Re: Cost per mile over 10 yr life?

Source: http://sci.tech−archive.net/Archive/sci.energy/2005−05/msg00309.html

- *From*: "Fritz Schlunder" <me@xxxxxxxxxxx>
- *Date*: Thu, 26 May 2005 02:08:21 −0700

"Tim Keating" <NotForJunkEmail@xxxxxxxxxxxxxxxxxxxxx> wrote in message
news:3h6a9151s6ueuflvgshkchr4hna08t2ja9@xxxxxxxxxx

> Steel case.. two electrodes are nickel based,
> Electrolyte is potassium hydroxide, some copper content as well.
>
> http://www.grs−batterien.de/english/technol/download/esslin02.pdf
>
> Page 4.. while NiMH is not listed..
> NiCd is.. On average 45% of the NiCd bat weight is Fe.
> 5% KOH and 10% H20...

That is an interesting link, but it is unfortunate they didn't include NiMH
on their composition table.

I might refer you to this link here:

http://www.electroenergyinc.com/products/technicalpapers/BipolarNickel.pdf

They aren't talking about "AA" size NiMH cells of course, but nevertheless
section "5" located near the end of that document has a small cost breakdown
of their product. They would have you believe the materials cost is
somewhere near $195/kWh.

> >Well... If you stick a small Li−Ion battery pack in it, weight could be
> >reduced. But then, so too will performance be reduced. The lead acid GM
> >EV1 had a curb weight of 2922 lbs. This obviously doesn't compare
favorably
> >with the Geo Metro at around 1830 lbs., or your more typical compact size
> >cars at 2400 lbs.
>
> Another "Fallacy of Composition".
>
> Their are other types of Li−ion chemistries which have in excess of

> 20x the energy storage capabilities of current laptop Li−ion tech.
> (Lookup Li−Si, they just haven't figure out how to make the battery
> structure handle recharge cycles, yet.)

For the moment, if a full scale commercial production EV were being designed it would need to be based around standard off the shelf well proven battery technologies. Even if a given battery technology can deliver phenomenal energy density, that doesn't guarantee its suitability for EV use. Obviously both cost and rechargeability are incredibly important, among other properties.

> >Ideally for ultra rapid charge EVs, the battery pack voltage should be as
> >high as possible. Otherwise the current required rapidly becomes
> >unmanageable since the hook up cables would not really be easily managed
by
> >non−muscular people. Since 1200V Insulated Gate Bipolar Transistors
(IGBTs)
> >are readily available and offer excellent bang for the buck, I suggest a
> >maximum in use battery pack voltage of about 1000V or somewhat less.
Even
>
> Not a good idea to run near maximum voltage limits.. Inductive
> kickback. Plus you must exceed nominal bat pack voltage by a
> significant margin to recharge bats at any usable rate.. (braking?)

What the power electronics look like depends upon the various design requirements and what kind of motor is used. Typically however, motor control is provided by H−bridge(s) or three half bridges for a three phase AC induction motor. When built from IGBTs, each device requires an antiparallel diode. With these diodes in place, the H−bridge is practically immune to overvoltages produced by driving inductive loads. The topology protects itself. If the inductive load ever tries to produce any voltage higher than the input DC rail voltage, current is delivered from the inductive device though the antiparallel diodes to the DC rail. Since the DC rail is presumably a direct connection to the battery pack, any inductive energy releases would end up charging the battery pack, harmlessly clamping the voltage to less than what the semiconductors are rated for.

That said, you still shouldn't run a 1200V rated IGBT at 1200V for reliability reasons. I made certain to include words like "maximum in use" and "or somewhat less" in my prior post. Whatever the "nominal" battery pack voltage is would presumably be less than 1.2V * the number of cells = 1000V. In other words, the pack should have less than 833 cells, assuming NiMH technology. As you suggested the battery voltage is higher during regnerative breaking (or even regular charging), so this should definitely be taken into account when deciding exactly how many cells to use.

During ultra rapid charge the per cell voltage may necessarily need to be much higher. Fortunately the H−bridge topology has an interesting property that if all switches are fully off, the converter can block twice the maximum switch voltage. So in theory, for an H−bridge constructed of 1200V devices, during ultra rapid charge the maximum voltage could reach 2400V without causing harm provided that all switches are fully off during recharge. A clever engineer might be able to take advantage of this property depending upon topologies used and other design constraints.

> Long strings of batteries decreases reliability..

This is true, but on the other hand, no matter how you arrange the cells performance suffers if one cell in a pack should fail. Something to consider though. NiMH batteries produce hydrogen gas if they are reverse charged for too long. If a singe cell in any series arranged pack has much lower capacity than the other cells, it will be reverse charged by the other cells. For sealed cells, this might activate the vents and hydrogen gas may leak out. This is unfortunate, but there isn't that much you can do about it since clearly an electric vehicle operating at 1.2V is not practical.

Li−Ion has its own safety quirks however, since under certain conditions they can produce lithium metal. Given the reactivity of lithium metal, they can conceivably violently rupture (ie: explode).

Of course, to put things in perspective a gasoline tank always contains volatile and highly reactive hydrocarbon liquids and vapors, so in that sense it is always a fire/explosion hazard. In either case safety is adequate.

As for reliability of battery packs... It seems to me the best way to improve reliability is to insure good quality control on the individual cells. Since a battery pack is in many ways as weak as its weakest element, it makes great sense to make sure there are no weak elements.

> >No electrical contact is made but they are magnetically coupled when together.
>
> Not practical.. too much loss..

Umm... What are your credentials? I have a bachelor's degree in electrical engineering. My particular area of expertise is in power electronics. I say inductive coupling is practical. The engineers at GM who made the EV1 clearly thought inductive coupling was practical. The GM EV1 used inductive coupling through the little paddle you plug into the hood. Presumably the car could be charged through this small device at a rate up to 50kW.

Inductive coupling was chosen in large part due to considerations of safety.

An ideal electric car should be able to be charged outdoors as well as indoors. Water and electricity don't mix so well, so I can definitely appreciate their design decision. GM advertised that the EV1 could be safely charged even if the whole bottom of the car, you, and the paddle itself was submerged under water. That isn't a realistic combination, but the claim was probably true.

On the other hand there were a few incidences of a capacitor failing and causing the paddle to get stuck in the car. The recommended procedure was to shut off power, cut the cable between charger and paddle, and drive to the nearest dealer for service.

> Another nice feature would be a EV with a PV roof.
> An EV that self charges would be great.
> Nt much extra range 25 miles a day worth of energy.. But it's
> transportation that's free of infrastructure. (A very handy feature
> after a widescale disaster).

A photvoltaic solar panel on the roof of a full size EV is almost worthless. The hood is subject to bombardment by road debris, and given the price of PV cells, it would be a real shame for it to get broken. Therefore, only the roof is a practical mounting location. This restricts you to a panel of perhaps one square meter or less.

At the earth distance from the sun (1 AU), the sun provides 1300 watts/square meter of radiation. On the surface of the earth, at the equator, at noontime, on a clear day, up to 1000W/m^2 of radiation is available. Solar cells are not typically better than 20% efficient. Typically they are much worse. Dramtically much worse. The efficiency drops off at high temperatures, a highly effective maximum power point tracker is needed, the panel must be perfectly clean and pependicular to the sun's rays, and the solar cell packing efficiency of a panel usually reduces the effective efficiency.

So, even with the absolute best possible conditions you could not exceed 200W of output from a roof mounted solar cell. If you assume 6 hours/day of strong sunshine producing 200W (which it clearly couldn't since the cell isn't tracking the sun when mounted on the roof), then you only get 1.2kWh less power electronics and battery chemistry charging inefficiencies. At 120 Watt hours per mile, that would be ten miles or less. That is of course highly unrealistic/optimistic.

Additionally NiMH cells have non−negligible self discharge rate. A rate of 1% per day (more for the first few days) is not unreasonable for many cell designs. A solar panel therefore might not be able to provide any extra range, only enough to combat self discharge. Of course, you are a fan of Li−Ion so that won't likely be of concern for you.

> Currently, people have no problem filling their cars with gas..
> Hooking up a high performance charging connector should be no problem.
> The EV would be programmed not to move unless the charging connector
> was properly disengaged. (verbal warning).

A verbal warning would not be enough. Electrical interlocks should be built into the devices such that the charger is not energized until after it has been fully plugged into the vehicle. Similarly, the car should be fully disabled when under charge/plugged in. Additionally the charger should fully deenergize before the plug can be unplugged from the car. Further, the connector moldings should be such that they naturally reject moisture, and that no human can touch any metal contacts. Additionally the chargers should be fully covered so that they do not get wet and can still be used during a rain storm.

I happen to know a guy (not me) who one time drove off in his car while the gas pump nozzle was still in the car filling the tank. Apparently it ripped off the hose from the pump but didn't shut off the pump in the process. So gas went everywhere, and he didn't even know there was a problem until he drove 1/4 mile down the street and stopped at a stoplight. At that point a driver next to him got his attention and pointed to the dangling gas nozzle and hose hanging from his vehicle. He said he felt stoopid afterwards, claims it was the dumbest thing he ever did.

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- ***Follow−Ups***:
  - ***Re: Cost per mile over 10 yr life?***
    - *From:* Tim Keating
- ***References***:
  - ***Cost per mile over 10 yr life?***
    - *From:* BobG
  - ***Re: Cost per mile over 10 yr life?***
    - *From:* Hatunen
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