Special Contemporary Issues -

MPSC ID H: Describe any research, investigation, consideration, and/or inclusion of long-duration energy storage (10 or more hours) as well as non-chemical energy storage technologies the Company performed in the development of its IRP update/ triennial analysis. Nonchemical energy storage technologies mainly refer to thermal or mechanical methods of storing energy which could include storing heat in solid materials such as sand, rocks, or concrete blocks or liquids such as molten salts or water and processes utilizing compression, displacement against gravity, rotation, or accumulation of kinetic energy. Include any details or analysis of costs estimates if relied upon.

Notes below detail research recently conducted related to long-duration energy storage (LDES). Below are titles and links to the documents along with the key takeaways:

1. Achieving the Promise of Low-Cost Long Duration Energy Storage – U.S. Department of Energy
    - The report provided implementation costs, implementation timelines, and potential innovations for 10 LDES technologies.
    - The ten technologies were: flow batteries, lead-acid batteries, lithium-ion batteries, sodium-ion batteries, electromechanical double layer capacitor supercapacitors, zinc batteries, hydrogen storage, compressed air energy storage, pumped storage hydropower, molten slat thermal energy storage
    - The average cost of implementing innovations range from ~ $100 million to $1 Billion and would take 6 – 11 years
2. NETL Study Investigates Long Duration Energy Storage Options | netl.doe.gov – National Energy Technology Laboratory (NETL)
    - This study, conducted in January of 2024 investigated long duration energy options and was published in the inaugural issue of Cell Reports Sustainability. (A techno-economic survey of energy storage media for long-duration energy storage applications - ScienceDirect)
    - This study focused on technologies that could economicalyy store and provide electricity over multi-day and seasonal timescales
    - The study found that among energy storage technologies studies, the ones that demonstrate promise for multi-day and seasonal LDES were select sensible thermal, latent thermal, thermochemical, synthetic fuel, coupled batteries, and flow battery systems
    - Energy storage technologies such as Lithium-ion batteries, pumped hydroelectric, and flywheels do not appear to be economically viable for LDES applications.
    - The need for research and development into new LDES focused technologies was emphasized

3. 2022 Grid Energy Storage Technology Cost and Performance Assessment.pdf
    - This technical report was sponsored by the U.S. Department of Energy
    - The assessment worked to provide a standardized approach to analyze cost elements of storage technologies and project 2030 costs based on each technology's current state of development.
    - Data for the report was obtained in 2021, thus 2021 is used for current costs
    - The report provided detailed cost and performance metrics for the following energy storage technologies across a range of energy to Power rations:
        - Lithium Iron Phosphate (LIP) Batteries
        - Nickle, Manganese, Cobalt (NMC) Batteries
        - Lead-Acid Batteries
        - Vanadium Redox Flow Batteries
        - Compressed Air Energy (CAES) Storage
        - Pumped Storage Hydropower (PSH)
        - Hydrogen Energy Storage Systems (HESS) – (bidirectional)
        - Zink-based Batteries
        - Gravity Energy Storage
        - Thermal Energy Storage
    - High-level results include:
        - Pumped Storage Hydropower is the dominant grid storage technology and has a 2021 cost estimate of $263/kWh
        - Fully installed 100MW, 10-hour batter systems of Li-ion LFP 2021 costs projections are $356/kWh, while Li-ion NMC is $405/kWh, Vanadium RFP is $385kWh, and Lead Acid is $409kWh.
        - Zinc-based systems are not available at the 100 MW scale, but for a 10MW,10-hour system, the total installed cost is $449/kWh
        - Compressed Air Energy Storage is estimated to be the lowest cost storage technology greater than 4-hrs. A 100 MW, 10-hr system would cost $122/kWh, but this is highly depended on siting the system near naturally occurring caverns that greatly reduces overall project costs.