Supercapacitors for Fuel savings with no Idle

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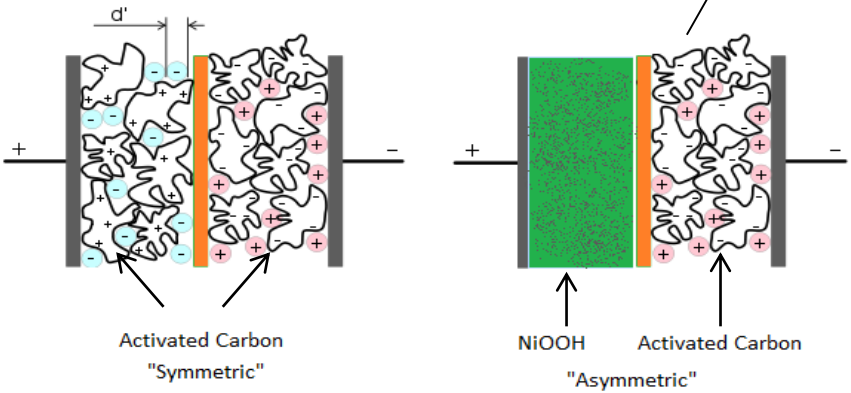
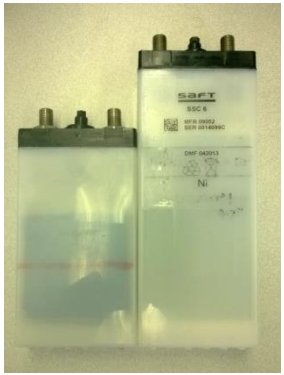
Brief History of Supercapacitors

- Supercapacitor or Ultra-Capacitor
- EDLC = Electric Double Layer Capacitor
- Power device not and energy device

Considered Hybrid Supercapacitor, Some properties of a Battery & Capacitor





$$C = \frac{e_r e_0 A}{d}$$

Large A, Small d = Very Large C

$$E = \frac{1}{2} C V^2$$

Asymmetric design results in higher capacitance 2X over Symmetric while maintaining low ESR and high power

Supercap and engine starting

- Saft Supercapacitor widely for Transit Bus for Engine starting
  - Partner KBI
  - All major OEM qualified
  - Small to large municipalities taking advantage
- Supercaps provide a bulk of the starting power and allow the bus to easily crank even at very cold temps
  - Start faster with Supercap vs battery
- Dead battery starting
- No need to worry about cranking if the lights were left on and battery is dead

- Supercap are electrostatic vs batteries electrochemical
  - No wear out mechanism
- Virtually unlimited number of cycles or engine starts

No-Idle Policy, Micro Hybrid, Start Stop

- Many cities and municipalities are restricting idling to less than 3 mins
  - Allowance are being made for emergency or, traffic or cold weather
- School Buses are the first big push, transit bus next
- Not fully implemented due to concerns over driver comfort lack of heat/AC or restarting worries.
  - APU & Battery systems can provide the heat/AC while keeping the Bus off
- Other No-Idle focus will be around the yard
  - How long are buses left running and why

- Automobile Start Stop (micro hybrid) system shuts down the engine saves 10% in fuel costs
- Typically see 50K start per year
- Automobile market have gone to more advanced starter motors
- Newer battery technologies are falling short
- Many if not all investing in supercapacitors to perform these starts

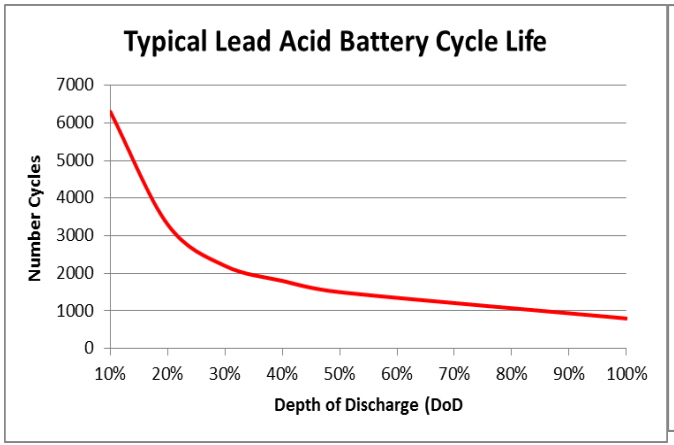
Lead Acid limits to starting

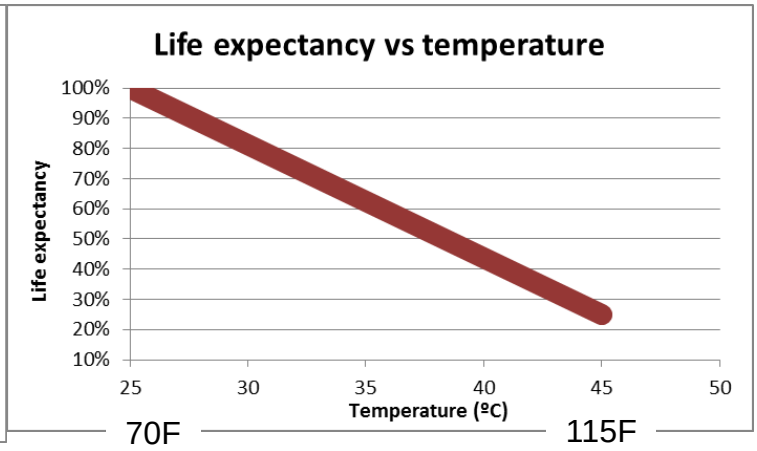
- Typical battery lasts 2 years less in warmer climates. Critical factors to life include depth of discharge and recharge regiment
  - Need time to fully recover from a start, long overcharge
- Most Batteries from 5K to 10K starts depending on engine size and battery type
  - Most Buses start 5 time a day
  - Battery life can be 1 to 3 years
- Depending on how aggressive a no Idle strategy will be engine have 20 50 start a day, 15K to 20K start per year
  - Standard battery dead in less than a year
  - Too many cycles and not enough time between - never fully recharge

- Supercapacitors more than 1 million starts
- Supercap recharges in 30 seconds ideal for start stop

- Standard starter motor can support 100K to 200K starts
  - New starter motors being developed for higher starts

Battery life





Batteries are limited by the number of cycles or starts they can perform and can be severely effected by higher temperatures

Cost of Idling a Bus

- Fuel
  - Typical transit Bus .8 to 1gal per hour at Idle
  - Generally idling 2 to 3 hours a day 5 days a week
    > With fuel at $3.5 per gal
  - Single Bus wastes $40 to $50 per week without carrying passengers
    > $2000 to $2500/year per bus – How large is your fleet?
  - Additional savings for yard and maintenance idling
    > $2000/year
- Environmental
  - Buses at idle produce 30g/hr of CO
  - Idle reduction fro 3 hours to .5 hours can eliminate 18,000g of CO

Impact

- In past Buses took 5 seconds to start and be ready to move
- Nearly all Buses start in under 2 seconds
- **Supercapacitors start even faster than PbA**
- Allowing almost unnoticed delay in starting to moving
- Restarting Bus uses no more fuel than idling for 5 seconds

- Hybrid Buses saves around 12% in fuel costs but cost 2X standard Bus, not to mention $50K battery every 6 years
  - Gets hard to justify
- **Supercap <1% total Bus cost investment, payback <2 years**
  - **Guarantee cranking regardless of battery SOC**

How to implement

- Two potential systems can be used

- Train drivers to turn off buses at each stop and at break times.
  - Remember Supercap can crank the bus regardless
- Train maintenance staff on no idle policy
- Develop with OEM automatic start stop system for Bus

- Several automated systems being looked at in the US, Europe and Asia
  - Cost run from $4,000 to $8,000

- A No idle implementation can save 5 to 10% in fuel costs depending on stops and how bus is maintained at start and end of shift
- Cost saving can be overshadowed by additional battery costs
- **Using a Supercap can allow implementation and save fuel and battery costs by reducing the number used**

Summary

- Anti idling laws have and will effect transit buses
- Bus batteries not designed to start engines that many times
- Using a Supercap can support increased engine starting
- Allowing implementation of no-idle strategies without compromising with constant battery replacement
- 5 to 10% fuel saving with little investment and training

- KBI Engine Starting Module is a system that uses Saft's Supercapacitors which reduces number of batteries used and is ready to crank the engine regardless of battery condition, can be programed and used for start stop type system