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Electric & Hybrid Propulsion Control

(M3X8668)

Series Hybrid Vehicle Requirements

BSc Motorsport Engineering

2017/2018

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## Table of contents.

|                                            |    |
|--------------------------------------------|----|
| Table of contents. ....                    | 2  |
| List of figures.....                       | 3  |
| 1. Introduction. ....                      | 4  |
| 2. Technology Review. ....                 | 5  |
| 2.1. Series Hybrid. ....                   | 5  |
| 3. System specification & Discussion. .... | 6  |
| 3.1. Internal Combustion Engine. ....      | 6  |
| 3.2. Series Hybrid System.....             | 6  |
| 4. Preliminary Costings. ....              | 7  |
| 5. Conclusion & recommendations.....       | 10 |
| 6. Bibliography. ....                      | 11 |

## List of figures.

|                                                                            |    |
|----------------------------------------------------------------------------|----|
| Figure 1; Image of the motor drive system. (Electricmotorsports.com) ..... | 7  |
| Figure 2; Image of the battery. (Electricmotorsports.com) .....            | 7  |
| Figure 3; Image of the Aprilia-Rs125cc engine. (eBay.co.uk).....           | 8  |
| Figure 4; Image of the fuel tank. (eBay.co.uk).....                        | 8  |
| Figure 5; Image of the buggy. (Blitzworld.co.uk, 2017). .....              | 9  |
| Figure 6; Graph illustrating the power required.....                       | 10 |

# 1. Introduction.

This report will focus on the following points. Duty cycle analysis and selection of appropriate vehicles. The report has been split into two sections. A literature review and results analysis. The first task was to select a suitable vehicle.

The vehicle selected is a Vigilante - Corporate USE from [blitzworld.co.uk](http://blitzworld.co.uk). This buggy has been selected for various reasons. The engines are cheap for the buggy, typically £100, so maintenance for the buggy will be cheap. The buggy has a 1200cc petrol engine which produces around 80-90bhp. This equates to around 59-67Kw. The speed of the buggy can be electronically limited, the buggy will be limited to 35mph. (*Blitzworld.co.uk, 2017*).

The company that produces the vehicle has now shown interest in producing series hybrid vehicles for their next line of products. A technology review into series hybrid technology has been conducted to assess and evaluate current options and which is best suited for the current vehicle being tested. An excel document including the results and findings will be accompanied with the report.

## 2. Technology Review.

### 2.1. Series Hybrid.

A series hybrid is an electrical vehicle with an engine and generator which is used to supply electricity and recharge the vehicles battery when it has been sufficiently discharged.

The primary function of the generator is to extend the range of the electrical powered vehicle beyond the range of the batteries. Many series hybrid vehicles are intended to have significant range in low speed city driving. These vehicles used low power engines.

There are certain parameters that must be considered when designing a series hybrid drivetrain. These are as follows; Maximum motor torque and power, maximum internal combustion power and the useable electrical range. For current battery technology the battery size is decided by one of two factors. The peak power required or the energy required to meet the vehicle range specification.

The general efficiency of the internal combustion engine is an important factor but not crucial. This is because the vehicle is operated on the battery using wall-plug power sockets for around 80-90% of the miles covered. The control strategy for the internal combustion engine in a series hybrid is rather simple. The internal combustion engine will usually be switched on when the battery percentage has dropped below a certain value, for example 20%, it may also be switched back on when the battery charge percentage has reached a desired value, for example 30%. With this control strategy in place the usage percentage of the internal combustion engine would depend on the ratio of average power required needed to propel the vehicle and the power output of the internal combustion engine. *(Burke, 1992)*

### 3. System specification & Discussion.

#### 3.1. Internal Combustion Engine.

The original system used a 1200cc petrol engine which produced around 80-90bhp. This equates to around 59-67Kw. This power output is much too high for the course requirements since the power needed for the course peaks at 27Kw. Therefore the engine can be downsized.

To reduce cost of the overall unit the new engine will be a refurbished Aprilia RS 125cc engine. The engine is a single cylinder 2 stroke, liquid cooled with a compression ratio of 12.5:1. The engine produces 278BHP at 10,500rpm, 21Kw. Yamaha YZF-R125 engines are quoted to achieve 40 mpg with a 3.7 gallon fuel tank. These engines can be purchased via private sellers for around £100-£700. (*Motorcycle Specifications, 2018*)

#### 3.2. Series Hybrid System.

The motor drive system will be purchased via electricmotorsport.com. The unit to be purchased is the PMAC 12kW Cont. / 30kW Pk. Liquid-Cooled Motor Drive System 48V 650A provided by electricmotorsport.com. This kit has been chose because it includes all that is needed for the hybrid conversion including the motor, generator and controller. The motor used in the kit provides 12 kW of continuous and 30 kW at its peak. The kit includes an optional foot pedal throttle instead of a twist throttle. This can be connected directly to the throttle body on the Yamaha engine. This motor drive system does not include a battery however so one will need to be purchased. The motor outputs 165 Amps AC at a continuous rate so the battery will need to be able to cope with this. The battery that has been selected is the GBS 12V (4-Cell) 200Ah LiFeMnPO4. (*Electricmotorsport.com*)

Since the Yamaha engine and the series hybrid system are both liquid cooled it is possible to integrate the cooling systems into one unit. Due to the design of the buggy the engine and hybrid system cannot be split to increase the weight distribution of the vehicle.

The motor drive system is a brushless motor so it will not need to be maintained, the system will have to be serviced off site unless a fully trained electrical/ mechanical engineer is employed. The Yamaha engine and buggy can be service on site if a mechanic is employed or sourced out to a third party if desired.

#### 4. Preliminary Costings.

It is no secret that implementing a hybrid system into ordinary road cars is a costly process. That is the case here also. The motor drive system itself costs \$3,600.00, £2546.21. This part will also need a battery which is sourced from the same company, it costs \$1380, £976.

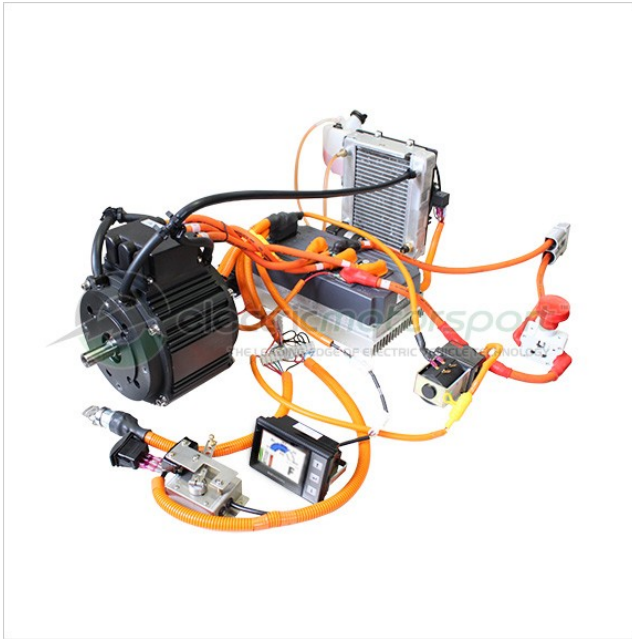


Figure 1; Image of the motor drive system. (Electricmotorsports.com)



Figure 2; Image of the battery. (Electricmotorsports.com)

The Aprilia engine can cost in the region of £100 to £800 depending on the condition. A better condition engine will be preferred because this will decrease the cost of maintenance. This part will also require the fuel tank which would cost £25.



Figure 3; Image of the Aprilia-Rs125cc engine. (eBay.co.uk)



Figure 4; Image of the fuel tank. (eBay.co.uk)

Finally there is the cost of the original buggy which can range from £1000 to £3000, again depending on condition.



Figure 5; Image of the buggy. (Blitzworld.co.uk, 2017).

The total cost of the hybrid system is shown in the costing chart below;

| Part                   | Price           |
|------------------------|-----------------|
| Motor drive system     | £2546.21        |
| Battery                | £976            |
| Aprilia-RS125cc engine | £800            |
| Fuel Tank              | £100            |
| Buggy                  | £3000           |
| <b>Total</b>           | <b>£7422.21</b> |

## 5. Conclusion & recommendations.

Series hybrid systems are on the rise, especially with the current climate state. Therefore many companies are looking to introduce hybrid systems into their products. The implementation of a series hybrid system in this project could be classed as a success. The increase in weight due to the implementation of the hybrid system means that the maximum power needed to complete the course has increased.

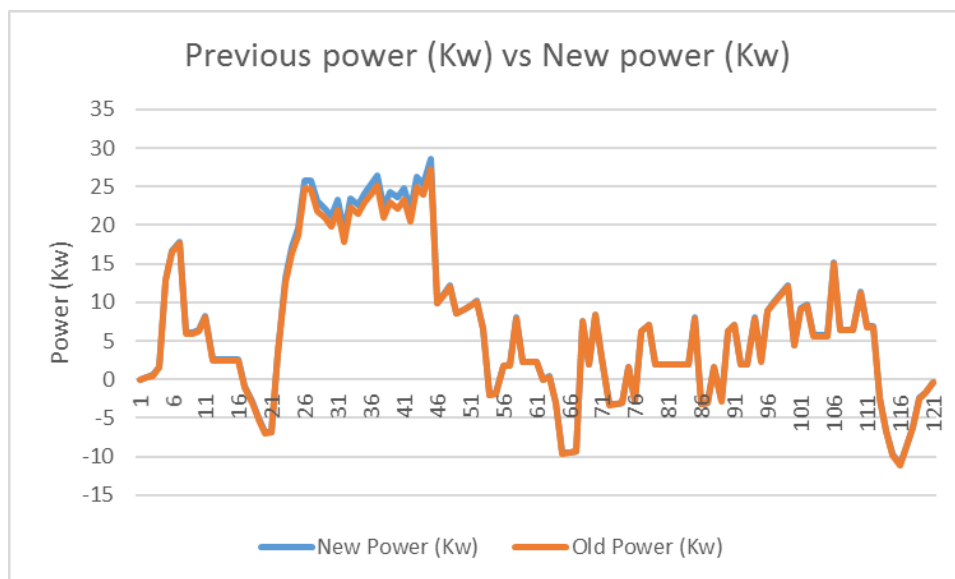


Figure 6; Graph illustrating the power required

As the graph shows the new power required has slightly increased. Usually this would be a problem but since the buggy was originally producing 59-67Kw, which was too much for the course, it is not a problem.

The implementation of the hybrid system will have no effect on the buggy's ability to complete the course. As the graph shows the max power required for the course is 29Kw. The Aprilia engine produces 21kw and the hybrid system produces 12Kw equating to a total of 33Kw of power which is more than enough for the course.

The negative of implementing the hybrid system is ofcourse the cost. The total cost of the hybrid system is over £7000, which does include the buggy. I personally feel that this is too much to be cost effective and the company should look at simply downsizing the engine. A larger motorbike engine, 600cc or above, should be sufficient for the course and would save the company a lot of money.

## 6. Bibliography.

1. Blitzworld.co.uk. (2017). Vigilante, corporate USE, any engine, Diesel, full roll cage. [online] Available at: <http://www.blitzworld.co.uk/vigilante-19-turbo-diesel-i2283.html>
2. Burke, A. (1992). Hybrid/Electric Vehicle Design Options and Evaluations. SAE Technical Paper Series.
3. Motorcycle Specifications, r. (2018). Aprilia RS-125. [online] Motorcyclespecs.co.za. Available at: [http://www.motorcyclespecs.co.za/model/yamaha/yamaha\\_r125%2008.htm](http://www.motorcyclespecs.co.za/model/yamaha/yamaha_r125%2008.htm)
4. Electricmotorsport.com. (2018). PMAC 12kW Cont. / 30kW Pk. Liquid-Cooled Motor Drive System 48V 650A - MOTOR DRIVE KITS - EV PARTS. [online] Available at: <http://www.electricmotorsport.com/ev-parts/motor-drive-kits/pmac-12kw-30kw-liquid-cooled-motor-drive-system-48v-650a.html>
5. Electricmotorsport.com. (2018). GBS 12V (4-Cell) 200Ah LiFeMnPO4 - Lithium - BATTERIES - EV PARTS. [online] Available at: <http://www.electricmotorsport.com/ev-parts/batteries/lithium/gbs-12v-4-cell-200ah-lifemnp04.html>
6. Image of Aprilia RS-125 engine. (2018). [image] Available at: <https://www.ebay.co.uk/i/142505084015?chn=ps&displtem=1&adgroupid=51456964475&rlsatarget=aud-414550640113%3Apla-404030379572&abclId=1130086&adtype=pla&merchantid=116604517&poi=&googleloc=9045394&device=c&campaignid=1029031424&crdt=0>
7. Image of the fuel tank. (2018). [image] Available at: <https://www.ebay.co.uk/itm/Genuine-APRILIA-Motorcycle-FUEL-TANK-RS125-99-05-AP8139124/291245095400?epid=848237709&hash=item43cf8f79e8:g:vHAAASwGvhUGZul>

