Final Project Presentation

Project Work

<BTECH, AE 8th Semester>

Design of an Electric 2-Wheeler Conversion Kit Model (for existing Indian vehicles)

Group Details

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Batch : FET2017

- **Proposed Supervisors**

  Main Supervisor: **V. R. Kiran, Asst. Professor**

  Supervisor 2: **Monish Gowda M.H., Asst. Professor**

- **Proposed Place of Work**

  Off campus

Outline

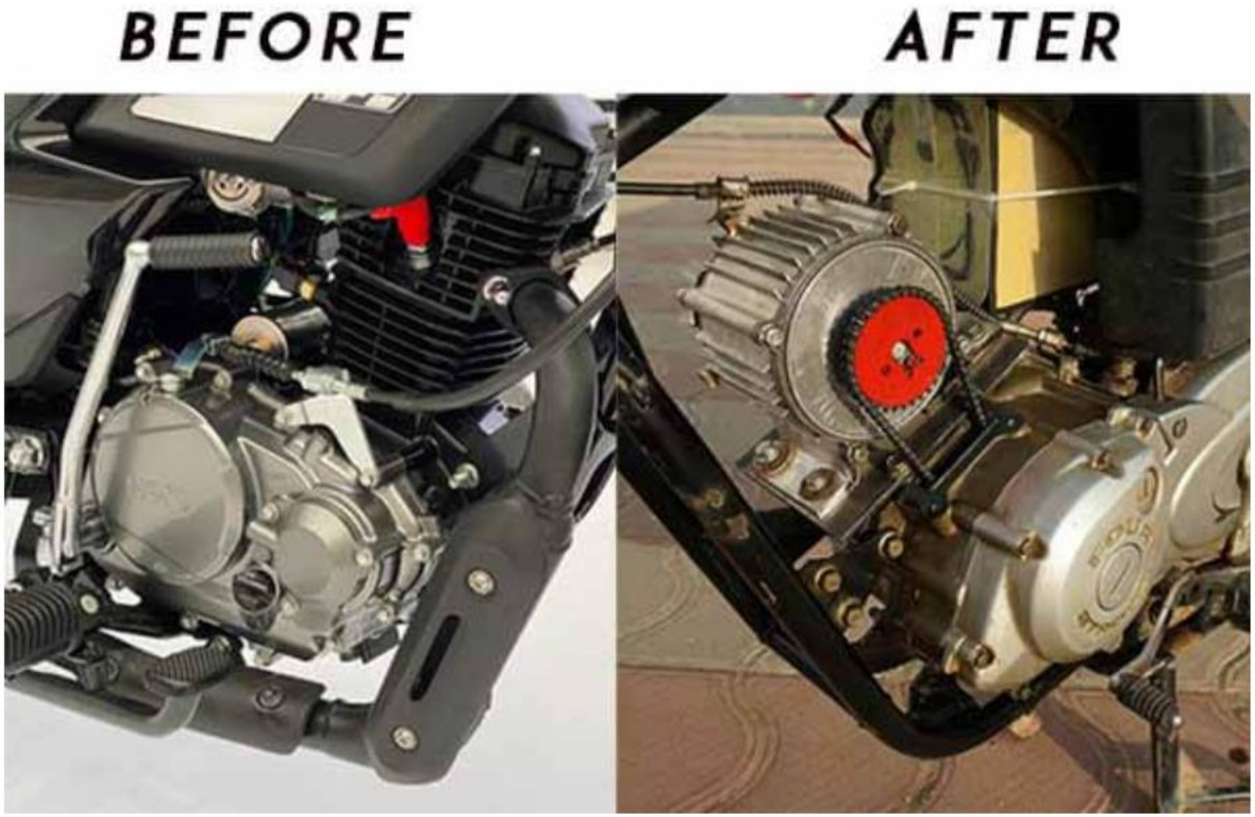
- Introduction
- Motivation(Project Concept and its relevance)
- Title and Aim
- Objectives
- Methods and Methodology
- Resources Required and Availability
- Outcomes
- Gantt Chart
- References

Our Vision

- The GOI has set a deadline of 2030 for electrification of all vehicles.
- So, first and most importantly we must recognize the need to control and reduce pollution.
- The remedial step is to incentivize conversion of conventional vehicles to Electric vehicles.
- Purchase Conversion by motivating customers to buy Electric vehicles instead of conventional vehicles.
- Conversion of existing or candidate vehicles to Pure EV(s).
- Conversion of existing or candidate vehicles to Hybrid EV(s).
- Replacing the Engine and Driveline configuration of a vehicle with a Motor, Battery and Driveline configuration.
- Using a conversion kit to do this or adopting Conversion plans designed for this purpose.

Introduction

- We propose to design a Conversion kit for an Electric 2-Wheeler in a staged manner.
- We intend to use **Design analysis & Software tools** to **plan for & validate the design of the conversion kit** and **to simulate and compare the performance characteristics** of the conversion from a Conventional IC engine 2-Wheeler to an Electric 2-Wheeler.



Converting Petrol Bike to Electric

Motivation

- We find that Electric Vehicles are important for the future of commuting.
- Though they have higher Initial Upfront Costs, their Lifetime Costs are lesser (that is lesser costs due to Fuel consumption, Service, Repair/Replacement).
- We as engineers would like to highlight the importance of design in problem solving, innovation and costs reduction.
- We feel that 2-wheeler market made up of scooters, mopeds & motorcycles has many good ICE powered products that need not meet a silent end-of-life.
- Semi-urban and rural two wheeler owners will not want to trade or discard their old vehicles, so cost effective conversion kits are the need of the day. Hence this project helps solve problems in this regard.
- We expect to design a Conversion kit that can help ICE vehicles pass stricter emission norms and fitness certification.

Title and Aim

Project Title: Design of an Electric 2-Wheeler Conversion Kit Model

Aim: To convert an Internal Combustion Engine (ICE) powered 2-Wheeler to a pure electric vehicle by the use of Conversion Kit Model.

Objectives

- To carryout a Literature/ comparative review of the available Conversion Kits and it's major components and to understand the impact and need for electric 2-wheeler conversion kits.
- To create a 3D model and arrive at packaging of BEV
- To perform powertrain calculations for ICE and BEV
- To develop mathematical model of ICE and BEV
- To plot the characteristics of ICE & BEV parameters and compare them

Methodology

Objectives	Methodology	Resources/Tools used
To carryout a Literature/ comparative review	Reading up Books	Books, Internet
	Reading up Technical articles	
To create a 3D model	Importing the Motorcycle model	CATIA V5
	Conversion plan	
To perform powertrain calculations	Equations from Automotive Mechanics	Microsoft Excel & Workbook
	Equations from Mathematical model	
To develop mathematical model of ICE and BEV	Simulink Equations method	MATLAB-Simulink
	Simulink Systems modeling	
To analyse the results	Comparison of mathematical model with simulation	
	Comparison of BEV with ICE	

Literature Survey

Understand the impact and need for electric 2 Wheeler Conversion kit.

- Studies indicate that the electrification of two wheelers of a capacity of 150cc is not yet a profitable option for two wheeler manufacturers, so efforts are on to address this issue.
- Almost all major players are in transitional phases of launching electric bikes due to the recent "Niti Aayog" directive.
- **Niti Aayog directive (National Institute for Transforming India)**

Directive to vehicle manufacturers to foster involvement and participation towards environmentally cleaner vehicles

- "FAME" (an abbreviation for Faster Adoption and Manufacturing of hybrid (& Electric) vehicles) in India is promoting Electrification.

Literature Survey

- Innovations sought for **positive vehicle waste management** and **controlling of EV related brand density on road** where it does not solely mean purchase of new electric vehicles
- **Bharat Stage BS-VI fuel compliant and emission norms**

Expected to apply from 2020 with estimated year of 2022 and later for complete compliance, where BS-VI emission levels of Particulate matter range from 20 to 40 micrograms per cubic metre as compared to BS-IV of 120 micrograms per cubic metre.

Assess the two wheeler market for the need of cost effective Conversion kits

❖ Top selling scooters have been “Honda Activa, Honda Dio, TVS Jupiter, Suzuki Access, Hero Maestro”.

Literature Survey

- Motorcycles hold a market share of 2/3rd of the two wheeler segment.
- Top motorcycles have been Hero Splendor, Hero HF Deluxe, Hero Passion, Honda Cb Shine, Honda Unicorn, Bajaj CT100 & Bajaj Platina, TVS apache etc.
- Ather Energy has signed a MOU with TN govt to manufacture 1,00,000 electric bikes and 1.2 million battery packs.
- Bengaluru based "Ultra-violette Automotive" expects to build an ecosystem for addressing need for sustainable transportation and solutions for energy.
- The business opportunity for EV players is promising with this regard

Literature Survey

Literature review of suitable conversion kits

- "Mechatronics Trading, Pune" manufacturer of Conversion kits for motor cycles, scooters and mopeds
- "Nanotech, Salem" supplier of Conversion kits for mopeds and cycles
- "Nanotech, Salem" supplier of Lithium ion Battery packs and chargers
- "Meladath Auto Components, Bengaluru" dealer for Hybrid kits for scooters

Literature Survey

Sl no	Company Name	Specifications	Price
1	Cloud Surfers (17-inch geared hub motor with disc brake)	• 17-inch 48v 20W geared hub motor with disc brake • Claimed top speed 60 to 75 kmph • IP65 approved water proofing • Includes Controller and throttle	Rs.24,000
2	Cloud surfers 17-inch geared hub motor with disc brake.	• 17-inch 72v 1000W geared hub motor with disc brake • Claimed top speed 70 to 80 kmph • IP54 approved water proofing • Includes Controller and throttle	Rs.30,000
3	Go Go A1 17inch electric hub motor.	• 17-inch 2000W geared hub motor with disc brake • Claimed top speed 70 to 80 kmph • IP54 approved water proofing • Max Torque 60 Nm • Load Carrying capacity 100 to 300 kg	Rs.20,889
4	Cloud surfers 17-inch geared hub motor with disc brake.	• 17-inch 60v 1000W geared hub motor with disc brake • Claimed top speed 70 to 80 kmph	Rs.18,000
5	Go Go A1 17inch hub motor with regenerative controller.	• 2000W,60Nm torque • includes regenerative controller throttle convertor	Rs. 10,989
6	Sri Electronics and embedded solutions. (Model Name: BM1412ZXF)	• 1500W, 48v,20.6Nm torque • Max carrying capacity 1000kg	Rs. 21,000
7	LAXIN Energy	• 48v, 1500W, 13Nm torque • Max Speed 40 to 60kmph • Ip64 water proofing	Rs. 20,000

Design Targets

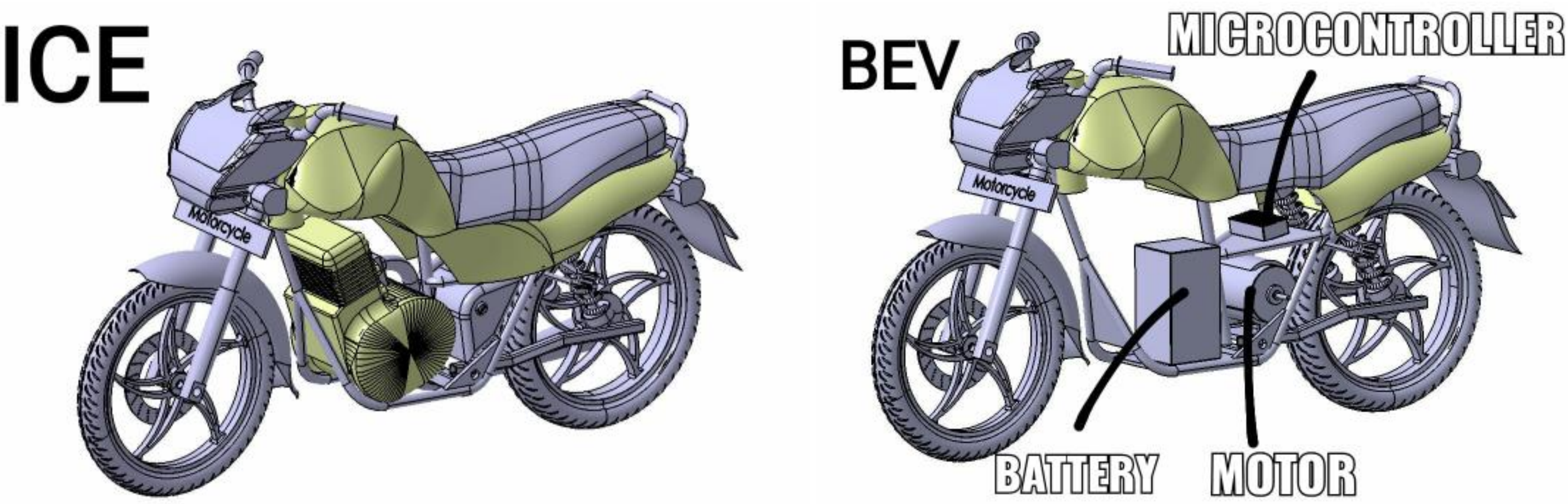
Plan for a universally viable cost effective kit model (continued)

❖ <u>Decide on the Lithium ion battery specification that is</u>

- Voltage rating of 48 V
- Ampere rating of 50Ah
- Plus charger

- <u>Consider other target specifications like</u>
- Battery Pack weight should be (30% or slightly more of) Gross or Kerb weight
- Range should be approximately 50 plus km (50 km being a practical range)
- Charging time should be approximately 5-6 hours

3D Modeling and Packaging



Packaging of Conversion Kit

ICE counterpart (mathematical model)

The model includes calculations for

- Tractive power
- Tractive effort
- Torque
- Gear box reduction ratio
- Final drive ratio

Electric Vehicle (mathematical model)

The model includes calculations for

- Tractive power
- Tractive effort
- Torque
- Gear box reduction ratio
- Final drive ratio
- Power motor, Power losses for motor, Efficiency of motor in propelling mode
- State of Charge new
- Power of battery
- Battery storage capacity

Important Calculations

- **Tractive effort = (T x ŋ x f x e) / r_{eff}**
- T = Torque in N/m
- ŋ = gear box reduction ratio f = final drive ratio
- e = Transmission efficiency (say 80%)
- r_{eff} = Effective radius of tire
- **ŋ = Gear box reduction ratio =** RPM at maximum Torque / RPM at maximum Power
- **ŋ = 6000/7500 = 0.8** (in our sample project)
- **Final drive ratio f = (**N_{max} x r x *0.377)* / (V_{max} x ŋ)
- We use for design Torque of 11 Nm @ 6000 rpm
- N_{max} = RPM "i.e. N" at top speed = 6000
- V_{max} = Top speed in km/h = 90 km/h = 25 m/s
- r = rolling radius (or radius of wheel) = 457.2 /2 mm = 228.6 mm = 0.2286 m
- **Final drive ratio f = (6000 x 0.2286 x 0.377)/ (25x0.8) = 25.85**
- **First gear ratio n1 = Tractive Resistance / Engine Torque * wheel radius**
- **Tire specification = 80/100-18 reff = 80/2 = 40 mm = 0.04 m**

Important calculations (Conventional vehicle)

Validation

- **Calculations for 60 km/h in m/s, level road:**
- Ftr = Faero + Fi + Fgrade + Frr
- Faero = ½ ρ Cd Af V^2 = ½ x1.13x 0.38 x 0.8 x 16.67 x 16.67 = 47.73 N
- Fgrade = mgsin(θ) = 115 x 9.8 x sin(0) = 0
- Frr = mg Crr = 115 x 9.8 x 0.01 = 11.27 N
- Ftr = Faero + Fi + Fgrade + Frr = 59 N + Fi
- **Calculations for possible speed in m/s, inclined road:**
- Faero = ½ ρ Cd Af V^2 = ½ x 1.13 x 0.38 x 0.8306 x 15.28 x 15.28 = 41.64 N
- Fgrade= mgsin(θ)= 115 x 9.8 x sin(25) = 115 x 9.8 x 0.423 = 476.72 N
- Frr = mg Crr = 115 x 9.8 x 0.01 = 11.27 N
- Ftr = Faero + Fi + Fgrade + Frr = 529.63 N + Fi

Important calculations (Conventional vehicle)

- **Calculations for 60 km/h, level road:**
- Ftr = Faero + Fi + Fgrade + Frr = 59 N + Fi
- a = (Ftr – Faero – Fgrade – Frr) / mi; a = Fi /122
- **Calculations for possible speed, inclined road:**
- Ftr = Faero + Fi + Fgrade + Frr = 529.63 N + Fi
- a = Fi / 122
- **Calculations for achieving 16.67 m/s or 60 km/h speed in 7.5s:**
- a= (16.67 – 0)/7.5 = 2.224 m/s2
- Fi = mi x a = 122 x 2.224 = 271.33 N
- Where estimations indicate Fi can increase till 340 N
- **Tractive force** is about **330.3 N** to scaled up values of **1254 N**
- **Tractive power=** Tractive force x velocity=330.3 x16.67 = **5506.6 W**

Important calculations (BEV)

Validation

- **Calculations for 60 km/h in m/s, level road:**
- Ftr = Faero + Fi + Fgrade + Frr
- Faero = ½ ρ Cd Af **V**2 = ½ x1.13x 0.38 x 0.8 x 16.67 x 16.67 = 47.73 N
- Fgrade = mgsin(θ) = 122 x 9.8 x sin(0) = 0
- Frr = mg Crr = 122 x 9.8 x 0.01 = 12 N
- Ftr = Faero + Fi + Fgrade + Frr = 59.73 N + Fi
- **Calculations for possible speed in m/s, inclined road:**
- Faero = ½ ρ Cd Af **V**2 = ½ x 1.13 x 0.38 x 0.8306 x 15.28 x 15.28 = 41.64 N
- Fgrade= mgsin(θ)= 122 x 9.8 x sin(25) = 122 x 9.8 x 0.423 = 505.74 N
- Frr = mg Crr = 122 x 9.8 x 0.01 = 12 N
- Ftr = Faero + Fi + Fgrade + Frr = 559.38 N + Fi

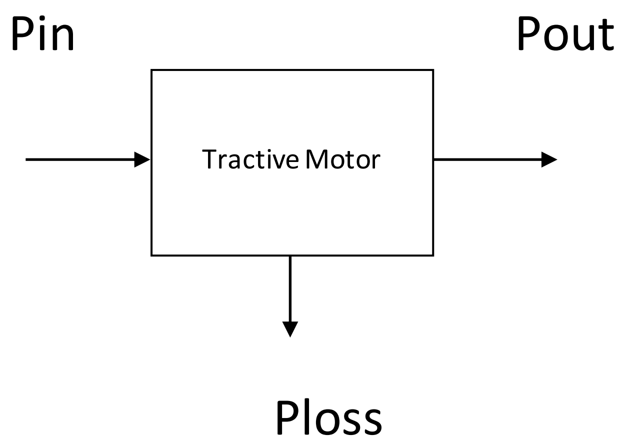
Important calculations (BEV)

Validation

- **Calculations for 60 km/h, level road:**
- Ftr = Faero + Fi + Fgrade + Frr = 59.73 N + Fi
- a = (Ftr – Faero – Fgrade – Frr) / mi; a = Fi /122
- **Calculations for possible speed, inclined road:**
- Ftr = Faero + Fi + Fgrade + Frr = 559.38 N + Fi
- a = Fi / 122
- **Calculations for achieving 16.67 m/s or 60 km/h speed in 7.5s:**
- a= (16.67 – 0)/7.5 = 2.224 m/s2
- Fi = mi x a = 122 x 2.224 = 271.33 N
- Where estimations indicate Fi can increase till 340 N
- **Tractive force** is about **331.06 N** to scaled up values of **1254 N**
- **Tractive power=** Tractive force x velocity=331.06x16.67 = **5518.8 W**

Electric Vehicle (mathematical model)

- **<u>We use a Tractive Motor model to specify the motor</u>**



- Pmotor = T x ω = **25.5 x 261.8 = 6675.9 W (for lower value of T)**
- Where T = Torque of the motor in Nm (range 25.5 to 27.5)
- ω = Base speed of the motor in rad/s (2500 RPM x 2π/60)
- Ploss = Kc x T^2 + Ki x ω + Kw x ω^3 + C, where
- Ploss = 0.12 x 25.5^2 + 0.01 x 261.8 + 1.2x10-5 x 261.8^3 + 0.13
- Ploss = 78.03 + 2.618 + 215.323 + 0.13 = 296.01 W

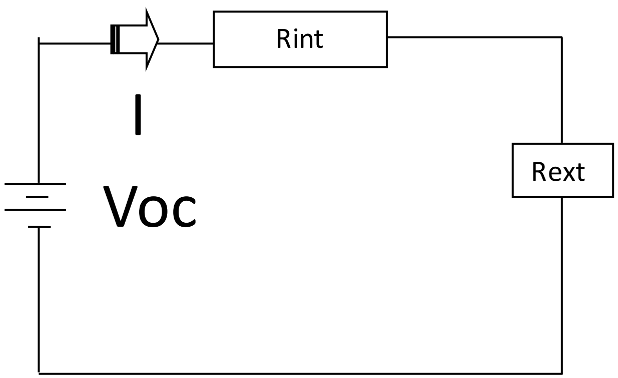
Electric Vehicle (mathematical model)

- Kc = Motor loss constant for reference motor (in $1/kgm^2$)
- Ki = Motor loss constant for reference motor (as I)
- Kw = Motor loss constant for reference motor (in kgm^2)
- C = Motor loss constant for reference motor (as W = mg)

- Despite 2 modes that the motor can operate in, that is, the Propelling mode and the Regenerative mode, we will calculate
- ŋprop for the Propelling mode only
- ŋprop = (T x ω) / (T x ω + Ploss) = **6675.9 / (6675.9+**296.01)
- ŋprop = **6675.9 / 6972.0 = 0.95%**
- ŋregen = (T x ω + Ploss) / (T x ω), not used in this model
- <u>**As per the calculations, for this conversion we need a 6KW motor**</u>

Electric Vehicle (mathematical model)

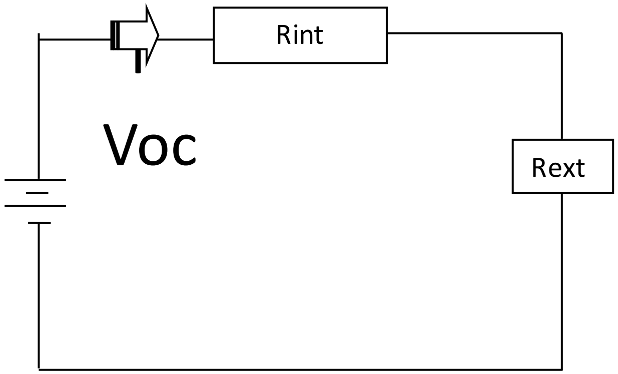
<u>We use a simple model to specify the battery</u>



- Voc = As per battery specifications
- $I = Voc - ((Voc^2 - 3 \times Rint \times Pactual)/(2 \times Rint))^{1/2}$
- $Pideal = I \times Voc$
- $Ploss = I^2 \times Rint$
- $Pactual = Pideal - Ploss$
- $Vterminal = Voc - (I \times Rint)$
- $SOCnew = SOCold + 100 \times dEint/E$
- Power of battery = Voltage x Current drawn
- Battery storage capacity = A-h = Current for discharge x number of hours before reaching endpoint voltage

Electric Vehicle (mathematical model)

Calculations for a 48 V 50 Ah battery



- **SOCold = 0.95**
- dEint/E = delta reduction in charge = 0.44-0.6
- for 10%
- SOCnew = SOCold + 100 x dEint/E
- **SOCnew = 0.95 + 100 x 0.044 = 5.35**
- Est Range: **50 km** x 0.621 = **31.05 miles**
- when Top speed: 60 km/h
- **Watt-hours of energy = 48 V x 50Ah = 2400 Wh = 2.4KWh**
- **Watt-hours of energy/kg = 2400 / 6 or 5.82 = 400 to 412.4 Wh/kg**
- Range = Watt hours of energy / average Watt-hours/mile
- **average Watt-hours/mile = 2400 / 31.05 = 77.3 Wh/mile**
- **average Watt-hours/km = 77.3 x 0.621 = 48 Wh/km**

Mathematical Modeling

To develop a MATLAB & Simulink System model

As our project expected to model the conversion an IC engine vehicle to an Electric vehicle, the main interest was to **develop a system model to study**

a. Motor operations
b. Battery operations
c. Drive Line operations

The **system model uses the following inputs**

a. Vehicle model specifications
b. Motor requirements
c. Drive Line configurations
d. Battery specifications / sizes

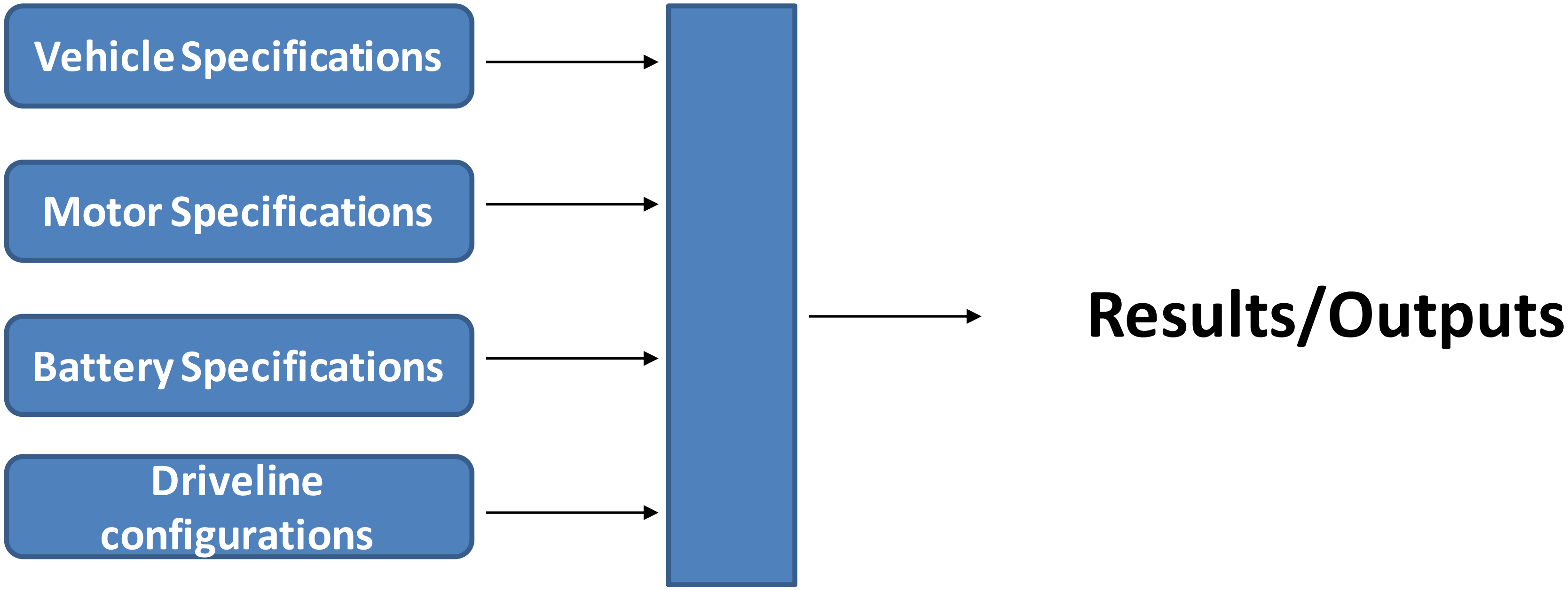
Mathematical Modeling

- <u>The **system model reports output characteristics such as**</u>

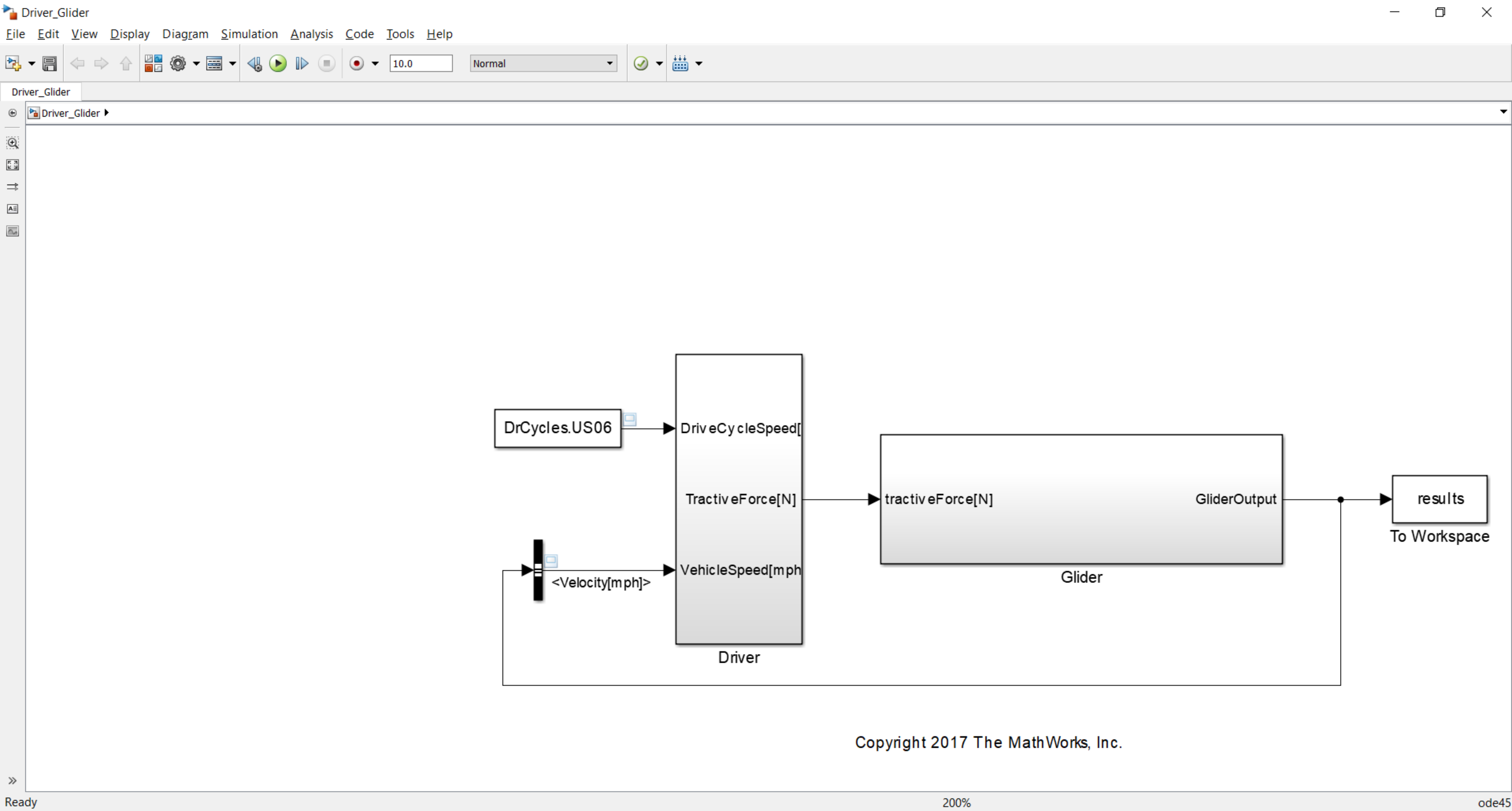
a. Torque versus speed (for ICE counterpart and BEV)

b. State of charge over drive cycle versus Time (for BEV)

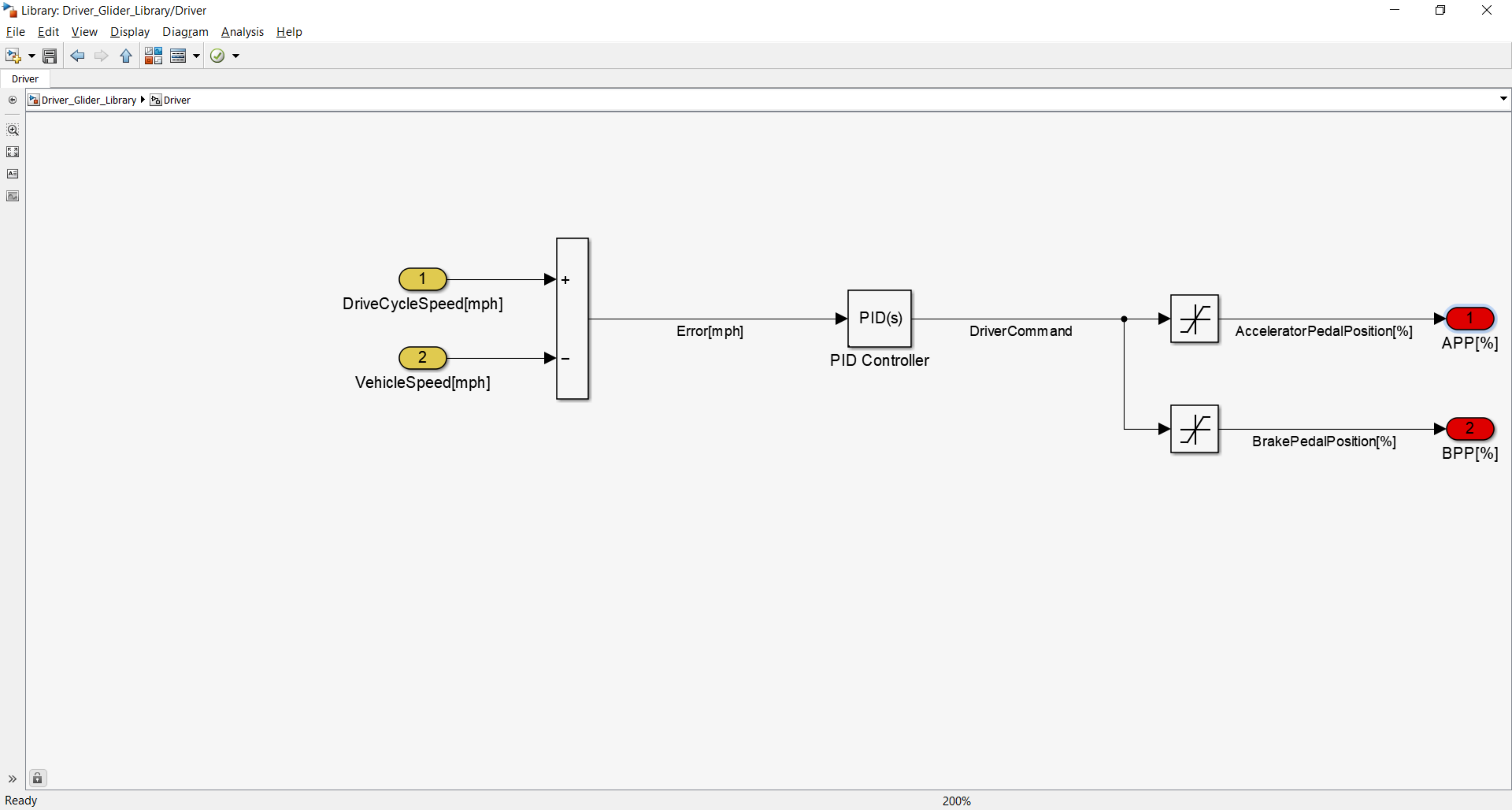
c. Battery power versus Vehicle speed (for BEV)



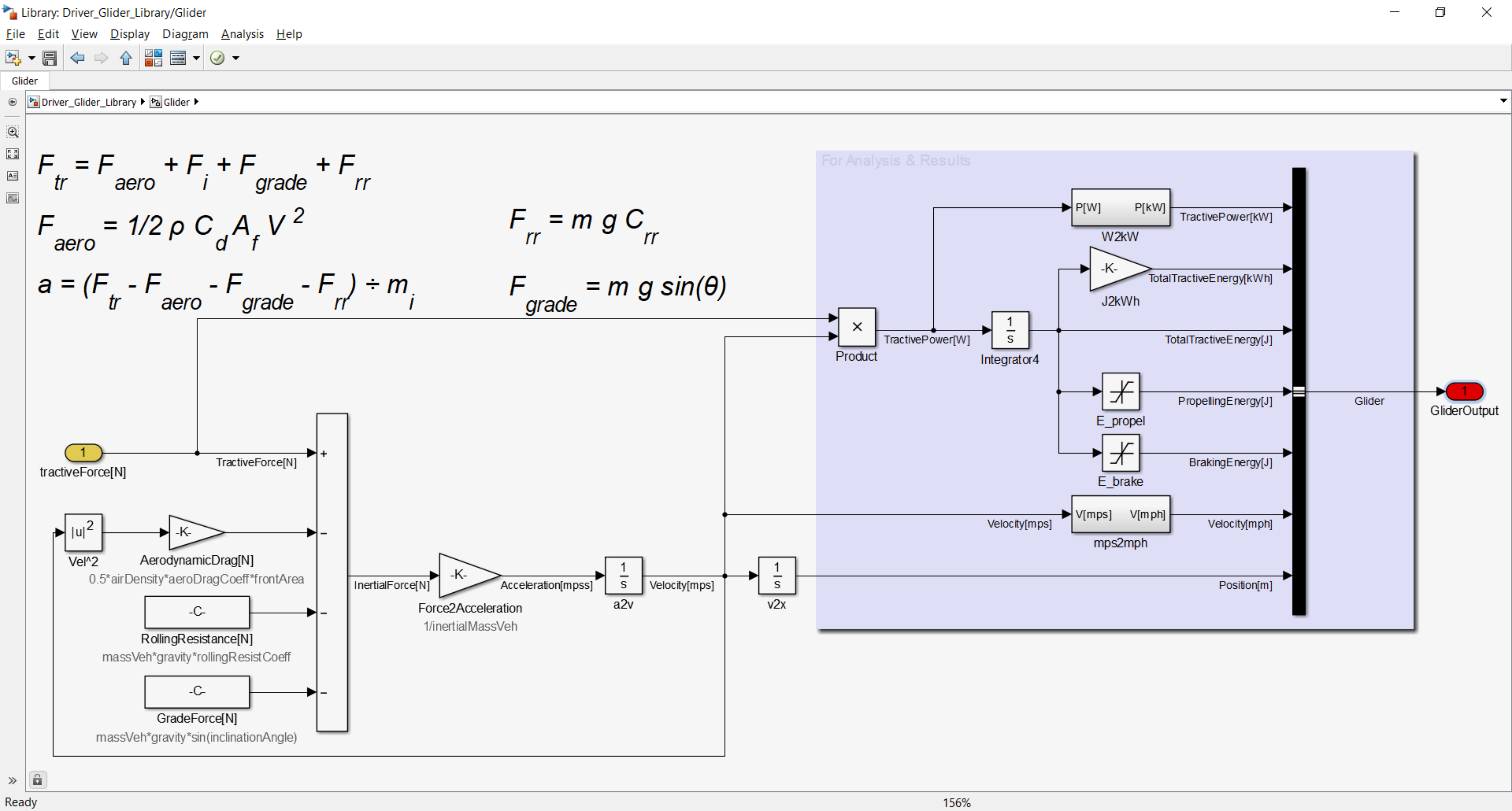
Related Glider*/System model



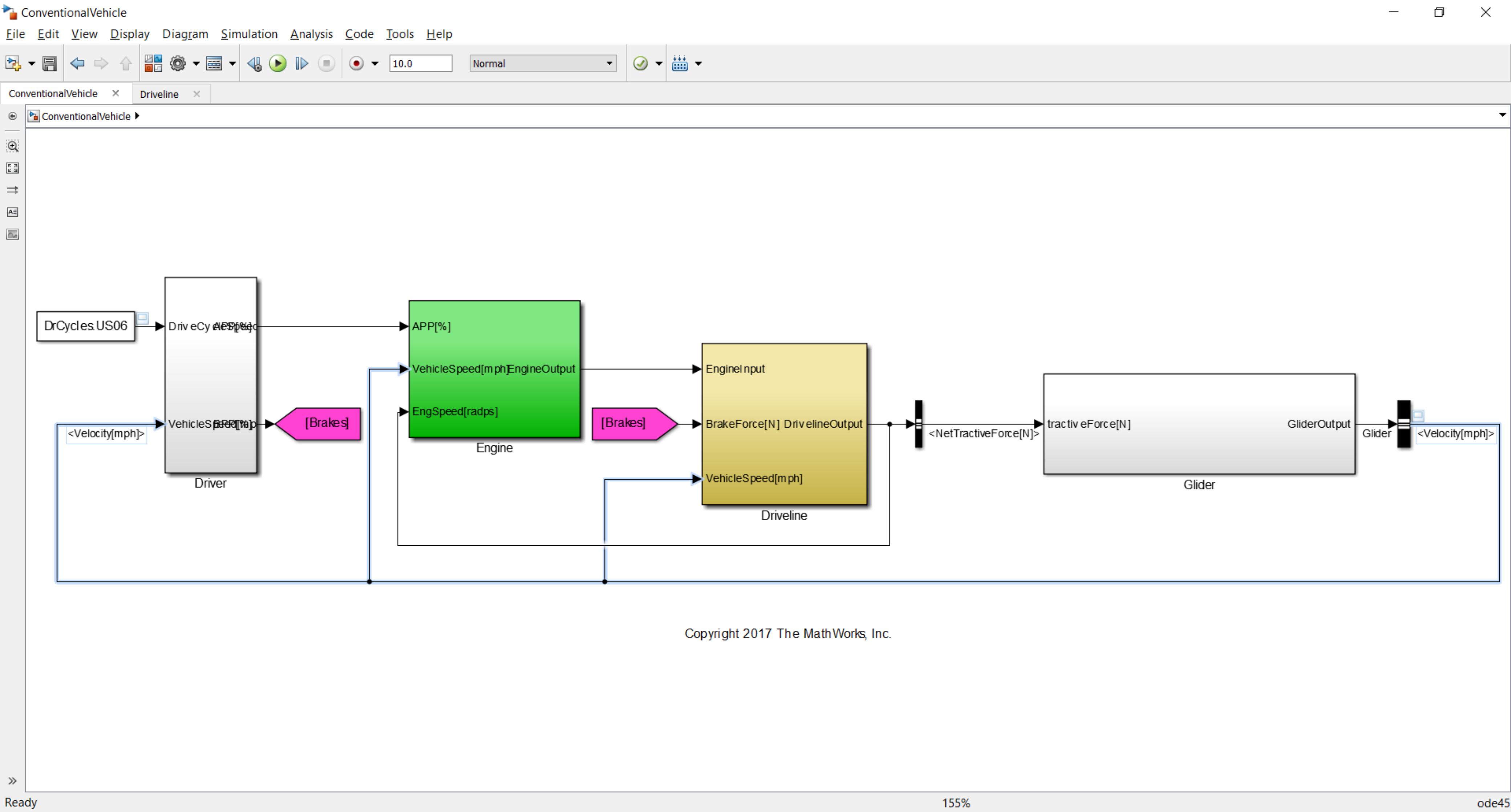
Related Driver/System model



Related Vehicle/System model



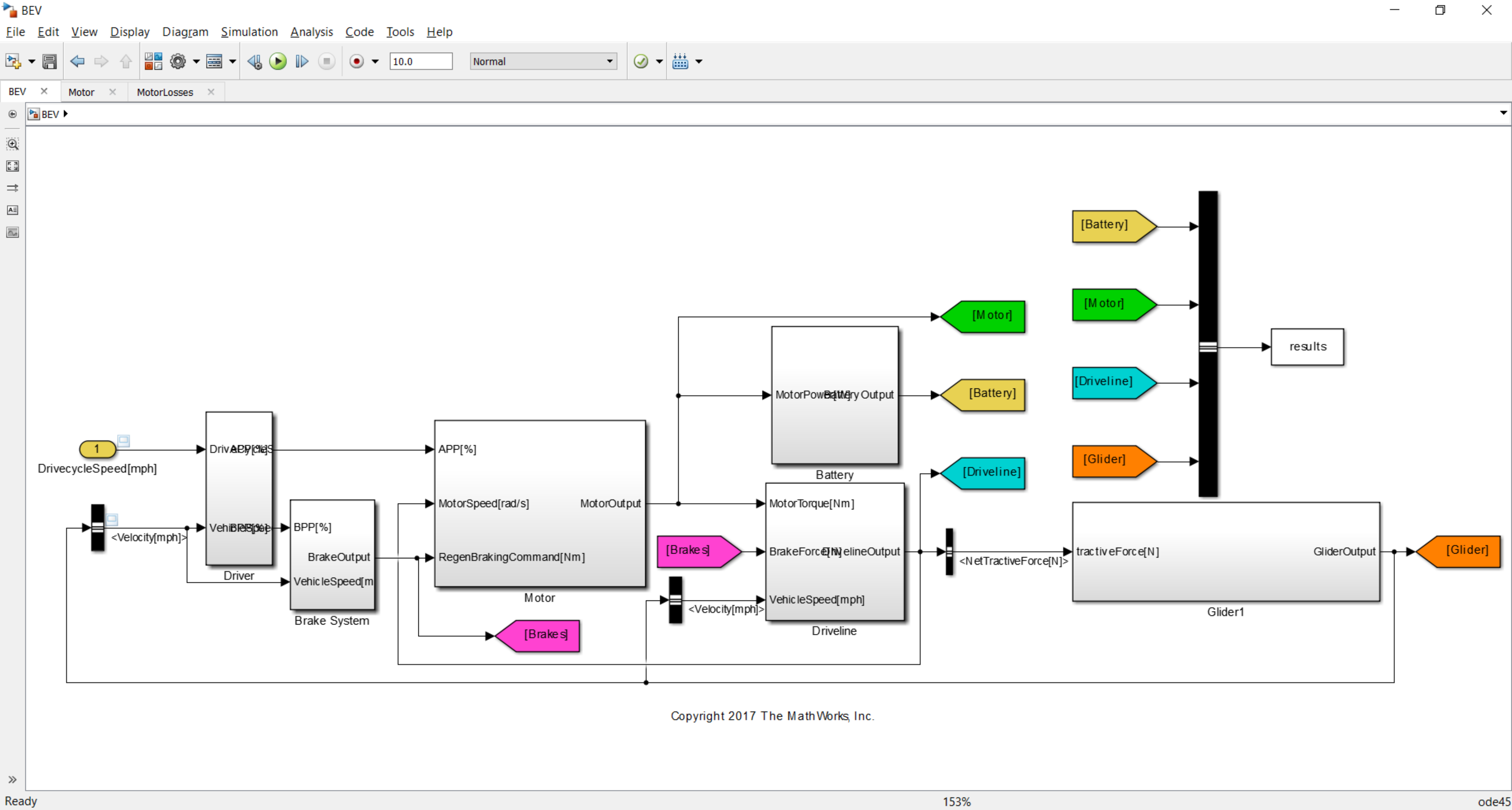
Related Conventional Vehicle/System model



Important data (Conventional vehicle)

- AeroDragCoeff = 0.38
- airDensity = 1.23
- frontArea = 0.8 (vehicle specifications)
- rollingResisCoeff = 0.01
- wheelRadius = 0.2286 (vehicle specifications)

Related BEV/System model



Important data (Battery Electric Vehicle)

- AeroDragCoeff = 0.38
- airDensity = 1.23
- frontArea = 0.8 (vehicle specifications)
- rollingResisCoeff = 0.01
- wheelRadius = 0.2286 (vehicle specifications)
- T_ref = 11 (vehicle specifications)
- T_max = 47.7 (our calculations)
- energyCapacity = 2.4
- initialSOC= 0.95 (specifications)
- internalResistance = 0.1
- openCircuitVoltage for 48 V Li-ion = 80 V (specifications)

Important data (Battery Electric Vehicle)

- K = 1.047162 (specifications)
- Kc_ref = 0.12 (specifications)
- Ki_ref = 0.01 (specifications)
- Kw_ref = 1.2×10^{-5} (specifications)
- C = 0.13 to 0.15 (specifications)

- New weight of BEV = Inertial weight + motor + battery pack
- **New weight = ~150 kg**
- (this is inclusive of motor controller, BMS, assemblage)
- **Weight on conversion = New weight – (weight of engine, weight of fuel) ~ 122 kg (inertial mass)**

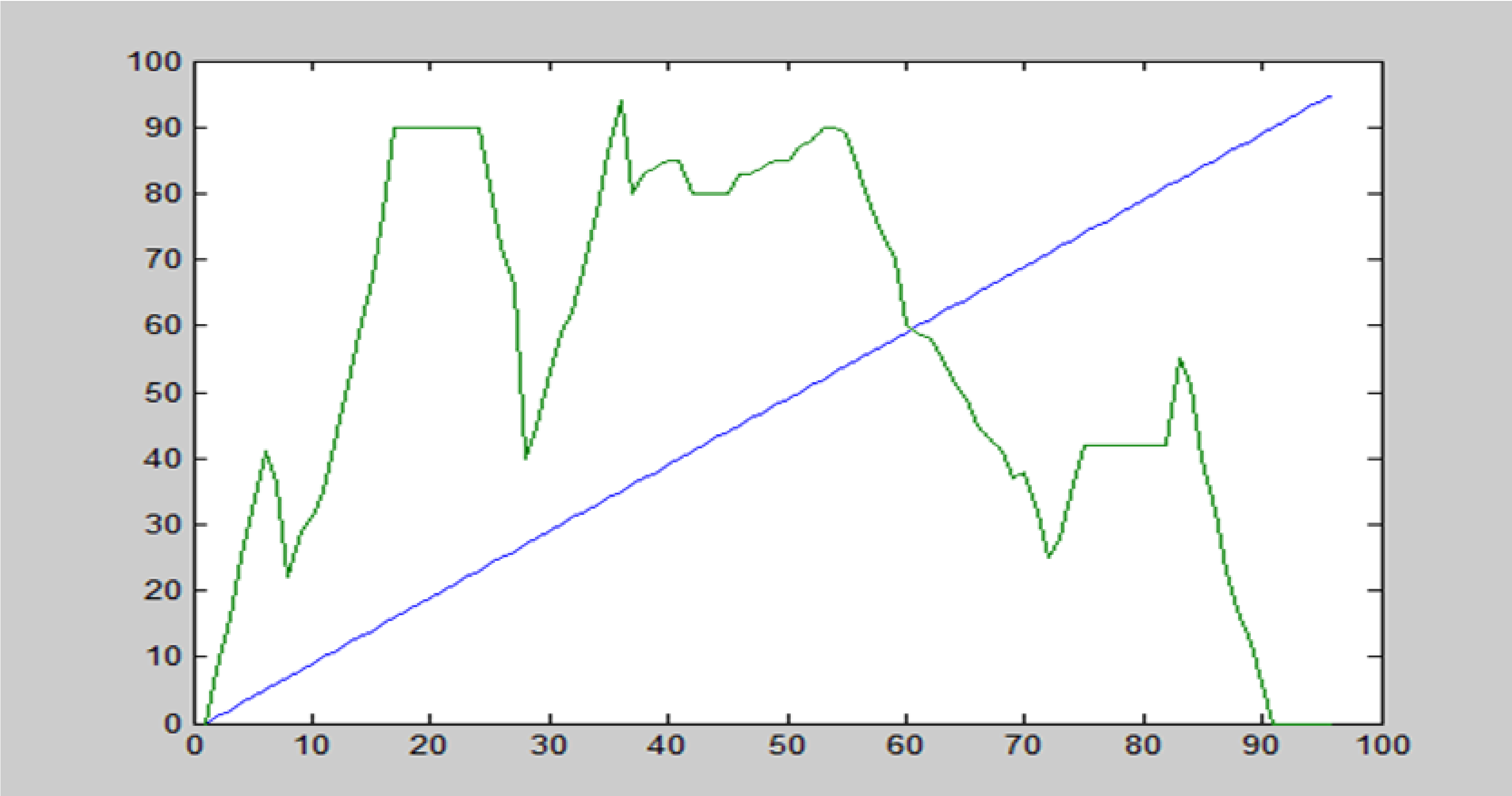
Related BEV/System model

- **Documentation**
- **Input(s):** (1) Drive cycle speed in mph and (2) Vehicle speed in mph (enabled as feedback)
- **Subsystem(s): Driver, Brake, Motor, Battery, Driveline and Glider (light weight vehicle model)**
- Details of each subsystem follow in the next page
- **Output(s): Simulation of results element and** Velocity in mph enabled as feedback to the Driver, Engine, Driveline subsystems and also to the Glider element

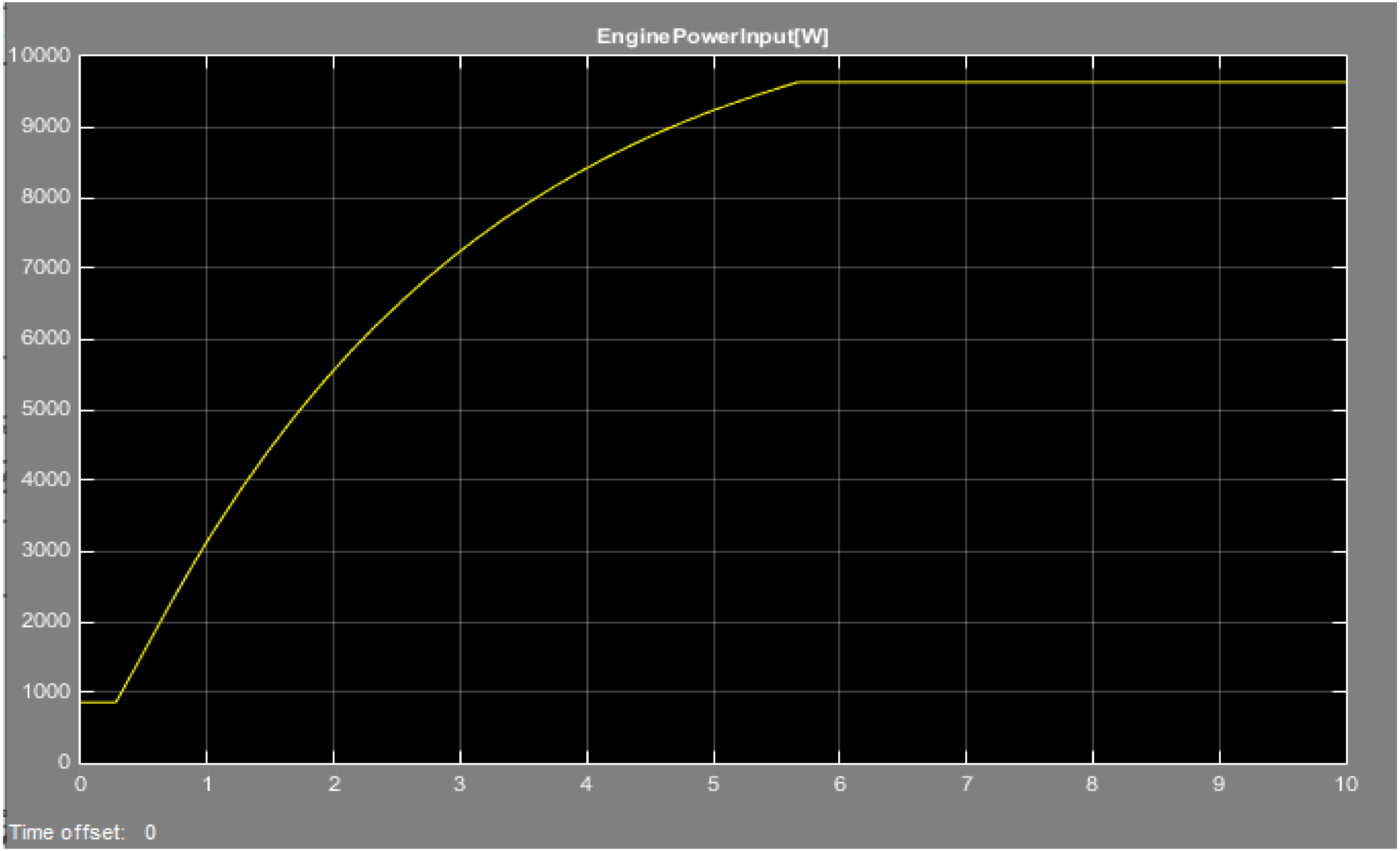
Results and Discussions

Results and plots of the characteristics of ICE & BEV.

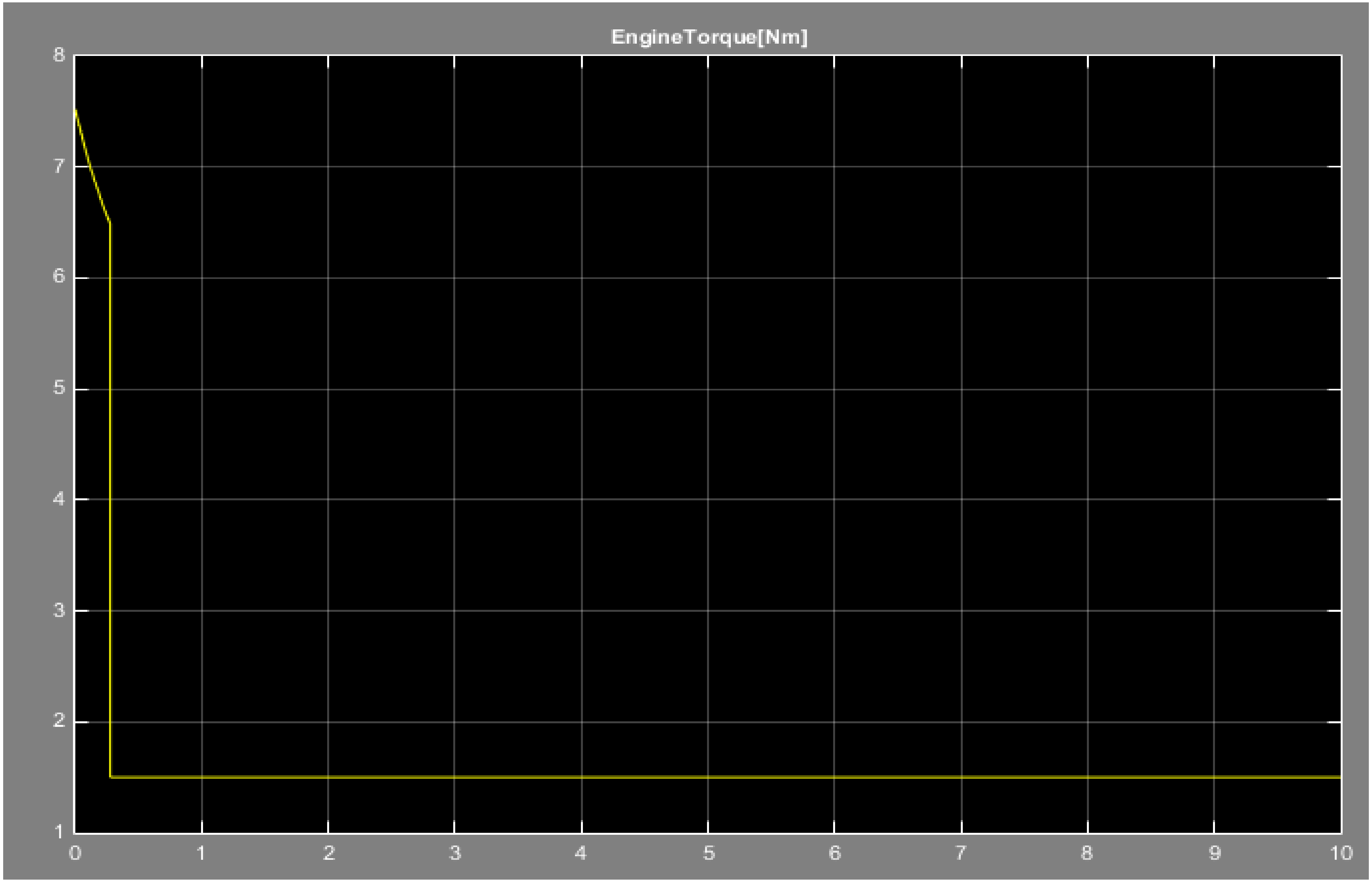
Drive Cycle Inputs (mph) for the system model



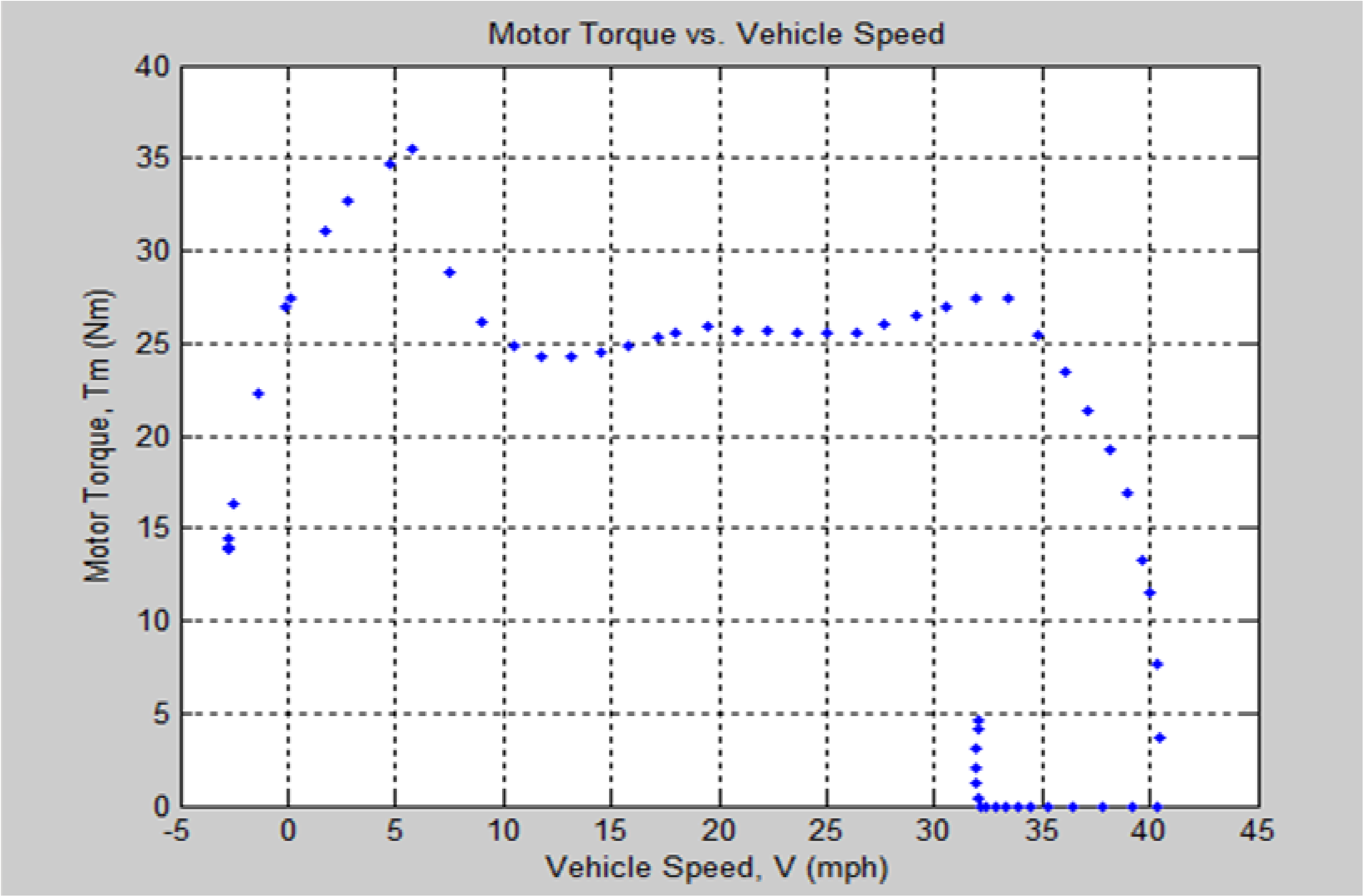
ICE Vehicle simulation(Engine Power) results



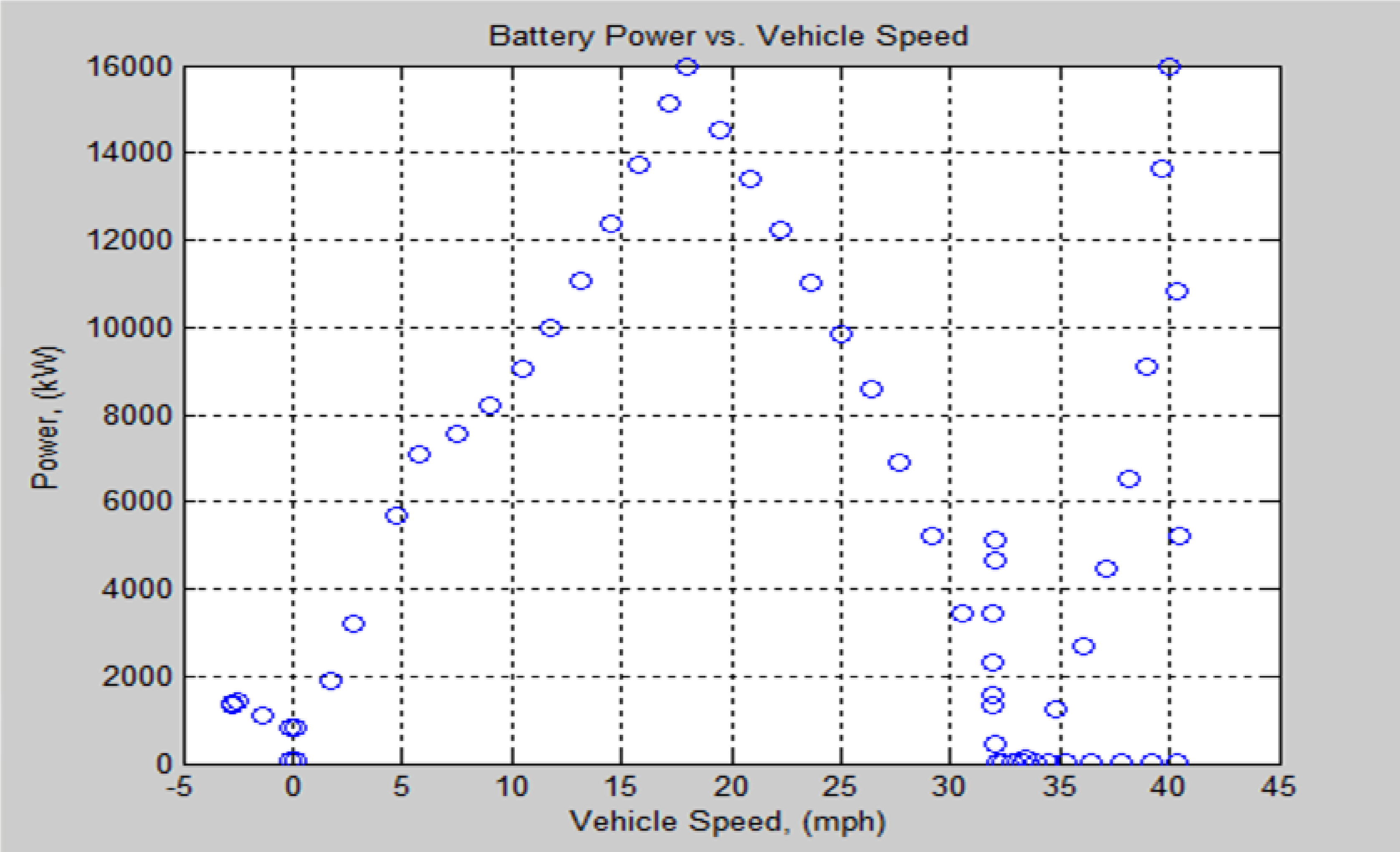
ICE Vehicle simulation(Engine Torque) results



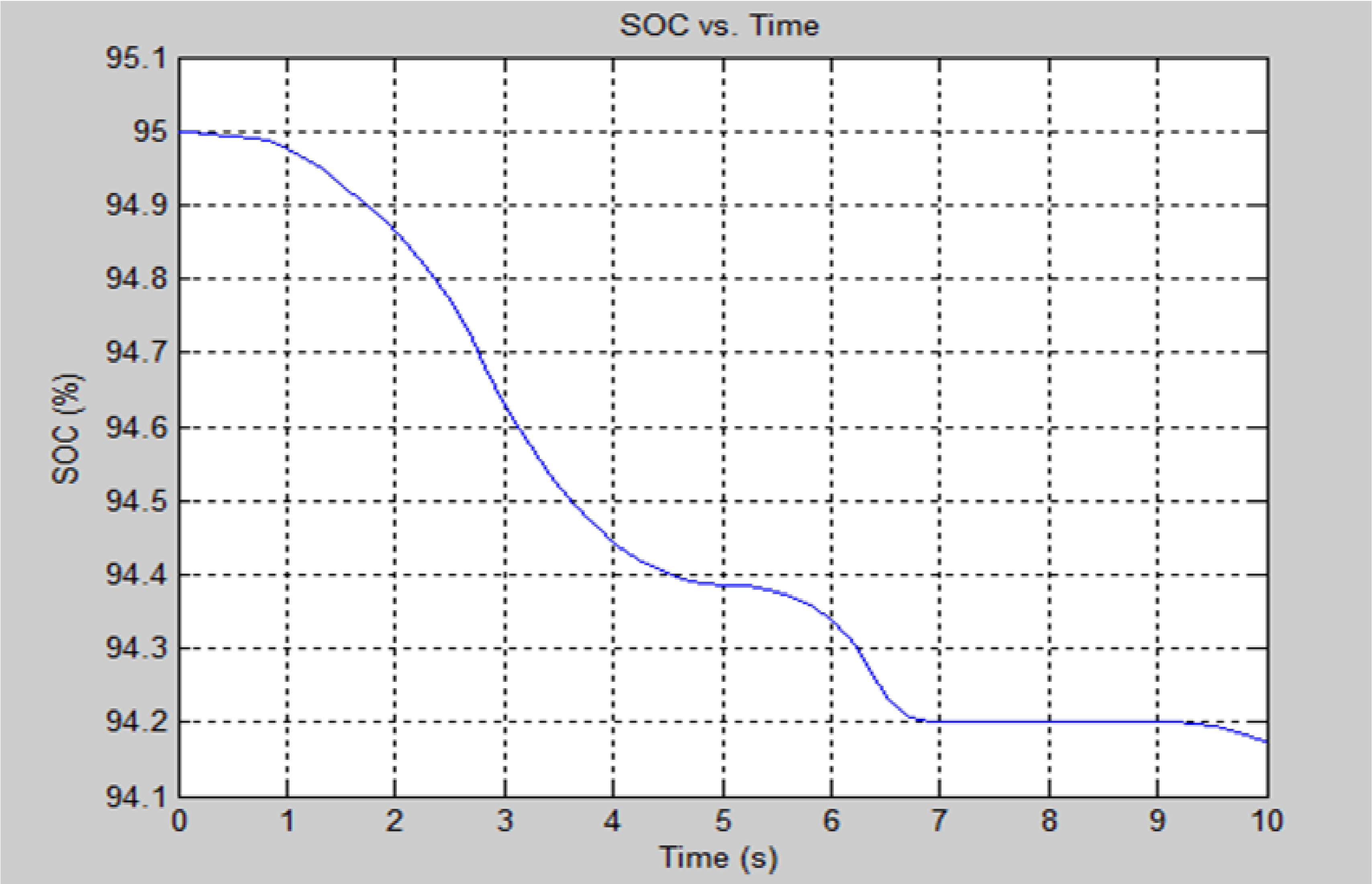
BEV simulation (Motor Torque versus Vehicle Speed) results



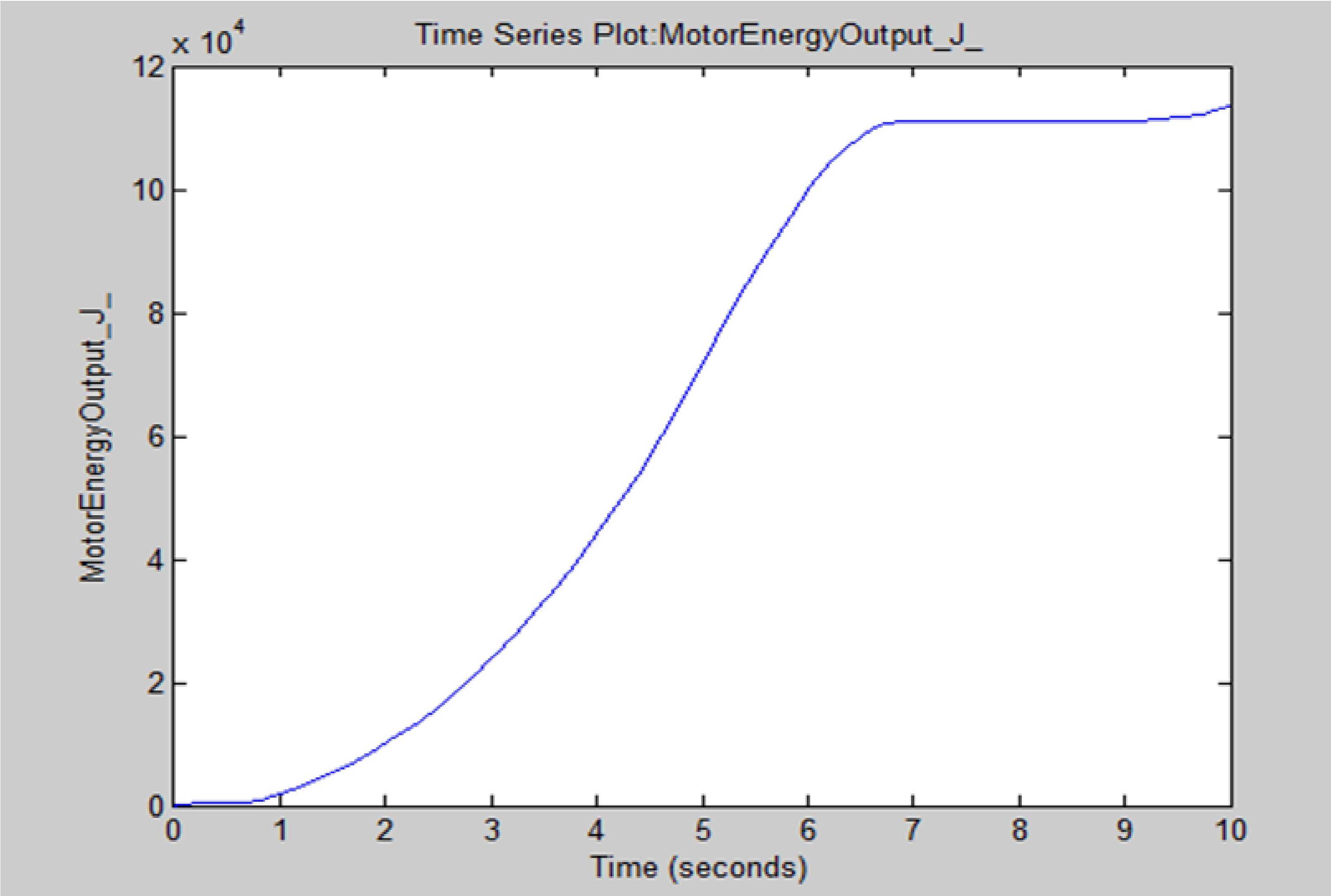
BEV simulation (Battery Power versus Vehicle Speed) results



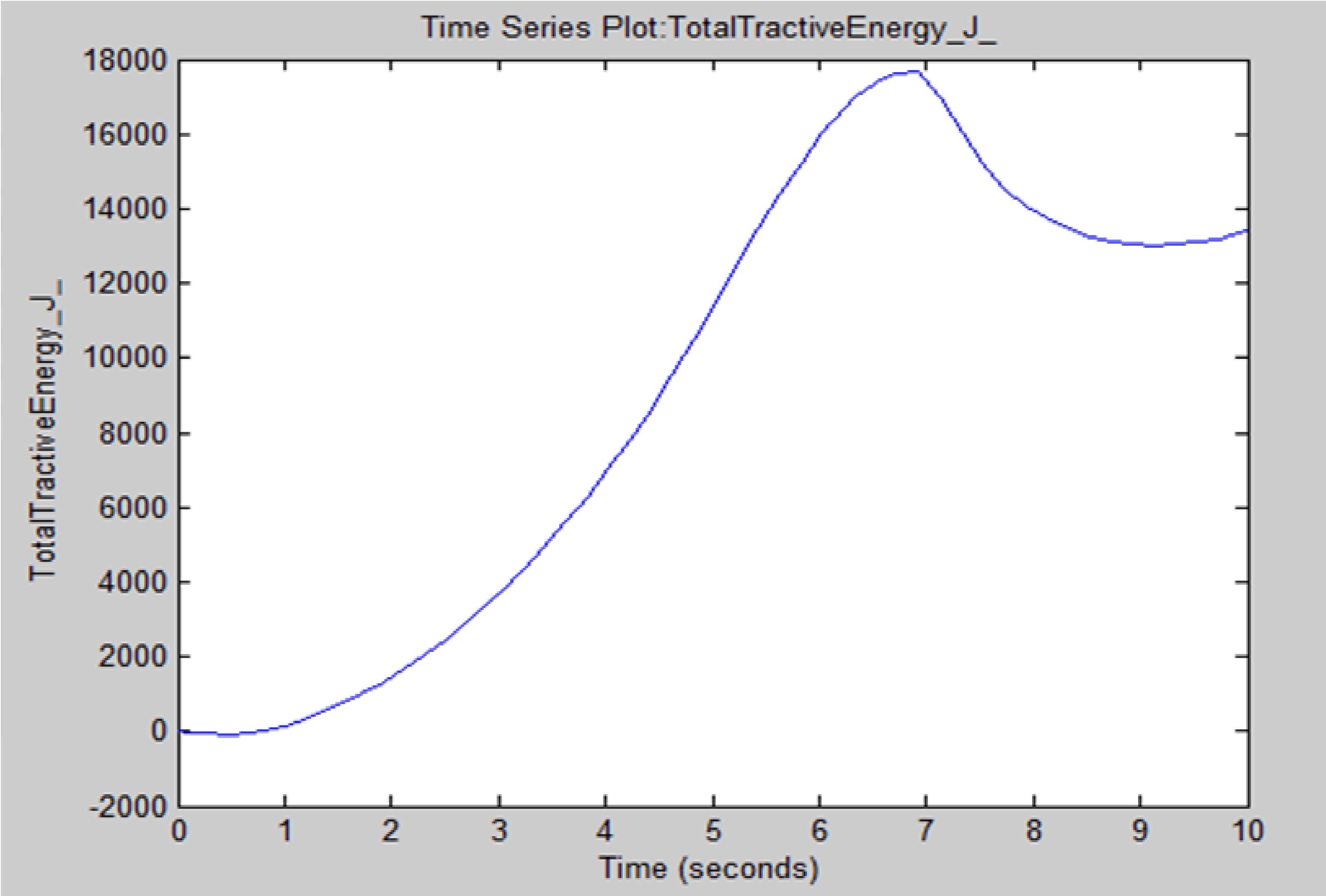
BEV simulation (SOC versus Time) results



BEV simulation (Motor Energy Output) results



BEV simulation (Total Tractive Energy) results



Comparison of (BEV versus ICE) results

Motor and Engine Related variables	(BEV) Simulation for drive cycle input data in mph for 100 s	(ICE) Simulation for drive cycle input data in mph for 100 s
Efficiency	87% as per specifications	80% or 0.7922 using (BP/IP)
Tractive Force	0 – 550 N	0 to 215.89 N
Speed	0 to 1100 rad/sec	0 to 1050 rad/sec
Torque	0 - 36 Nm	1.5 to 7.5 Nm
Power Input	PI: 0 - 33 KW PO: 0 - 33 KW	PI: 0.9 to high 9.9 KW

Simulation (Driveline) results

Driveline related variable	(BEV) Simulation for drive cycle input data in mph for 100 s	(ICE) Simulation for drive cycle input data in mph for 100 s
Tractive Force	0 - 550 N	14.52 to 566.5 N
Gear Ratio	Constant with zero Driveline losses	9.8 to 19.26 range
Driveline Torque	0 -36 Nm Same as Motor Torque with no influence on performance	28 to 142 Nm

Simulation (BEV/Glider/ICE) results

Performance Variables	BEV	Glider No Motor No Driveline	ICE
Tractive Force (N)	0 –550 N	0 to 215.89 N	0 to 220 N
Tractive Power (KW)	0 - 5 KW	0 to 1.75 KW	Lesser than Glider model in Watts
Total Tractive Energy (J)	0 to 17.9 KJ	0 to 4.206 KJ	Lesser than Glider model in Joules
Velocity explanation	Increasing / Decreasing acceleration sequence ~ 0.33 m/s2	Increasing / Decreasing acceleration sequence ~ 0.5 m/s2	Increasing / Decreasing acceleration sequence ~ 0.11 m/s2

Recommended Specifications

Specification	Rating
6KW BLDC for Top speed of 90 plus km/h **(This is our Theoretical / Simulation based choice)**	Rated Power: 6000 W 48 / 60 V **Max O/P Power: > 6000 W** **Rated Torque: ~ 25.5 to 27.5 Nm** Max O/P Torque: 400% of Rated Torque Rated Speed: 2500 - 6000 RPM Efficiency: 87% at full load and full RPM Weight: ~15 to 20 kg
Lithium Ion / Lithium Phosphate Battery (cheaper) **(This is our Theoretical / Simulation based choice)**	**48 V 50 Ah (onwards depending upon motor specification)** **Energy Storage Capacity = 2.4 kWh with Lithium Phosphate Battery Charger** **48 V 5 A/10 A**

Project Cost Estimates

- **To achieve critical vehicle performance, our specification of Conversion kit identifies basic Mechatronics components for the candidate vehicle**

1. 3KW to 6KW Brushless DC Motor – Rs. 21,600 to Rs. 34,000
2. Controller – Rs.10,820
3. Throttle set – Rs. 380
4. Primary sprocket – Rs. 680
5. 15A Converter – Rs. 470

- **Lithium ion battery specification**

- Lithium ion battery- 2.4KWh (specification 48 V, Ampere rating: 50Ah) plus charger – Rs. 17,500

Conclusions

- The BEV has more Tractive power when powered by the Right Motor or Battery.
- BEV is 7% more efficient than its ICE counterpart.(Statistically)
- The tractive force of BEV is 334.11N more than its ICE counterpart.
- There is no gear ratio in BEV, hence no Driveline losses.
- Torque of BEV is better than it's ICE counterpart as it has no engine loss and driveline loss effecting it.
- BEV(Constant geared) gives relative performance as compared to an IC engine with the Gear box.
- BEV can achieve better performance with following benefits:
  - Reduction in the use of Lubricants and fuels.
  - It produce fewer direct emissions, thus contributing less to climate change.
  - Cost of ownership is reduced.

Future Scope

- Enabling system modeling for faster and sustainable results
- Aiding the approvals sought process
- Adding Conversion Planning to the current flowchart
- **Conversion Plan ->** Proposal -> Test -> Approval -> **Facilitators**

R & D Factors that can improve Conversion

- **System modeling that includes**
- (a) **Modeling to show objective-change and assembly**
- (b) **Modeling that shows changes relevant to vehicle performance and ride**
- (c) **Simulations to compare EV versus ICE results…**
- The Motor Torque envelope versus Vehicle speed
- State Of Charge (SOC) versus Time
- Battery power versus vehicle speed

Approval expected for Conversion

- Approvals by

❑ **ARAI**

❑ **RTO**

❑ **FAME**

Gantt Chart

Week	1	2	3	4	5	6	7	8	9	10	11	12
Major Activities												
Project Started												
Work breakdown and design approach												
Design analysis												
Writeup of conversion plan												
Model preparation												
Simulation and Analysis of conversion plan												
Make Report												
Make Presentation												
Report submission												
Presentation submission												
Close out												
CCE												

References

- https://www.wheelsupdates.com/electric-vehicle/convert-petrol-bike-to-electric-india/amp/
- S Srinivasan, Automotive Mechanics S Srinivasan
- Carl Vogel, Build Your Own Electric Motorbike
- Gary Inman, How to build a motorcycle
- Seth Leitman and Bob Brant, Build Your Own Electric Vehicle
- github_repo for Vehicle Modeling using Simulink

Additionally

Acknowledgments

- Due to the second wave of the COVID-19 pandemic, there were changes in the original scope of the project, that is, the scope changed from actual fabrication of a conversion kit to a model with simulation and analysis using MATLAB/Simulink and CATIA.
- Each and every member of the group is responsible for completing the project. Everyone has done their share of background research for designing the conversion kit. They have done their best in designing and implementing a model, the packaging & assembly and for solving problems that arose in the associated simulation and analysis.
- Importantly our sincere thanks to our HOD Dr Raja Sir, Guides Prof V R Kiran Sir and Prof Monish Gowda M H Sir.

Team Experience

- Each and every member of the group is responsible for completing the project. Everyone has done their share of background research for designing the conversion kit. We have done our best in designing and implementing a model, the packaging & assembly and for solving problems that arose in the associated simulation and analysis.

- The need to work across locations was a little challenging but familiarity has set in due to the various Remote meetings scheduled by the faculty.

- Importantly our sincere thanks to our HOD Dr Raja Sir, Guides Prof V R Kiran Sir and Prof Monish Gowda M H Sir.

Thank You