Battery Energy Storage For Extreme Climates

Dragon Q Energy

www.dragonqenergy.com

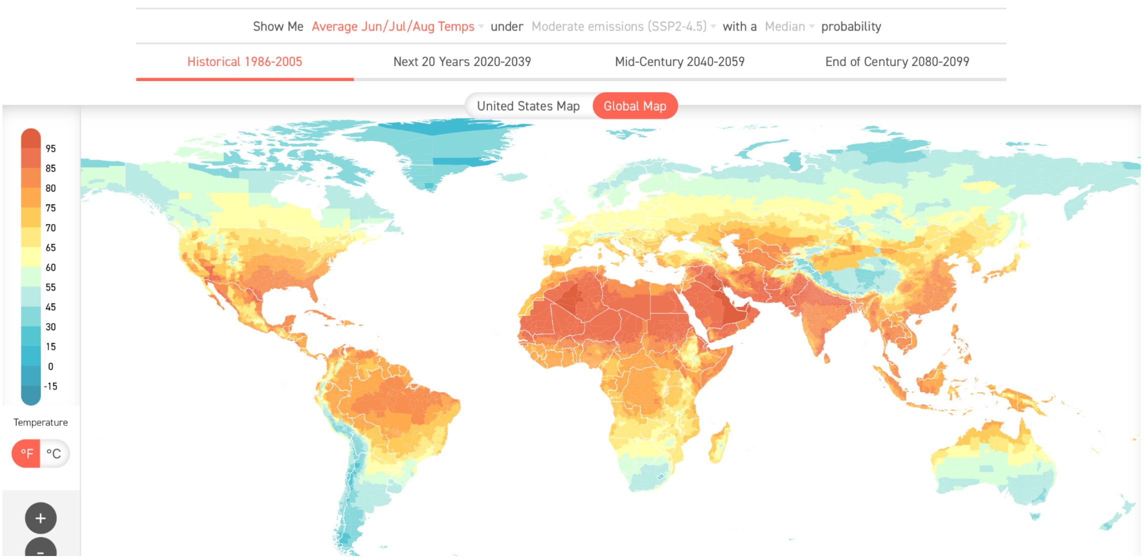
info@dragonqenergy.com

+1(805)-421-6888

Dragon Q Energy's Solution

Dragon Q Energy (DQE) is developing a safe, fit-for-purpose, large format battery energy storage system (BESS) for extreme climates. With our forward looking, patent pending pack housing, we are enabling a cell to pack BESS design that can readily integrate commercial lithium-ion (Li-ion) and Nickel Metal Hydride (NiMH) cells. Our container utilizes a modular, weld free design with direct liquid cooling and an inert atmosphere on the pack level, affording enhanced safety, simplified pack assembly, and improved cycle life. This platform design strategy can seamlessly scale from 10 kWh residential packs to 10 MWh packs for grid applications, and can be buried underground for geothermal regulation, increasing energy resilience and security.

a)



b)

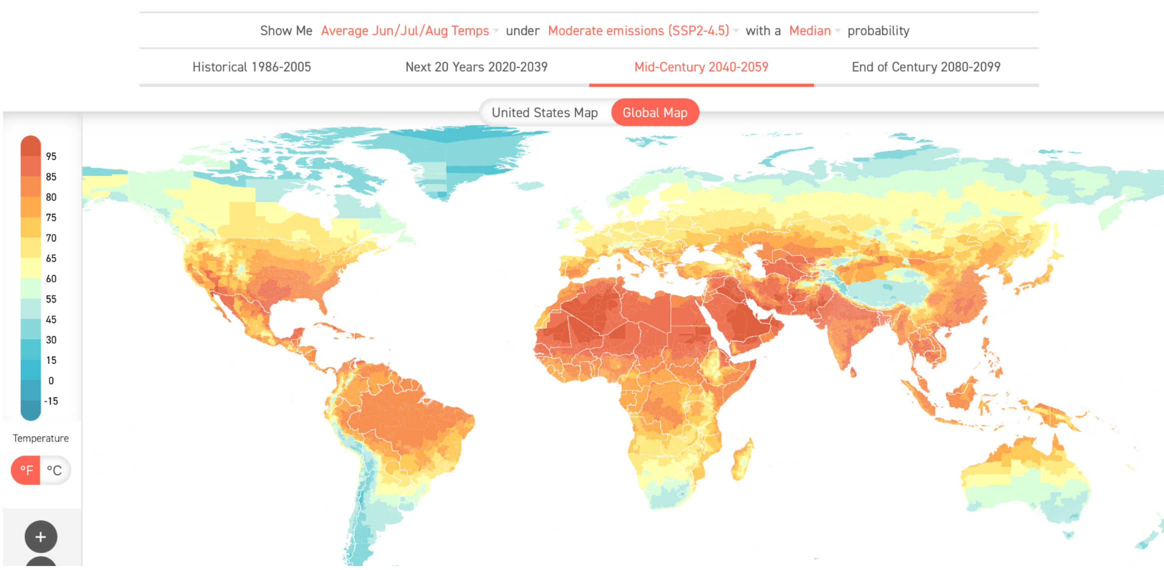


Figure 1. (a) A global heatmap comparing average historical temperatures from 1986-2005 in June, July, and August at a moderate emission rate over (b) the projected average temperatures in 2040-2050 under the same conditions. The increase in temperatures is seen globally, but the greatest difference is seen in the Southern United States, Sub-Saharan Africa, South America, and in South Asia (especially the Middle East, Southeast Asia and India). This highlights the need for a robust energy storage system that can withstand the harsh weather conditions which we have begun to see and will continue to have in the future. [7]

The Problem

To address climate change and reach net zero emissions for electricity generation, low cost, scalable energy storage must be implemented in quantities 44-fold greater than what is in use today, over a time span of only 7 years.[1] However, the leading energy storage systems used for this application are insufficient for the job- with short operational lifetimes, high cost, and high risk of fire.

There is a need for safer, lower cost energy storage solutions that can incorporate both lithium-ion and non-lithium-ion chemistries, ensuring a robust supply chain and rapid adoption of this critical technology.

DQE's Product Design

Rather than repurposing electric vehicle module/pack designs for the grid, a method which has become a commonplace in today's BESS landscape, DQE acknowledges that cost, safety, and resiliency can be improved dramatically by designing a system specifically for stationary applications in extreme climates. With our patent-pending housing, we utilize a pressure vessel like container to hermetically seal all cells on the pack level- providing an extra mitigation step in the case of thermal runaway. Furthermore, it has been shown that increasing the pressure within the container can more than double the cycle life of NiMH cells- making this established, but often overlooked chemistry, a viable Li-ion alternative for a supply-chain diverse BESS.[2]

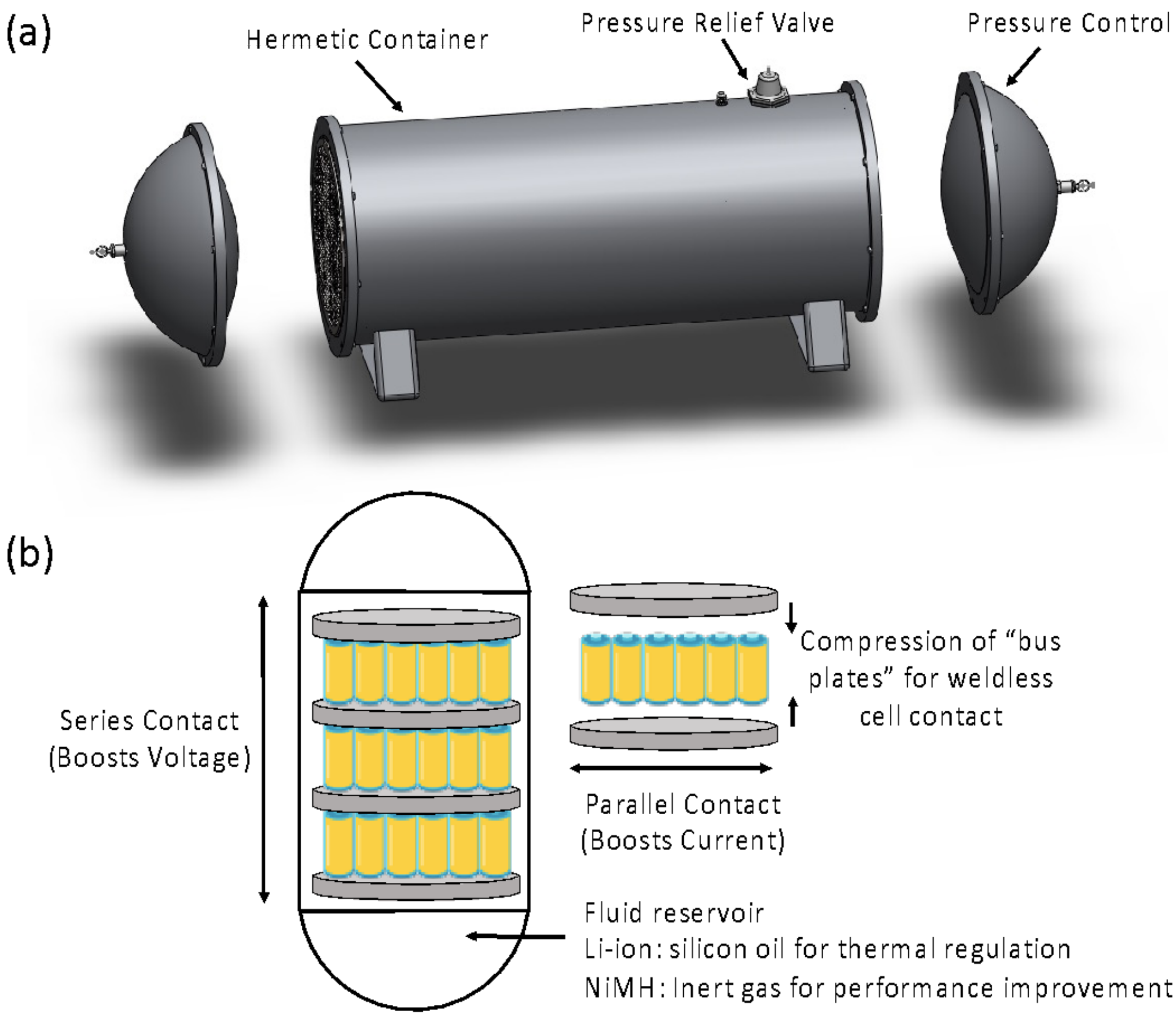


Figure 2. A schematic of DQE's product, where (a) shows an external view of the housing, and (b) shows the internal cell array. The container seamlessly integrates the module and pack into one system (i.e. cell to pack). Cells are arranged horizontally for parallel configuration to boost current. These horizontal arrays are then stacked vertically to boost potential (series connection). Compression provides electrical contact without the need for welds. Finally, all cells are enclosed within the same, sealed container. For Li-ion cells, this makes thermal management via direct immersion straightforward. Additionally, the sealed design of the pack maintains an oxygen free environment on the pack level, further mitigating risk of fire. For Nickel Metal Hydride cells, pressurizing this container with inert gas has been shown to double cycle life.[2]

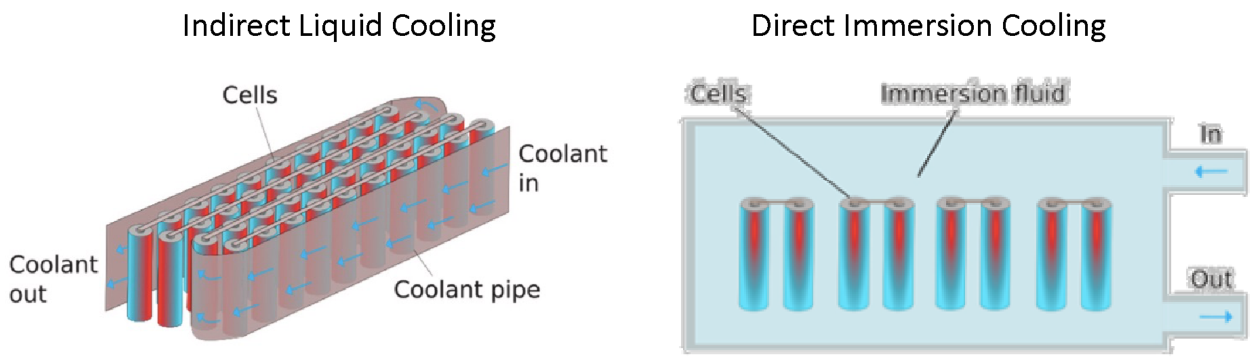


Figure 3. A comparison of indirect liquid cooling and direct immersion cooling. Indirect liquid cooling is the most common technique used today, as it is well suited for light weight, high power EV applications. However, this introduces complexity to the system with the need for sealed loops wrapping each cell. This inherently creates a multitude of failure points and does not provide an oxygen free environment to quench fires, should thermal runaway occur. Immersion cooling (while heavier) offers immense benefits for grid applications- with minimal assembly steps, reduced failure points, and full immersion of the cell to inherently prevent fire propagation in the event of thermal runaway. Figures adapted from the following source.[3]

Universal to the product is the “weldless pack” design, which can be adopted to any existing cell chemistry, with Nickel Metal Hydride (NiMH) and Lithium ion chemistries being the most promising (summarized below). The most obvious benefit is that the weldless design is easy to assemble and reduces contact resistance, which will lower cost and improve performance, respectively. While much focus is given to cell level improvements to lower cost, module/pack assembly is a substantial contributor- with labor and hardware accounting for about 20% of the final pack cost.[4] Improving on this area gives Dragon Q Energy a critical competitive advantage.

Improvements such as this have likely been overlooked due to the immense focus given to Electric Vehicle (EV) pack designs. DQE’s weld free design, with simplified cooling and safety, utilizes long stacks of cells to achieve the required voltages, and thus does not lend itself to the flat pack designs required for EV applications. However, this is not a limitation for grid storage.

Lithium-ion Design

This utilizes the most scaled cell chemistry, in a safer and more straightforward manner for grid-scale packs.

- Abundance of cell suppliers
- The cylindrical container and cell to pack design enables low cost, effective direct immersion cooling
- Lack of oxygen within the pack (both due to immersion in cooling fluid and sealed housing) prevents fire propagation if thermal runaway does occur

Nickel Metal Hydride Design

DQE's housing enables this well-known (but often overlooked) cell chemistry to be competitive for grid applications. NiMH cells originally led the hybrid and electric vehicle space before Li-ion chemistries rose to dominance. NiMH initially fell out of favor due to the memory effect, charge retention issues, and lower energy density compared to Li-ion cells. However, advancements in cell designs and material improvements have largely addressed all concerns- with modern NiMH cells having little to no memory effect and good charge retention. Additionally, unlike EV applications, energy density is not an issue for grid storage. Finally, recent literature has shown that by applying high pressure inert gas in a sealed chamber will more than double the cycle life of NiMH cells, making this lithium alternative a competitive choice when applied in Dragon Q Energy's housing.

- Intrinsically non-flammable (water based electrolyte)
- Substantially cheaper chemistry than lithium-ion (up to 50% less)
- Simplified BMS
- Diversified supply chain (reduced reliance on Lithium and Cobalt)
- Double the cycle life with pressurized inert gas

Underground BESS projects

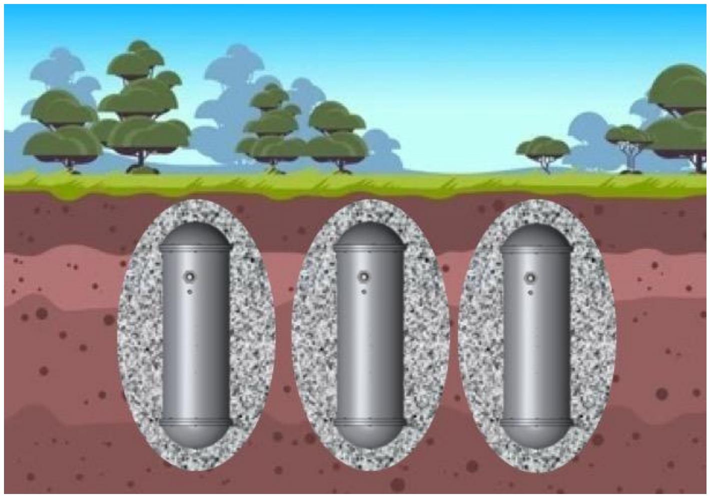


Figure 4:

It is well understood that the temperature just under the surface of the earth (3-4 meters) is significantly cooler and less prone to seasonal, diurnal and heatwave related temperature swings than that on the surface, even in tropical climates.[5] This temperature consistency lends itself to being a thermal management solution for BESS when buried underground, and may play a key role as more and more regions begin to experience unseasonably warm temperatures. DQE is conducting customer discovery in Southeast Asia, Middle East, and Central/South America. We have identified opportunities in large cities (load centers) where real estate for BESS projects is expensive, and the climate has been altered by global temperature increases.

Conclusion

Dragon Q Energy is developing a platform housing design that can be applied to both Li-ion and NiMH cell chemistries, offering a diverse supply chain for a variety of stationary storage applications. The sealed container allows direct immersion liquid cooling to be easily applied to Lithium-ion cells, while NiMH cells will benefit from the application of high pressure inert gas. The ability to apply compressive force enables good contact between cell terminals and "bus plates" without the need to weld individual tabs, affording a cell to pack design with simple, low cost assembly.

References

(1) Schoenfisch, M.; Dasgupta, A. *Grid-Scale Storage*. IEA. https://www.iea.org/reports/grid-scale-storage (accessed 2023-06-25).

(2) Maeda, K.; Moritoki, M.; Yae, S.; Fukui, K.; Fukumuro, N.; Sugahara, T. Pressure-Induced Evolution in the Durability of Nickel-Metal Hydride Batteries under High-Current Charge. *Physical Chemistry Chemical Physics* **2022**, *24* (22), 14085–14091. https://doi.org/10.1039/d1cp05100h.

(3) Roe, C.; Feng, X.; White, G.; Li, R.; Wang, H.; Rui, X.; Li, C.; Zhang, F.; Null, V.; Parkes, M.; Patel, Y.; Wang, Y.; Wang, H.; Ouyang, M.; Offer, G.; Wu, B. Immersion Cooling for Lithium-Ion Batteries – A Review. *J Power Sources* **2022**, *525*, 231094. https://doi.org/https://doi.org/10.1016/j.jpowsour.2022.231094.

(4) Schneider, G.; Maier, H.; H�cker, J.; Siegele, S. Electricity Storage With a Solid Bed High Temperature Thermal Energy Storage System (HTTES) - A Methodical Approach to Improve the Pumped Thermal Grid Storage Concept. In Proceedings of the 14th International Renewable Energy Storage Conference 2020 (IRES 2020); Atlantis Press, 2021; pp 26–33. https://doi.org/10.2991/ahe.k.210202.005.

(5) Alam, M. & Zain, M. & Kaish, A. B. M & Jamil, Md. (2015). Underground Soil and Thermal Conductivity Materials Based Heat Reduction for Energy Efficient Building in Tropical Environment. Indoor and Built Environment. 24. 185-200. 10.1177/1420326X13507591.

(6) Underground Soil and Thermal Conductivity Materials Based Heat Reduction for Energy Efficient Building in Tropical Environment. March 2015 Indoor and Built Environment 24(2):185-200; https://doi.org/10.1177/1420326X13507591

(7) “Impact Map.” Climate Impact Lab, 30 Mar. 2023, impactlab.org/map/#usmeas=absolute&usyear=1986-2005&gmeas=absolute&gyear=2040-2059&tab=global&grcp=ssp245&gvar=tas-DJF.