



The Electric TT [Peter Williams 31/03/09]

I am involved with the EVO Design Solutions Isle of Man TTxGP. The EV-0 RR racer uses my monocoque Shell Chassis system because it affords the space it needs for batteries and because of the materials it is made from the bike is “green” as well as “Zero Emission.”

Zero emission means different things to different people and the jury is still out as to what form of energy we will be using in and for our cars and bikes in forty years from now. Digging it out from deep under ground has been an easy option but it is clear that it will not be an option at all soon. We have to consider the energy chain and not just the end use. Indeed, there is an awful lot to consider. It’s not just the fuel; it’s the “Total Energy” we must think about and do something about.

The Isle of Man TT has been a significant part of the development of the motorcycle for the last 100 years and Zero Emission TTXGP is continuing the tradition. The rules mean that no carbon based fuel is allowed. It is necessarily restricted narrowly and as an historic experiment it is part of the debate and research into what energy we can use in the future.

Currently it restricts the rear wheel to be driven by electric energy and at the current stage of the Quest for zero emission that can only be given by on-board electric batteries or hydrogen.

Hydrogen is not necessarily burnt in a piston engine but can be more efficiently passed through what is called a fuel cell to produce electricity. It is an apparently enormously attractive prospect as a fuel because the products of the chemical reaction in the fuel cell are electricity, heat and water and because hydrogen has an extraordinarily high specific chemical energy content of 142MJ/Kg (Megajoules/kilogram). Petrol’s content of 42.7MJ/Kg is pretty poor stuff in comparison but the modern lithium ion (Li-ion) batteries are puny compared to both with only 0.75MJ/Kg. And for each of the three options when we account for their efficiencies of transmission of power to the rear wheel, one kilogram will give 85MJ from hydrogen using a fuel cell, 9.4MJ from petrol and 0.5MJ from batteries.

These numbers hide many issues.

For the moment most competitors will be using the puny way for the simple reason that it is convenient. But we will not be hauling bottles of compressed hydrogen across the Irish Sea to the Island for the EV-0 RR even though very little would be needed – about a kilogram. You will see why soon.

We will need much more than 1Kg of lithium-ion batteries. My racing was in the days when a 100mph lap was good going but I think it will be just as good if a zero emission bike can do it now forty years later. Let's calculate equivalence of battery power and hydrogen power with my Matchless G50 "Wagonwheels"

Petrol (My G50 lapped at 102mph)	
Specific energy (LHV)	42.7 MJ/Kg
Efficiency of delivery to rear wheel	20%
Weight of fuel	4.7Kg (1.4 Gallons)
Energy delivered to rear wheel	40.4MJ

Li-ion battery	
Specific energy	0.75 MJ/Kg
Efficiency of delivery to rear wheel	70%
Energy delivered to rear wheel	40.4MJ (Same energy as my G50)
Weight of fuel	77Kg
Hydrogen	
Specific energy (LHV)	120 MJ/Kg
Efficiency of delivery to rear wheel	60%
Energy delivered to rear wheel	40.4MJ (Same energy as my G50)
Weight of fuel	0.56Kg

The specific energy content by mass of hydrogen looks pretty good (nearly three times better than petrol). BUT because of low density even at 700 bar pressure the specific energy by volume is very poor (only 22%). We may not be seeing many Hydrogen Gas Stations since the storage and transport will require either enormous containers or enormous pressures and consequent huge costs. And although we only need 0.5 Kg of the gas to do a TT lap it must be compressed at (say) 700 bar (700 atmospheres) to get a volume as small as 8 litres in a very

sturdy and heavy container. It could be a worry for most people to be rolling around on a bike with a 10,000 psi hydrogen bomb between their knees. (Industrial gas bottles are very safe but they are at only 150bar pressure.)

Perhaps we can keep the piston engine alive with solar energy if another possible future is the "alcohol fuel economy". Adaptation of existing engines to methanol is the easy way and perhaps the only way. The growing of plants and catching CO₂ by photosynthesis can create the new holy grail of a zero net CO₂ creation and enable an easy adaptation to methanol of the existing system of liquid fuel supply and use.

Lithium-ion battery power, even though nearly three times better than lead-acid, is clearly low energy per kilogramme. The energy efficiency of delivery from well to wheel is pretty poor too but it is the answer for now and the motors and controllers can give amazing and exciting performance and hopefully a spectacle in the Isle of Man.

But here is a "boy problem". There is no noise! So we are fitting an on-board sound amp. Now we have to decide whether to play the Moto Guzzi V8, the Honda 500-4 (or my G50?)

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