JIM KANESS SYSTEMS ENGINEERING
4267 Varsity St., Ventura, CA 93003

ELECTRIC VEHICLE REPORT

Revised 7 November 2015

INTRODUCTION

Most of us today drive gasoline or diesel powered vehicles. The technology is a century old. But, a century ago, battery powered electrically propelled vehicles led the way- for a short time. A very comprehensive report on all this may be read at http://en.wikipedia.org/wiki/Electric_vehicle

ELECTRIC MOTORS

Electric motors are superior to internal combustion engines for propelling vehicles. They offer higher torque and a wider power band while using fewer parts. Perhaps that is why railroads around the world use them, as discussed at http://en.wikipedia.org/wiki/Electric_locomotive

SERIES HYBRIDS

One common railroad approach is the modern diesel-electric locomotive in which a diesel engine drives an electric generator, which in turn powers electric motors that drive the wheels. The diesel engine is not mechanically connected to the drive wheels. Some call this a 'true series hybrid'. For more on this, see http://en.wikipedia.org/wiki/Diesel_locomotive

Automotive series hybrids have been around since the early 20th century but their higher cost kept them out of favor. Two current sources of fleet trucks and other vehicles using the series hybrid approach are Via Motors at http://www.viamotors.com and ePower Engine Systems at http://www.epowerengines.com/ePower/Home.html .

PARALLEL HYBRIDS

Most of the 'hybrid' vehicles sold today are what some call 'parallel hybrids', meaning that either the electric motor (with on-board batteries) or the internal combustion engine (or both together in some cases) can propel the vehicle – both are mechanically connected to the drive wheels.

BATTERY ELECTRIC VEHICLES (BEV)

A battery electric vehicle uses only an electric motor to propel the vehicle, and only on-board batteries to power the electric motor. The batteries are recharged from the electric utility or other source through a charger.

The same lead-acid battery used a century ago for electric vehicles is still being used today. The recent advent of various Lithium batteries has breathed new life into the electric vehicle business. Lithium-ion and other forms (several different lithium chemistry batteries are in production) offer much higher energy per pound of battery, much longer lifetimes and other benefits---but at a much higher cost. For a comprehensive discussion about this see http://www.aps.org/publications/apsnews/201208/backpage.cfm

BATTERY CHARGING

Recharging the batteries in a full-size BEV takes a significant amount of energy. These batteries range in size (energy storage) from about 16 kilowatt-hours (KWH) to 85 KWH. For comparison, the batteries in my golf cart are rated at 7 KWH, and the battery in my son's electric bicycle is rated at only 0.36 KWH.

The common 120-volt, 15-ampere house outlet can provide up to 1.8 kilowatts (KW) of power. A 240-volt, 30-ampere electric dryer or RV outlet can provide up to 7.2 KW. A 240-volt, 50-ampere electric range or RV outlet can provide up to 12 KW. The power in kilowatts (KW) available from the source times the number of hours (H) that power flows continuously equals the available energy in kilowatt-hours (KWH). To fully recharge a Tesla model S from a 240-volt, 50-ampere outlet can be expected to take all night (85 KWH / 12 KW = 7.1 hours) not counting any losses in the charging process. The rate of charge will then be approximately 1.2 x 12 KW / 85 KWH = 0.17, a relatively slow rate.

Fast charging, in a time frame comparable to filling up the tank at a gasoline station, will require industrial sized electric "refueling" stations throughout the nation and a battery management system that can safely accept this fast charging rate. At this writing, electric refueling is roughly comparable to around 1900 when gasoline was sold by the local hardware or general store and poured into the vehicle's gas tank one gallon at a time.

COST OF ELECTRIC REFUELING

Southern California Edison (SCE) Company has a four-tier rate structure for the purpose of encouraging energy conservation. Our suburban home regularly uses tiers 1 and 2, about 400 KWH per month, roughly comparable to fully recharging an 85 KWH Tesla model S four times a month. Adding a BEV to our home's usual energy consumption would start in tier-3 and extend upward in cost. The current tier prices on my bill are given as (tier 1) 15 cents/KWH, (tier 2) 21 cents/KWH, (tier 3) 24 cents/KWH and (tier 4) 30 cents/KWH. Please contact your local electric company for their electric vehicle charging options.

REFERENCES

1. List of modern plug-in electric vehicles, http://en.wikipedia.org/wiki/List_of_modern_production_plug-in_electric_vehicles
2. List of production battery electric vehicles, throughout the years, http://en.wikipedia.org/wiki/List_of_production_battery_electric_vehicles
3. A comparison of vehicle energy sources follows on the next page.

VEHICLE ENERGY SOURCES

A	B	C	D	E	F
LIQUID FUELS	ENERGY DENSITY/KG	ENERGY DENSITY/ L	*MOTOR EFFICIENCY	**MERIT	POUNDS / GALLON
Gasoline	47.5 MJ	34.6 MJ	15%	1.0 (Defined)	6.06
Diesel #2	43.1 MJ	35.9 MJ	25%	1.7	6.93
BATTERIES					
Lead-Acid	0.15 MJ	0.36 MJ	70%	0.05	19.98
NiCd	0.14 MJ	0.50 MJ	70%	0.07	29.7
NiMH	0.34 MJ	1.08 MJ	70%	0.14	26.5
Lithium Ion	0.46 MJ	0.82 MJ	70%	0.11	14.84
Lithium-Air EXPERIMENTAL	4.7 MJ	5.4 MJ	70%	0.7	9.6

CONVERSIONS
1 MJ = 277.77 Watt-Hours = 0.277 KWH (kilowatt-hours)
1 KWH = 3.6 MJ (Mega Joule)

*Motor efficiency is as installed and utilized in a street legal vehicle. By itself on a test stand the efficiency can be much higher.

**Combined efficiency of fuel volume (not weight) and motor, as compared with a gasoline powered vehicle (my chosen standard of comparison).

EXAMPLES
For a given gasoline powered vehicle with a 15 gallon tank of gas and a 300-mile range---

1. The same vehicle with a diesel engine would need roughly 15 / 1.7 = 8.8 gallons of diesel fuel for the same 300-mile range.
2. The same vehicle with an electric motor would need roughly 15 / 0.11 = 136.4 gallons (18.2 cubic feet) of lithium-ion batteries for the same 300-mile range.
3. The same vehicle with an electric motor would need roughly 15 / 0.7 = 21.4 gallons (2.9 cubic feet) of lithium-air batteries for the same 300-mile range.

FUEL WEIGHT
Referring to columns in the table above, C / B = fuel weight in KG / Liter. That times 8.327 = fuel weight in pounds / gallon shown in column F. The lightest weight of all the available batteries listed is the Lithium-ion. Lithium-Air is still in the laboratory.