Specific Energy Comparisons in Aeromodeling

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Although electric powered "Quiet Flight" is attractive and the technology is progressing rapidly, we still must face the sobering reality that the energy stored in our best batteries is only 1/40th of the energy stored in an equal weight of gasoline.

The "Specific Energy" of a fuel is defined as the energy per unit of mass. In our case, specific energy expressed in units of kWh/kg (kilowatt hours per kilogram) are convenient because the capacity of the battery in mAh and the weight of the battery are readily found (1). The direct comparison of the specific energy of a battery to gasoline is not quite as bad as it seems at first blush, if we consider that the weight of the fuel in an average model is only 10% of the total weight (8 oz of fuel in a 5 pound "40 Trainer"). Also, complicating the analysis, are the relative efficiencies that various conversion systems exhibit. Whereas a brushless electric motor can transform the incoming electric power to mechanical power at an efficiency exceeding 90%, a typical 4 stroke engine manages only 20% efficiency (two strokes are even less efficient). I have wondered if the total energy in my high-start would contribute materially to the energy stored in my flight battery. A comparison of the specific energies shows just how much it will.

The specific energy of various fuels is shown below. The specific energy of most of these energy sources may range in value as much as 20%.

Energy Source	**kWh/kg**	**Notes**
Liquid Hydrogen	34	Same for gaseous H2 at 700 bar
Compressed Natural Gas	15	CNG
Diesel	14	Kerosene, (2)
Gasoline	12	
Ethyl ether	11	(2)
Castor oil	11	(2)
Liquid Propane	9.5	LPG
Methanol	5.5	Primary component of "glow fuel"
Fuel cell	.5	(3)
Solar cell	.38	NASA's best, satellite power (4)
Primary Lithium battery	.30	Non-rechargeable
Lithium polymer battery	.20	Rechargeable
Flywheel	.13	
NiMH battery	.062	
NiCd battery	.048	
Solar cell	.023	Sunlinq, commercially available (4)
High quality rubber	.015	
Ultra capacitor	.0056	
Rubber band	.002	

(1) Converting our normal battery capacity expressed in mAh to kWh is simply a matter of multiplying by the terminal voltage and dividing by 1,000,000.

(2) “Diesel” fuel for model airplane engines is approximately 45%/30%/25% mixture of kerosene, ether and castor oil, all of which have more than double the specific energy than methanol.

(3) NASA report, 2003, H_2 O_2 fuel cell of 10 hours capacity, analyzed for space missions. This reflects the realities of the weight of tankage and conversion.

(4) Again, like the fuel cell, this is not really the specific energy of the “fuel” because the fuel is light (***light***, not lightweight).