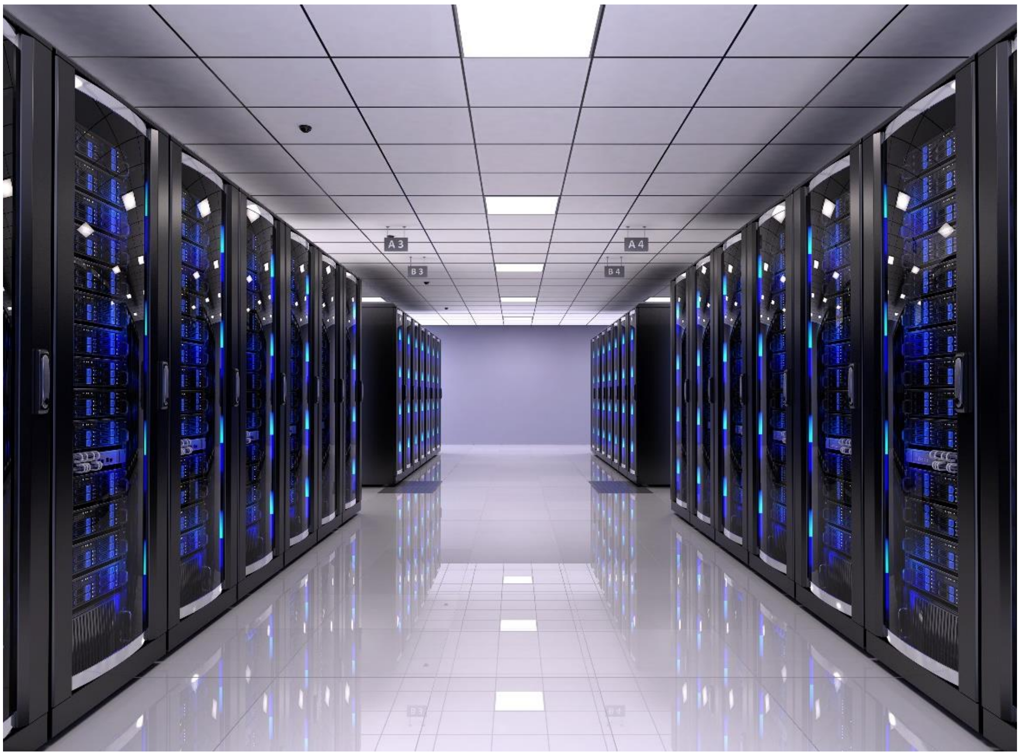
LITHIUM-ION BACKUP BATTERIES : A NEW COMPETITIVE EDGE FOR DATA CENTERS



Data Centers

Saft White Paper

Lithium-ion backup batteries : A new competitive edge for data centers

Saft White Paper

EXECUTIVE SUMMARY

Data center operators are now turning to lithium-ion (Li-ion) batteries as the technology at the heart of their uninterruptible power supply (UPS) systems.

Until recently, almost all data centers have relied on valve-regulated lead-acid (VRLA) batteries but **Li-ion** is set to take at least a **10 percent share** of the market **within five years** (Bloomberg Energy storage research note April 2017).

Li-ion offers significant benefits over the lead-acid electrochemistry that has been used traditionally. Especially Saft **highly reliable and fast charging rates** Li-ion technology ensures higher levels of protection, whereas its ability to withstand **higher temperatures** results in **less energy for cooling**.

Total **Cost of Ownership is lowered** by Li-ion's **long calendar life** and **low maintenance** requirements. In addition, Li-ion can be integrated with electronic **monitoring systems**, enabling condition-based maintenance.

Scalable power and energy means the UPS can closely match a facility's requirements and be expanded to grow alongside the servers.

In addition, being **compact** and **lightweight**, it requires less space and structural support.

INTRODUCTION

Ensuring the continuous operation of data centers is essential for businesses in finance, commerce, communication and media. Therefore, today's mission-critical facilities require high availability and reliability.

A power outage at a data center can have **severe repercussions on reputation** and **customer loyalty** for operators, their customers and end-users that far exceed the loss of service during the outage and the cost of repairing damaged equipment.

One example was a power outage in May 2017 at a British Airways data center near London Heathrow airport. The power outage caused a ripple effect when a loss of data resulted in the cancellation of 726 flights. While it initially left 75,000 passengers stranded around the world, reports estimated that the operator took 14 days to resume normal flight service.

An outage for US carrier Delta Airlines in August 2016 led to similar problems and cost $150 million. Then, a few weeks later in September 2016, the major Global Switch 2 (GS2) data center in central London experienced an outage of less than one second but took one customer offline for two days.

According to research by the Ponemon Institute in early 2016, the average cost of unplanned outages, including **direct costs** for hardware, services, lost revenue as well as lost business and reputational damage is **$9,000 per minute**. However, this **can rise to $17,000 per minute** for the most data-dependent businesses.

The cost of downtime and our reliance on data is growing thanks to the Internet of Things (IoT), e-commerce, autonomous vehicles and Industry 4.0.

Another trend is for data center operators to meet increasingly tight legislation to improve their energy performance as part of the drive to control climate change.

According to Environment Edits by Tom Bowden, **global data center energy consumption** accounted for **416.2 TWh** (tera-watt hours) in 2016, equivalent to **3 percent of the world's energy consumption** and 2 percent of total greenhouse gas emissions.

Reducing energy consumption will have the additional benefit of making savings on utility bills.

THREE DATA CENTER SEGMENTS

Broadly speaking there are three data center end user segments: Enterprise, co-location and cloud.

Enterprise data centers are the in-house, on-premise centers that give companies complete control over their core services and data. They typically have Tier 3 or Tier 4 performance, which is a categorization that reflects extremely high uptime, characterized by availability, security and performance. Their operators have complete cradle-to-grave control over these centers and often specify redundant, ultra-high quality and reliable components to ensure high-speed responsiveness as well as high availability. They often subcontract to engineering, procurement and construction (EPC) contractors.

A co-location or multi-tenant data center is an outsourced facility where corporate customers rent space. The priority of operators of co-located sites is to meet the technical requirements set by its customers. These vary and can include uptime, speed of response and requirement for backup time.

Cloud providers usually operate giant data center infrastructures and should experience huge growth in the near future due to the rising demand of cloud-based data centers. There is an emerging trend for modular approach that gives the ability to scale up quickly to meet fast-growing data needs of its customers. For operators, the priority is to optimize costs.

EVOLVING ROLE OF THE UPS

The combination of **growing reliance of data** and **tightening environmental legislation** means that operators are moving towards **ever-higher** levels of **reliability, energy efficiency and performance**. This is impacting every area of data center architecture, including the UPS.

The basic role of the UPS is to maintain a consistent high-quality power supply to keep the servers running in the unlikely event of an outage of mains power or a short-lived drop in power quality. To achieve this, it contains switchgear, batteries, a battery charger and an inverter.

The UPS draws on battery power for periods ranging **from 1 to 15 minutes**. This maintains power until the switchgear controls the shift to an alternative utility supply or to a backup diesel genset. In many cases, the UPS also acts as a power conditioner by absorbing or injecting power to overcome the short-term spikes and sags in mains power caused by transients when other large grid-connected loads are switched on and off.

According to the Ponemon Institute, **failure of UPS systems is the number one cause of unplanned data center outages**. As a result, operators are keen to **enhance the reliability of** all the **UPS** components**, including the battery system.**

In addition, the global drive to combat climate change means that **governments are introducing new legislation designed to reduce energy consumption** and therefore carbon dioxide emissions. As a result, energy efficiency, as measured by Power Utilization Effectiveness (PUE) is an important target. Operators are looking at all systems in data center architecture, including the UPS, with a view to enhancing energy efficiency.

In an effort to optimize investment, there is as well a trend for **operators** to **specify battery** systems that deliver **shorter backup time**, typically in the region of **1 to 10 minutes,** rather than the traditional 15 minutes.

Such batteries have a smaller capacity, with shorter charging times. They are also physically smaller and lighter. This is an important when considering physical replacement or where real estate and infrastructure costs are high.

DRAWBACKS OF VRLA BATTERIES

VRLA batteries are a well-proven technology with a low capital cost and they have traditionally been used in the vast majority of data center UPS applications. However, **they have several drawbacks**.

Perhaps the most important of these is their **reputation for low reliability**. Reliability is essential to avoid unplanned outages. VRLA batteries need a **stringent maintenance** regime that includes regular servicing and testing. **Monitoring and battery analysis are mandatory** to ensure continuous availability **requiring additional CAPEX**. Their reliability can also be affected by a condition called '**sudden death**', which happens when the lead structure inside the batteries fails without warning.

Charging rates of VRLA batteries **are limited** because the internal resistance (or impedance) rises when DC (direct current) power is passed through a water-based electrolyte. This leads to loss of water as it transforms to gas and escapes.

The **charging period for a VRLA battery** can vary **from eight to 24 hours** to charge to full capacity.

Operating costs are another factor. VRLA batteries have a relatively **short calendar life**, which means that they need to be replaced more frequently compared to Flex'ion.

Exposure to **high operating temperatures reduces the calendar life of VRLA batteries**, leading operators to install and run cooling equipment to overcome this. This adds complexity whilst increasing energy consumption and reducing PUE performance.

When time for replacement comes, **large size and heavy weight** mean that replacement can be physically demanding and logistically difficult. In addition, their large size and weight mean that they require a lot of space and reinforced structures to support.

LITHIUM-ION TECHNOLOGY

Having been **introduced** into commercial applications such as consumer electronics **in the 1980s**, Li-ion batteries are a mature technology.

Compared with lead-acid batteries, **Li-ion brings higher power** and **energy density** meaning that it can deliver more power with less footprint and lower weight for more time over a **longer life**.

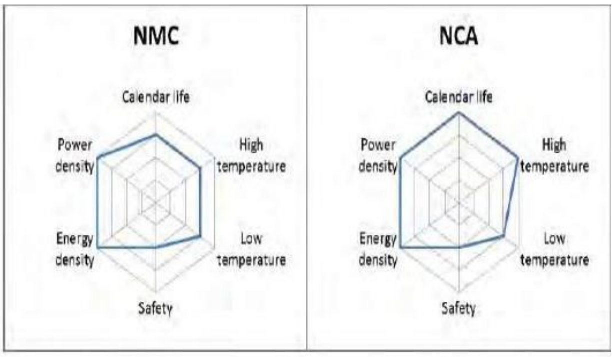
As a result, **Li-ion's share** of the battery market has risen fast from less than 1 percent in 2000 to more than **14 percent** in 15 years. Today they are used in electronic devices, electric vehicles, energy storage for renewables and other applications such as industrial backup.

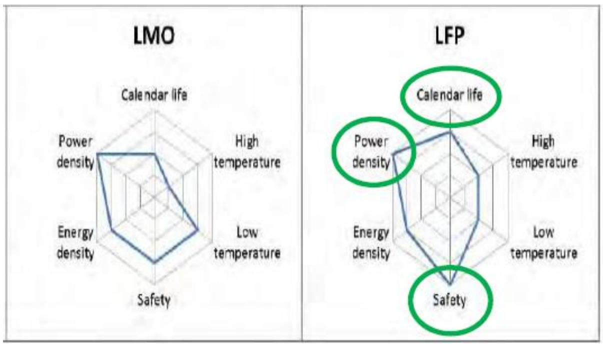
The name 'Li-ion' is in fact an umbrella term for multiple types of battery chemistry that have been steadily introduced since the 1980s.

These mature technologies include **lithium iron phosphate** (LFP), **lithium cobalt oxide** (LCO), **lithium manganese oxide** (LMO), lithium **nickel manganese cobalt** oxide (NMC), lithium **nickel cobalt aluminum** oxide (NCA) and **lithium titanate** (LTO).

Each of these offers different advantages in terms of power density, energy density and inherent safety. The types can be used individually or blended to create battery systems tailored to meet the demands of different applications.

Saft is among the first companies to develop Li-ion batteries nearly 30 years ago and today focuses on different technologies such as NMC, NCA, blended NMC/NCA and LFP chemistries.





SUPER LITHIUM IRON PHOSPHATE (SLFP)

In 2012 Saft developed a proprietary version of lithium-ion phosphate known as **Super Lithium Iron Phosphate (SLFP)** based on LFP. This was first introduced in the forklift market and has since been rolled out to other industries where safety, power density and calendar life are important.

Saft's long experience of Li-ion technology and mission critical applications has led it to the conclusion that its **SLFP Li-ion chemistry is well suited to data centers.**

For mission-critical applications where safety is paramount, SLFP offers the **highest level of safety and power density** as well as **excellent calendar life.**

As a manufacturer, Saft's customers include operators of **mission-critical** and industrial **applications where availability, safety and performance are top priorities.** These **include Li-ion systems for data centers**, as well as ships, aviation, offshore oil and gas and space.

For example, a SLFP battery system will boost engine power for icebreaking on board the polar research vessel the RRS Sir David Attenborough.

Another SLFP system is the technology inside a hybrid airport tractor, the Kalmar TBL 800, that pushes aircraft as large as a fully laden Airbus A380, and Airbus also offers Saft Li-ion batteries as onboard backup on its A350 XWB.

With **marine and aviation safety codes** being among the **most stringent in the world,** operators of other mission-critical applications such as data centers and offshore oil and gas installations can look at this track record to gain insight into performance, safety and longevity.

FLEX'ION CERTIFIED FOR DATA CENTERS

Today SLFP chemistry is central to the Flex'ion battery system that was launched in December 2017 for data center, oil and gas and utility applications. The battery system is **fully IEC, UL** and **UN certified** to meet the **high safety standards** for UPS data center requirements.

Flex'ion battery technology has significant advantages over VRLA batteries.

THE VALUE OF FLEX'ION IN DATA CENTERS

While Li-ion technology has many advantages, it's worth exploring these in detail and considering their potential value to data center operators.

High reliability and availability

With no risk of sudden death, **low maintenance** requirements and **fast discharging rates**, Flex'ion battery systems have high availability. This minimizes the likelihood of an unplanned outage.

In addition, they are amenable to **fast charging**, increasing system availability after an outage or discharge.

Saft's Flex'ion features **accurate** State of Health (SOH) and State of Charge (SOC) **monitoring**. These ensure high battery availability and reduce risk of downtime.

Whereas **VRLA batteries** require **8-12 hours recharge time**, a **Flex'ion Li-ion battery** takes only **75 minutes**, meaning that the battery will be fully charged and ready within an hour and 15 minutes. The **High Power version of Flex'ion** can be even **recharged within 15 minutes**. This could enable the operator to reduce its specification for contingency backup.

Flex'ion system also has a technical edge due to its built-in intelligence, called **Intelli-Connect supervision**. This ensures that the **battery will remain available even when its charger is disconnected**. This feature has been specifically designed for data center operators, where uptime is extremely important.

A further benefit is that Flex'ion's features **self-powered monitoring**, so its operator can check the battery status at any time, even during a power outage.

While this is hard to place a value on, Ponemon Institute found that the average **cost of an unplanned downtime event** was **$740,000 in 2016**, a figure that has increased by 38 percent since 2010.

Smart and connected

Risk of downtime can also be minimized by smart and connected battery management. In addition, the industry's expectations of control, communication and monitoring are also growing. **Flex'ion battery systems can be connected to the building management** as any other critical equipment.

Flex'ion operates with conventional or smart UPS systems using the industrial **communication protocols,** including **Modbus, OPC, TCP/IP and CANopen** or simply using **dry contacts** which has been **proven during the development process.**

Flex'ion's Battery Management System can integrate with building management system. This enables monitoring of key performance indicators, such as state of charge (SOC), state of health (SOH) and temperature from a control room or a smart device.

Whereas most UPS battery controllers rely on a secondary power supply, the **Flex'ion monitoring system is self-powered and independent of mains power** thanks to a built-in DC-DC converter.

This is an unusual feature in the world of UPS and a key advantage for operators who want equipment that is capable of black-start functionality.

Improved Power Usage Effectiveness (PUE)

Power usage effectiveness (PUE) is a common measure of data center energy efficiency. It is calculated as the ratio of the total energy consumed by a data center to the energy consumed by computing equipment. Ideally, a PUE of 1.00 means that all energy is dedicated to computing and the lower the PUE number is, the higher efficiency the building is being operated at.

Li-ion systems can save energy is through their high round-trip efficiency of 90 to 97 percent. **Flex'ion solution achieves 97 percent efficiency**, which compares with only 80 percent for VRLA batteries or 73 percent for other lead-acid technologies.

This is important when the UPS is used in a power conditioning role – the greater efficiency, the lower the PUE.

The **operating temperature** for a VRLA battery is ~25˚C, compared to **35˚C for Flex'ion** at full performance **for up to 20 years**. Savings can be made either by reducing the size of HVAC equipment (CAPEX) or by lower energy consumption over its lifetime (OPEX).

Compact and lightweight

Li-ion has higher power density than VRLA batteries; Flex'ion system is up to **three times more compact** and up to **six times lighter**.

This results in batteries that have small size and light weight. These features offer major benefits including **ease of handling** and **minimizing land take**. Reduced weight and size unlocks **huge infrastructure savings** for enterprise and co-location datacenters located in major cities.

By **switching to a smaller battery**, operators can free up more space for servers or other services.

However, a less obvious benefit is that every kilogram of battery needs to be physically supported by structural steelwork. A heavy-weight VRLA battery system on a high floor will need more bracing and vertical support than a Li-ion battery that is up to six times lighter. **The cost of the structure to support a VRLA battery can dwarf the cost of the Li-ion battery.**

Therefore, it's worth considering the bigger picture and the value of saved weight and space. **Opting for a Li-ion battery system** can achieve **significant savings** on the **cost of a building** that houses a data center.

Scalable and modular

Elasticity is another major priority in data centers, with operators striving towards flexible data center architecture that can adapt to rapid growth. Ideally, power infrastructure and UPS systems should deliver the same level of flexibility as servers, with the ability to scale up power storage to react to growing racks of servers.

Being **modular, Flex'ion battery** technology is **scalable** in terms of voltage, power and energy. The system design is optimized for each application. Flex'ion battery systems can deliver power ranging from kilowatts to megawatts from seconds to hours.

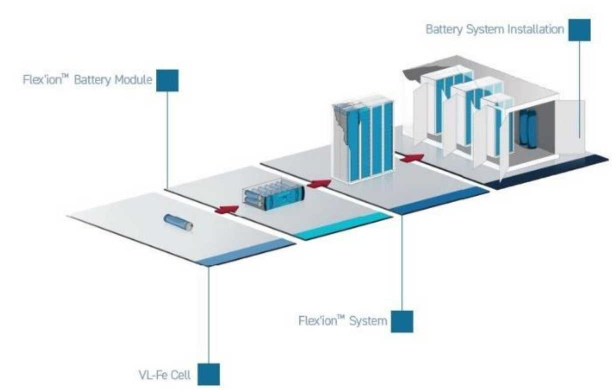
Flex'ion comprises 4 main components: battery modules, Battery Management Module (BMM), Programmable Logic Controller (PLC) with Master BMM (MBMM) and Intelli-Connect™.

Battery systems are scalable in terms of voltage **from 87 to 750 V, high power of up to 2.3 MW or high energy of up to 500 kWh.**

Flex'ion components can be integrated with **standard 19" racks**. The battery module **front face design allows quick installation and serviceability**.

A Flex'ion system can be supplied either as a complete system including cabinets or as a kit of sub-components for a UPS manufacturer to integrate with power electronic equipment.

Saft value chain : from cell, to module and system



Optimized Total Cost of Ownership (TCO)

TCO is based on the initial purchase cost as well as operating, maintenance and replacement.

Flex'ion usually has a higher capital cost than lead-acid. Due to its extensive performance, it is though **less expensive over the equipment life time.** The return on investment (ROI) is usually 4 to 6 years.

Long and predictable life

Saft's extensive experience with Li-ion in the field has two major advantages for its customers.

The first is the assurance in the **long-term performance** of the battery systems.

The second is that Saft has developed sophisticated models that enable its engineers to **accurately predict the calendar and cycle life** of the systems that it installs.

For operators, SLFP technology also offers the benefit of a flat discharge curve – a major advantage for UPS applications that need to supply **constant power.**

A GROWING TREND

Given that **Li-ion** battery technology has clear **advantages** in terms of the **reliability, energy efficiency and operating expenditure** (OPEX) of data centers, it's no wonder that they are growing in popularity.

Saft developed the Flex'ion battery system to bring together the benefits of Li-ion for operators of data centers such as **high reliability, improved PUE, low TCO over a long life, scalability** to deliver 1 to 15 minutes backup time**, light weight and small size.**

The Flex'ion design then builds on these with additional advantages, including **safety certification, 19" racks, black-start capability** and straightforward **remote monitoring.**

END-TO-END QUALITY

But perhaps the biggest advantage of Saft Li-ion technology, including the SLFP chemistry, is that **Saft takes control of every stage of development.** This includes sourcing of raw materials, manufacture and system integration at Saft's dedicated engineering, production and service centers around the world.

This means that Saft's customers have straightforward accountability and a single point of contact.

Battery systems such as the Flex'ion are optimized for each specific application, to ensure full compatibility between cells, modules and battery systems.

CONCLUSIONS

Flex'ion battery systems deliver significant performance improvements for all data center operators:

- **High reliability, smart and connected** Li-ion battery systems are better able to help data center operators avoid unplanned outages.
- Saft Li-ion batteries have **lower total cost of ownership** than VRLA batteries – and being small and lightweight are less trouble to replace when the time comes. In addition, because they can withstand high temperatures, they **need less energy for cooling.**
- Saft Flex'ion systems are **safe, with full IEC, UL and UN certification** for data center operations.

ABOUT THE AUTHORS

Nick Finney is **Li-ion Business Development, Product and Applications Manager for Li-ion battery systems** at **Saft**. He is based in Harlow, UK and after joining Saft in 1989, he developed knowledge of batteries, including the manufacture and quality testing from the level of individual cells right up to large battery systems. Today he is responsible for product development of Li-ion battery applications in stationary industrial settings. These include systems for UPS, switchgear and backup power.

Email: nick.finney@saftbatteries.com

Francois Danet is **Li-ion Business Development Manager at Saft for the Data Center/Big Data within Industrial markets**. He is based in Levallois-Perret, France at Saft's headquarters. After working for SKF Group as an Application Engineer, he launched and monitored International tools for Citroen vehicle manufacturer as After Sales Manager. He has joined Saft in 2007 first as Railway Sales Engineer and Sales Manager. Today, he prescribes and develops channels to market, builds high level relationship with key players, supports strategic product development, potential partnerships and investments.

Email: francois.danet@saftbatteries.com

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