feature

Battery Power

WORDS AND PHOTOGRAPHY BY **SUPPLIED**

TIRED BATTERIES? GO LITHIUM-ION

Lithium-ion battery technology has revolutionised energy storage across multiple industries, offering unrivalled performance, capacity, weight and longevity advantages. But what are the cost implications of upgrading to lithium-ion?

Jeremy Peacock, co-owner of marine energy specialists Enertec, likes to illustrate the cost vs performance profile of the tecŠology through examples, and stresses that not all lithium-ion batteries are created equal.

LITHIUM-ION VS LEAD-ACID AGM BATTERIES CASE STUDY

Using a 40-43ft vessel, this analysis is based on the following specs:

- Direct current (DC) electric refrigeration with a daily load of around 100-120 amp-hours (AH) per day
- Additional loads on the vessel (lights, electronics, inverter, pumps etc) using another 40-50 AH per day
- Total daily load of between 140-170 AH per day.

A typical lead-acid (flooded/AGM/GEL) battery bank for this size vessel is a 12-volt system of around 400 AH capacity. Two of the biggest issues with lead-acid battery tecŠology are the small amount of usable capacity and the slow recharge ability.

Li-ion batteries have created a far superior alternative in both areas, along with a vast reduction in battery weight and size, better voltage stability and far greater cycle life. To accurately compare the two types of batteries, let's first look at the differences between the two tecŠologies.

USABLE CAPACITY

All types of lead-acid batteries use the same chemistry, which limits the tecŠology's performance. One limiting factor is 'usable capacity'. This refers to the percentage of the battery that can be discharged and recharged (depth of discharge – DoD) without seriously degrading the cycle life. Users are advised not to discharge the battery below 50% State of Charge (SoC).

Recharging lead-acid batteries is very slow – around four hours to fully recharge from 50% SoC. The slowest portion of the battery to recover is the last 15% which takes around three hours to recharge – no matter how powerful the charging system.

Away from the marina most vessels of this size rely on engine and/or solar charging. So, because of the time it takes to recover lead-acid batteries it is not practical (often impossible), to recover a lead-acid battery bank past 75% SoC when at sea.

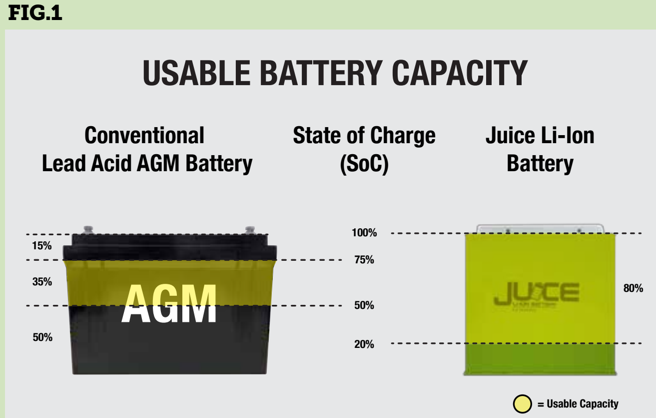
Realistically this only allows for a usable capacity of approximately 35% of the total battery capacity (see Fig 1).

In our typical 40-43 ft vessel with 400 AH of house battery capacity, this equals around 140 AH of usable energy.

Li-ion batteries use a different chemistry which allows them to be discharged to a far greater depth than lead-acid batteries while still offering a vastly superior cycle life. They can also be charged much faster making it possible to recover them to 100% SoC from an engine alternator or solar. (See Fig 2.)

Using Juice PRO Series Li-ion batteries as an example, these can be discharged to 20% SoC and then fully recharged to 100% SoC in an hour – with the correct charge ratio. In most cases the vessel's charging system will not be powerful enough to achieve charging this quickly, but even with a smaller system, charging will be considerably faster than for lead-acid tecŠology.

FIG.1



ENGINE CRANKING BATTERIES

While Li-ion batteries offer significant advantages in a house bank application, the cost vs advantages of swapping to cranking batteries to Li-ion is harder to justify. We usually advise the continued use of lead-acid technology.

With some Li-ion batteries, including the Juice PRO Series, it is still possible to charge both the cranking battery and Li-ion house battery from a single engine alternator. To achieve this the alternator is fitted with an external smart regulator and both battery banks are charged via an isolation diode. A typical emergency switch to allow cranking off the Li-ion house batteries (if the cranking battery fails) is still possible.

FIG.2

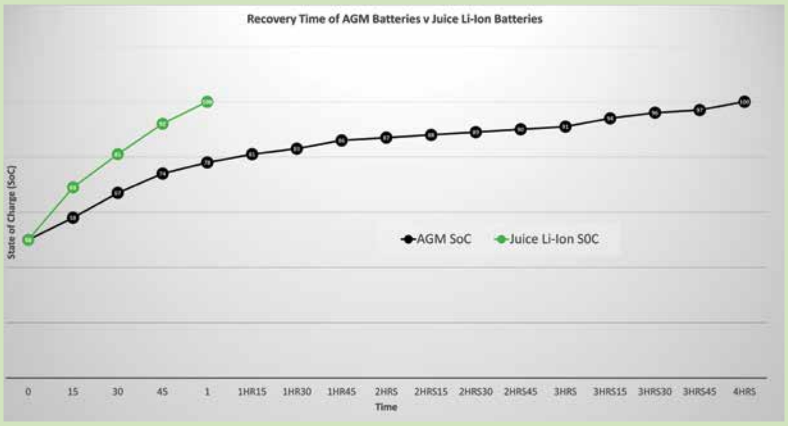


FIG.3

Lead Acid AGM Battery 12V 200 a/hr		Juice Li-Ion Battery 12V V 200 a/hr
200 a/hrs	Nominal Capacity	200 ahrs
12.8V	Fully Charged Voltage	13.25V
12.2V	50% SoC Voltage	13.0V
11.8V	Full Discharged Voltage	12.8V
70-80 a/hrs	Useable Capacity	160 a/hrs
4hrs	Fastest poss Recovery Time from 50% SoC	30 mins
64kg	Weight	26kg
0.03m²	Volume	0.02m²
500 cycles	Cycle Life to 50% DOD	6000 cycles
200 cycles	Cycle lfe to 80% DOD	3000 cycles
50,000 a/hrs	Lifetime available energy (Available capacity x cycle life)	480,000 a/hrs

These two advantages allow Juice PRO Series Li-ion batteries to deliver 80% of their rated capacity as usable energy (see Fig 1).

In our typical 40-43ft vessel this would allow the installation of a single 12V 200 AH Juice PRO Series battery in the place of the 400 AH lead acid bank. This single 12V 200 AH Li-ion battery would provide 160 AH of usable energy, require less space and reduce battery weight from around 140kg to only 27kg.

The end result is a battery of half of the nominal capacity providing the same, and often greater, usable energy.

CYCLE LIFE

Cycle life refers to the number of times a battery can be discharged and recharged before it is degraded beyond viability.

Li-ion batteries offer far greater cycle life than lead-acid, allowing them to deliver considerably more energy during their service life (see Fig 3).

A typical lead acid AGM battery will have a cycle life rated at approx. 500 cycles to 50% DoD. Li-ion tecŠology, like that used for the Juice PRO Series batteries, offers 3000+ cycles down to 80% DoD.

Combining their greater usable capacity and far greater cycle life, Li-ion batteries deliver around 9-10 times the energy throughout their life than conventional lead-acid tecŠologies.

BELOW This launch – as well as the yacht at the beginning of this story – have made the switch to Lithium-Ion batteries.

LI-ION BATTERIES OFFER FAR GREATER CYCLE LIFE THAN LEAD-ACID...

AVOID LOW-COST LI-ION 'DROP-IN' OPTIONS

There are low-cost 'drop-in' lithium batteries available with internal disconnects to protect the battery. But these can lead to much larger issues.

These batteries have huge limitations on the current they can deliver or be charged with. They can also cause damage if disconnecting themselves when being charged by an engine alternator. This will open-circuit the alternator and can lead to damage to the alternator and all other connected electrical equipment on the vessel.

The marine electrical regulations have been written to preclude these sorts of issues. Unfortunately, the majority of Li-ion batteries offered in the marine market don't comply with these standards and at best will provide poor performance. At worse these are dangerous and can cause complications with insurance cover.

SAFETY

Misconceptions around safety issues with Li-ion technology have, in some cases, unfairly damaged their reputation. To set the record straight there are several points to cover.

The first thing to understand is that there are various Li-ion chemistries under the Li-ion umbrella. All have advantages and disadvantages and some are better suited to particular industries.

In the marine industry, Li-ion iron phosphate (LiFePO4) chemistry is typically used thanks to its chemical stability which ensures high safety standards. Different Li-ion chemistries used in electronic devices, toys and electric vehicles generally place a high value on greater energy density. But the type largely used in marine batteries is extremely safe and considerably more tolerant than other lithium chemistries.

As an example, Juice PRO Series batteries are tested to IEC standards which require them to be subjected to an over-discharge test,a forced discharge test, external short circuit tests, a thermal abuse test, crush test, nail penetration test and drop test. Through every single test the battery cells – while damaged and possibly unusable – did not cause any safety issues.

Based on this, it can be argued that the inherent safety of Li-ion iron phosphate chemistry coupled with a suitably-designed battery management system means that Li-ion batteries could be considered safer than traditional lead-acid batteries.

While the initial outlay for Li-ion (purchase plus installation) is higher than for lead-acid technologies, the performance advantages (more usable energy and much higher cycle life) make Li-ion batteries far less expensive per AH of energy delivered.

Add this to the savings in weight (and associated performance implications), size and better voltage stability and the argument for converting to correctly designed compliant Li-ion batteries stacks up. Basically, if finances allow, make the switch at your next battery change and enjoy the features this technology has to offer.

ABOVE Lithium-ion batteries have a longer service cycle – they can be discharged to a much lower level than conventional lead-acid batteries.

From a cost perspective, while a high-quality Li-ion battery will cost around two or three times as much as lead-acid variants, the cost analysis stacks firmly in favour of Li-ion batteries. No surprise then, that today nearly every industry sector reliant on stored energy uses Li-ion tecŠologies.

INSTALLATION

Full disclosure: changing from lead-acid to Li-ion batteries is not as simple as removing the old and dropping in the new. Installations in New Zealand or Australia must comply with the marine electrical regulations (AS/NZS 3004.2:2014). These specify the requirements for installing Li-ion batteries.

Among other things, these regulations require the battery to be able to disconnect the load (after a pre-alarm) to prevent it from over-discharge. It must also be able to disconnect all charge sources (after a pre-alarm) – preventing charging issues from damaging the vessel's Li-ion batteries and wider electrical system.

When installing compliant li-ion batteries, the biggest variable is how the charge control side of the battery system will work. This feature allows the battery to disconnect charge sources in the event of any problems.

Some manufacturers require all the charging equipment (alternator regulators, AC battery chargers, solar regulators etc.) to be the same brand as the batteries. Others, like the Juice PRO Series, are designed to work with a variety of makes and models and don't require specific Li-ion settings on the equipment.

This reduces installation time when swapping to Li-ion batteries and significantly lowers the overall cost of the changeover. The flexibility in controlling charge sources is achieved by using an integrated solid-state charge control relay on the battery, sending a signal to each charge source to switch off if there is a charging issue.

Although it takes longer to install compliant Li-ion batteries compared to traditional lead-acid batteries, a correctly designed Li-ion installation is relatively straight forward. Suppliers will advise on the best system design for your vessel and ensure compliance with the marine electrical regulations. BNZ