

Pitfalls of Battery Energy Storage

Battery Energy Losses in MISO Future 2A

Batteries are large net users of electricity. Assuming 85% round-trip efficiency, the energy losses associated with 4-hour lithium-ion batteries are significant. MISO Future 2A includes 20 GW of new 4-hour lithium-ion batteries.

MISO's projected 2042 energy use under Future 2A is 953,960 GWH. The energy produced by the batteries is 72,900 GWH while the energy needed to charge the batteries is 87,600 GWH. Thus, the battery energy losses are 14,700 GWH per year¹. MISO would need 8,390 MW of solar farms just to supply these losses². At 7 acres per MW these solar farms would require a land area of about 58,700 acres, which is 91.7 square miles (9.6 miles x 9.6 miles)!

The heat produced by these losses³ is 5.017×10^{13} BTU. This amount of heat energy is enough to raise the temperature of Lake Erie (capacity 4.78×10^{12} gallons) by 1.26°F³.

¹ These losses do not include the cooling and auxiliary power usage of battery energy storage facilities.

² Assumes 20% annual solar capacity factor.

³ $14,700,000 \text{ MWH} \times 1000 \text{ kWh/MWH} \times 3413 \text{ BTU/kWh} = 5.017 \times 10^{13} \text{ BTU}$.

Lake Erie contains 4.78×10^{12} gallons of water * 8.33 pound/gallon weighing 3.98×10^{13} pounds.

Since 1 BTU raises the temperature of 1 pound of water by 1°F, 5.017×10^{13} BTU would raise the temperature of 3.98×10^{13} pounds of water by 1.26°F.

Batteries have near zero winter capacity value

Under the MISO Direct Loss of Load (DLOL) capacity accreditation process, capacity accreditation is based on a resource's ability to support the system during critical load hours, i.e. peak demand periods for each of the four seasons. During winter peak periods the daily load curve flattens, leaving little opportunity for batteries to recharge. This was particularly evident during winter storm Elliot on December 23, 2022. See Figure 1 and Table 1 below.

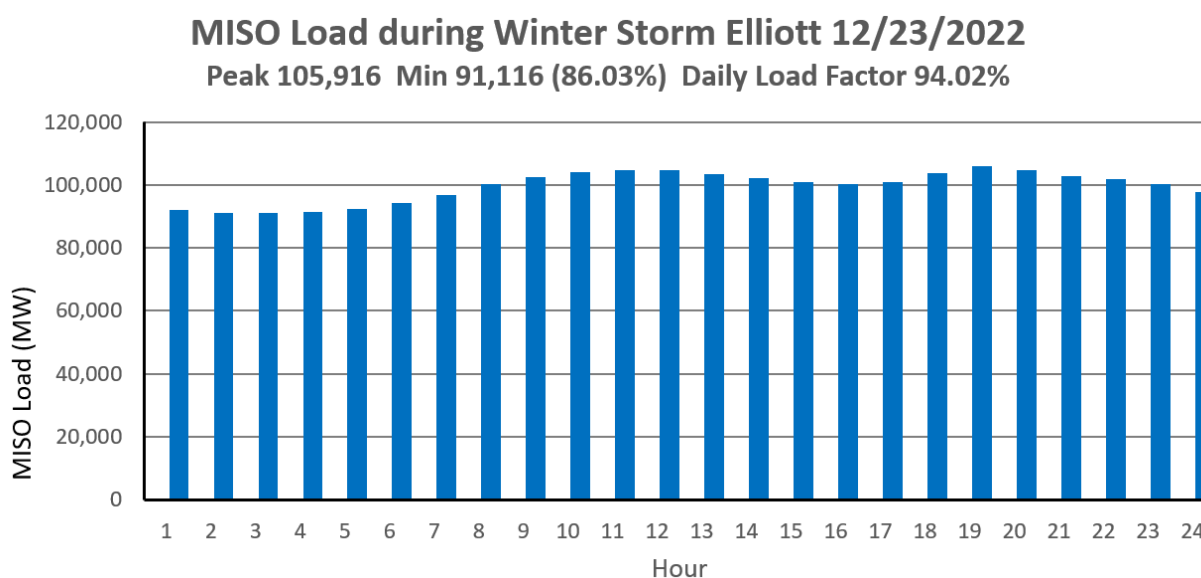


Figure 1

There is truly little room to charge batteries on a winter peak day especially if the amount of battery energy storage increases dramatically (by 20 GW) as in Future 2A. Electrification, including building heat, data centers, and electric vehicle charging will have a pronounced effect on the load curve, energy use, and peak demand going forward, making the winter peak load curve even flatter with virtually no opportunity for charging battery energy storage systems.

MISO DAILY LOAD CURVE 12/23/2022			
HOUR ENDING	MISO LOAD-MW	PERCENT OF PEAK	COMMENTS
1	92,011	86.87%	
2	91,180	86.09%	
3	91,116	86.03%	MINIMUM LOAD
4	91,478	86.37%	
5	92,335	87.18%	
6	94,152	88.89%	
7	96,777	91.37%	
8	100,138	94.54%	
9	102,539	96.81%	
10	104,061	98.25%	
11	104,804	98.95%	
12	104,577	98.74%	
13	103,560	97.78%	
14	102,057	96.36%	
15	100,952	95.31%	
16	100,318	94.72%	AFTERNOON VALLEY
17	100,997	95.36%	
18	103,786	97.99%	
19	105,916	100.00%	PEAK LOAD
20	104,623	98.78%	
21	102,745	97.01%	
22	101,802	96.12%	
23	100,315	94.71%	
24	97,745	92.29%	
MAX	105,916	100.00%	
MIN	91,116	86.03%	
ENERGY	2,389,982		DAILY ENERGY (MWH)
LD FCTR	94.02%	94.02%	DAILY LOAD FACTOR

Table 1

Battery Storage Versus Coal Storage

To compare battery energy storage to coal storage, consider a typical 500 MW coal unit burning Illinois coal with 30 days of coal storage. Suppose the unit operates at a 70% annual capacity factor. It would produce (500 MW) (0.70) (720 H) = 252,000 MWH of energy per month. If the unit had a net heat rate of 10,000 BTU/kWH and burned coal with a heating value of 10,000 BTU/pound, the required coal storage is 126,000 tons⁴. At \$50/ton, the inventory value of this 30-day coal reserve would be \$6.3 million.

Now let's calculate the number of batteries needed to store the same amount of energy. Assume 100 MW, 4-hour lithium-ion batteries with 85% efficiency and two charging/discharging cycles per day. Each battery would consume 800 MWH per day and would produce 680 MWH/day or 20,400 MWH per month. Thus, it would take 13 batteries (rounded up from 12.353) to store the same amount of energy as available from the coal storage. It is also important to point out that the battery system does not, in fact, produce the electricity. The production must come from another source. The 252,000 MWH supplied by the batteries would require 296,471 MWH for charging.⁵ The energy losses calculate to 44,471 MWH per month.

Assuming a capital cost of \$1000/kW for each battery energy storage system, the 13-100 MW batteries would cost \$1.3 billion. This is 206 times the inventory cost of the energy stored in the coal pile! So, while retiring fossil fuel plants is a primary goal in the efforts to slow down climate change, the economics are very problematic without significant improvement in energy storage technologies.

⁴ 252,000 MWH * 10,000 BTU/kwh * 1000 kWH/MWH * 1 ton/2000 pound * 1 pound/(10,000 BTU = 126,000 tons

⁵ 12,3530*680*30 = 252,000 MWH.