

LIQUID METAL BATTERY CORPORATION

**LMBC**

# SAVING ELECTRICITY FOR OUR FUTURE

## LOW COST

LMBC achieves low cost through the use of inexpensive, earth-abundant materials that are easy to procure. Our products take advantage of the economies of scale inherent to electro-metallurgy and conventional manufacturing. The all-liquid construction avoids cycle-to-cycle capacity fade because the liquid electrodes are reconstituted with each charge - similar systems have operated in a lab environment for more than 17 months with daily cycling and no reduction in performance. The molten salt electrolyte combines high conductivity with abuse tolerance at low cost. Self-segregation due to three immiscible liquid phases of different densities (e.g. oil and water separation) allows for robust operation and ease of manufacture. Together, these attributes will enable the liquid metal battery to exceed 70% round-trip AC efficiency for over a decade without degradation.

## EASY TO DEPLOY

LMBC's product will be modular - allowing repeatable manufacturing and ease of transport. When integrated onsite, the modules have the footprint of a shipping container, and the system will be rated at 500 kW with 2 MWh storage capacity. The management and control electronics are configured to allow remote operation and monitoring of the battery without on-site personnel. The liquid metal battery operates silently, is emissions-free and has no moving parts. These characteristics allow LMBC's product to be sited in the middle of the city or the middle of the desert without special regulatory or permitting requirements. LMBC will utilize existing power electronics and follow interconnection standards to provide the reliability required by its customers.

## FLEXIBLE OPERATIONS

In the world of electricity storage, liquid metal battery technology performs like both a tractor and a race car. LMBC's storage solutions respond to regulation signals with its entire nameplate capacity in milli-seconds while simultaneously storing up to twelve hours of energy and discharging it slowly over time. This ability to be both a power and energy resource to the electric grid distinguishes LMBC and opens up numerous lucrative markets for development. This value proposition makes the liquid metal battery a valuable solution for system operators, power developers, utilities and power marketers balancing the supply of and demand for energy.



500 kW / 2 MWh

### A Message from our CEO:

Thank you for your interest in the Liquid Metal Battery Corporation. We are working to develop and commercialize a new battery technology that will enable new grid-scale power storage solutions. Our team is committed to delivering inexpensive, flexible electricity storage that will enable the separation of energy supply and demand everywhere. Using both components and processes that are well-understood and documented, our liquid metal battery will be a major enabler of widespread use of sustainable energy and help create more efficient power systems.



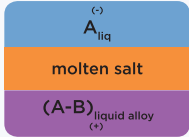
We have achieved substantial progress in the last few months and with backing from Bill Gates and Total SA, I am excited by the road that lies ahead as we begin saving electricity for our future.

Sincerely,

Philip Giudice

## A||B

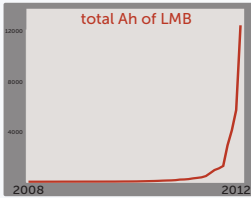
liquid metal battery



### Energy storage by electro-alloying

The liquid metal battery stores electricity by de-alloying the negative (-ve) electrode material, A, from the positive (+ve) electrode material, B. As the battery is charged, a power source extracts electrons from the +ve electrode, causing A to de-alloy from B, and A dissolves into the electrolyte as an ion (A<sup>+</sup>). Simultaneously, A<sup>+</sup> ions from the electrolyte accept electrons at the -ve electrode and A deposits as a liquid metal. The energy difference between 'pure A' and 'A dissolved in B' generates a cell voltage. To discharge the battery, electrons are driven by the cell voltage through an external circuit/load, resulting in A<sup>+</sup> ions moving from the top -ve electrode through the electrolyte, and alloying with B, thus returning the stored energy.

<sup>‡</sup> [http://sadoway.mit.edu/wordpress/wp-content/uploads/2011/10/Sadoway\\_Resume/141.pdf](http://sadoway.mit.edu/wordpress/wp-content/uploads/2011/10/Sadoway_Resume/141.pdf)



### Rapid scale-up

Our technology has been under development for more than six years. Recent accomplishments and the inherent scalability of the liquid metal battery have resulted in a significant increase both in scale of size and total capacity of batteries tested. The graph to the left shows cumulative amp hours of storage. LMBC is accelerating the path to the commercial marketplace for this transformative technology.

METRIC	PERFORMANCE
cost(\$/kWh)	✓✓✓
cost(\$/kW)	✓✓✓
cycle life	✓✓
efficiency	✓✓✓
consistency	✓✓

### High performance battery solution

ARPA-e sponsorship of technology development at MIT has been critical to the rapid maturity of the liquid metal battery. The team set aggressive goals and exceeded all the performance metrics. The table to the left indicates a single check mark for demonstrated performance meeting the metric, two check marks for beating the metric and three check marks for exceeding a multiple of the metric. The cost metrics were \$100/kWh and \$1000/kW; the cycle life metric was 0.1% capacity fade; the DC efficiency metric was 65%; and, the consistency metric was the requirement that the average performance of seven cells meet the metrics. The liquid metal battery is not only the low-cost solution, but also a great storage battery.



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