2019 CARIS 1 70x30 Scenario - Energy Storage Modeling

Benjamin Cohen
Sr. Planning Environmental Engineer

Electric System Planning Working Group

October 4, 2019

DRAFT – FOR DISCUSSION PURPOSES ONLY

Agenda

- Methodology Explanation and Comparison for Energy Storage Resources ("ESR")
- Results Comparison
- Discussion and Suggestions

Methodology Comparison

NEW YORK INDEPENDENT SYSTEM OPERATOR

ESR Input Parameters and Objective

Parameter	MAPS Pumped Storage ("PS") model	Hourly Resource Modifier ("HRM")
ESR Specifications	• generating and recharging rates (MW) • storage capacity (MWh) • cycle efficiency (%) • unit name and ownership • location (bus) • starting energy (initial state of charge – MWh) • assigned company, area, or system load • may be different than location of ESR	• power capacity (±MW) • energy capacity (MWh) • round trip efficiency (%)
Objective	• MAPS thermal unit cost commitment – global objective to minimize system production cost • ESR objective is to find arbitrage opportunities along the initial thermal unit cost commitment curve (prior to final thermal unit commitment)	• minimize daily net-load deviations • other objectives possible (*e.g.,* load, net load, arbitrage revenue (LBMP), congestion, emissions, renewable energy (RE), local transmission issues)

ESR Modeling Process and Results

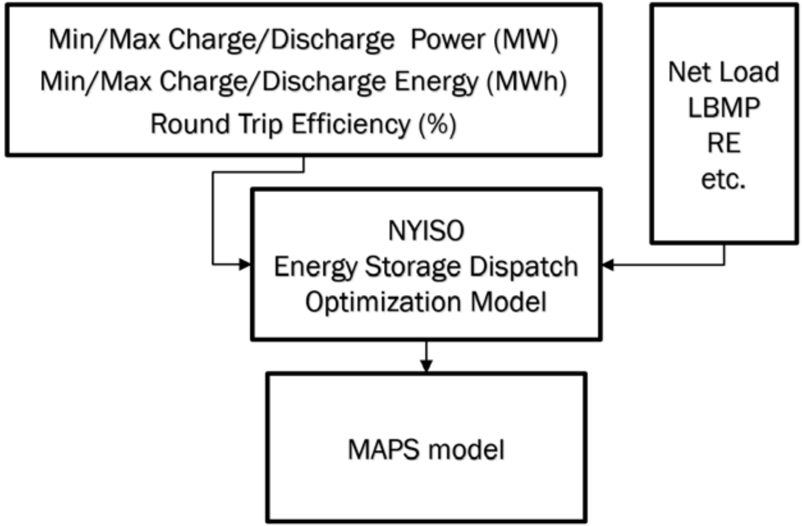
<table>
<tr><th>Methodology</th><th>MAPS PS model</th><th>Hourly Resource Modifier</th></tr>
<tr><td rowspan="2">Process</td><td>• initial thermal unit commitment performed and thermal unit cost curve constructed for each week based on committed units’ characteristics
• available ESR scheduled against this cost curve and appropriate load curve
    • indirectly includes information on RE load modifiers
    • user specified order of ESR scheduling
    • option to recommit thermal units between each ESR</td><td>• ESR dispatched against given shape (net load, LBMP) while respecting the battery constraints
• optimized ESR dispatches input to MAPS as Hourly Resource Modifier/distributed resources</td></tr>
<tr><td colspan="2">• thermal unit commitment performed including ESR schedules impact on bus level loads</td></tr>
<tr><td>Result</td><td>• internal calculation of ESR dispatch and impact all within MAPS</td><td>• externally calculated ESR dispatch integrated within MAPS optimization</td></tr>
</table>

Exogenous ESR Dispatch Optimization

- **Implemented in MATLAB Optimization Toolbox**
- **Solved on an independent daily basis**
- **Objective is to:**
  - Minimize net load fluctuations from average net load
  - Maximize zonal energy arbitrage revenues
  - Optimize timing of RE injections

Exogenous ESR Dispatch Optimization

- **Subject to constraints:**
  - Power (ESR dispatch) level
  - Energy (state of charge) level
  - Round Trip Efficiency losses (upon charging)
  - No new higher peak in demand created



Comparison Testing Assumptions

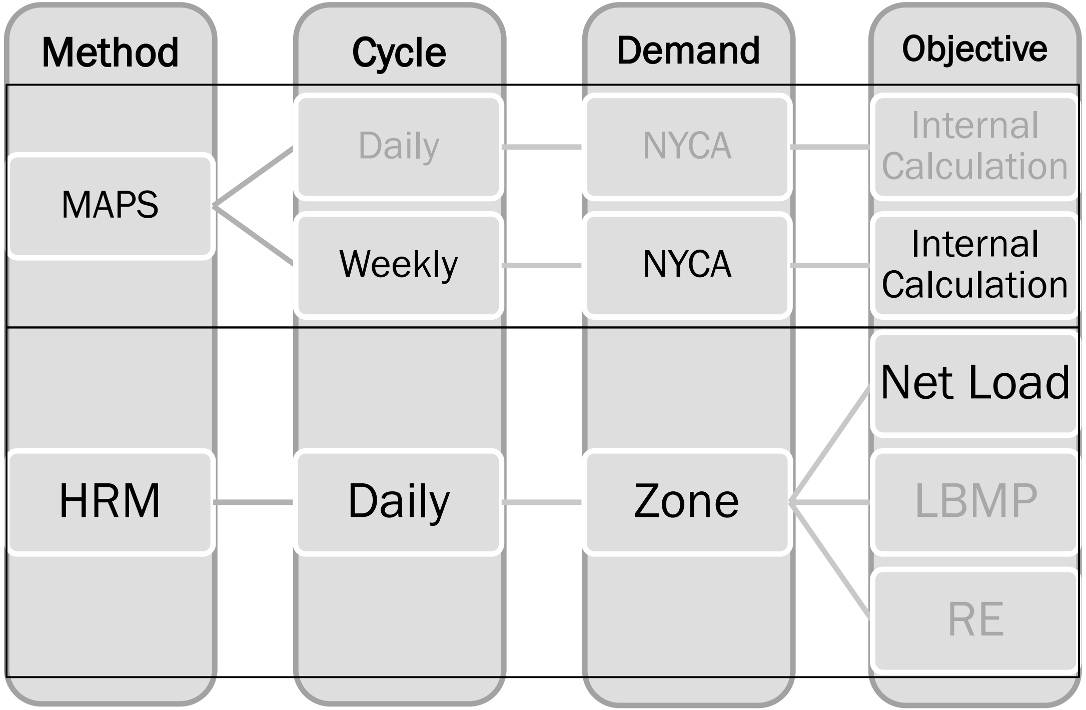
- Based off 2019 CARIS 1 Base Case (2028)
- All ESR have 4-hour duration capacity and 85% efficiency
- Preliminary zonal ESR capacity distribution based on NYSERDA Energy Storage Roadmap, for initial comparison testing purposes only
- ESR dispatch priority order for MAPS methods assigned based on decreasing zonal ESR capacity prior to dispatching pumped storage (e.g., Gilboa)
- For MAPS methods, assume one ESR per zone placed at highest load bus in each zone

Zone	MW
A	120
B	60
C	60
D	60
E	60
F	420
G	240
H	60
I	120
J	1,350
K	450
S	3,000

DRAFT – FOR DISCUSSION PURPOSES ONLY

Comparison Testing Overview

- Performed tests for several methodological parameters in MAPS and using HRM approach for comparison purposes
  - To accommodate objective of MAPS ESR model, NYCA load was used



Results Comparison

Example ESR dispatch results available as an appendix to this presentation

CARIS Metrics NYCA Comparison – Base Case Deltas

NYCA 2028 Base Case Metric Deltas	MAPS-Daily	MAPS-Weekly	HRM-NL	HRM-LBMP
Production Cost	0.7%	0.6%	-1.3%	-1.2%
Demand Congestion	-3.3%	-7.9%	-7.8%	-9.1%
Generation Payment	-0.2%	-0.8%	-0.1%	-0.2%
Load Payment	-0.5%	-1.5%	0.1%	-0.1%
Generation	0.2%	0.3%	-0.7%	-0.7%
Net Imports	-1.7%	-2.0%	4.8%	4.4%
CO_2 Emissions	0.7%	1.0%	-1.0%	-0.9%

DRAFT – FOR DISCUSSION PURPOSES ONLY

Modeling ESR Methodologies Pros and Cons

	MAPS's "pumped storage" model	Hourly Resource Modifier
PRO	• Endogenous dispatch calculation solves ESR constraints • Simplifies workflow for running cases • Accounts for operating reserves from unused ESR capacity	• Distribute to all busses as BTM-PV and/or selected bus as a project • Requires zonal capacity distribution • Multiple ESR objectives possible • More flexible and controllable • No initial state of charge assumption required • Typically higher ESR utilization (MWh injected/year) observed

CON	• Global objective to minimize system production cost
	• Dispatches ESRs in order listed in input file
	• Requires more resource level assumptions
	• Scheduling ESR units against pool load instead of area load
	    • potential disconnect between location of ESR dispatched and thermal re-dispatch in congested systems
	    • thermal commitments decrease with increased RE
		• Exogenous in-house optimization algorithm developed and maintained
		• Requires off-line data processing and input-output method

DRAFT – FOR DISCUSSION PURPOSES ONLY

ESR Modeling Recommendation

- **Initial testing utilizing the Base Case provides roughly comparable NYCA ESR dispatch results**
  - HRM ESR performed to expectations at zonal level
- **In the 70x30 Scenario, NYISO recommends modeling both MAPS Weekly and HRM Net Load methodologies given the dramatically differing system assumptions**
  - Compared to MAPS Daily cycle, MAPS Weekly cycle utilized the ESR more
  - Allows continued testing/comparison of ESR modeling methodologies to be performed

DRAFT – FOR DISCUSSION PURPOSES ONLY

Feedback/Comments?

- Email additional feedback to: BCohen@nyiso.com

The Mission of the New York Independent System Operator, in collaboration with its stakeholders, is to serve the public interest and provide benefit to consumers by:

- Maintaining and enhancing regional reliability
- Operating open, fair and competitive wholesale electricity markets
- Planning the power system for the future
- Providing factual information to policy makers, stakeholders and investors in the power system

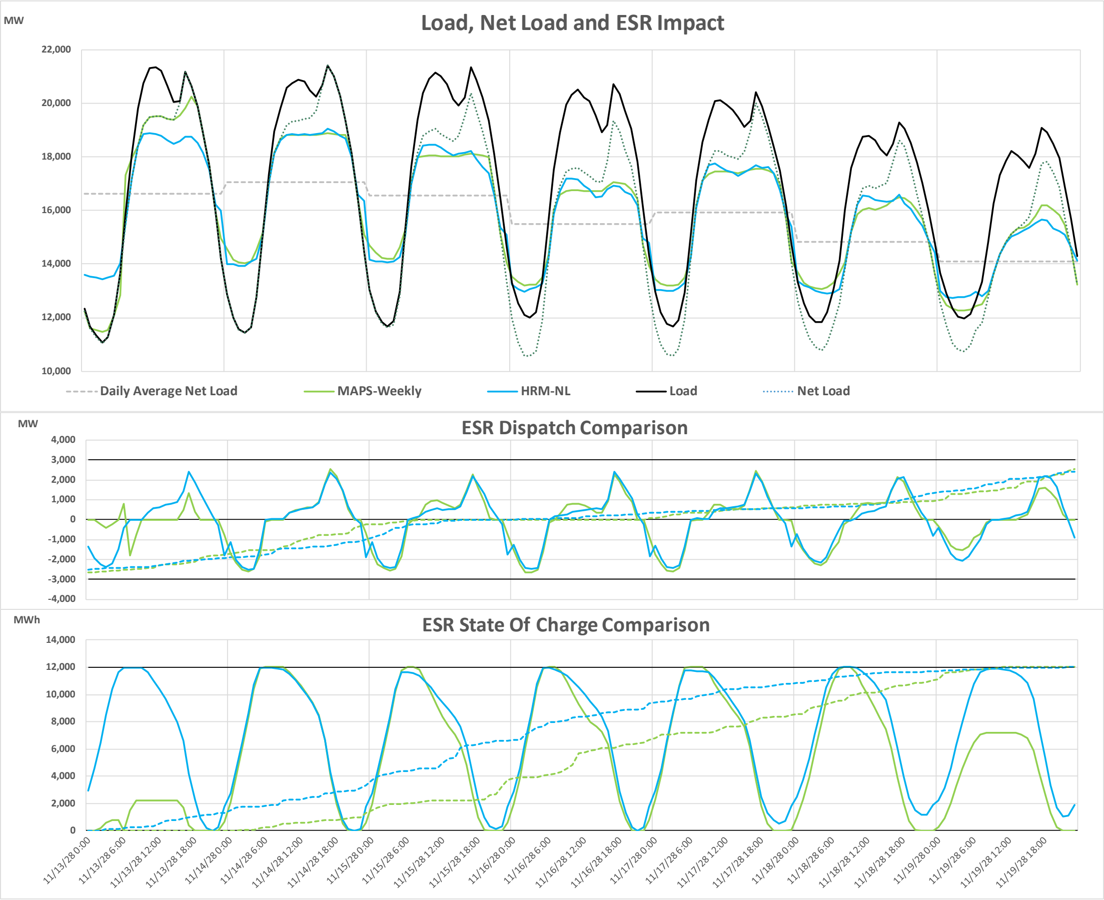
www.nyiso.com

Appendix – Example Week ESR Dispatch Comparison

NEW YORK INDEPENDENT SYSTEM OPERATOR

MAPS Weekly Cycle vs. HRM Net Load

MAPS-Weekly vs. HRM-NL

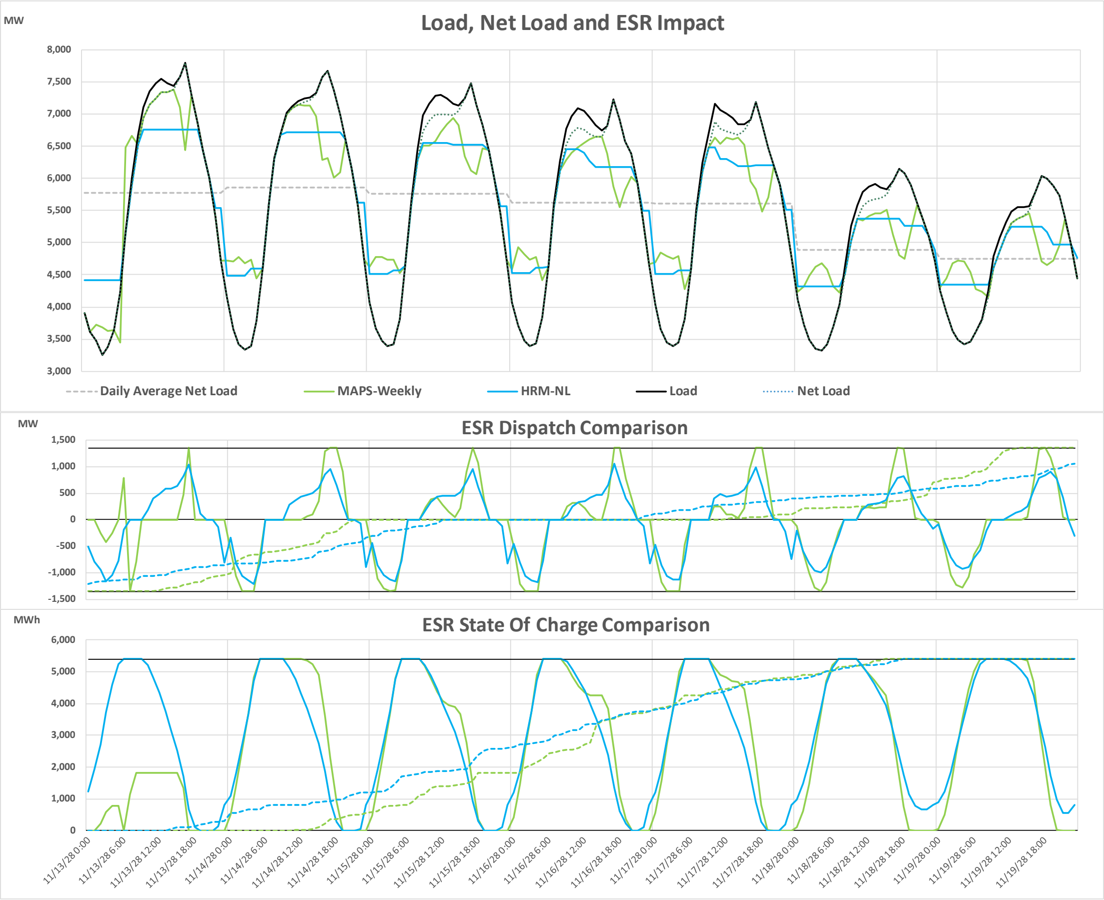


Energy Storage Methodology Comparison

2019 CARIS Base Case - 2028 - Zone S

	Case Results Ratio MAPS-Weekly / HRM-NL
ESR Parameters	
Round Trip Efficiency (%)	100%
ESR Power Capacity (MW)	100%
ESR Duration Capacity (hours)	100%
ESR Energy Capacity (MWh)	100%
Weekly ESR Metrics	
Maximum ESR Injection (MW)	106%
Maximum ESR Withdrawl (MW)	106%
ESR Injection Total (MWh)	87%
ESR Withdrawl Total (MWh)	87%
State of Charge Range (MWh)	100%
Energy Arbitrage Profits (k$)	91%
Capacity Factor	87%
Weekly Net Load Impact Metrics	
Peak Net Load (MW)	100%
Peak ESR Modified Net Load (MW)	106%
Peak Reduction (MW)	49%
Annual ESR Metrics	
ESR Injection Total (MWh)	72%
ESR Withdrawl Total (MWh)	72%
Annual Energy Arbitrage Profits (M$)	76%
Capacity Factor	72%
Annual Net Load Impact Metrics	
Peak Net Load (MW)	100%
Peak Modified Net Load (MW)	102%
Peak Reduction (MW)	74%

DRAFT – FOR DISCUSSION PURPOSES ONLY

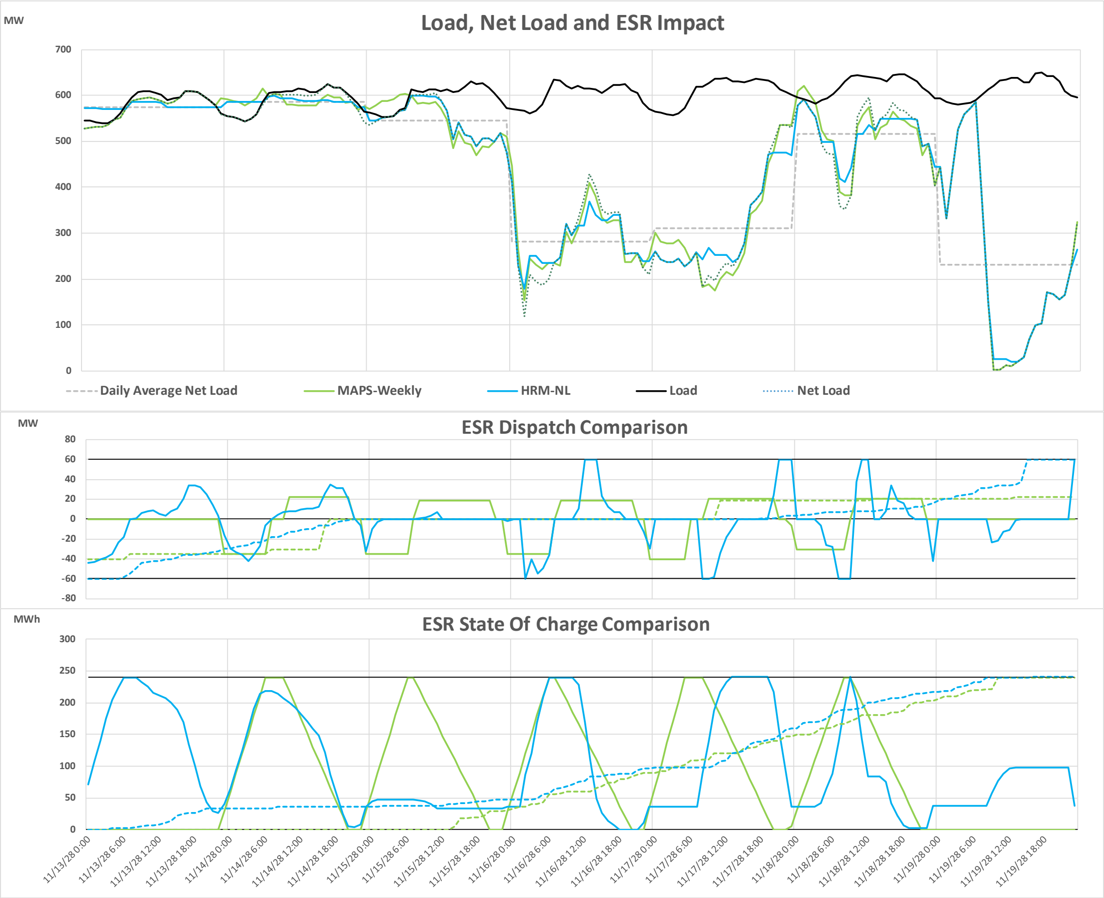


Energy Storage Methodology Comparison

2019 CARIS Base Case - 2028 - Zone J

	Case Results Ratio
	MAPS-Weekly / HRM-NL
ESR Parameters	
Round Trip Efficiency (%)	100%
ESR Power Capacity (MW)	100%
ESR Duration Capacity (hours)	100%
ESR Energy Capacity (MWh)	100%
Weekly ESR Metrics	
Maximum ESR Injection (MW)	129%
Maximum ESR Withdrawl (MW)	112%
ESR Injection Total (MWh)	96%
ESR Withdrawl Total (MWh)	96%
State of Charge Range (MWh)	100%
Energy Arbitrage Profits (k$)	117%
Capacity Factor	96%
Weekly Net Load Impact Metrics	
Peak Net Load (MW)	100%
Peak ESR Modified Net Load (MW)	109%
Peak Reduction (MW)	39%
Annual ESR Metrics	
ESR Injection Total (MWh)	88%
ESR Withdrawl Total (MWh)	88%
Annual Energy Arbitrage Profits (M$)	99%
Capacity Factor	88%
Annual Net Load Impact Metrics	
Peak Net Load (MW)	100%
Peak Modified Net Load (MW)	104%
Peak Reduction (MW)	45%

DRAFT – FOR DISCUSSION PURPOSES ONLY



Energy Storage Methodology Comparison

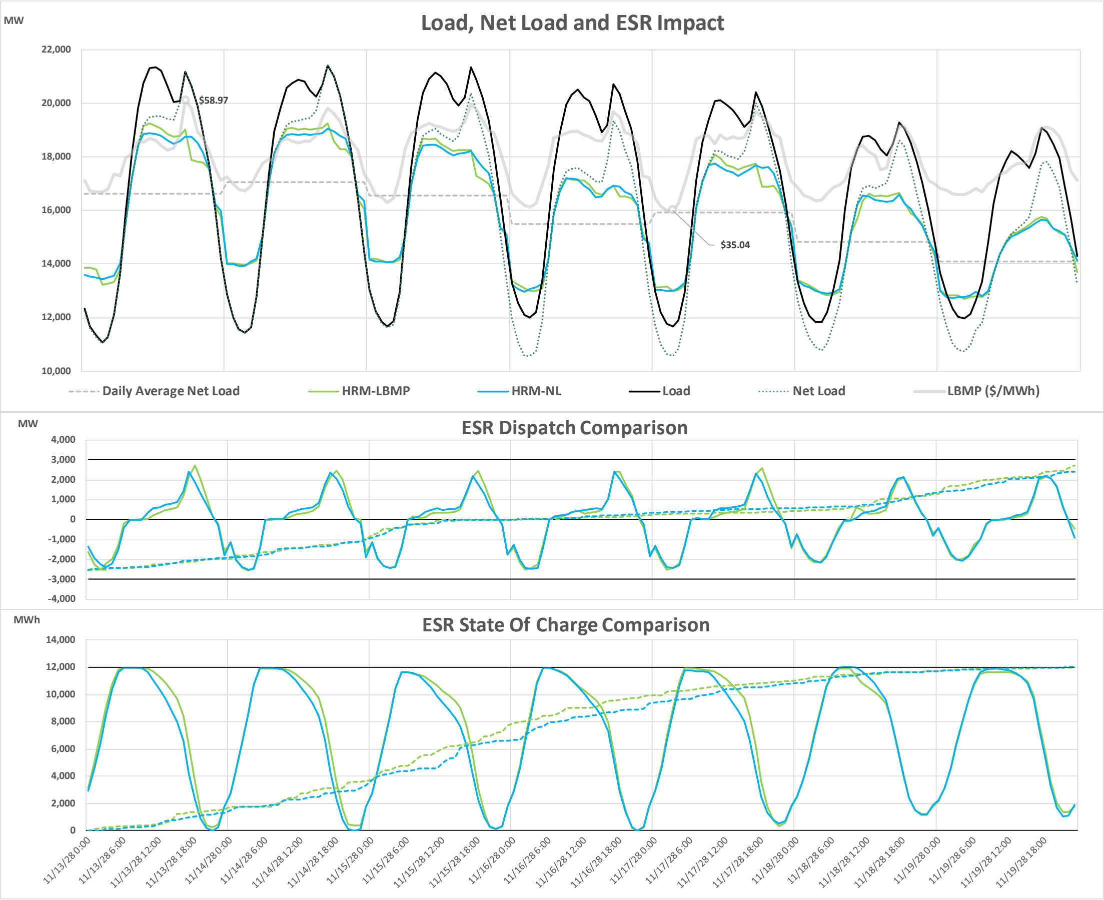
2019 CARIS Base Case - 2028 - Zone D

	Case Results Ratio
	MAPS-Weekly / HRM-NL
ESR Parameters	
Round Trip Efficiency (%)	100%
ESR Power Capacity (MW)	100%
ESR Duration Capacity (hours)	100%
ESR Energy Capacity (MWh)	100%
Weekly ESR Metrics	
Maximum ESR Injection (MW)	36%
Maximum ESR Withdrawl (MW)	67%
ESR Injection Total (MWh)	101%
ESR Withdrawl Total (MWh)	101%
State of Charge Range (MWh)	100%
Energy Arbitrage Profits (k$)	-574%
Capacity Factor	101%
Weekly Net Load Impact Metrics	
Peak Net Load (MW)	100%
Peak ESR Modified Net Load (MW)	104%
Peak Reduction (MW)	10%
Annual ESR Metrics	
ESR Injection Total (MWh)	44%
ESR Withdrawl Total (MWh)	44%
Annual Energy Arbitrage Profits (M$)	209%
Capacity Factor	44%
Annual Net Load Impact Metrics	
Peak Net Load (MW)	100%
Peak Modified Net Load (MW)	108%
Peak Reduction (MW)	0%

DRAFT – FOR DISCUSSION PURPOSES ONLY

HRM LBMP vs. HRM Net Load

HRM-LBMP vs. HRM-NL

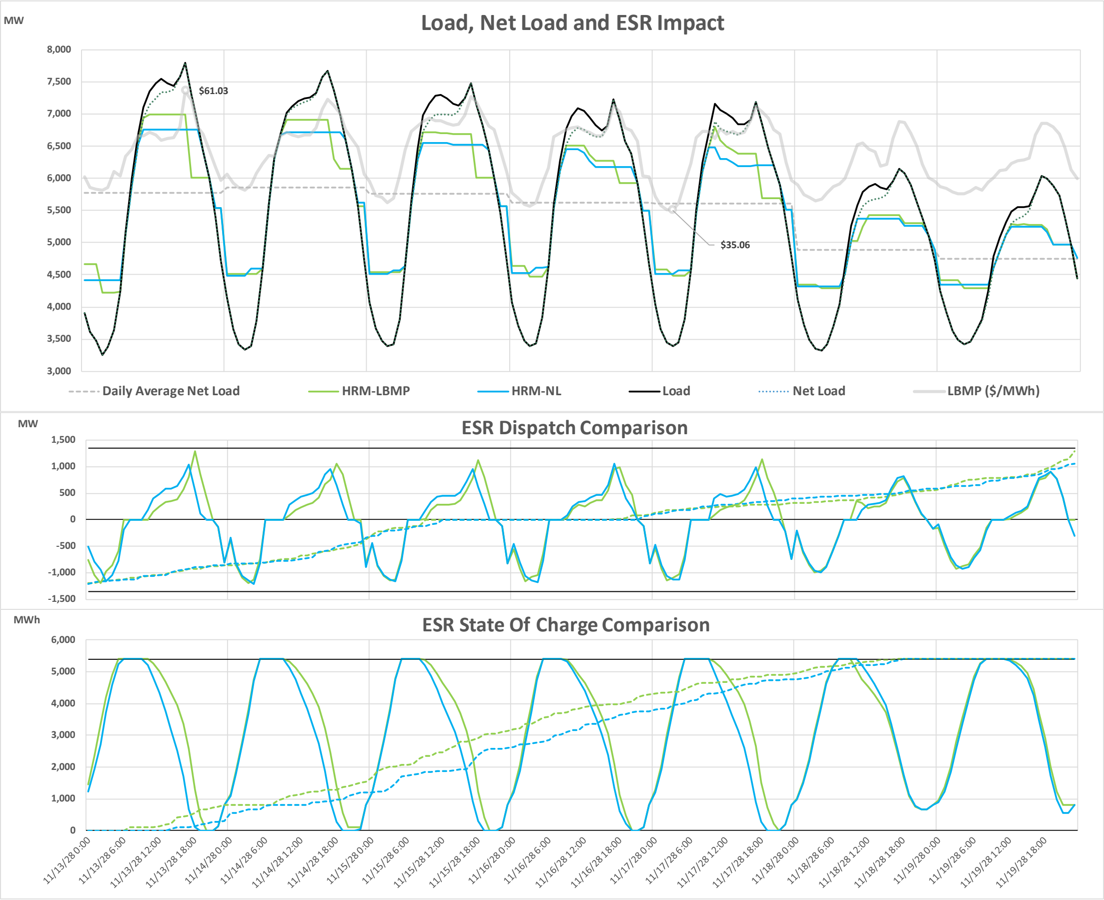


Energy Storage Methodology Comparison

2019 CARIS Base Case - 2028 - Zone S

	Case Results Ratio HRM-LBMP / HRM-NL
ESR Parameters	
Round Trip Efficiency (%)	100%
ESR Power Capacity (MW)	100%
ESR Duration Capacity (hours)	100%
ESR Energy Capacity (MWh)	100%
Weekly ESR Metrics	
Maximum ESR Injection (MW)	114%
Maximum ESR Withdrawl (MW)	102%
ESR Injection Total (MWh)	99%
ESR Withdrawl Total (MWh)	99%
State of Charge Range (MWh)	99%
Energy Arbitrage Profits (k$)	106%
Capacity Factor	99%
Weekly Net Load Impact Metrics	
Peak Net Load (MW)	100%
Peak ESR Modified Net Load (MW)	101%
Peak Reduction (MW)	92%
Annual ESR Metrics	
ESR Injection Total (MWh)	94%
ESR Withdrawl Total (MWh)	93%
Annual Energy Arbitrage Profits (M$)	110%
Capacity Factor	94%
Annual Net Load Impact Metrics	
Peak Net Load (MW)	100%
Peak Modified Net Load (MW)	102%
Peak Reduction (MW)	78%

DRAFT – FOR DISCUSSION PURPOSES ONLY



Energy Storage Methodology Comparison

2019 CARIS Base Case - 2028 - Zone J

	Case Results Ratio HRM-LBMP / HRM-NL
ESR Parameters	
Round Trip Efficiency (%)	100%
ESR Power Capacity (MW)	100%
ESR Duration Capacity (hours)	100%
ESR Energy Capacity (MWh)	100%
Weekly ESR Metrics	
Maximum ESR Injection (MW)	123%
Maximum ESR Withdrawl (MW)	99%
ESR Injection Total (MWh)	99%
ESR Withdrawl Total (MWh)	99%
State of Charge Range (MWh)	100%
Energy Arbitrage Profits (k$)	105%
Capacity Factor	99%
Weekly Net Load Impact Metrics	
Peak Net Load (MW)	100%
Peak ESR Modified Net Load (MW)	104%
Peak Reduction (MW)	76%
Annual ESR Metrics	
ESR Injection Total (MWh)	94%
ESR Withdrawl Total (MWh)	94%
Annual Energy Arbitrage Profits (M$)	108%
Capacity Factor	94%
Annual Net Load Impact Metrics	
Peak Net Load (MW)	100%
Peak Modified Net Load (MW)	102%
Peak Reduction (MW)	80%

DRAFT – FOR DISCUSSION PURPOSES ONLY