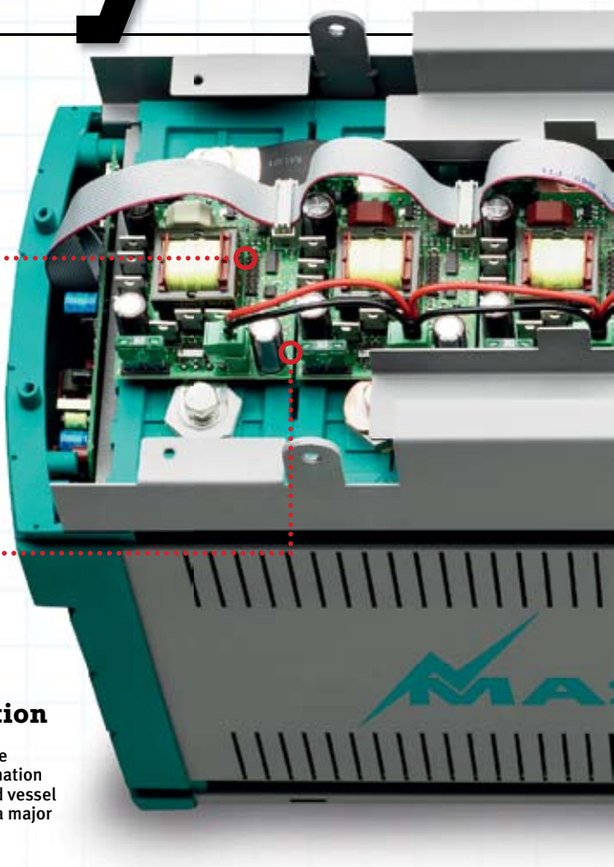
Battery powered revolution



Charge and discharging
Battery management electronics ensure all cells charge and discharge equally. Batteries can be charged with full current within one hour, dramatically faster than a comparitive lead-acid battery

Communication
MasterBus (CANbus) communication interface allows all battery information to be passed to onboard vessel management systems, a major plus for larger boats

Are lithium-ion batteries the magic bullet for marine electrical sytems? Colin Pawson of Enertec Marine weighs up the new technology.

NOT SINCE Gaston Planté showed the first lead-acid battery in 1859 has there been any significant change to battery technology with a dramatic effect on marine electrical applications.

That was until recently that is, when lithium-ion arrived on the scene, evolving from the miniature lithium batteries Sony first introduced for their Walkman products in the early 1990s.

While undoubtedly the lead-acid battery has undergone significant enhancements since the original primitive cell, it has still been saddled with limitations imposed by the fundamental technology. For our marine applications these limitations include slow re-charge time, considerable self-discharge over time (most wet cell types), production of explosive hydrogen gas when charging, heavy weight and large physical size and limited cycle life. Enhancements that have occurred in lead acid technology have included Gel, AGM and AGM/Gel Hybrids. While these variants have overcome some of the disadvantages of the wet cell lead-acid batteries the fundamental problems of weight, size and prolonged re-charge periods remained.

The lithium-ion technology used in the modern consumer electronics products are unfortunately unsuitable for marine use due to their poor stability and limited cycle life. In marine applications safety is paramount and the cells need to be protected from damage and the possibility of thermal runaway which can result in explosion.

A complete electric propulsion system on a US-built production 33-foot keeler. Two chargers, mounted either side of the batteries, provide recharging when on shore power. Energy recovery is also available off the prop shaft when sailing.

Leading Dutch power electronics company, Mastervolt, commenced development of large capacity lithium-ion batteries for marine applications six years ago and released one of the first commercial versions, the MLI 24/160 (24V, 160 amp/hours) in 2008. The technology utilised is lithium-ion iron phosphate,

Safety
Mastervolt found lithium-ion iron phosphate to be the most stable composition for larger battery capacities, ensuring completely safe operation under the most adverse conditions

Price
At approx $9500 for the MLI 24/160, lithium-ion batteries aren't cheap on the surface. However, the technology offers 30-40 percent more useable energy and three times the cycle life of a lead-acid battery. They are also a third of the size and weight.

The boat is fitted with a 7.5kW Bellmann electric motor, mounted within a standard sail drive bed. Together with the lithium-ion technology, it offers near silent running for 3-4 hours at 6-7 knots.

which offers greater stability and hence safety, than other variants. This battery subsequently won an IBEX award for innovation in 2009 and the coveted Pittman award for marine products in 2010.

Other manufacturers that offer lithium-ion technology to the marine industry are Lightweight Energy, LifeBATT and Torqeedo.

Mastervolt released a 12V, 320 A/Hr version earlier this year.

The major advantages of these batteries include the ability to recharge at a rate equivalent to 1C (a 200A/Hr battery can in theory be fully recharged in one hour with a 200A charger compared with seven hours for a lead-acid battery), small size and light weight, a constant voltage throughout the discharge period and no dangerous gassing.

Furthermore, the lithium battery can be discharged to a depth of 80% as opposed to 50% for its lead-acid equivalent. This results in 30% more useable capacity. Since the battery contains no poisonous material, recycling is a simple matter.

Batteries found in marine applications are typically 6V or 12V blocks and comprise multiples of 2V cells internally. In a lead-acid battery these cells remain fairly balanced during charge and discharge cycles. For lithium-ion this is not the case and inherently the cells can become unbalanced with severe consequences. To avoid this Mastervolt's MLI series incorporate a sophisticated array of cell balancing electronics that ensure all cells discharge and re-charge evenly. This electronics also includes an interface to the MasterBus (CANbus) communication protocol allowing all battery data to be sent to onboard monitoring and control systems for added safety.

As an example of the huge advantages lithium-ion batteries can offer, consider the following example:

A 24V 750A/Hr battery bank comprising 24 x 2V gel cells weighs 1200kg, is rated at 36kWH gross (kWH is the product of voltage, current and time) and can actually only deliver 21kWH net.

The same capacity bank comprising 6 x Mastervolt MLI 24/160 weighs 330kg, has a capacity of 25kWH gross and 20kWH net.

Physically the lithium bank will be a third of the volume, less than a third of the weight and offer dramatically shorter charging times.

Since the lithium battery can be cycled down to at least 80% depth of discharge it is possible to reduce the actual battery capacity in most installations.

The above advantages have immediate benefits for marine electric propulsion since the power density, rapid recovery and weight of the batteries drastically alters the viability of such projects.

USA manufacturer Pearson Composites recently delivered one of their Alerion 33 day-sailers with a 7.5kW Bellman electric motor and a pair of the MLI 24/160 lithium-ion batteries (320A/Hrs). The vessel easily achieved a cruising speed of between six and seven knots and a battery endurance of three-four hours depending on conditions.

With the development of specially designed retractable turbines the possibility of energy recovery with minimal effect on boat speed while sailing will be viable in the near future.

The current price penalty (a factor of four times that of an equivalent 2V Gel battery bank) is a significant handicap to the widespread adoption of lithium-ion, but prices are forecast to steadily decrease over the coming years. ■