Pumped Storage Considerations within MISO's FERC Order 841 Compliance Filing

Stakeholder Presentation

MISO Market Subcommittee

May 10, 2018

EXECUTIVE SUMMARY

Purpose:

- To provide some considerations for MISO's FERC Order 841 Compliance filing relative to pumped storage

Key Takeaways:

- A few modeling considerations need to be made, to provide pumped storage the option to participate, in energy storage related market changes
- Don't leave pumped storage behind when it is MISO's largest existing energy storage resource (~2,700 MWs)
- May be a good use for a task team to fully vet the specifics
- Pumping provides demand response potential
- Provide greater transparency and price certainty if pumping was part of the day ahead model

MISO's compliance filing should allow the Option for pumped storage to participate under FERC Order 841 market changes

- Many of the ESR Characteristics identified in MISO's 4/4/18 presentation could be expanded to include pumped storage parameters

State of Charge	⇔	Upper Reservoir Level
Maximum State of Charge	⇔	Maximum Upper Reservoir Level
Minimum State of Charge	⇔	Minimum Upper Reservoir Level
Maximum Charge Limit	⇔	Maximum Pumping MW
Maximum Discharge Limit	⇔	Maximum Generation Limit (EcoMax)
Minimum Charge Time	⇔	Minimum Pump Time
Maximum Charge Time	⇔	Maximum Pump Time
Minimum Run Time	⇔	Minimum Generation Time
Maximum Run Time	⇔	Maximum Generation Time
Minimum Discharge Limit	⇔	Minimum Generation Limit (EcoMin)
Minimum Charge Limit	⇔	Minimum Pumping MW

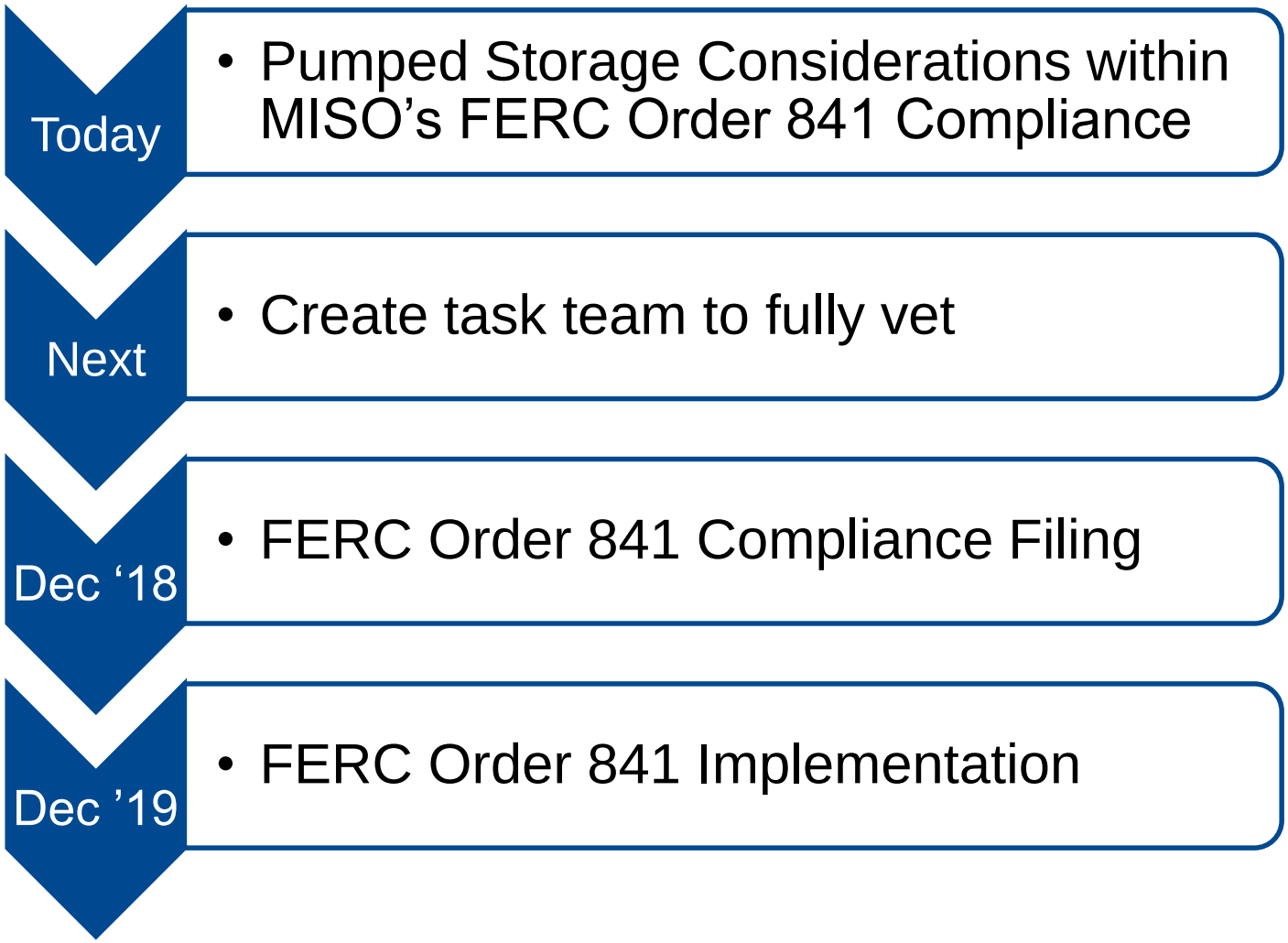
In addition to the ESR Characteristics from previous page, other parameters that need to be included for pumped storage integration include the following:

Pump/gen cycle transition times
Pumped storage cannot instantaneously transition between cycles
Pump Startup Max
Some pumped storage cannot charge when storage is higher than this level
Generation Function Curve
Output (injection) varies based on head (charge) level
Pump Function Curve
Pump (withdrawal) varies based on head (charge) level
Net output limitation
A parameter which represents the ceiling of net output
Max Pump or Generation Starts per Day
Starts may be limited due to equipment dynamics
Pump/Gen Ratio
Defines additional energy and time required for pumping versus generation

There may be opportunity to better leverage pumped storage in serving MISO's load

- Sub-optimal optimization
  - Underutilized energy at pumped storage facilities could help to lower production costs
  - Currently, MISO cannot optimize schedules for pumping/charging cycles
  - Multi day optimization could yield better results in the future
- Task team
  - MSE could direct a task team to fully vet the aspect of pumped storage with the FERC 841 compliance filing

Next steps


Today
• Pumped Storage Considerations within MISO's FERC Order 841 Compliance
Next
• Create task team to fully vet
Dec '18
• FERC Order 841 Compliance Filing
Dec '19
• FERC Order 841 Implementation