EKPC Cooper Station BESS Evaluation

East Kentucky Power Cooperative (EKPC)

Rev A
July 2023

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1. INTRODUCTION

East Kentucky Power Cooperative (EKPC) requested Burns & McDonnell (BMcD) to perform a technical assessment and feasibility report for a 300 megawatt, 4-hour battery project at EKPC existing Cooper Station in Somerset, Kentucky. Project scope of work includes two (2) tasks.

The initial task was to evaluate Original Equipment Manufacturers (OEM's) for Battery Energy Storage Systems (BESS) and integrators of these battery systems. The evaluation was to review key technical considerations and to determine the OEM's domestic sourcing availability. The OEM's domestic sourcing availability was indicated by EKPC as a primary evaluation consideration as it is a component for receiving grant funds from the Rural Utility Service (RUS) through the Inflation Reduction (IRA).

The OEM's & Integrator batteries technologies listed in this evaluation source more than 50% of their major materials from outside United States. Based on the current market sourcing data, if the construction starts in 2025 then EKPC will still be eligible for 85% of the IRA credit. If the construction starts in 2026 or after, then EKPC will not be eligible for any IRA credit (this may change in future).

1.1. KEY DEFINTIONS

LFP- Lithium Iron Phosphate (Iron-Phosphate based cathode): A type of Lithium-ion (rechargeable) battery chemistry currently in the market.

NMC- Nickel Manganese Cobalt (Nickel, Manganese, Cobalt based Cathode): A type of Lithium-ion (rechargeable) battery chemistry currently in the market.

NCA- Nickel Cobalt Aluminum (Nickel, Cobalt, Aluminum based Cathode): A type of Lithium-ion (rechargeable) battery chemistry currently in the market.

Thermal Runaway- an incident that occurs when there is an uncontrollable increase in battery cell temperature that results in the destruction of the battery or, in severe cases, may propagate into a fire.

UL 9540- UL (Underwriters Laboratories) Safety standards such as fire detection suppression, environmental performance, functional safety, among others) for energy storage (ESS) and equipment intended for connection to a local utility grid or

standalone application. There is a certificate issued by UL, if the all the requirements are met.

UL 9540A- test method that was established by UL, this testing is required within UL 9540, to identify risk and gather cell, module, and unit level data during simulated thermal runway events. This information is then used to ensure safety systems have appropriate detection set points for the system in place. There is no certificate for this; it is just a test method that should result in data.

UL 1973- Test method that was established by UL, which is part of the UL 9540 standard for batteries for use in stationary, vehicle auxiliary power and light electric rail (LER) applications.

2. BESS OEM & INTEGRATORS EVALUATION

BMcD performed a desktop evaluation of battery suppliers to provide information, including high-level equipment costs, energy density, auxiliary load requirements, local codes, and standards, for EKPC's use in selecting a potential battery supplier to support further development of the project's feasibility. In this report, BMcD summarized the difference between an OEM and an Integrator. The table in Appendix A.1 and A.2 provides technical details to support the evaluation for each of the BESS OEM and BESS Integrators as well as the equipment only cost per kilowatt-hour (kwh) for each battery technology.

2.1. BATTERIES FROM OEM

Original Equipment Manufacturer (OEM): An OEM is a manufacturer that offers utility scale energy storage enclosures that house lithium-ion batteries. The enclosures are integrated with Thermal Management Systems (TMS), in the form of air or liquid cooling that are responsible for maintaining battery cell temperatures during operations. Additionally, the enclosures are integrated with OEM provided Battery Management Systems (BMS) that monitor battery cell/module temperatures, system State of Charge (SOC), system State of Health (SOH), and active battery cell balancing.

The following Battery OEM's were evaluated.

- CATL EnerC+
- SBYD MC Cube ESS
- LG DC Link
- Samsung SSB
- Saft Intensium

2.2. BATTERY TECHNOLOGIES FROM INTEGRATORS:

Integrator: Integrators are responsible for procuring individual components, primarily the battery modules / racks, power conversion system (PCS) and other balance of plant, assembling the system, providing a wrap on warranties, integrating the controls and battery management system (BMS), often providing project design, and engineering expertise, and providing operation, monitoring, and maintenance services.

The following battery integrator technologies were evaluated.

- Tesla Megapack 2XL
- Powin Stack750 Centipede
- Sungrow ST2752UX-US
- Wartsila GridSolv Quantum

APPENDIX A.1- BATTERY OEM EVALUATION

Appendix A.1 - BATTERY OEM EVALUATION

	CATL EnerC+	SAFT Intensium	BYD MC Cube ESS	LG DC Link	Samsung SBB
Manufacturing Country	China	France	China	South Korea	South Korea
Integrated DC-DC Converter	No	Yes	No	No	No
Wiring Method	Bottom Entry	Through the Cable Entry Hole	External cable entry	Bottom entry for E-Link Side entry for B-Link and WIU	Above ground cable tray
UL9540A Testing Completed	Yes	Yes	Yes	Yes	Yes
UL9540 Listed	No	Yes	Yes	No	Yes
Thermal Management System Type	Liquid Cooled	Air Cooled	Air Cooled	Air Cooled	Liquid Cooled
Fire Suppression System	Aerosol Standard, Sprinklers Optional	Nitrogen agent fire suppression system (IG55-50% Argon and 50% Nitrogen) Optional, Sprinklers Optional	None, Aerosol Optional	None	Direct injection with Novec 1230 cleaning Agent, Aerosol fire extinguish system, Dry Pipe Sprinkler Optional
External Water Supply Required By Manufacturer	Optional for Sprinklers	Optional for Sprinklers	No	Water Injection Unit (WIU)	Optional for Sprinklers
Chemistry	LFP	LFP	LFP	NMC	NCA
Cell Manufacturer	CATL	Saft	BYD	LG Energy Solution	Samsung SDI
Enclosure IP / NEMA Rating	IP55	IP54	IP55	IP54	IP55
Short Circuit Contribution per Enclosure (kA)	72.7 kA	TBD	61.4 kA	200.0 kA per (3) B-Links	8.7 kA per string
Energy Capacity per Container (kWh)	4070	2300	4946	2860	3841.9
DC Voltage Range (V)	1164.8 - 1497.6	960.0-1460.0	1081.6 - 1497.6	1008.0 - 1411.2	1116.0-1494.0
DC Round-Trip Efficiency	TBD	95%	92.19%	TBD	95.70% @ 0.2 c-rate
Max Aux Power Consumption per Enclosure	37.1 kW	23.6 kW	39.0 kVA @ 0.8 PF	TBD according to LG documentation	26 kW
External Aux Power Connections	480 VAC, 4 wire 230 VAC, single phase from an external UPS	TBD	480 VAC, 4 wire	208 VAC, 3 phase	208 VAC, 3phase, 4 wire from an external UPS
Additional Information	~High energy density. ~UL1973 listed. ~DC/DC converter not integrated into container (only necessary for DC augmentation). ~Equipped standard with smoke detectors, hydrogen detectors, and integrated fire control panel. Options include heat detectors and carbon monoxide detectors. ~Compliant explosion prevention fan system. ~No internal UPS. ~Fire water connection is towards the top of the container.	~Planned manufacturing in USA at the end of 2023. ~UL1973 listed. ~PCS & Site Controller can also be supplied. ~Multi sensor spot detectors to detect both gas and smoke. ~Inhouse cell manufacturer. ~Roof-mounted blast panels and door-mounted overpressure panels. ~Offers services maintenance packages. ~No fire suppression system is standard. Nitrogen agent suppression is optional. ~Optional Sprinkler system. ~Thermal insulation between cells to avoid cell to cell propagation in case of thermal runaway. ~3 meters minimum clearance between the containers and the PCS at customer site level. ~Offers NMC (Nickel Manganese Cobalt Oxide) & LFP (Lithium Iron Phosphate) technologies for battery chemistry. ~Cloud-enabled communication system.	~High energy density. ~DC/DC converter not integrated into container (only necessary for DC augmentation).	~All information listed is based on LG's NMC battery chemistry. LG intends to produce LFP batteries in the future. Therefore, the information given is subject to change with LFP. ~Requires a combination of three separate equipment enclosures: B-Link (houses the battery racks, thermal management system, and fire protection piping system), E-Link (houses the Battery Management System, DC output to the PCS, and auxiliary power distribution to each connected B-link), and Water Injection Unit (WIU) (houses local water tank and piping system to administer water to the B-link in the event of thermal runaway or the precursors to thermal runaway). ~Maximum of three (3) B-Links per single WIU and E-Link. ~Lowest energy density of battery options. ~Required quantities for augmentation do not fit within the space on site. ~Working on switching to LFP battery. ~WIU requires freeze protection on sites prone to freezing.	~Samsung is currently working on an indoor rack. ~Working on switching to LFP battery. ~Built-in 2 hours UPS that serve as a back-up power. ~An optional active ventilation system with gas detection and exhaust fan. ~Deflagration panel on the roof in the SBB design. ~Active ventilation system with gas detection and exhaust fan (optional). ~BMcD has been helping Samsung with the design concept. ~Water and Glycol mix for the liquid cooled thermal management system. ~Applies MES system (Manufacturing Execution System) during the manufacturing process.
Cost/kwh(Battery Only)	TBD	[redacted]	[redacted]	[redacted]	[redacted]

APPENDIX A.2- BATTERY INTEGRATOR EVALUATION

Appendix A.2 - BATTERY INTEGRATOR EVALUATION

	Tesla Megapack 2XL	Sungrow ST2752UX-US	Powin Stack750 Centipede	Wartsila GridSolv Quantum
Manufacturing Country	USA *	China	Mexico	Finland
Integrated DC-DC Converter	N/A	Yes	Optional	No
Wiring Method	Above ground cable tray	Bottom Entry	Top entry for Stack750 Bottom entry for Collection Segment	Bottom Entry
UL9540A Testing Completed	Yes	Yes	Yes	Yes
UL9540 Listed	Yes	Yes	No	No
Thermal Management System Type	Liquid Cooled	Liquid Cooled	Liquid Cooled	Liquid Cooled
Fire Suppression System	None	Sprinklers	Sprinklers	Dry pipe sprinklers, optional automatic fire suppression system
StanExternal Water Supply Required By Manufacturer	No	Optional for Sprinklers	Optional for Sprinklers	Standard for sprinklers
Chemistry	LFP	LFP	LFP	LFP
Cell Manufacturer	CATL, TBD on others	TBD	CATL and EVE	CATL
Enclosure IP / NEMA Rating	IP66 / NEMA 3R	IP54 / NEMA 3R	IP56 / NEMA 4X	IP55
Short Circuit Contribution per Enclosure (kA)	85.0 kA at 480 VAC	TBD	13.5 kA	TBD
Energy Capacity per Container (kWh)	3916.8	2752	746	1490
DC Voltage Range (V)	N/A	1160.0 - 1500.0	1210.0 - 1491.0	1165.0-1498.0
DC Round-Trip Efficiency	92.7%, includes inverter	TBD	95.00%	TBD
Max Aux Power Consumption per Enclosure	N/A	30.0 kVA	5.4 kW	9kW
External Aux Power Connections	~ 120 VAC up to 480 VAC for Controller. ~ Controller is separate from the Megapack. ~ No external aux connection required directly to Megapack.	~ 480 VAC, 3 wire	~ 480 VAC, 3 phase to Collection Segment. ~ No external feeds needed directly to each Stack. Single feed to Collection Segment.	~ 480 VAC, 4 wire ~ 230 VAC, single phase from an external UPS
Additional Information	~ High energy density. ~ Separate 480V/34.5kV transformer is required. ~ Megapack does not include grounding lugs. All grounding is run back through to the 480V step-up transformer. ~ Megapack neither contains nor needs built-in smoke, gas, or fire detection or suppression devices. When required by the AHJ, third-party multi-spectrum infrared heat or flame detectors can be installed externally at the site-level. ~ The site design shall include at least one (1) receptacle socket positioned such that the outlet is not more than 50 ft from all Megapacks at the site. ~ Tesla System Controller/Enclosure required. ~ Can only be used for AC augmentation. ~ AC and DC ESS are UL9540 listed.	~ DC/DC converters integrated into container. ~ OEM provides 1hr fire rating on walls of back-to-back containers. ~ Sungrow is aiming to release the Power Titan II in 2024. The ST2752UX-US could be discontinued. ~ Low energy density. ~No internal uninterruptible power supply (UPS).	~ Optional DC/DC converters can be integrated into the Collection Segment (only necessary for DC augmentation). ~ Powin's control system, which is cloud-based and hosted by Amazon, is required. Can not use Ovation controls.	~The Enclosure Rack is pre-installed liquid- cooled Battery Racks. ~Up to Eight Enclosures can be linked together to form a complete system. ~Made with pre-designed jumpers and cables, in addition to unit-to-unit DC connection and AC auxiliary distribution- as well as signals, and communication interconnection.
Cost/kwh(Battery Only)	[redacted]	[redacted]	TBD	[redacted]

*** Although the manufacturing country is indicated as USA, the batterires and serveral other major components are sourced from outside the USA and merely assembled in the USA.**