

Going Lithium

– A case study on the benefits of replacing Lead Acid batteries with Lithium Ion

LiTHIUM BALANCE converted an Aixam Mega electric Mini tipper from lead Acid batteries to Lithium Ion (Li Ion), and improved driving performance, doubled driving range per charge and reduced battery cost over vehicle life.

The customer and their need for change

Frederiksberg Kommune is an affluent inner city borough in Copenhagen, famous for its parks, classic buildings and its well maintained infrastructure. With an operating budget of DKK 3.8 billion, it is the model of a modern, urban, environment, clean and efficient, while retaining its culture and heritage. With 93,000 inhabitants crowded into less than 9km², keeping everything ship shape is no simple task.

As a forward looking Kommune, Frederiksberg purchased a fleet of electric vehicles to transport the army of support staff employed for maintaining and improving the infrastructure. The fleet includes Mega Mini trucks made by Aixam of France.



The electric Aixam Mega Mini tipper

Aixam have been in business since 1983 and have been making vehicles under the Mega brand since 1992. With annual sales of around 14,000 units spread across a range of utility vehicles and micro cars, Aixam – Mega is Europe's largest producer of micro cars. Their vehicles are available as either diesel or fully electric vehicles. The subject of this article is the Electric Mega Mini tipper.

The Mini tipper comes in two versions, with 8 and 12 batteries. The specification for the 12 battery version quotes a range of 60-100km although 45-60km per charge is more realistic in practice. In the case of the Mini tipper in question, however, with continual usage, the range was seen to drop to 15km as the battery performance deteriorated. This greatly limited the usefulness of the vehicle as it could not be relied on to complete its rounds and recharging during the working day is impractical as this is when the vehicle is needed.

Lead Acid and Li Ion batteries compared

The performance deterioration witnessed is not uncommon despite the use of high quality Lead Acid Gel (maintenance free) batteries in the Mega Mini tipper. The different types of Lead Acid battery require different treatment according to type. Whereas Gel batteries tolerate deep discharge well, they are very sensitive to how they are charged, over-charging in particular will damage them, and they also hate low temperatures, a common feature of life in Denmark in the winter.

Performance drops off as Sulfation takes place where the lead plate electrodes get coated in Lead Sulphate which prevents both the charging and discharging reactions of the battery taking place. This mechanism is responsible for the 80% of battery degradation and failure.

A Li Ion Battery pack was specified and constructed to fit into the battery bay for the lead Acid batteries. The superior performance of the Li Ion battery pack meant that they needed less than half the space and weighed less than half as much as the original Lead Acid batteries to double the performance of the original battery pack! The 48V lithium

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BATTERY MANAGEMENT SYSTEMS

Ion battery pack peaks at 60V which was a bit too much for Mega's motor controller. To protect it, the battery was only charged up to 57 volts giving a useful power increase without damaging the motor controller.

The secret of the success of the conversion was the fully integrated battery pack and battery management system. Li Ion batteries have typically three times the performance of lead Acid batteries of an equivalent mass, but to unlock this performance advantage reliably, it is essential to have a good battery management system that ensures the correct charging and discharging of the battery, monitors thermal performance, and individual cell balancing. This makes the integrated Li Ion battery pack completely maintenance free with 3-5 times the longevity in charge cycles (less batteries to dispose of over the vehicles life time). With typical prices for Deep cycle lead Acid batteries around US\$ 150/kwh and Li Ion batteries between US\$ 300-500/kwh, the overall economy works in favour of switching to Li Ion even before you factor in the other benefits.

To summarize:

- Less weight
- Less volume
- More Power
- Better range
- Better driving - no tail off in performance
- Better longevity and reliability
- Better return on investment
- Less environmental impact



**Installation of the
Lithium Ion
battery pack**

The results speak for themselves

With more power and range at the driver's disposal, the driving experience was transformed with the vehicle now having a range of 122km on a single charge with constant performance! The end user's comments were "The comfort and ease of use is much better now. The range is amazing! We do not need to worry anymore about whether or not we'll have battery power enough to finish our work and come back to home on time."

The importer of Mega trucks for Denmark also voiced his opinion, "there is no doubt, this is what the customers need and want." But the final word must go to the company servicing and maintaining the trucks: "reduced need for maintenance increases revenues of my service business." This was very much in line with one of the stated goals of the project and that was to: investigate and quantify the benefits of this conversion for fleet operators, the results speak for themselves.

The idea that you can convert an existing vehicle from Lead Acid batteries to Li Ion batteries with all of the previously discussed benefits makes sense. Why? Well, because there is no downside, the performance is improved in all measurable ways, rather than the alternative which would be to continually replace failing Lead Acid batteries with more Lead Acid batteries, throwing good money after bad, reducing the utility and consequently the return on investment of the truck. A step beyond this would be to specify the truck at purchase with Li Ion batteries and enjoy the benefits from day one. Lead Acid battery technology is 150 years old (Invented in 1859), maybe its time has simply passed...

LiTHIUM Balance undertook all engineering work including specification and installation. The installation included the proprietary computerised battery management system from LiTHIUM Balance.