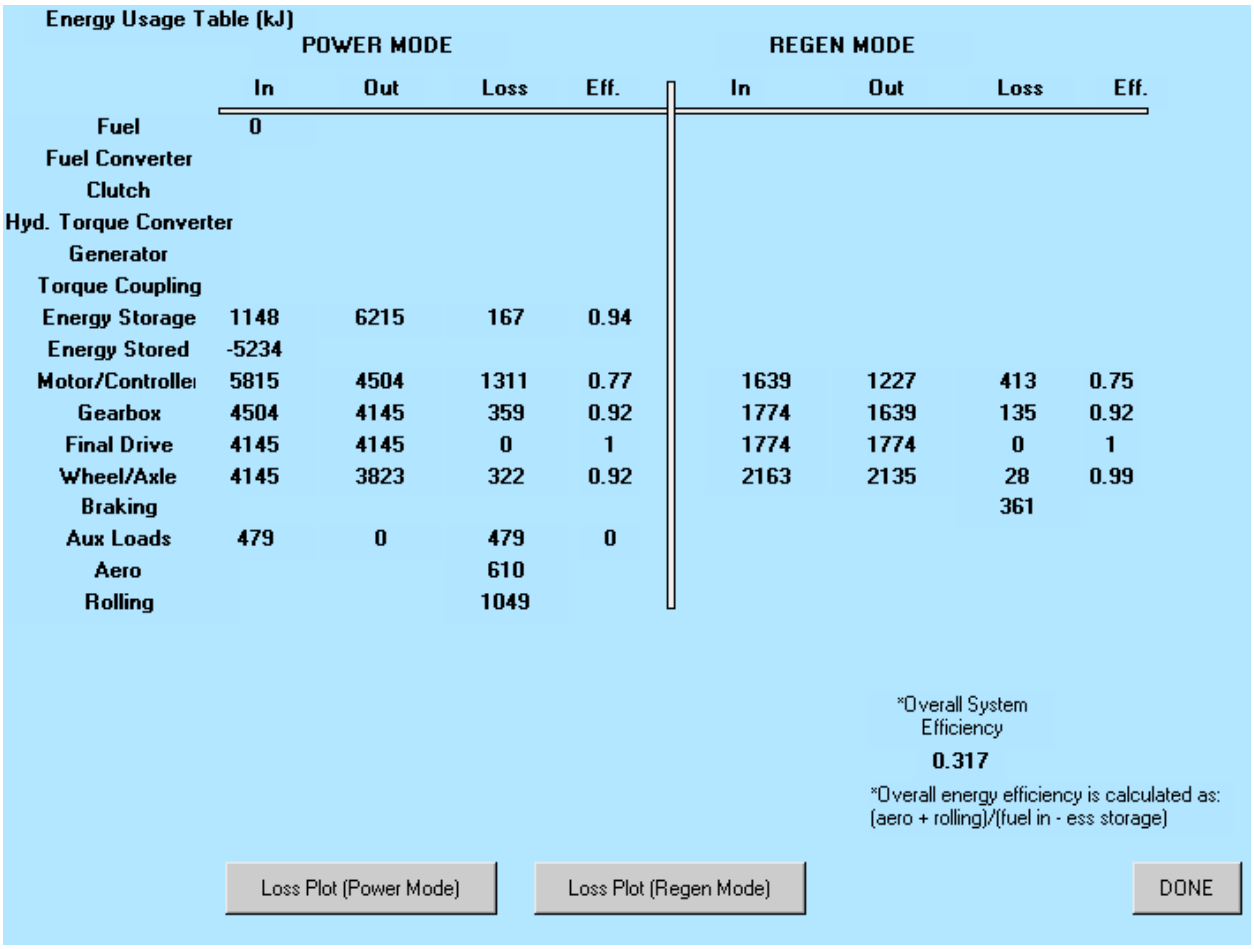
Range: **96.78 mile**



From this diagram we can get that:

To 60 mph acceleration time:7.3S

Wh/mile energy consumption:193.85Wh/mile



Energy Usage Table (kJ)

	POWER MODE In	Out	Loss	Eff.	REGEN MODE In	Out	Loss	Eff.
Fuel	0							
Fuel Converter								
Clutch								
Hyd. Torque Converter								
Generator								
Torque Coupling								
Energy Storage	1148	6215	167	0.94				
Energy Stored	-5234							
Motor/Controller	5815	4504	1311	0.77	1639	1227	413	0.75
Gearbox	4504	4145	359	0.92	1774	1639	135	0.92
Final Drive	4145	4145	0	1	1774	1774	0	1
Wheel/Axle	4145	3823	322	0.92	2163	2135	28	0.99
Braking							361	
Aux Loads	479	0	479	0				
Aero			610					
Rolling			1049					

*Overall System Efficiency

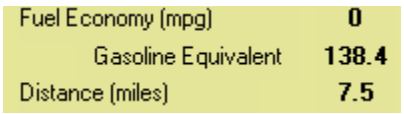
0.317

*Overall energy efficiency is calculated as: (aero + rolling)/(fuel in - ess storage)

Loss Plot (Power Mode) | Loss Plot (Regen Mode) | DONE

Open the energy use figure we can find that the total consumption of energy in this cycle. The consumption equals the energy stored which is 5234kJ=1453.89Wh (1Watt hour (Wh) is equal to 3.6 kilojoules KJ). We also can find the distance of this cycle which is 7.5mile from the diagram. Then we can get Wh/mile consumption=1453.89/7.5mile=193.85Wh/mile

fuel economy (mpg): 138.4(Gasoline Equivalent)



Range: **96.78 mile**

```
ess_max_ah_cap=[
    80
    80
    80
];  % (A*h), max. capacity at C/5 rate, indexed by ess_tmp
```

We can get the capacity of battery from the Matlab file, which is 80 Ah(in C/5 rate). The nominal voltage of battery pack is 335V

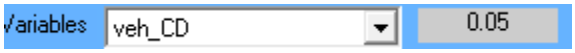
The energy of Battery=80Ah*335V=26800Wh

We set the DOD is 70% then we can get the range:

Range=26800Wh*70%/ (193.85Wh/mile)=96.78mile

The former setting of Cd is 0.19

Now change Cd to 0.05



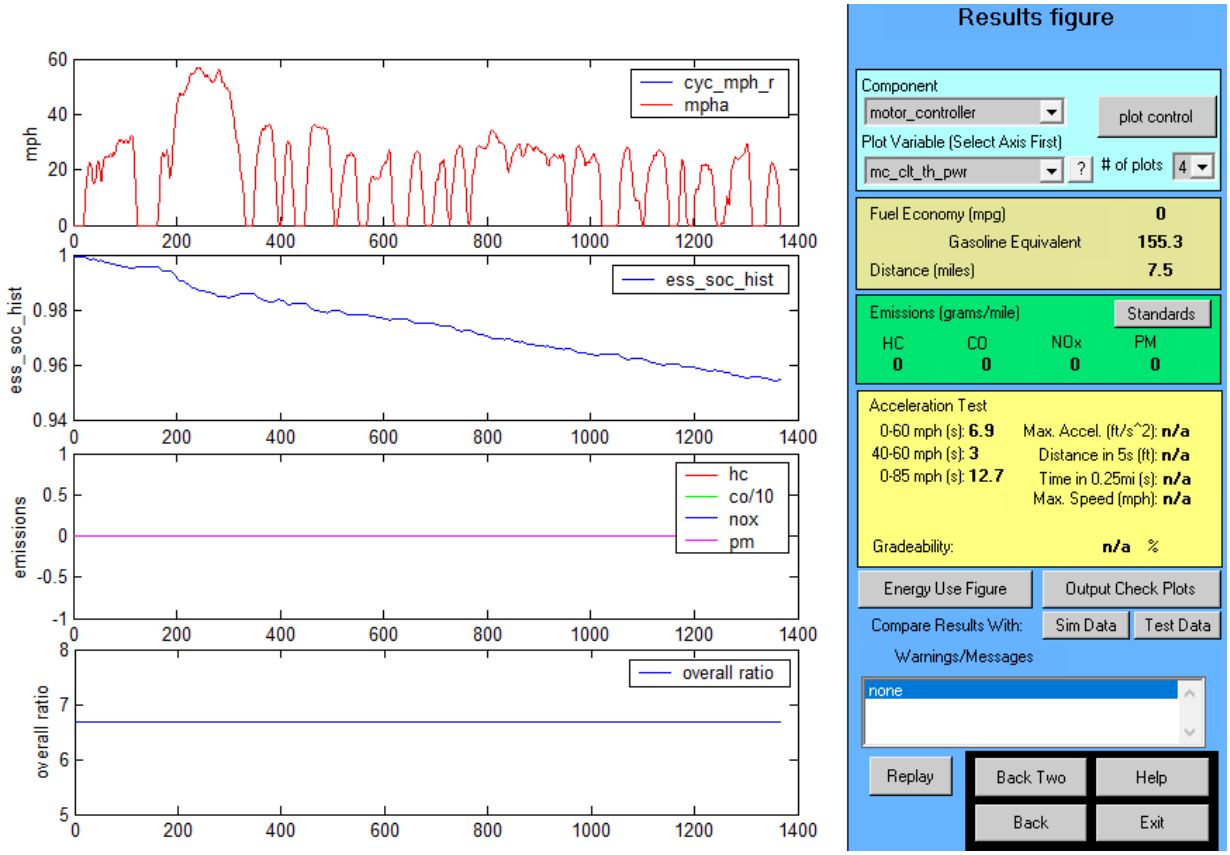
Running an UDDS cycle we can get:

To 60 mph acceleration time: 6.9S

Wh/mile energy consumption: 169.93Wh/mile

fuel economy (mpg): 155.3 (Gasoline Equivalent)

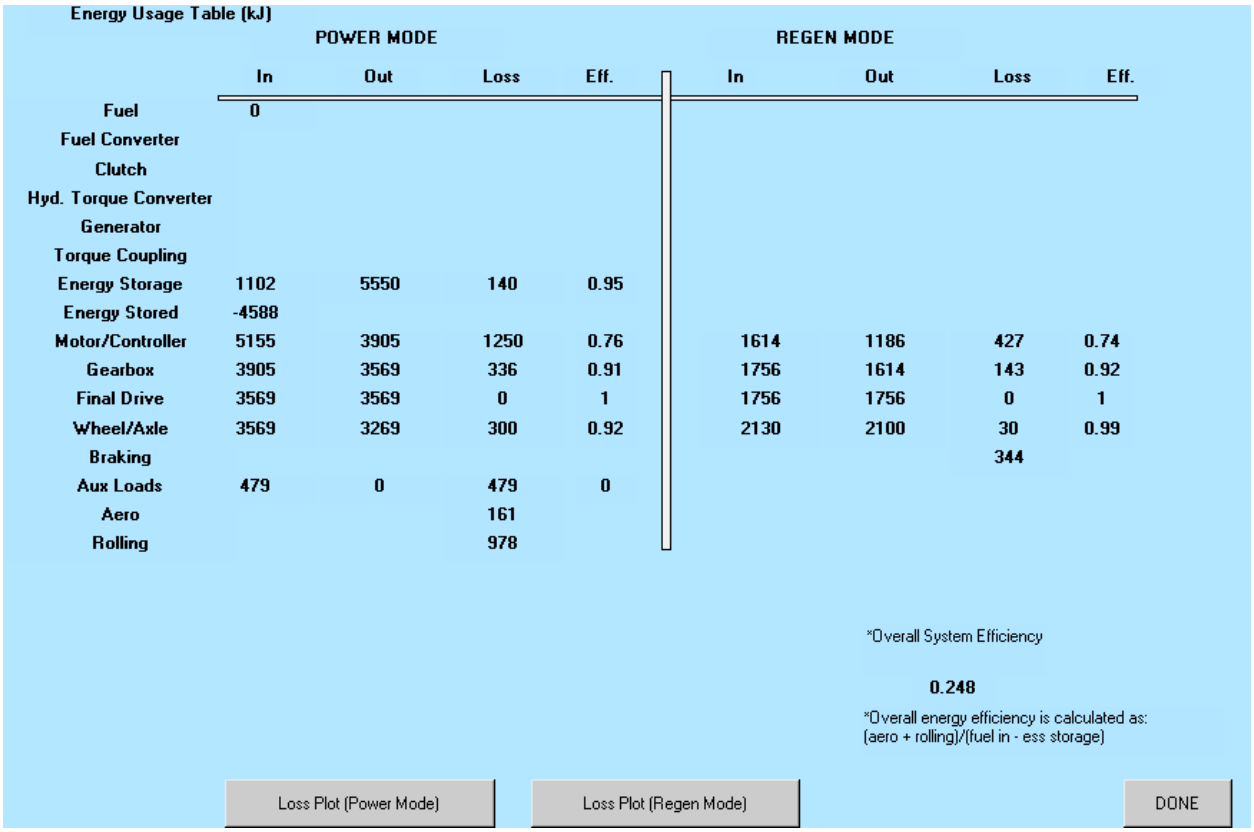
Range: **110.4 mile**



From this diagram we can get that:

To 60 mph acceleration time: 6.9S

Wh/mile energy consumption: 169.93Wh/mile



Energy Usage Table (kJ)

	POWER MODE				REGEN MODE			
	In	Out	Loss	Eff.	In	Out	Loss	Eff.
Fuel	0							
Fuel Converter								
Clutch								
Hyd. Torque Converter								
Generator								
Torque Coupling								
Energy Storage	1102	5550	140	0.95				
Energy Stored	-4588							
Motor/Controller	5155	3905	1250	0.76	1614	1186	427	0.74
Gearbox	3905	3569	336	0.91	1756	1614	143	0.92
Final Drive	3569	3569	0	1	1756	1756	0	1
Wheel/Axle	3569	3269	300	0.92	2130	2100	30	0.99
Braking							344	
Aux Loads	479	0	479	0				
Aero			161					
Rolling			978					

*Overall System Efficiency

0.248

*Overall energy efficiency is calculated as:
(aero + rolling)/(fuel in - ess storage)

Loss Plot (Power Mode) | Loss Plot (Regen Mode) | DONE

Energy Stored	-4588

Open the energy use figure we can find that the total consumption of energy in this cycle. The consumption equals the energy stored which is 4588kJ=1274.44Wh (1Watt hour (Wh) is equal to 3.6 kilojoules KJ). We also can find the distance of this cycle which is 7.5mile from the diagram. Then we can get Wh/mile consumption=1274.44Wh/7.5mile=169.93Wh/mile

fuel economy (mpg): 155.3 (Gasoline Equivalent)

Fuel Economy (mpg)	0
Gasoline Equivalent	155.3
Distance (miles)	7.5

Range: **110.4 mile**

```
ess_max_ah_cap=[
    80
    80
    80
];  % (A*h), max. capacity at C/5 rate, indexed by ess_tmp
```

We can get the capacity of battery from the Matlab file, which is 80 Ah(in C/5 rate). The nominal voltage of battery pack is 335V

The energy of Battery=80Ah*335V=26800Wh

We set the DOD is 70% then we can get the range:

Range=26800Wh*70%/ (169.93Wh/mile)=110.4mile

Now change Cd to 0.3

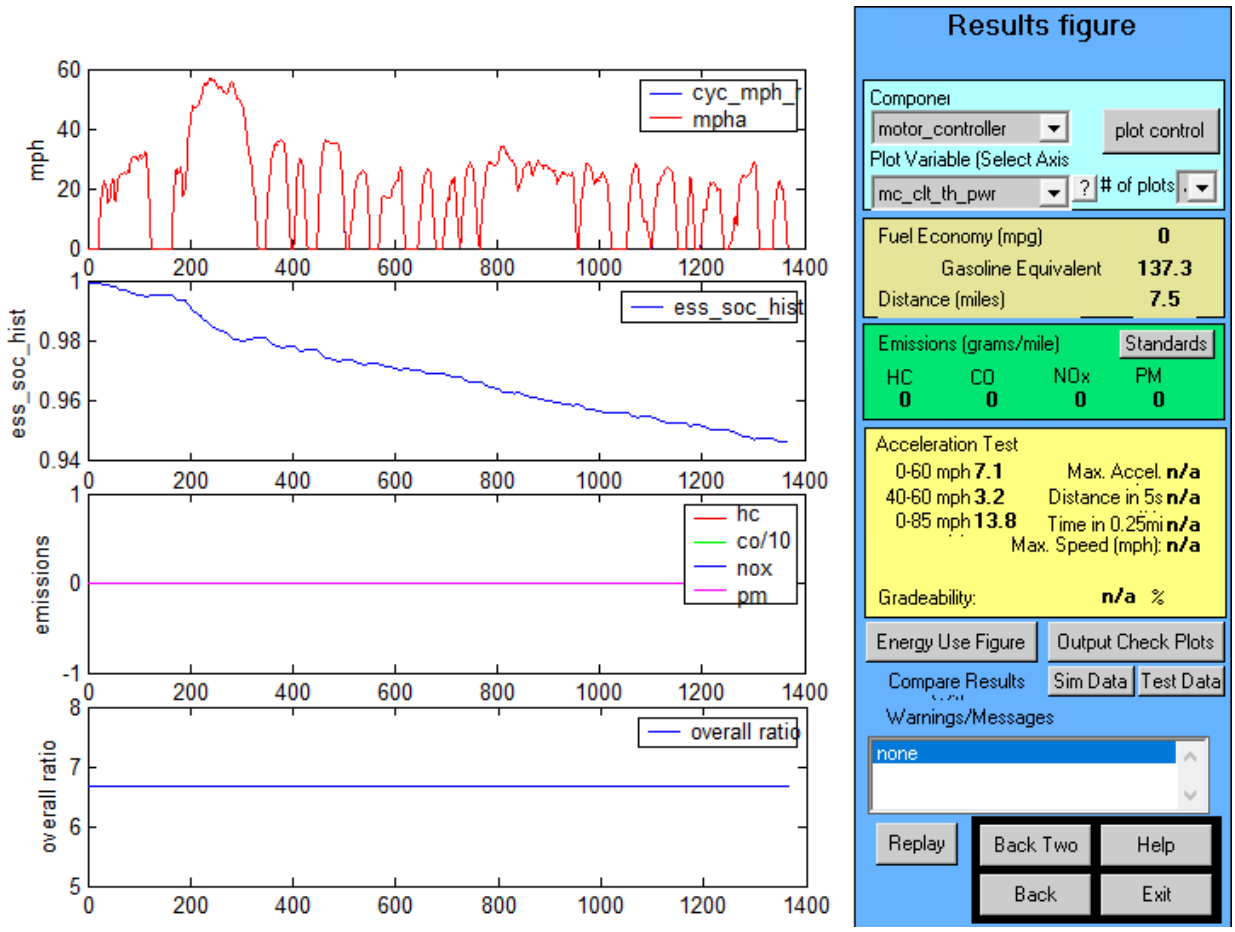
Running an UDDS cycle we can get:

To 60 mph acceleration time: 7.1S

Wh/mile energy consumption:200.56Wh/mile

fuel economy (mpg): 137.3 (Gasoline Equivalent)

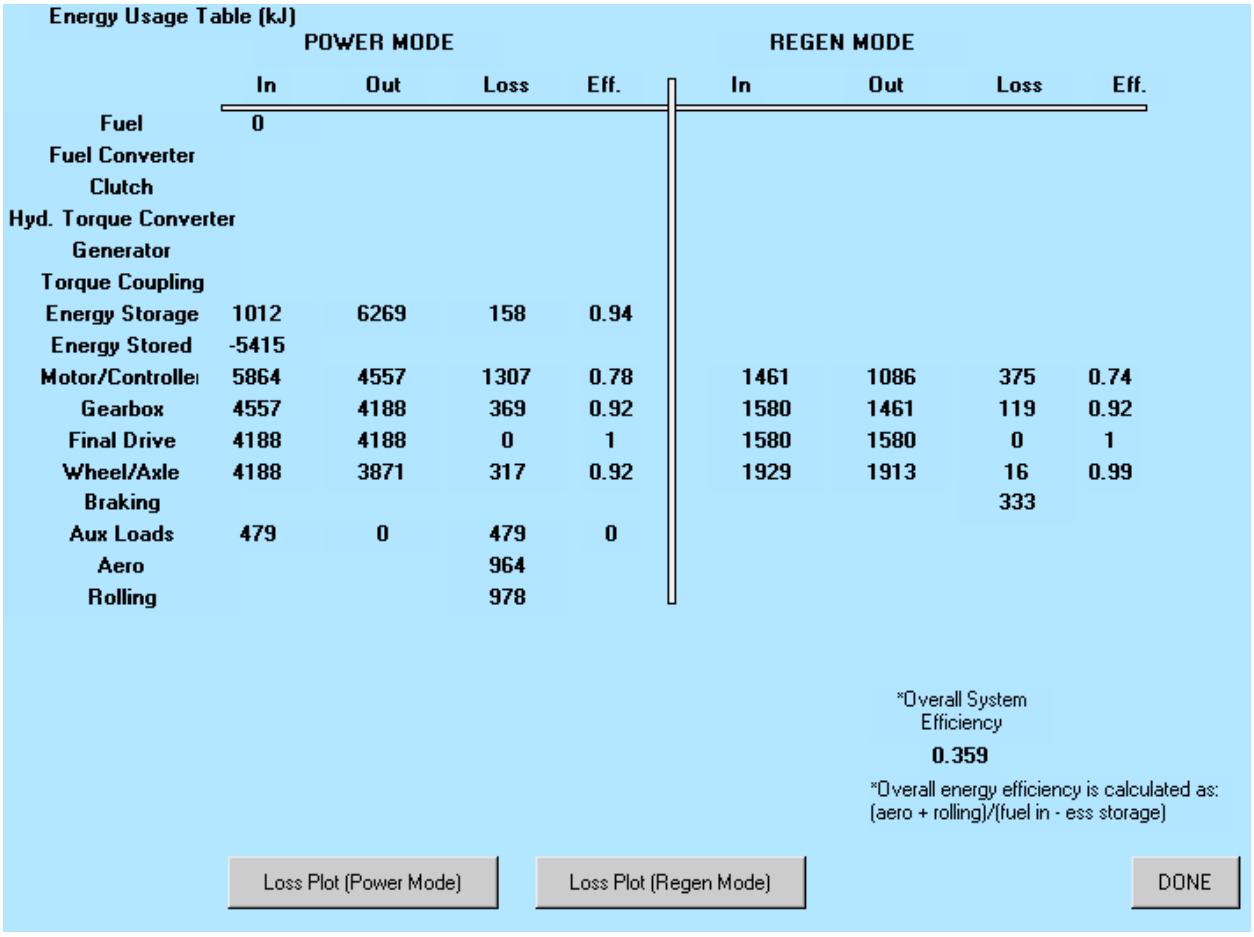
Range: 93.54 mile



From this diagram we can get that:

To 60 mph acceleration time: 7.1S

Wh/mile energy consumption:200.56Wh/mile



Energy Usage Table (kJ)

	POWER MODE In	Out	Loss	Eff.	REGEN MODE In	Out	Loss	Eff.
Fuel	0							
Fuel Converter								
Clutch								
Hyd. Torque Converter								
Generator								
Torque Coupling								
Energy Storage	1012	6269	158	0.94				
Energy Stored	-5415							
Motor/Controller	5864	4557	1307	0.78	1461	1086	375	0.74
Gearbox	4557	4188	369	0.92	1580	1461	119	0.92
Final Drive	4188	4188	0	1	1580	1580	0	1
Wheel/Axle	4188	3871	317	0.92	1929	1913	16	0.99
Braking							333	
Aux Loads	479	0	479	0				
Aero			964					
Rolling			978					

*Overall System Efficiency

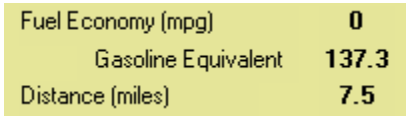
0.359

*Overall energy efficiency is calculated as: (aero + rolling)/(fuel in - ess storage)

Loss Plot (Power Mode) | Loss Plot (Regen Mode) | DONE

Open the energy use figure we can find that the total consumption of energy in this cycle. The consumption equals the energy stored which is 5415 kJ=1504.17Wh (1Watt hour (Wh) is equal to 3.6 kilojoules KJ). We also can find the distance of this cycle which is 7.5mile from the diagram. Then we can get Wh/mile consumption=1504.17Wh/7.5mile=200.56Wh/mile

fuel economy (mpg): 137.3 (Gasoline Equivalent)



Range: 93.54 mile

```
ess_max_ah_cap=[
    80
    80
    80
];  % (A*h), max. capacity at C/5 rate, indexed by ess_tmp
```

We can get the capacity of battery from the Matlab file, which is 80 Ah(in C/5 rate). The nominal voltage of battery pack is 335V

The energy of Battery=80Ah*335V=26800Wh

We set the DOD is 70% then we can get the range:

Range=26800Wh*70%/ (200.56Wh/mile)=93.54mile

In summary, we can get the information presented in this following table.

Vehicle Mass(kg)	1112	1223	1312
0 to 60 mph acceleration time(s)	6.7	7	7.3
energy consumption (Wh/mile)	178.93	187.04	193.85
fuel economy (mpg) (Gasoline Equivalent)	153.4	144.8	138.4

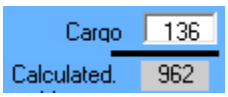
Range(mile)	**104.85**	**100.3**	**96.78**

Cd	**0.05**	**0.19**	**0.3**
0 to 60 mph acceleration time(s)	**6.9**	**7**	**7.1**
energy consumption (Wh/mile)	**169.93**	**187.04**	**200.56**
fuel economy (mpg) (Gasoline Equivalent)	**155.3**	**144.8**	**137.3**
Range(mile)	**110.4**	**100.3**	**93.54**

We can find that with increasing weight of vehicle or Cd, the acceleration time from 0 to 60mph, Wh/mile energy consumption will increase correspondingly, meanwhile the fuel economy and range will decrease.

INSIGHT_defults_in

We can change vehicle weight by changing the weight of cargo. The former setting is



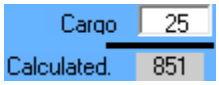
In this setting, running an UDDS cycle we can get the data from question2:

To 60 mph acceleration time: 11.5s

Wh/mile energy consumption:537.89Wh/mile

fuel economy (mpg): 62

Now change cargo mass to 25kg and the vehicle weight will become 851kg.

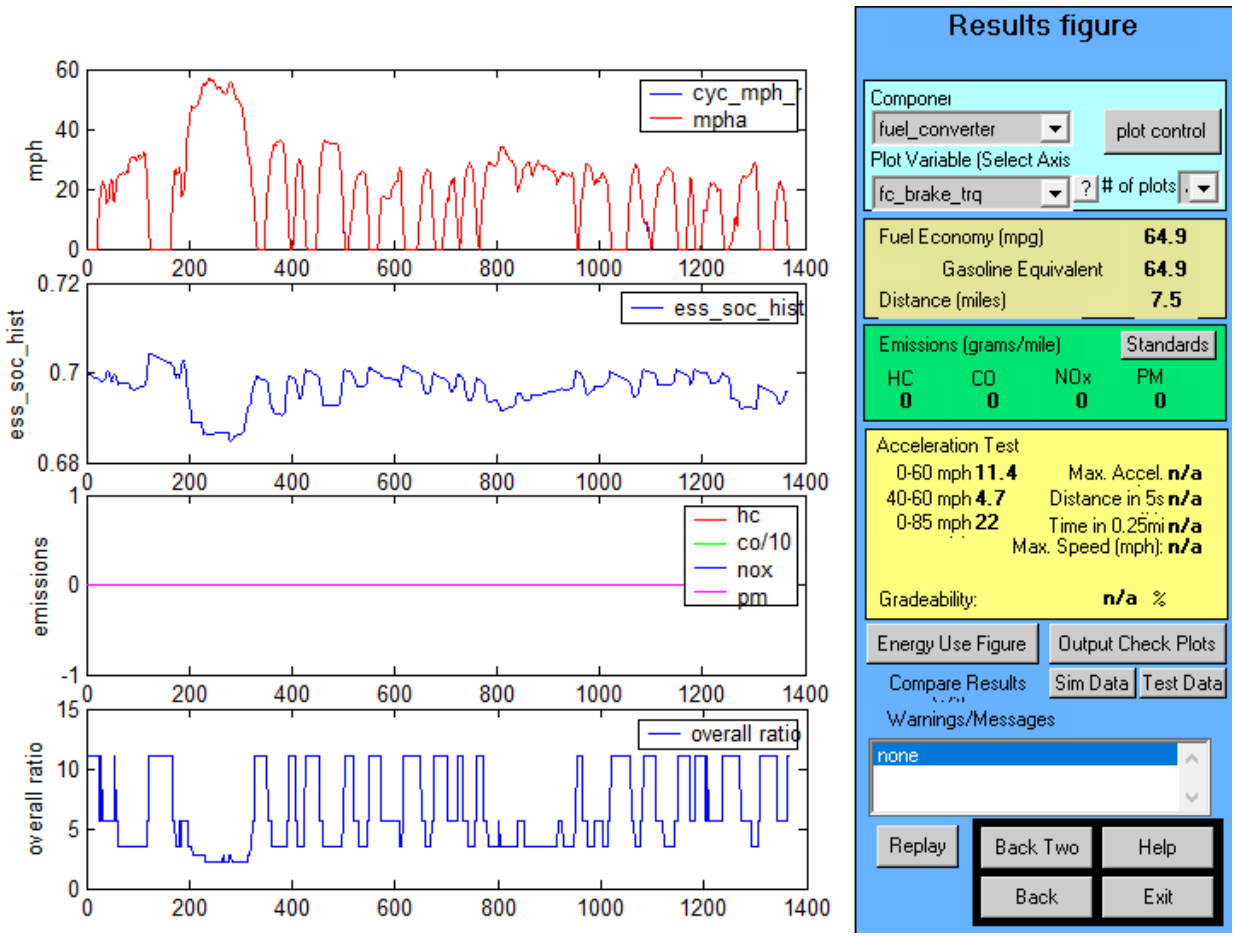


Running an UDDS cycle we can get:

To 60 mph acceleration time:11.4 S

Wh/mile energy consumption:513.56Wh/mile

fuel economy (mpg): 64.9



From this diagram we can get that:

To 60 mph acceleration time:11.4 S

Wh/mile energy consumption:513.56Wh/mile

Energy Usage Table (kJ)

	POWER MODE				REGEN MODE			
	In	Out	Loss	Eff.	In	Out	Loss	Eff.
Fuel	0	13866						
Fuel Converter	13866	3251	10615	0.23			398	
Clutch	3282	3189	94	0.97	957	957	0	1
Hyd. Torque Converter								
Generator								
Torque Coupling	3282	3282	0	1	961	961	0	1
Energy Storage	456	392	80	0.83				
Energy Stored	-16							
Motor/Controller	277	241	36	0.87	772	614	158	0.8
Gearbox	3189	2917	272	0.91	1042	957	84	0.92
Final Drive	2917	2917	0	1	1042	1042	0	1
Wheel/Axle	2917	2655	262	0.91	1366	1369	-3	1
Braking							327	
Aux Loads	274	0	274	0				
Aero			749					
Rolling			540					

*Overall System Efficiency

0.093

*Overall energy efficiency is calculated as: (aero + rolling)/(fuel in - ess storage)

Loss Plot (Power Mode) | Loss Plot (Regen Mode) | DONE

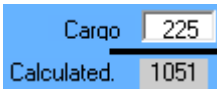
Fuel Converter 13866

Open the energy use figure we can find that the total consumption of energy in this cycle. The consumption equals the input of fuel converter which is 13866kJ=3851.67Wh (1Watt hour (Wh) is equal to 3.6 kilojoules KJ). We also can find the distance of this cycle which is 7.5mile from the diagram. Then we can get Wh/mile consumption=3851.67Wh/7.5mile=513.56Wh/mile

fuel economy (mpg): 64.9

Fuel Economy (mpg)	64.9
Gasoline Equivalent	64.9
Distance (miles)	7.5

Now change cargo mass to 225kg and the vehicle weight will become 1051kg.



Running an UDDS cycle we can get:

To 60 mph acceleration time:12.3S

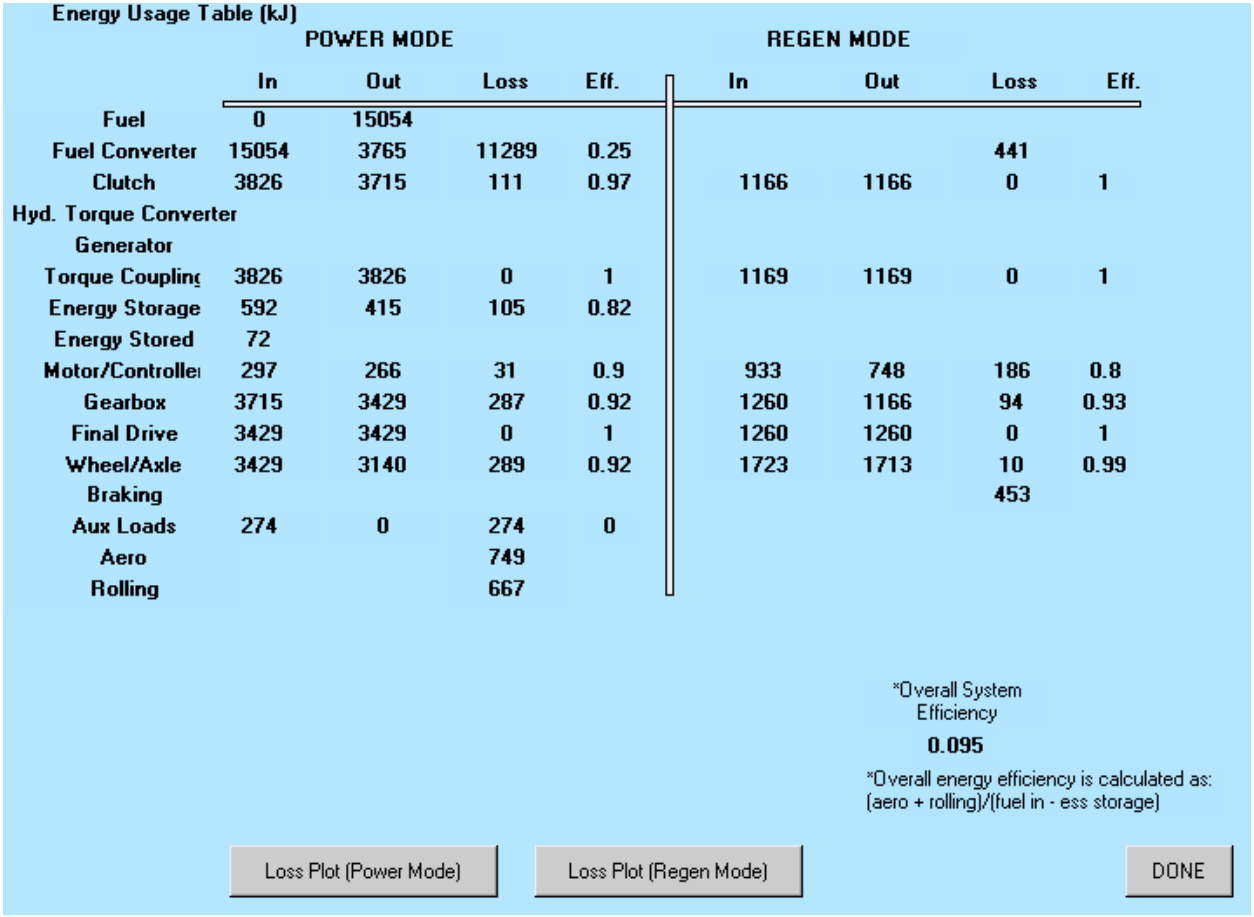
Wh/mile energy consumption:557.56Wh/mile

fuel economy (mpg): 59.8(Gasoline Equivalent)

From this diagram we can get that:

To 60 mph acceleration time:12.3S

Wh/mile energy consumption:557.56Wh/mile



Energy Usage Table (kJ)

	POWER MODE				REGEN MODE			
	In	Out	Loss	Eff.	In	Out	Loss	Eff.
Fuel	0	15054						
Fuel Converter	15054	3765	11289	0.25			441	
Clutch	3826	3715	111	0.97	1166	1166	0	1
Hyd. Torque Converter								
Generator								
Torque Couplin	3826	3826	0	1	1169	1169	0	1
Energy Storage	592	415	105	0.82				
Energy Stored	72							
Motor/Controlle	297	266	31	0.9	933	748	186	0.8
Gearbox	3715	3429	287	0.92	1260	1166	94	0.93
Final Drive	3429	3429	0	1	1260	1260	0	1
Wheel/Axle	3429	3140	289	0.92	1723	1713	10	0.99
Braking							453	
Aux Loads	274	0	274	0				
Aero			749					
Rolling			667					

*Overall System Efficiency

0.095

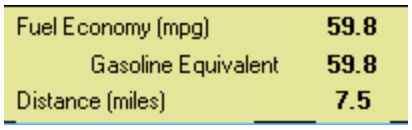
*Overall energy efficiency is calculated as: (aero + rolling)/(fuel in - ess storage)

Loss Plot (Power Mode) | Loss Plot (Regen Mode) | DONE

Fuel Converter 15054

Open the energy use figure we can find that the total consumption of energy in this cycle. The consumption equals the input of fuel converter which is 15054kJ=4181.67Wh (1Watt hour (Wh) is equal to 3.6 kilojoules KJ). We also can find the distance of this cycle which is 7.5mile from the diagram. Then we can get Wh/mile consumption=4181.67Wh/7.5mile=557.56Wh/mile

fuel economy (mpg): 59.8



The former setting of Cd is 0.25

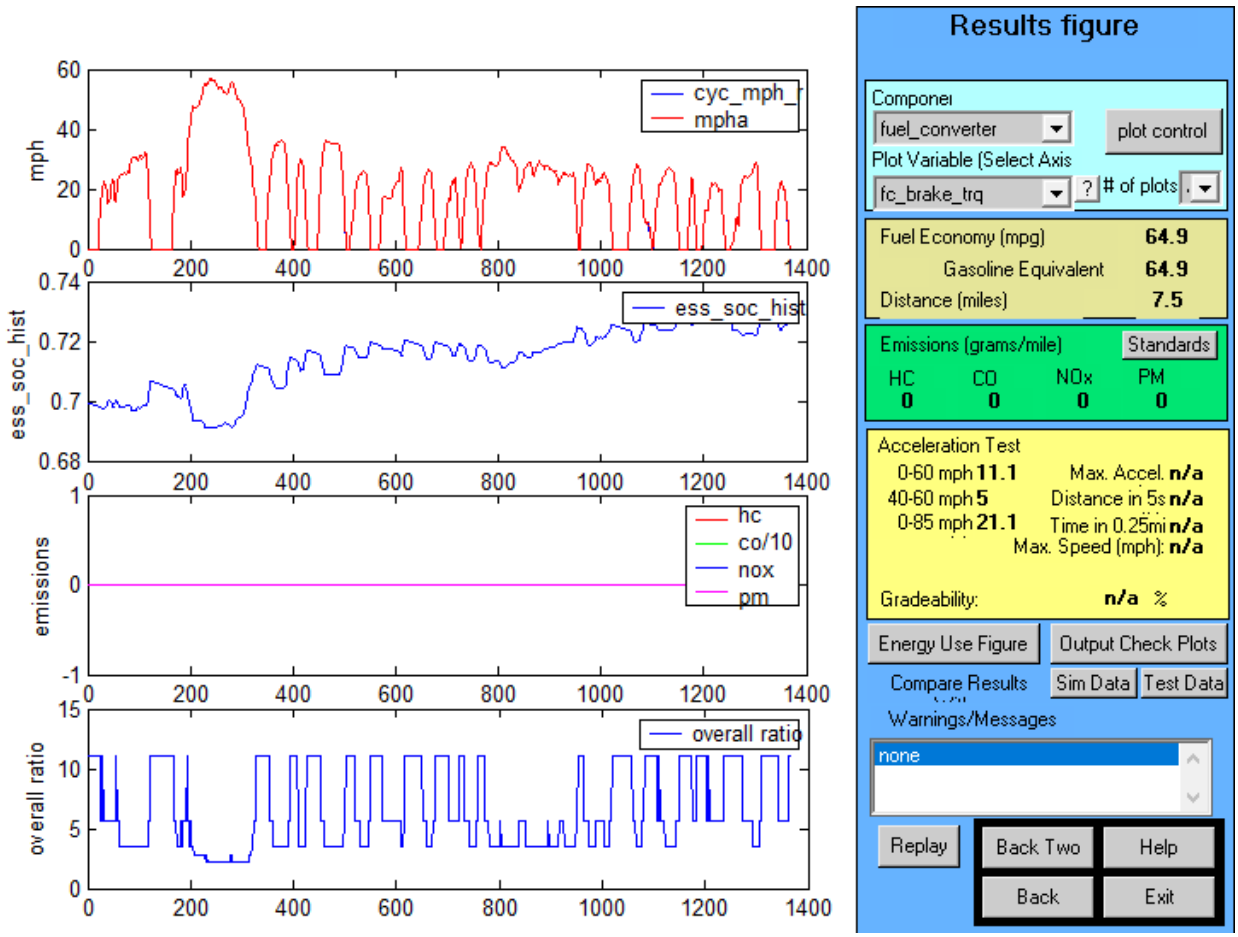
Now change Cd to 0.1 

To 60 mph acceleration time: 11.1S

Wh/mile energy consumption:513.22Wh/mile

fuel economy (mpg): 64.9

Running an UDDS cycle we can get:



From this diagram we can get that:

To 60 mph acceleration time: 11.1S

Wh/mile energy consumption:513.22Wh/mile

Energy Usage Table (kJ)

	POWER MODE				REGEN MODE			
	In	Out	Loss	Eff.	In	Out	Loss	Eff.
Fuel	0	13857						
Fuel Converter	13857	3178	10679	0.23			449	
Clutch	3219	3116	103	0.97	1155	1155	0	1
Hyd. Torque Converter								
Generator								
Torque Coupling	3219	3219	0	1	1158	1158	0	1
Energy Storage	573	389	98	0.82				
Energy Stored	86							
Motor/Controller	273	244	29	0.89	913	731	181	0.8
Gearbox	3116	2878	238	0.92	1256	1155	101	0.92
Final Drive	2878	2878	0	1	1256	1256	0	1
Wheel/Axle	2878	2587	291	0.9	1676	1688	-11	1.01
Braking							432	
Aux Loads	274	0	274	0				
Aero			299					
Rolling			611					

*Overall System Efficiency

0.066

*Overall energy efficiency is calculated as: (aero + rolling)/(fuel in - ess storage)

Loss Plot (Power Mode) | Loss Plot (Regen Mode) | DONE

Fuel Converter 13857

Open the energy use figure we can find that the total consumption of energy in this cycle. The consumption equals the input of fuel converter which is 13857kJ=3849.17Wh (1Watt hour (Wh) is equal to 3.6 kilojoules KJ). We also can find the distance of this cycle which is 7.5mile from the diagram. Then we can get Wh/mile consumption=3849.17Wh/7.5mile=513.22Wh/mile

fuel economy (mpg): 64.9

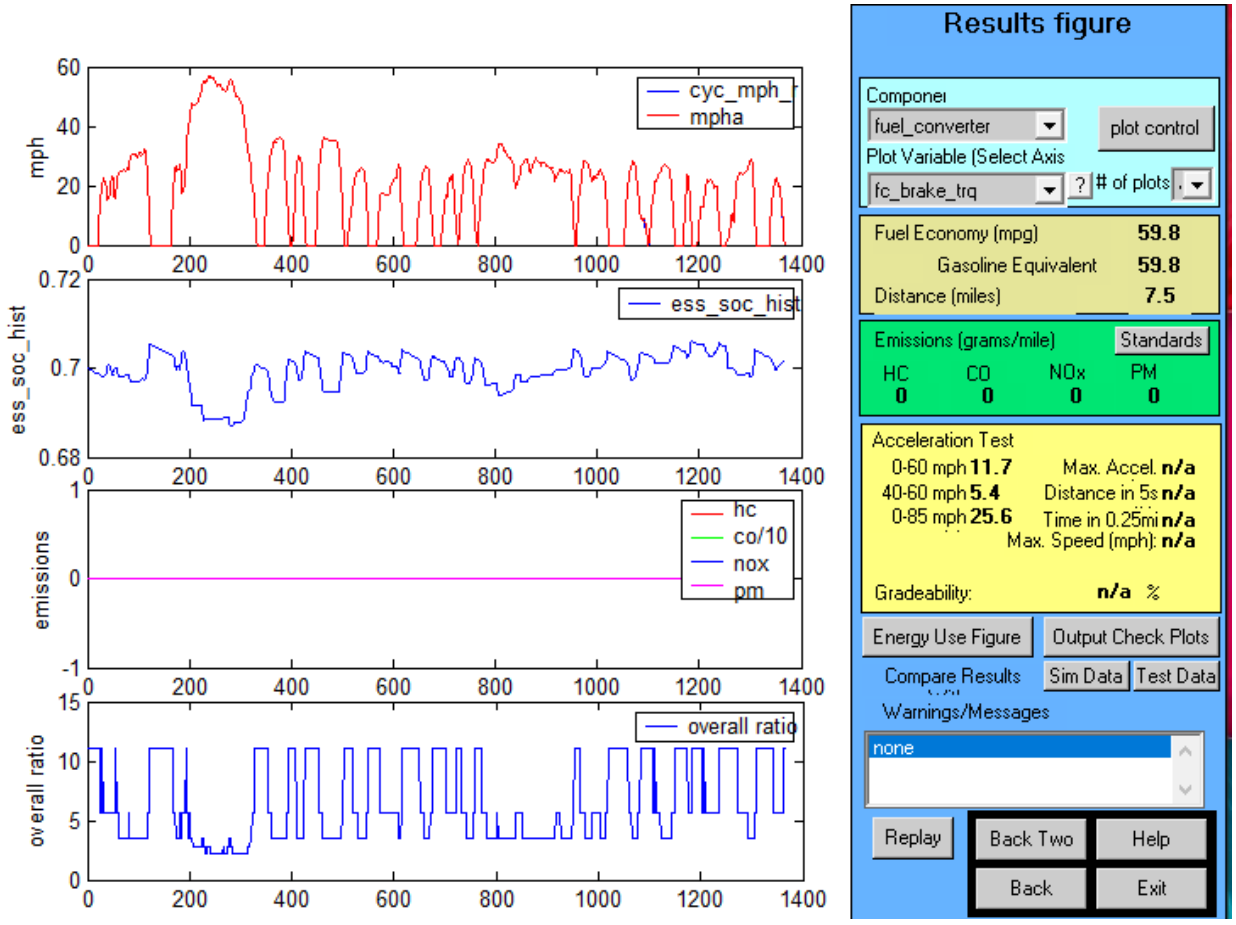
Fuel Economy (mpg)	64.9
Gasoline Equivalent	64.9
Distance (miles)	7.5

Now change Cd to 0.35 

To 60 mph acceleration time:11.7S

Wh/mile energy consumption:556.93Wh/mile

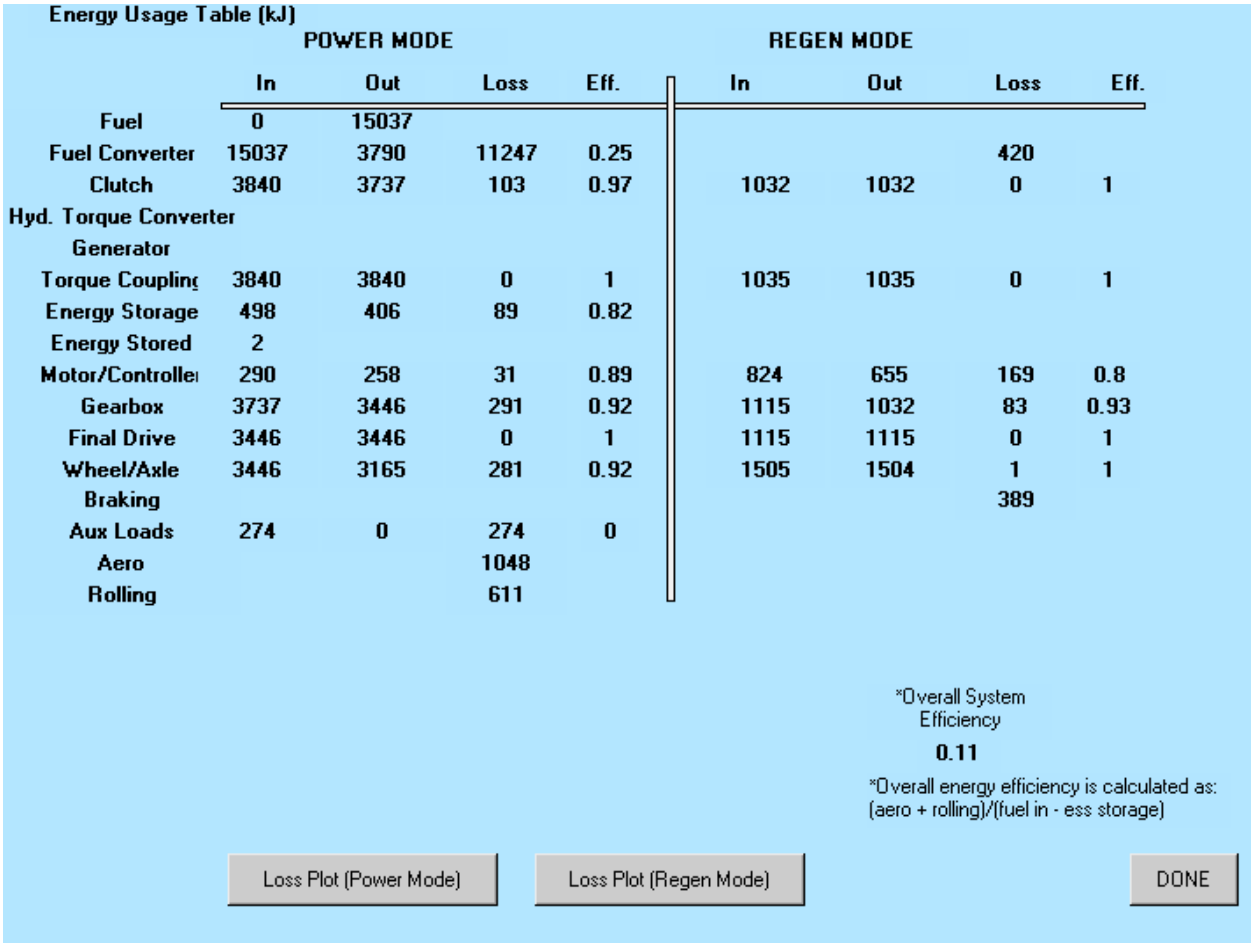
fuel economy (mpg): 59.8



From this diagram we can get that:

To 60 mph acceleration time:11.7S

Wh/mile energy consumption:556.93Wh/mile



Energy Usage Table (kJ)

	POWER MODE				REGEN MODE			
	In	Out	Loss	Eff.	In	Out	Loss	Eff.
Fuel	0	15037						
Fuel Converter	15037	3790	11247	0.25			420	
Clutch	3840	3737	103	0.97	1032	1032	0	1
Hyd. Torque Converter								
Generator								
Torque Coupling	3840	3840	0	1	1035	1035	0	1
Energy Storage	498	406	89	0.82				
Energy Stored	2							
Motor/Controller	290	258	31	0.89	824	655	169	0.8
Gearbox	3737	3446	291	0.92	1115	1032	83	0.93
Final Drive	3446	3446	0	1	1115	1115	0	1
Wheel/Axle	3446	3165	281	0.92	1505	1504	1	1
Braking							389	
Aux Loads	274	0	274	0				
Aero			1048					
Rolling			611					

*Overall System Efficiency

0.11

*Overall energy efficiency is calculated as: (aero + rolling)/(fuel in - ess storage)

Loss Plot (Power Mode) Loss Plot (Regen Mode) DONE

Fuel Converter 15037

Open the energy use figure we can find that the total consumption of energy in this cycle. The consumption equals the input of fuel converter which is 15037kJ=4176.94Wh (1Watt hour (Wh) is equal to 3.6 kilojoules KJ). We also can find the distance of this cycle which is 7.5mile from the diagram. Then we can get Wh/mile consumption=4176.94Wh/7.5mile=556.93Wh/mile

fuel economy (mpg): 59.8

Fuel Economy (mpg)	59.8
Gasoline Equivalent	59.8
Distance (miles)	7.5

In summary, we can get the information presented in this following table.

Vehicle Mass(kg)	851	962	1051
0 to 60 mph acceleration time(s)	11.4	11.5	12.3
energy consumption (Wh/mile)	513.56	537.89	557.56
fuel economy (mpg)	64.9	62	59.8

Cd	0.1	0.25	0.35
0 to 60 mph acceleration time(s)	11.1	11.5	11.7
energy consumption (Wh/mile)	513.22	537.89	556.93
fuel economy (mpg)	64.9	62	59.8

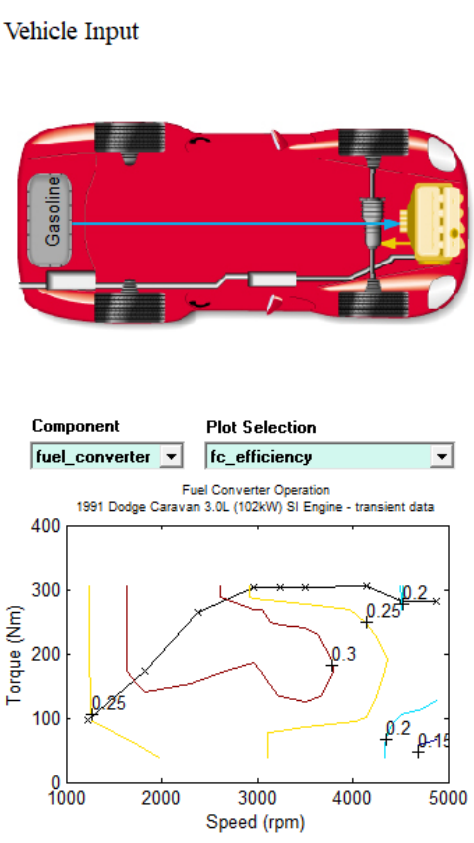
We can find that with increasing weight of vehicle or Cd, the acceleration time from 0 to 60mph, Wh/mile energy consumption will increase correspondingly, meanwhile the fuel economy will decrease.

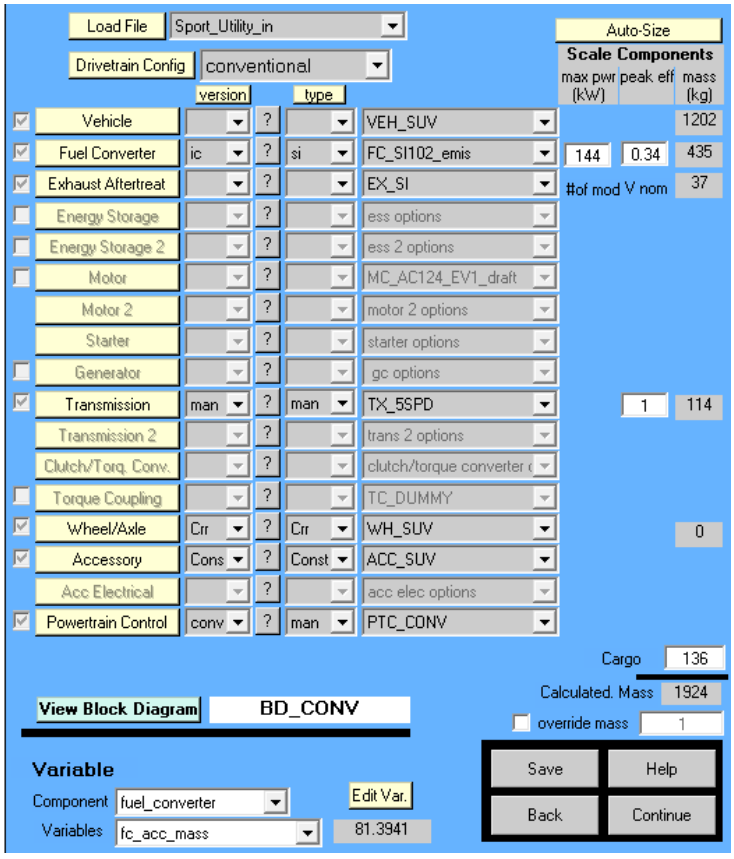
Answer questions 4 to 5 based on electrification of one Sport Utility Vehicle (SUV) Now you are an electric-drive vehicle engineer in one

major automotive OEM, you are assigned to convert one conventional SUV to a pure battery SUV.

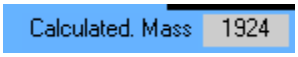
4. Use ready-made file for conventional SUV (Sport_Utility_in) as a baseline vehicle. Determine baseline vehicle performance by simulation: 0 to 60 mph acceleration time by simulation Wh/mile energy consumption and fuel economy (mpg) on UDDS, HWFET, US06, and NEDC schedules.

Sport_Utility_in



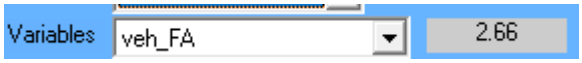


Vehicle Mass: 1924kg

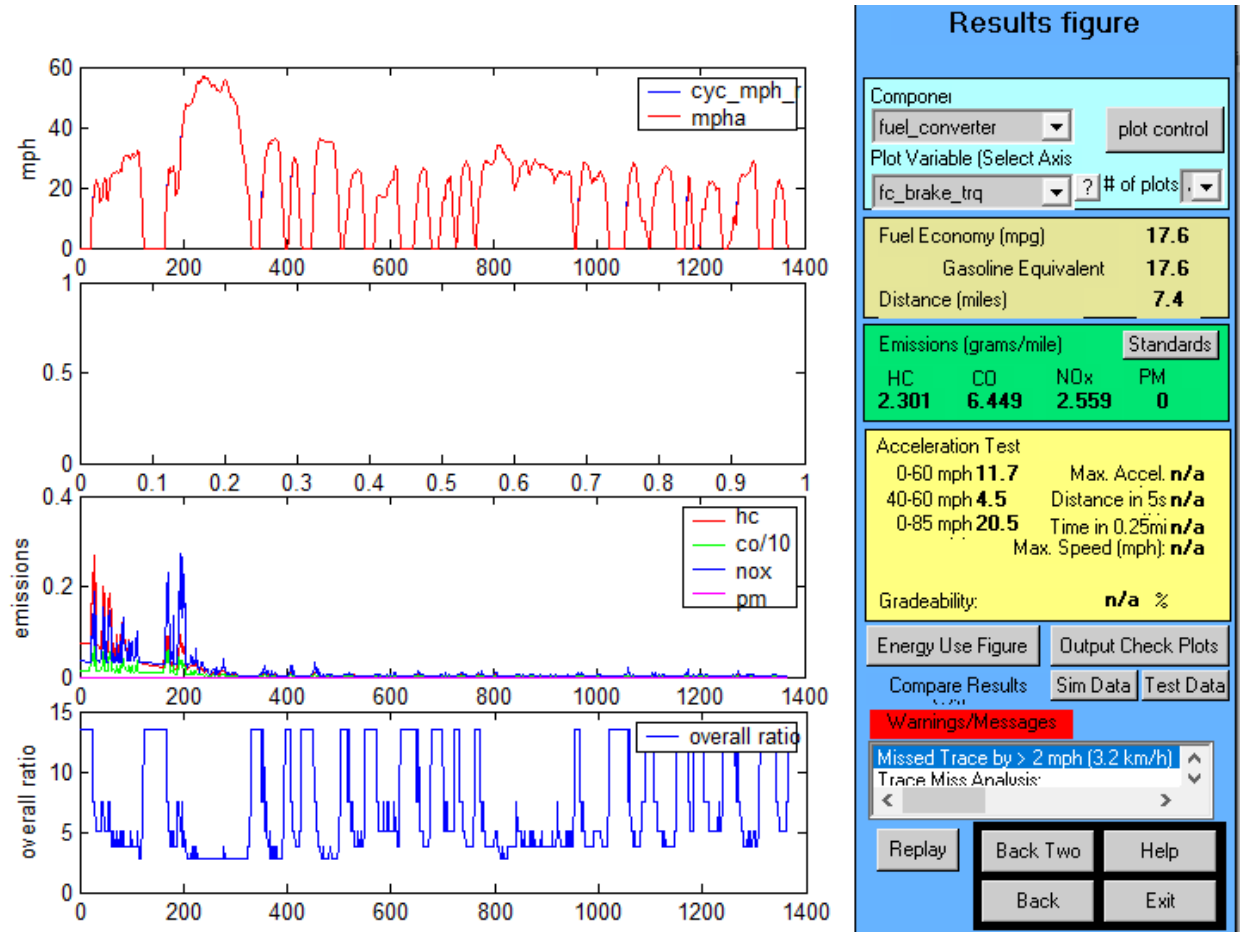


Cd: 0.44

Af: 2.66

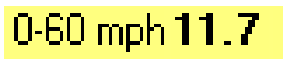


UDDS

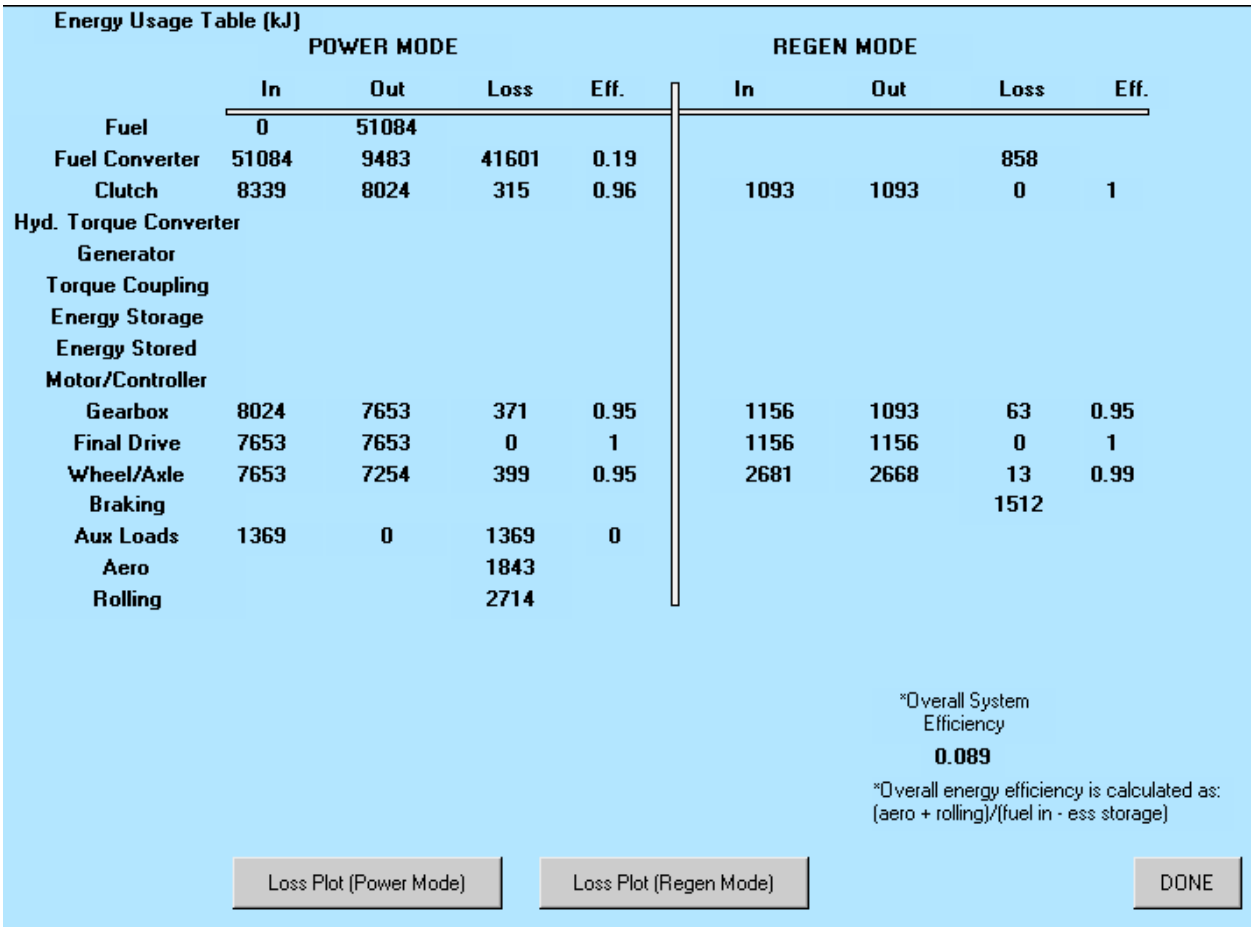


From this diagram we get that:

To 60 mph acceleration time: 11.7s



Wh/mile energy consumption:1917.57Wh/mile



Energy Usage Table (kJ)

	POWER MODE				REGEN MODE			
	In	Out	Loss	Eff.	In	Out	Loss	Eff.
Fuel	0	51084						
Fuel Converter	51084	9483	41601	0.19			858	
Clutch	8339	8024	315	0.96	1093	1093	0	1
Hyd. Torque Converter								
Generator								
Torque Coupling								
Energy Storage								
Energy Stored								
Motor/Controller								
Gearbox	8024	7653	371	0.95	1156	1093	63	0.95
Final Drive	7653	7653	0	1	1156	1156	0	1
Wheel/Axle	7653	7254	399	0.95	2681	2668	13	0.99
Braking							1512	
Aux Loads	1369	0	1369	0				
Aero			1843					
Rolling			2714					

*Overall System Efficiency

0.089

*Overall energy efficiency is calculated as: (aero + rolling)/(fuel in - ess storage)

Loss Plot (Power Mode) | Loss Plot (Regen Mode) | DONE

Fuel Converter	51084

Open the energy use figure we can find that the total consumption of energy in this cycle. The consumption equals the input of fuel converter which is 51084kJ=14190Wh (1Watt hour (Wh) is equal to 3.6 kilojoules KJ). We also can find the distance of this cycle which is 7.4 mile from the diagram.

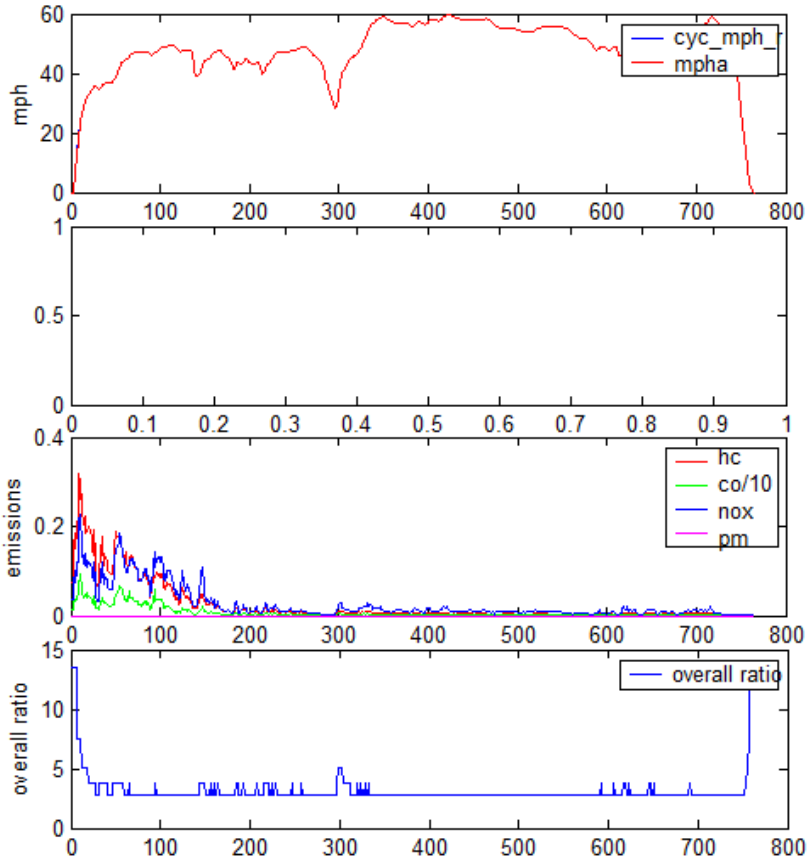
Distance (miles)	7.4

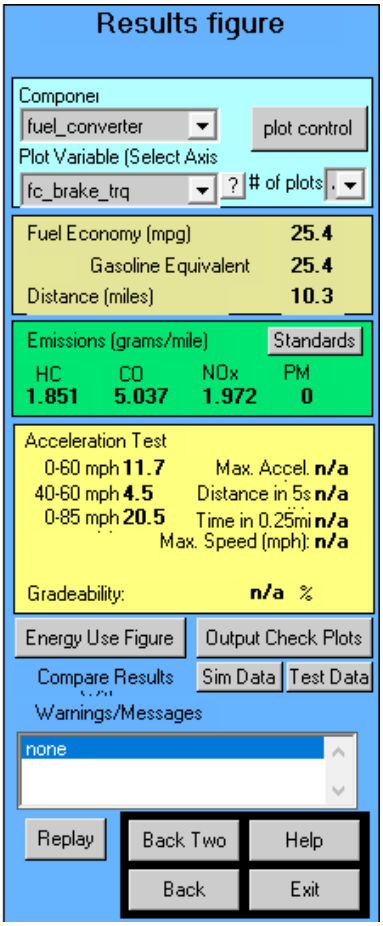
Then we can get Wh/mile consumption=14190Wh/7.4mile=1917.57Wh/mile

fuel economy (mpg): 17.6

Fuel Economy (mpg)	17.6
Gasoline Equivalent	17.6
Distance (miles)	7.4

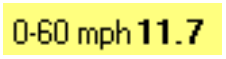
HWFET:



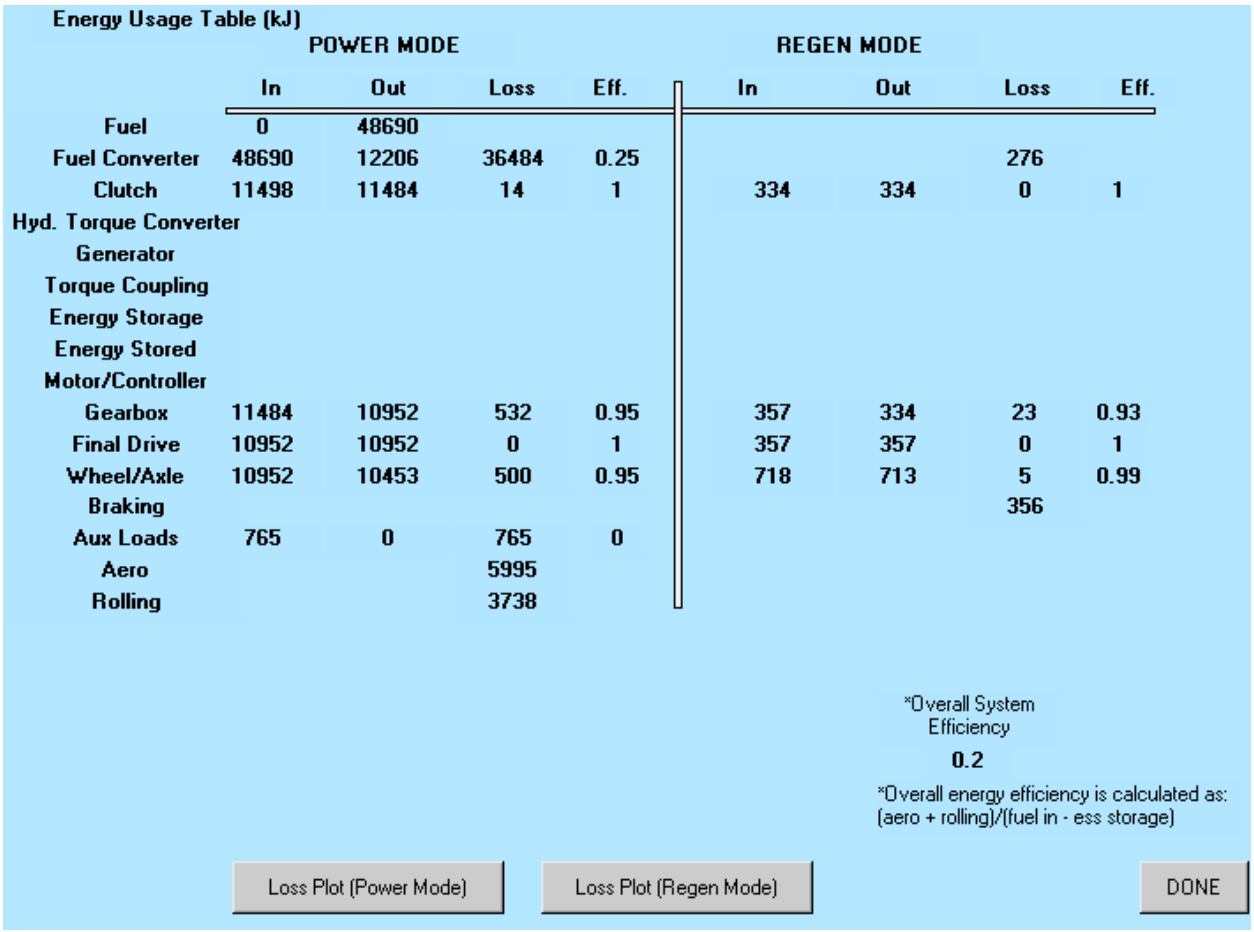


From this diagram we get that:

To 60 mph acceleration time: 11.7s



Wh/mile energy consumption:1313.11Wh/mile



Energy Usage Table (kJ)

	POWER MODE				REGEN MODE			
	In	Out	Loss	Eff.	In	Out	Loss	Eff.
Fuel	0	48690						
Fuel Converter	48690	12206	36484	0.25			276	
Clutch	11498	11484	14	1	334	334	0	1
Hyd. Torque Converter								
Generator								
Torque Coupling								
Energy Storage								
Energy Stored								
Motor/Controller								
Gearbox	11484	10952	532	0.95	357	334	23	0.93
Final Drive	10952	10952	0	1	357	357	0	1
Wheel/Axle	10952	10453	500	0.95	718	713	5	0.99
Braking							356	
Aux Loads	765	0	765	0				
Aero			5995					
Rolling			3738					

*Overall System Efficiency

0.2

*Overall energy efficiency is calculated as: (aero + rolling)/(fuel in - ess storage)

Loss Plot (Power Mode) Loss Plot (Regen Mode) DONE

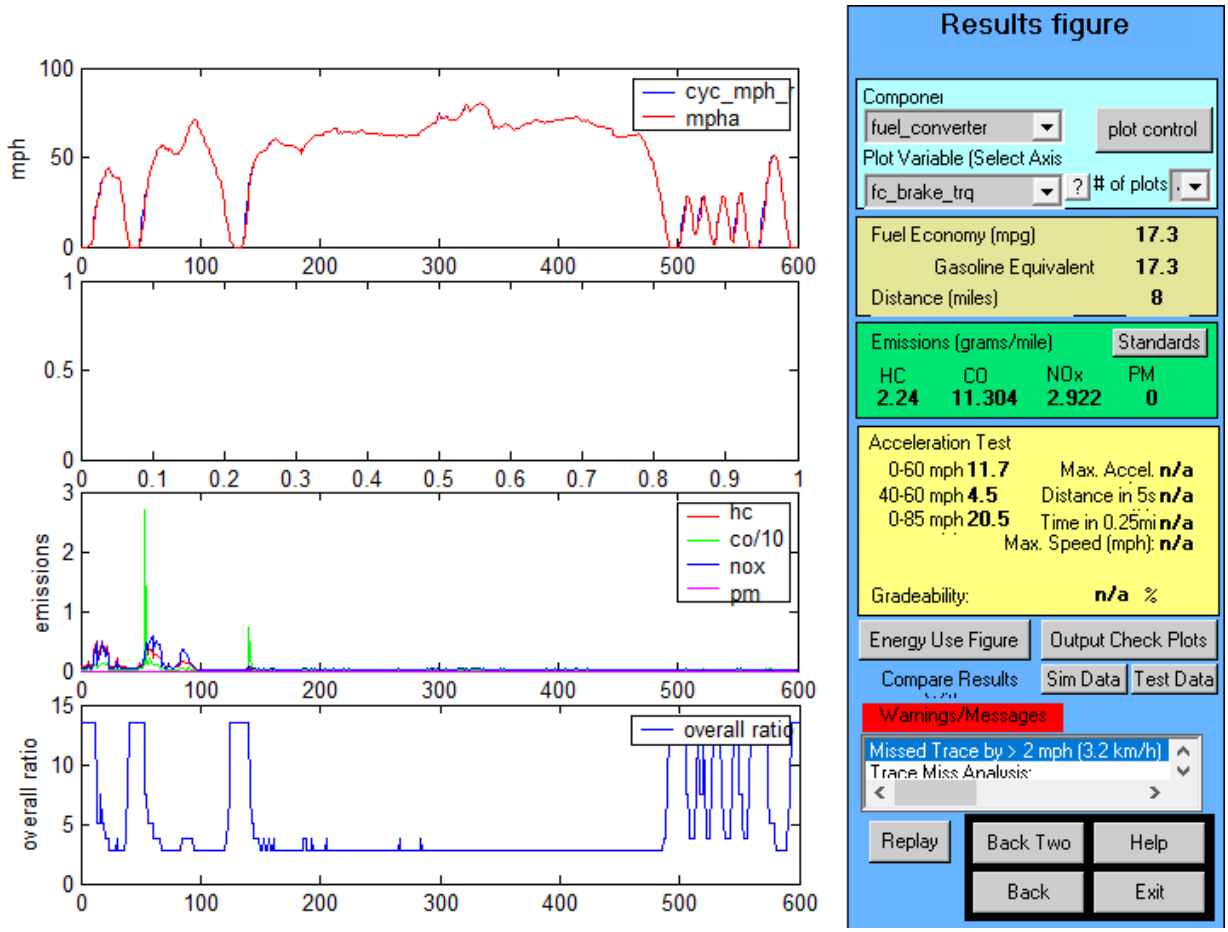
Fuel Converter 48690

Open the energy use figure we can find that the total consumption of energy in this cycle. The consumption equals the input of fuel converter which is 48690kJ=13525Wh (1Watt hour (Wh) is equal to 3.6 kilojoules KJ). We also can find the distance of this cycle which is 10.3mile from the diagram. Distance (miles) 10.3 Then we can get Wh/mile consumption=13525Wh/10.3mile=1313.11Wh/mile

fuel economy (mpg): 25.4

Fuel Economy (mpg)	25.4
Gasoline Equivalent	25.4
Distance (miles)	10.3

US06:

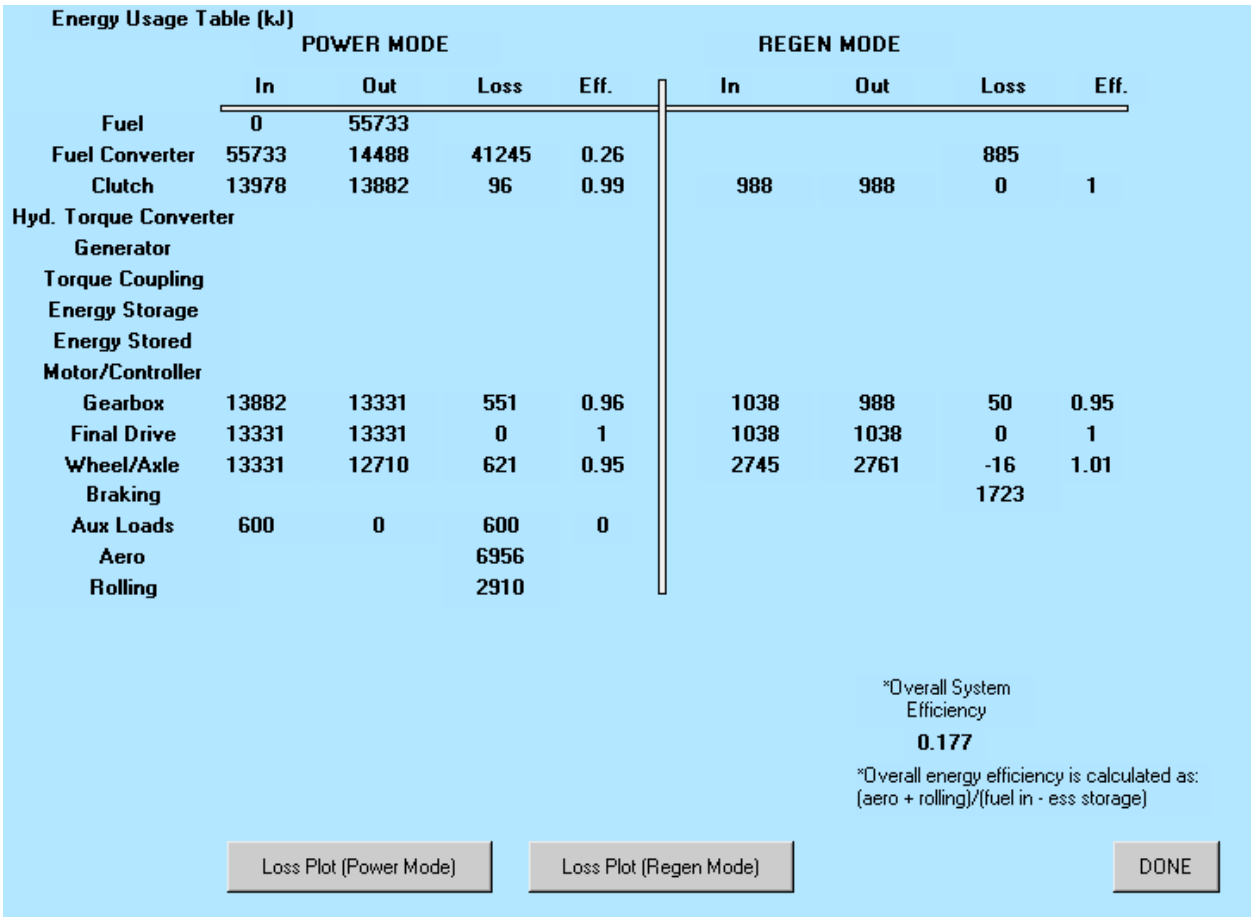


From this diagram we get that:

To 60 mph acceleration time: 11.7s

0-60 mph **11.7**

Wh/mile energy consumption:1935.17Wh/mile



Energy Usage Table (kJ)

	POWER MODE				REGEN MODE			
	In	Out	Loss	Eff.	In	Out	Loss	Eff.
Fuel	0	55733						
Fuel Converter	55733	14488	41245	0.26			885	
Clutch	13978	13882	96	0.99	988	988	0	1
Hyd. Torque Converter								
Generator								
Torque Coupling								
Energy Storage								
Energy Stored								
Motor/Controller								
Gearbox	13882	13331	551	0.96	1038	988	50	0.95
Final Drive	13331	13331	0	1	1038	1038	0	1
Wheel/Axle	13331	12710	621	0.95	2745	2761	-16	1.01
Braking							1723	
Aux Loads	600	0	600	0				
Aero			6956					
Rolling			2910					

*Overall System Efficiency

0.177

*Overall energy efficiency is calculated as: (aero + rolling)/(fuel in - ess storage)

Loss Plot (Power Mode) Loss Plot (Regen Mode) DONE

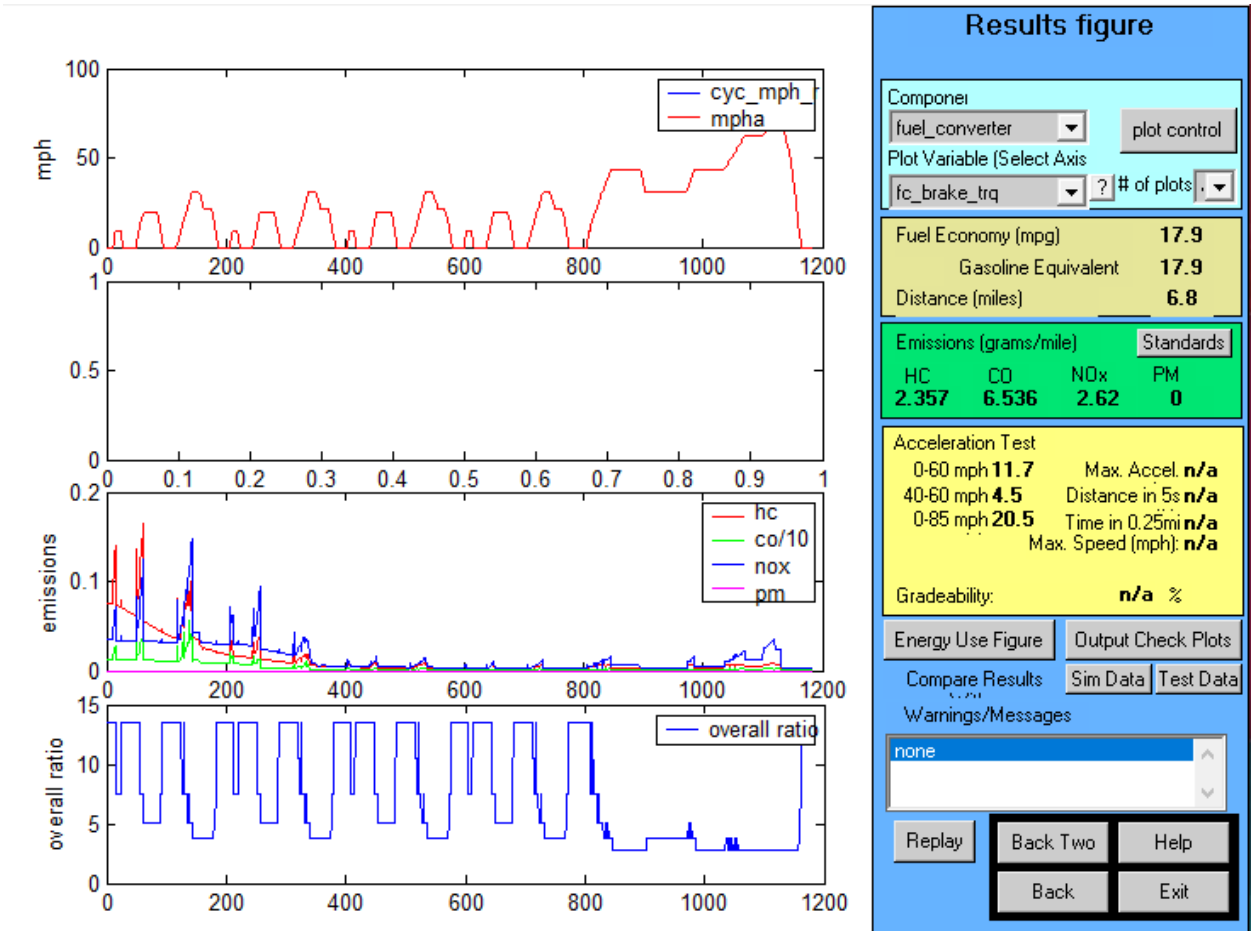
Fuel Converter 55733

Open the energy use figure we can find that the total consumption of energy in this cycle. The consumption equals the input of fuel converter which is 55733kJ=15481.39Wh (1Watt hour (Wh) is equal to 3.6 kilojoules KJ). We also can find the distance of this cycle which is 8 mile from the diagram. Distance (miles) 8 Then we can get Wh/mile consumption=15481.39Wh/8mile=1935.17Wh/mile

fuel economy (mpg): 17.3

Fuel Economy (mpg)	17.3
Gasoline Equivalent	17.3
Distance (miles)	8

NEDC:

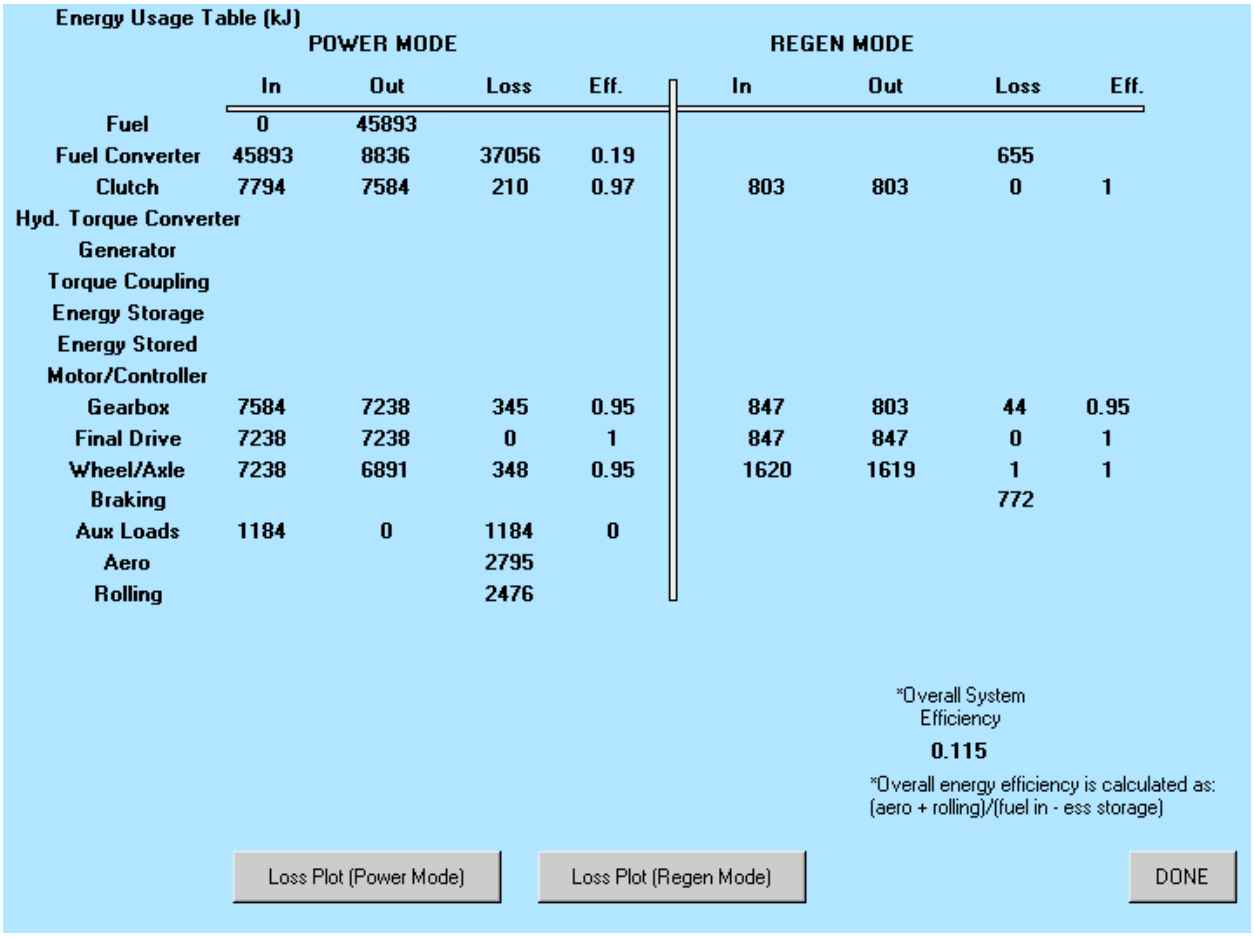


From this diagram we get that:

To 60 mph acceleration time: 11.7s

0-60 mph	11.7

Wh/mile energy consumption:1874.71Wh/mile



Energy Usage Table (kJ)

	POWER MODE				REGEN MODE			
	In	Out	Loss	Eff.	In	Out	Loss	Eff.
Fuel	0	45893						
Fuel Converter	45893	8836	37056	0.19			655	
Clutch	7794	7584	210	0.97	803	803	0	1
Hyd. Torque Converter								
Generator								
Torque Coupling								
Energy Storage								
Energy Stored								
Motor/Controller								
Gearbox	7584	7238	345	0.95	847	803	44	0.95
Final Drive	7238	7238	0	1	847	847	0	1
Wheel/Axle	7238	6891	348	0.95	1620	1619	1	1
Braking							772	
Aux Loads	1184	0	1184	0				
Aero			2795					
Rolling			2476					

*Overall System Efficiency

0.115

*Overall energy efficiency is calculated as: (aero + rolling)/(fuel in - ess storage)

Loss Plot (Power Mode) | Loss Plot (Regen Mode) | DONE

Fuel Converter 45893

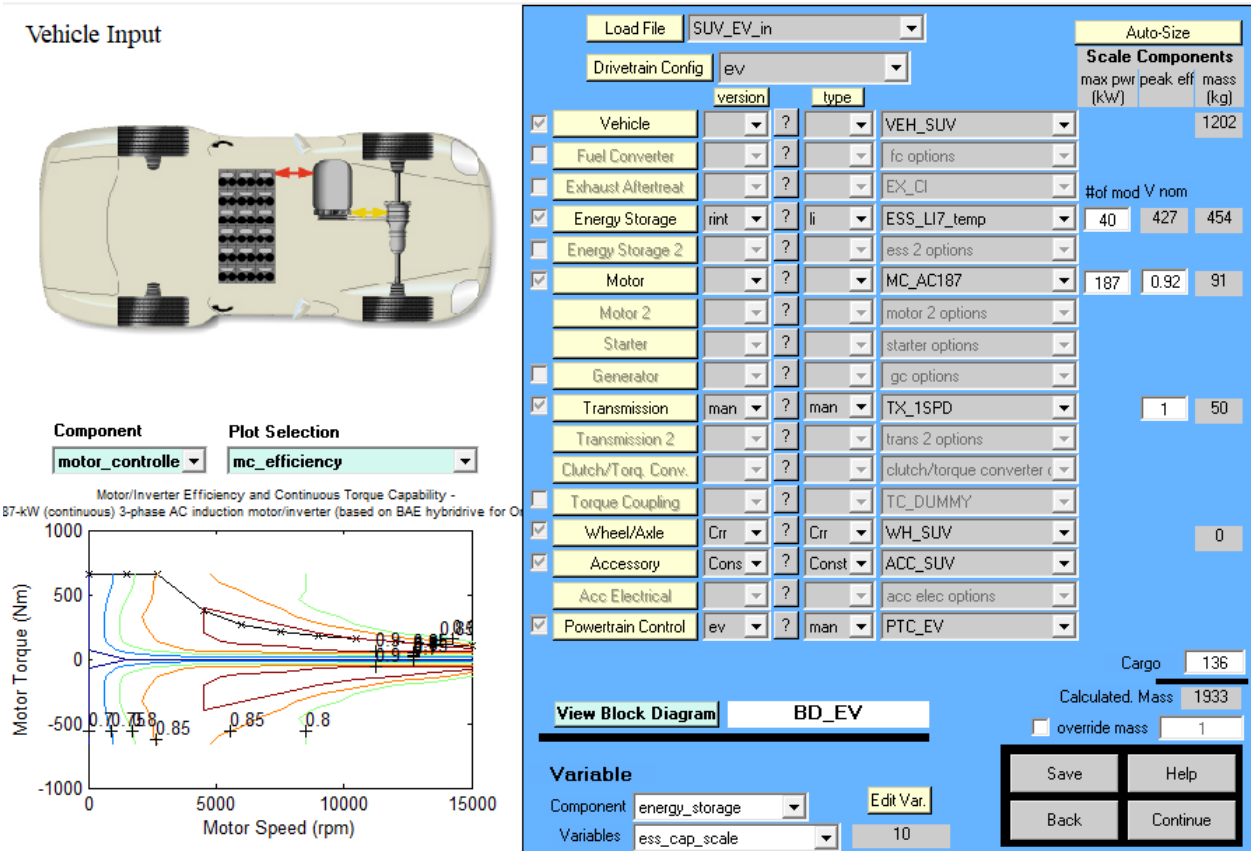
Open the energy use figure we can find that the total consumption of energy in this cycle. The consumption equals the input of fuel converter which is 45893kJ=12748.06Wh (1Watt hour (Wh) is equal to 3.6 kilojoules KJ). We also can find the distance of this cycle which is 6.8 mile from the diagram. Distance (miles) 6.8 Then we can get Wh/mile consumption=12748.06Wh/6.8mile=1874.71Wh/mile

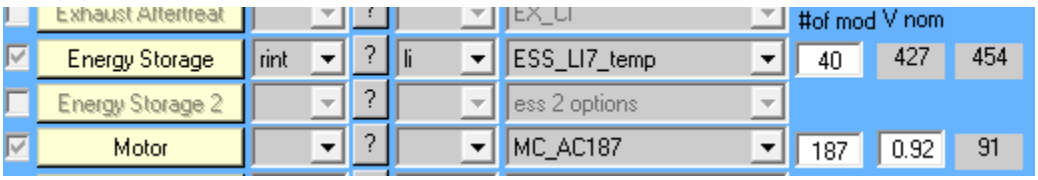
fuel economy (mpg): 17.9

Fuel Economy (mpg)	17.9
Gasoline Equivalent	17.9
Distance (miles)	6.8

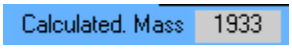
5. Convert this conventional SUV (Sport_Utility_in) to a pure battery SUV using the same vehicle parameters of mass, Af, Cd, etc.). Name your designed EV as SUV_EV_in.

(a) Component sizing on battery, motor, etc. You need to determine/select the battery type (NiMH, Li-ion, etc.) and size, motor type and size, motor control, etc.





Vehicle Mass: 1933kg



A little heavier than conventional version(1924kg).

Battery selecting:

Li-ion battery `ess_description='6 Ah Saft Lithium Ion battery';`

40 modules: 120 cells (each module contains 3 cells)

Battery pack nominal voltage: 427V

Battery pack weight: 454kg

Capacity:6*10=60

Ah

```
ess_description='6 Ah Saft Lithium Ion battery';
```

The nominal capacity of this battery is 6Ah according the data above. Change capacity scale factor to 10, so the total capacity could be 6*10=60Ah.

Motor selecting:

AC187 electric motor

Max power: 187kw

Peak efficiency: 0.92

Electric motor weight: 91kg

Transmission:

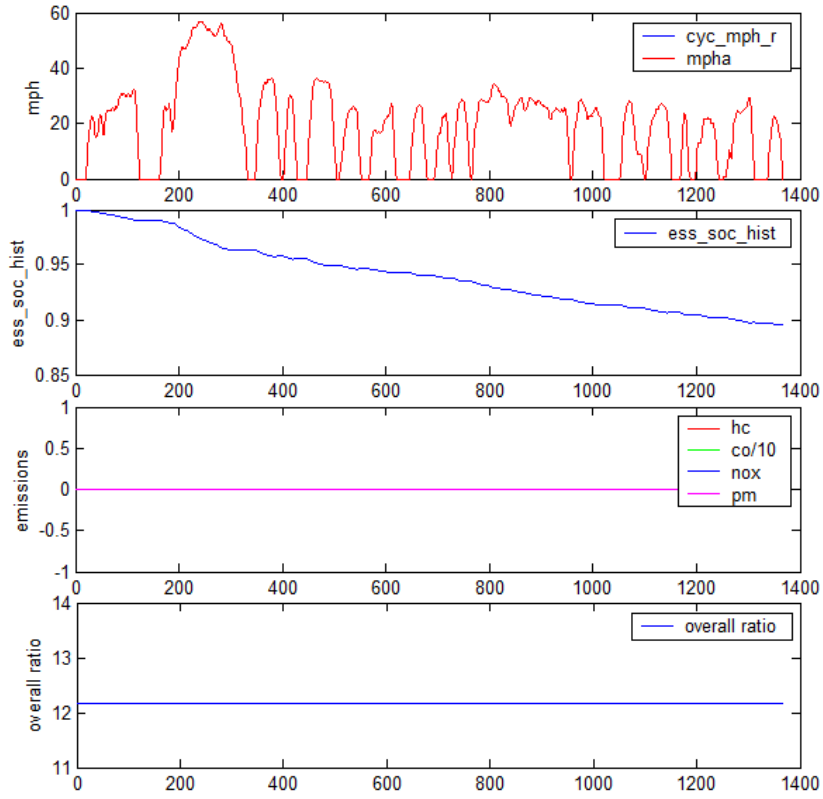
Transmission and wheel are same to the conventional version.

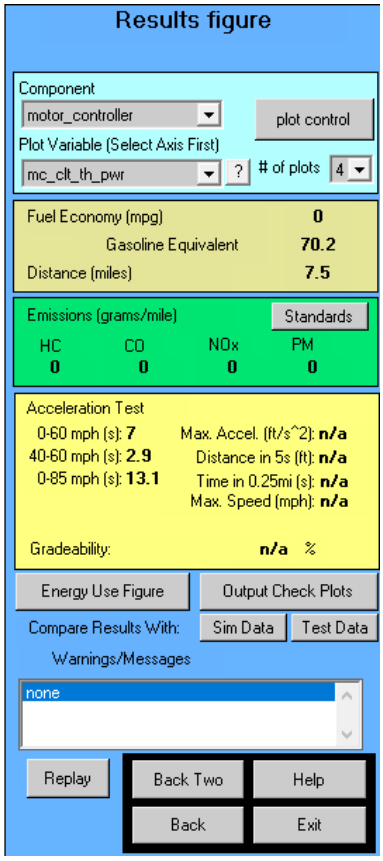
Cd: no change still 0.44

Af: no change still 2.66

(b) Determine performance by simulation: 0 to 60 mph acceleration time by simulation Wh/mile energy consumption and fuel economy (mpg) on UDDS, HWFET, US06, and NEDC schedules.

UDDS





From this diagram we can get that:

To 60 mph acceleration time:7 S

Wh/mile energy consumption:447.26Wh/mile

Energy Usage Table (kJ)

	POWER MODE				REGEN MODE			
	In	Out	Loss	Eff.	In	Out	Loss	Eff.
Fuel	0							
Fuel Converter								
Clutch								
Hyd. Torque Converter								
Generator								
Torque Coupling								
Energy Storage	538	12509	104	0.98				
Energy Stored	-12076							
Motor/Controller	12509	8207	4302	0.66	1287	538	749	0.42
Gearbox	8207	7663	544	0.93	1404	1287	117	0.92
Final Drive	7663	7663	0	1	1404	1404	0	1
Wheel/Axle	7663	7268	395	0.95	2695	2679	17	0.99
Braking							1275	
Aux Loads	0	0	0	0				
Aero			1845					
Rolling			2728					

*Overall System Efficiency

0.379

*Overall energy efficiency is calculated as:
(aero + rolling)/(fuel in - ess storage)

Loss Plot (Power Mode) | Loss Plot (Regen Mode) | DONE

Energy Stored	-12076

Open the energy use figure we can find that the total consumption of energy in this cycle. The consumption equals energy stored which is 12076kJ=3354.44Wh (1Watt hour (Wh) is equal to 3.6 kilojoules KJ). We also can find the distance of this cycle which is 7.5mile from the diagram.

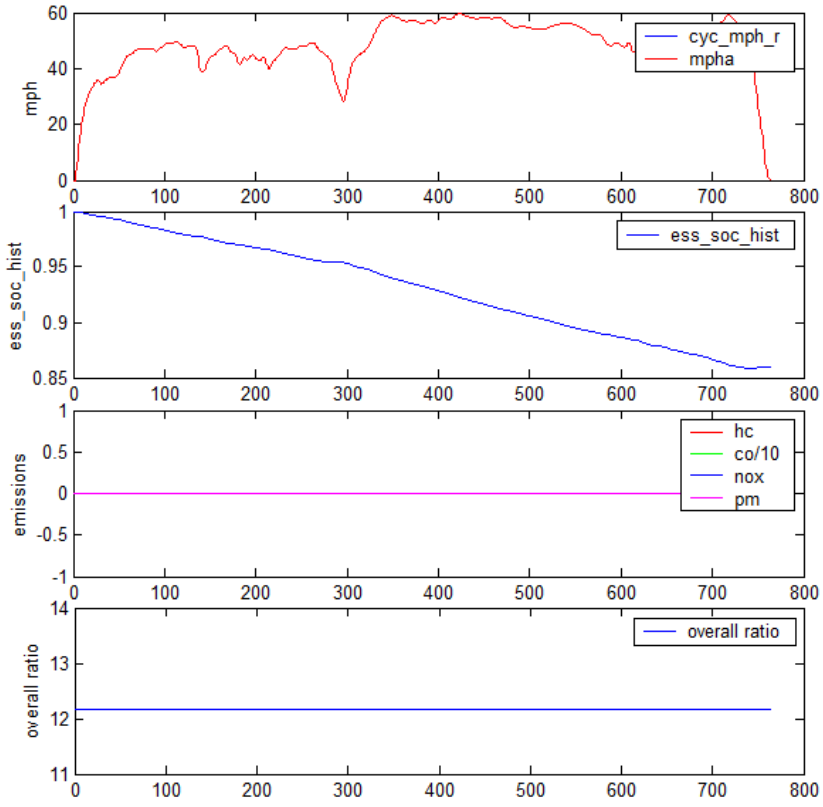
Distance (miles)	7.5

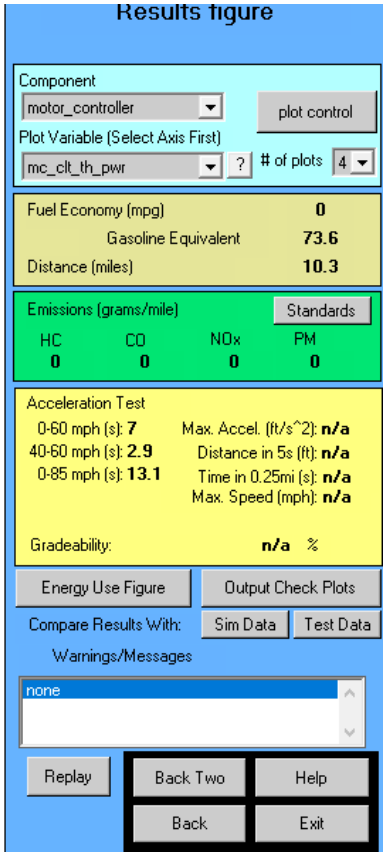
Then we can get Wh/mile consumption=3354.44Wh/7.5mile=447.26Wh/mile

fuel economy (mpg): 70.2(Gasoline Equivalent)

Fuel Economy (mpg)	0
Gasoline Equivalent	70.2
Distance (miles)	7.5

HWFET:



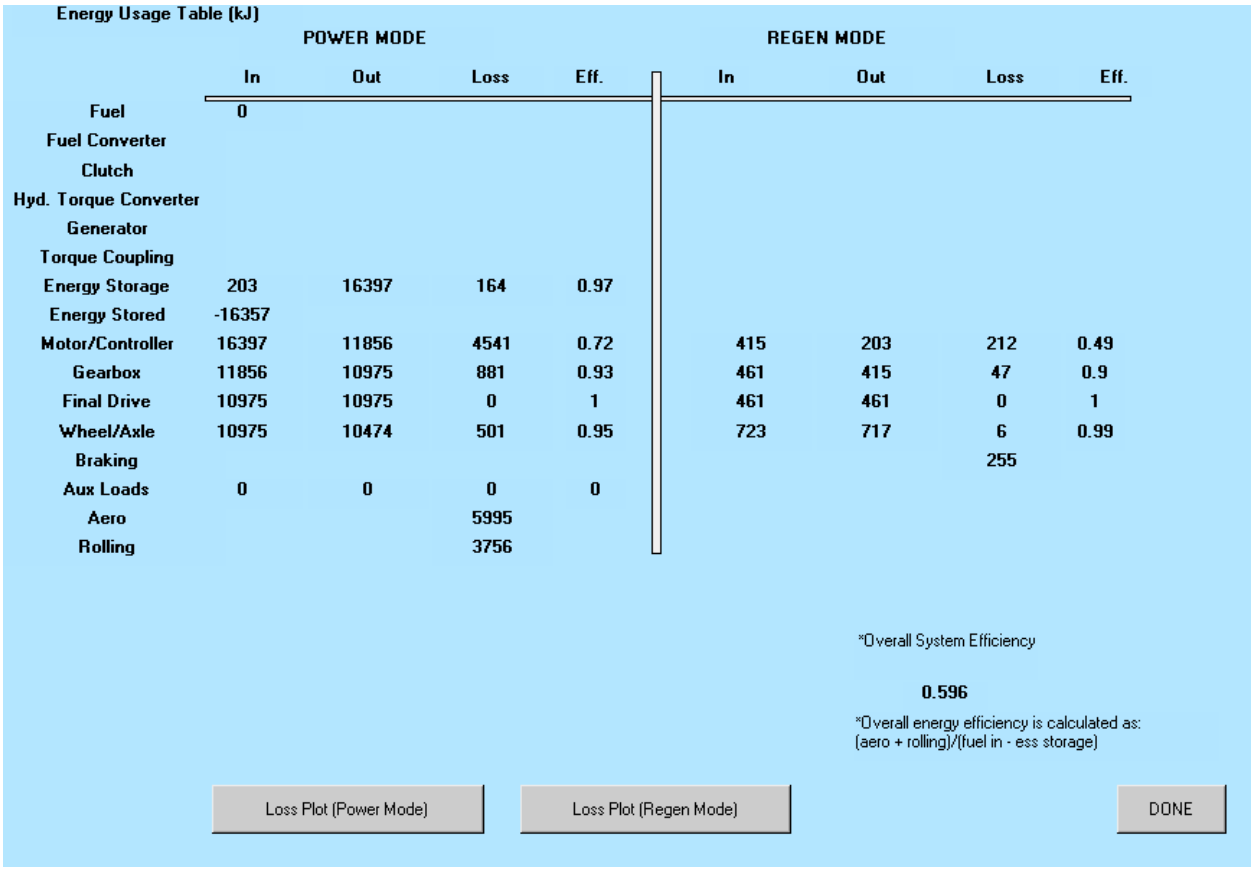


From this diagram we can get that:

To 60 mph acceleration time:7 S

0-60 mph 7

Wh/mile energy consumption:441.13Wh/mile



Energy Usage Table (kJ)

	POWER MODE In	Out	Loss	Eff.	REGEN MODE In	Out	Loss	Eff.
Fuel	0							
Fuel Converter								
Clutch								
Hyd. Torque Converter								
Generator								
Torque Coupling								
Energy Storage	203	16397	164	0.97				
Energy Stored	-16357							
Motor/Controller	16397	11856	4541	0.72	415	203	212	0.49
Gearbox	11856	10975	881	0.93	461	415	47	0.9
Final Drive	10975	10975	0	1	461	461	0	1
Wheel/Axle	10975	10474	501	0.95	723	717	6	0.99
Braking							255	
Aux Loads	0	0	0	0				
Aero			5995					
Rolling			3756					

*Overall System Efficiency

0.596

*Overall energy efficiency is calculated as:
(aero + rolling)/(fuel in - ess storage)

Loss Plot (Power Mode) | Loss Plot (Regen Mode) | DONE

Energy Stored	-16357

Open the energy use figure we can find that the total consumption of energy in this cycle. The consumption equals energy stored which is 16357kJ=4543.61Wh (1Watt hour (Wh) is equal to 3.6 kilojoules KJ). We also can find the distance of this cycle which is 10.3mile from the diagram.

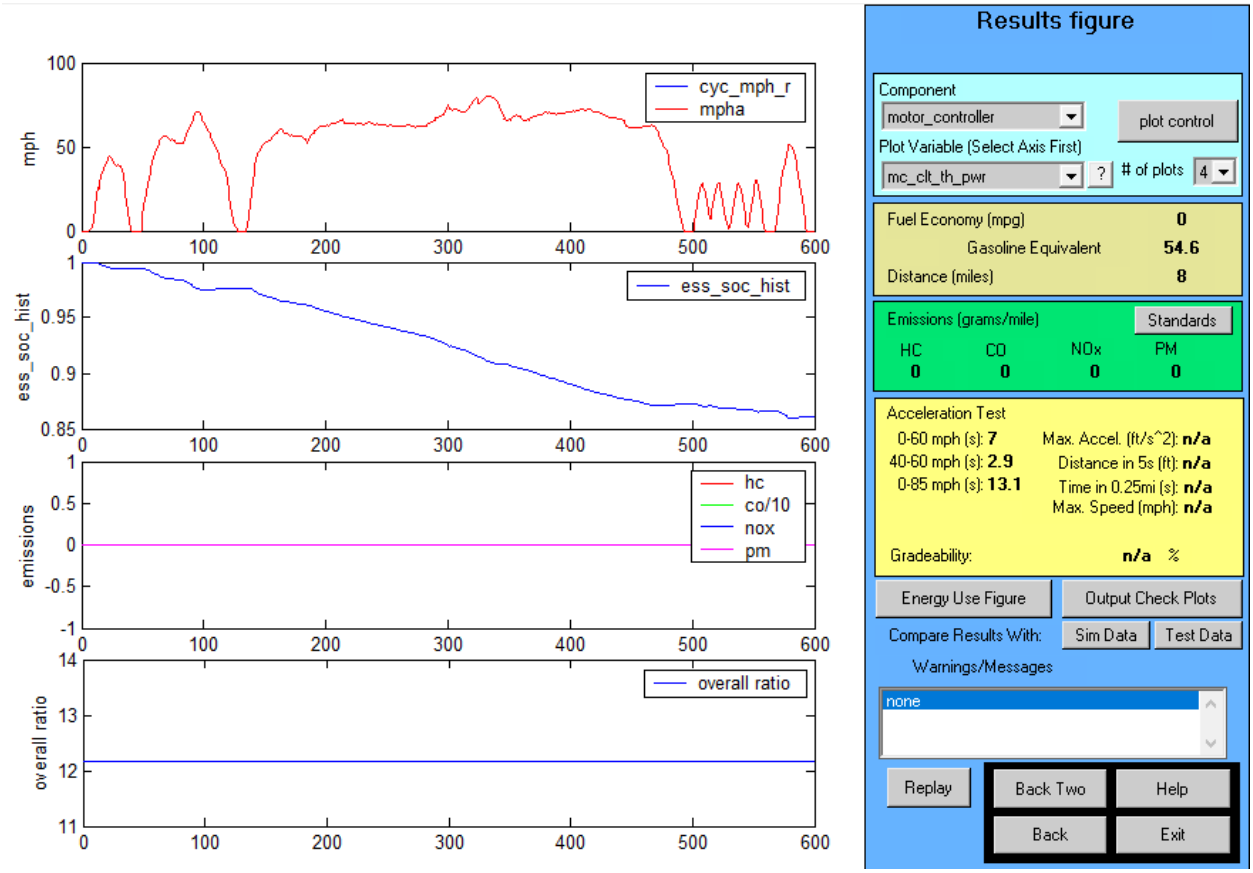
Distance (miles)	10.3

Then we can get Wh/mile consumption=4543.61Wh/10.3mile=441.13Wh/mile

fuel economy (mpg): 73.6(Gasoline Equivalent)

Fuel Economy (mpg)	0
Gasoline Equivalent	73.6
Distance (miles)	10.3

US06:



From this diagram we can get that:

To 60 mph acceleration time:7 S

0-60 mph 7

Wh/mile energy consumption:570.17Wh/mile

Energy Usage Table (kJ)

	POWER MODE				REGEN MODE			
	In	Out	Loss	Eff.	In	Out	Loss	Eff.
Fuel	0							
Fuel Converter								
Clutch								
Hyd. Torque Converter								
Generator								
Torque Coupling								
Energy Storage	1018	17118	321	0.97				
Energy Stored	-16421							
Motor/Controller	17118	14040	3078	0.82	1522	1018	504	0.67
Gearbox	14040	13241	800	0.94	1632	1522	110	0.93
Final Drive	13241	13241	0	1	1632	1632	0	1
Wheel/Axle	13241	12695	545	0.96	2798	2803	-5	1
Braking							1171	
Aux Loads	0	0	0	0				
Aero			6966					
Rolling			2932					

*Overall System Efficiency

0.603

*Overall energy efficiency is calculated as:
(aero + rolling)/(fuel in - ess storage)

Loss Plot (Power Mode) | Loss Plot (Regen Mode) | DONE

Energy Stored	-16421

Open the energy use figure we can find that the total consumption of energy in this cycle. The consumption equals energy stored which is 16421kJ=4561.39Wh (1Watt hour (Wh) is equal to 3.6 kilojoules KJ). We also can find the distance of this cycle which is 8 mile from the diagram.

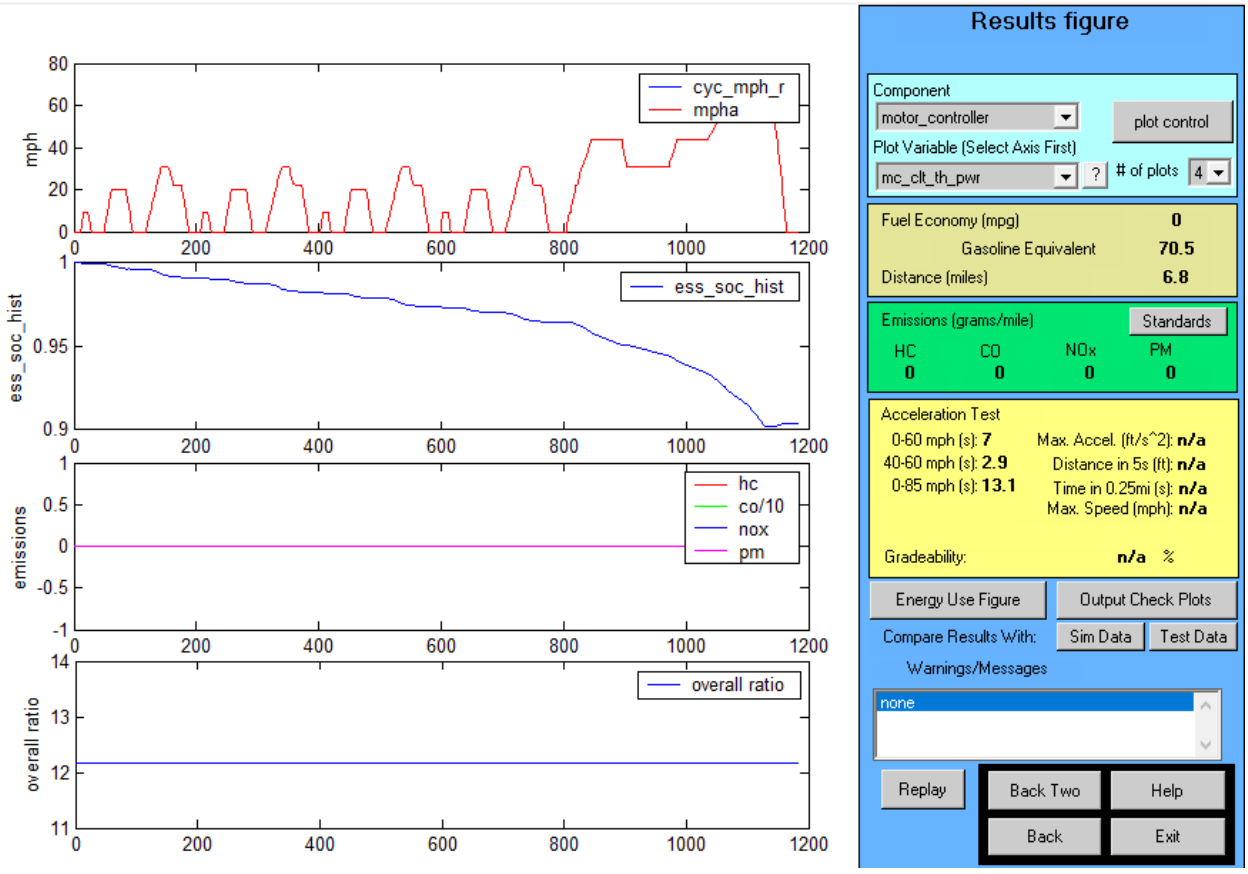
Distance (miles)	8

Then we can get Wh/mile consumption=4561.39Wh/8mile=570.17Wh/mile

fuel economy (mpg): 54.6(Gasoline Equivalent)

Fuel Economy (mpg)	0
Gasoline Equivalent	54.6
Distance (miles)	8

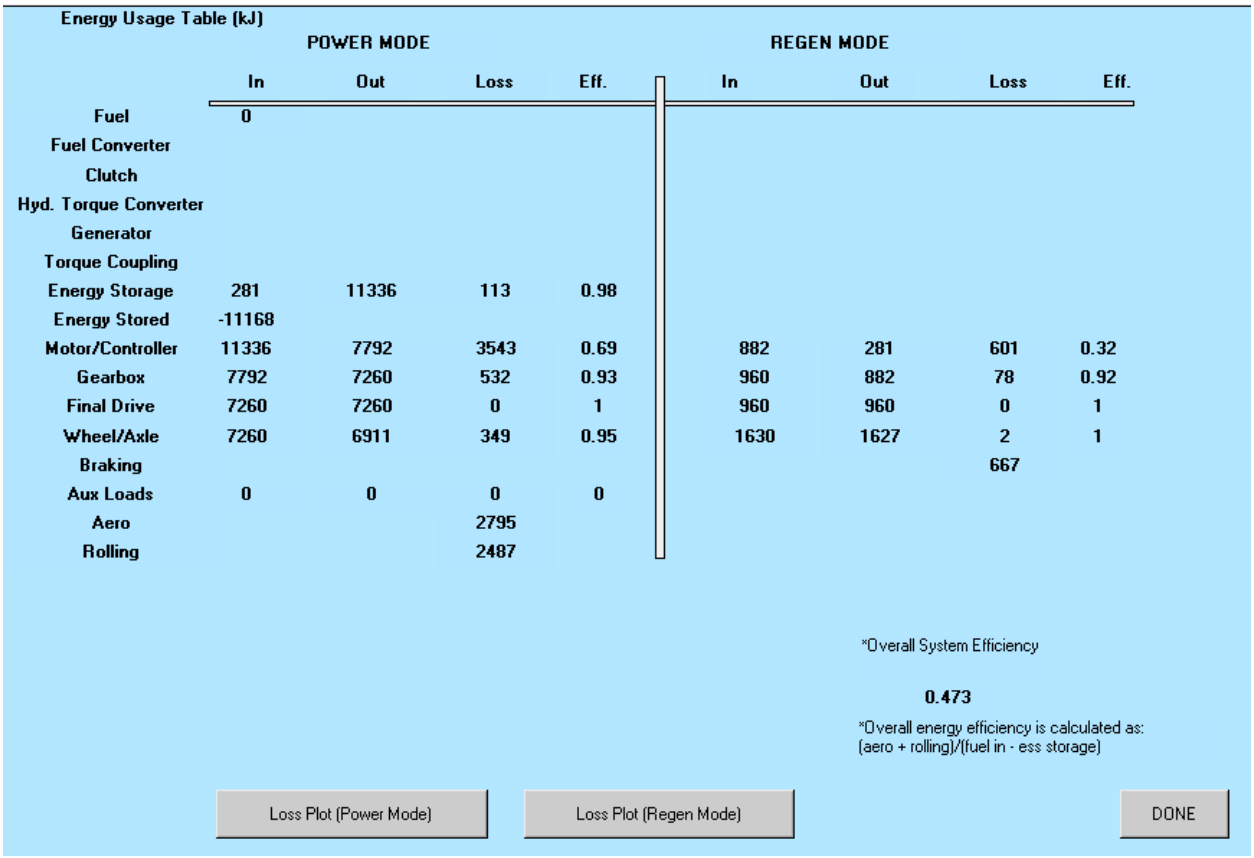
NEDC:



From this diagram we can get that:

To 60 mph acceleration time:7 S

Wh/mile energy consumption:456.21Wh/mile



Energy Usage Table (kJ)

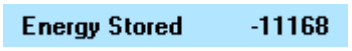
	POWER MODE In	Out	Loss	Eff.	REGEN MODE In	Out	Loss	Eff.
Fuel	0							
Fuel Converter								
Clutch								
Hyd. Torque Converter								
Generator								
Torque Coupling								
Energy Storage	281	11336	113	0.98				
Energy Stored	-11168							
Motor/Controller	11336	7792	3543	0.69	882	281	601	0.32
Gearbox	7792	7260	532	0.93	960	882	78	0.92
Final Drive	7260	7260	0	1	960	960	0	1
Wheel/Axle	7260	6911	349	0.95	1630	1627	2	1
Braking							667	
Aux Loads	0	0	0	0				
Aero			2795					
Rolling			2487					

*Overall System Efficiency

0.473

*Overall energy efficiency is calculated as:
(aero + rolling)/(fuel in - ess storage)

Loss Plot (Power Mode) | Loss Plot (Regen Mode) | DONE



Open the energy use figure we can find that the total consumption of energy in this cycle. The consumption equals energy stored which is 11168kJ=3102.22Wh (1Watt hour (Wh) is equal to 3.6 kilojoules KJ). We also can find the distance of this cycle which is 6.8 mile from the diagram. 

Then we can get Wh/mile consumption=3102.22Wh/6.8mile=456.21Wh/mile

fuel economy (mpg): 70.5(Gasoline Equivalent)

Fuel Economy (mpg)	0
Gasoline Equivalent	70.5
Distance (miles)	6.8

(c) Your designed electrified SUV could be heavier than the conventional SUV, but vehicle performance and fuel economy should be better than conventional one.

COMPARISON:

UDDS:

Version	**Conventional**	**EV**
0 to 60 mph acceleration time(s)	**11.7**	**7**
energy consumption (Wh/mile)	**1892**	**447.26**
Fuel economy (mpg)	**17.6**	**70.2**

HWFET:

Version	**Conventional**	**EV**
0 to 60 mph acceleration time(s)	**11.7**	**7**
energy consumption (Wh/mile)	**1313.11**	**441.13**
Fuel economy (mpg)	**25.4**	**73.6**

US06:

Version	**Conventional**	**EV**
0 to 60 mph acceleration time(s)	**11.7**	**7**
energy consumption (Wh/mile)	**1935.17**	**570.17**
Fuel economy (mpg)	**17.3**	**54.6**

NEDC:

Version	**Conventional**	**EV**
0 to 60 mph acceleration time(s)	**11.7**	**7**
energy consumption (Wh/mile)	**1874.71**	**456.21**
Fuel economy (mpg)	**17.9**	**70.5**

By comparisons in four cycles we can find that EV has faster acceleration which means that EV costs less time from 0 to 60mph in just 7s, reduces about 40% acceleration time compared with conventional one. Energy consumption could be reduced about 66%~76% by using EV version. Fuel economy increases significantly by using EV version that in NEDC, HWFET, UDDS EV could achieve 70+ mpg, which is far above the conventional one. So, in aspect of both dynamic and fuel economy, EV would achieve a better performance than the conventional one.