Dispatchable Power
For our Clean Energy Future

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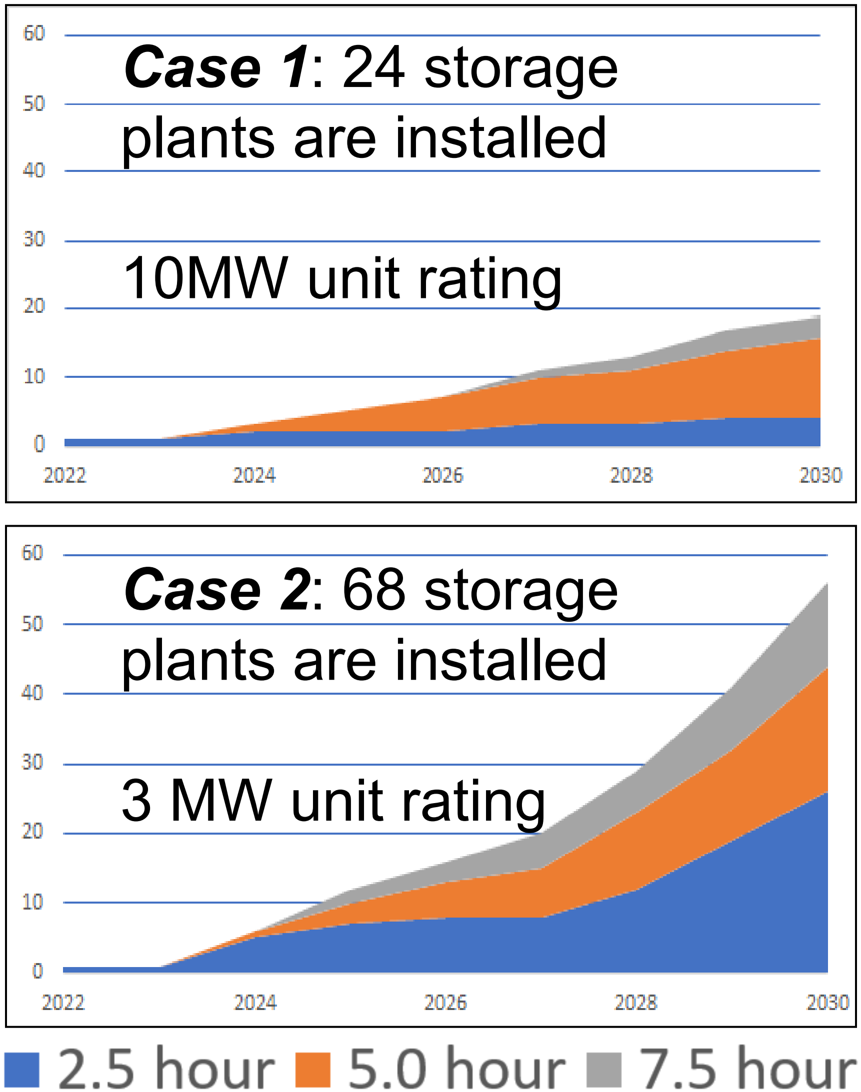
Utility-Scale Energy Storage Market

- ***ESS*** energy storage systems is a key topic for NM RETA's mission
- Storage Market study (2022) reported an early-phase evaluation of New Mexico's possible energy storage fleet:
  - ***Dispatchable ESS*** co-located with large-scale renewable generation, connected to the transmission system at least 100 kilovolts (kV) or higher
  - In-development by 2026 and operating by 2030
  - Key study inputs were based on a renewable planning analysis issued by ICF International, Inc. Fairfax, Va.

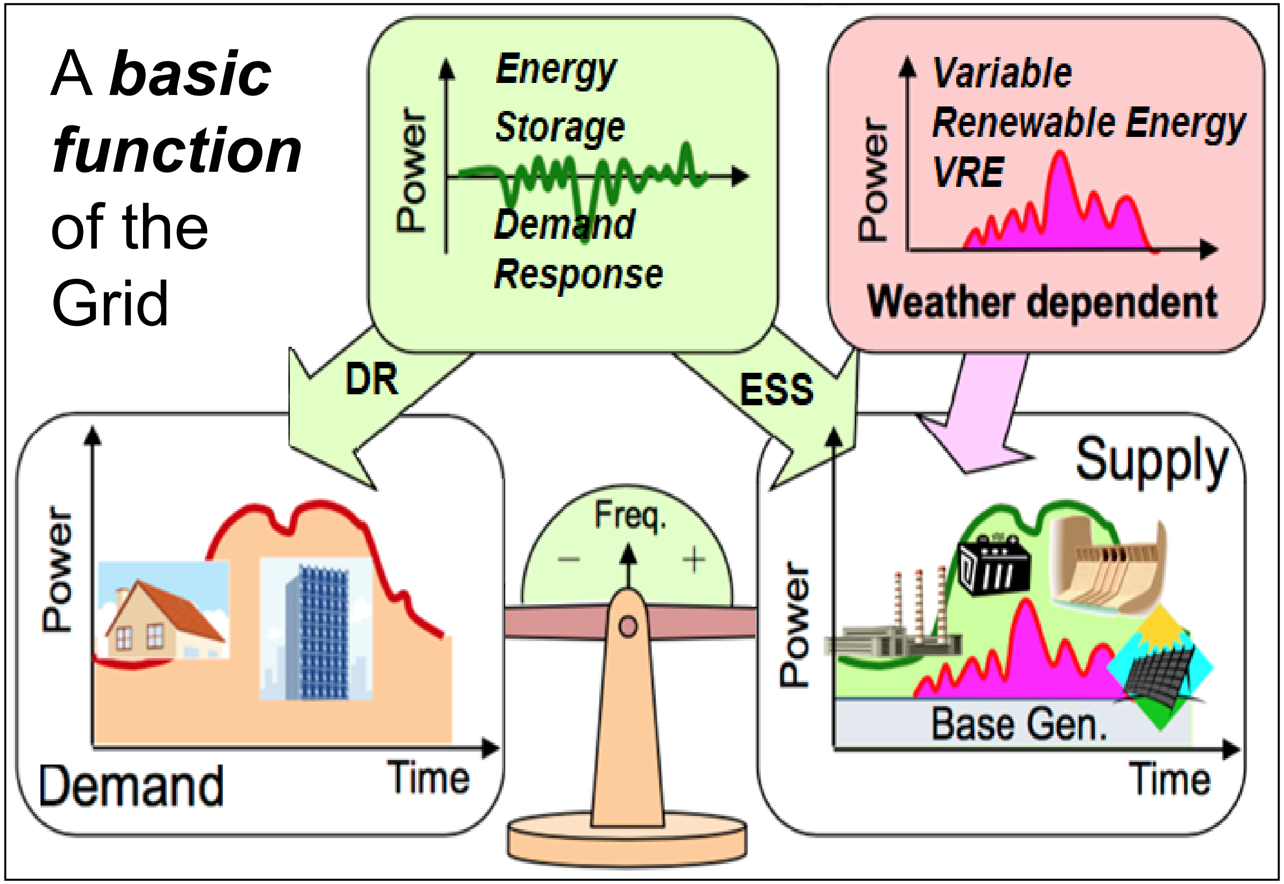
Findings: Storage Market 2030



- A mix of 2.5-, 5- and 7.5-hour duration units projected for year 2030
- Discharged energy could exceed ***280,000 MWh annually***
- ***Likely outcome:*** hybrid of Case 1,2 unit sizes
- Mainly Lithium-Ion battery technology

MW Megawatt: Power or capacity;
MWh Megawatt-hours: Energy consumed or supplied

What is Dispatchable Power?



- ***Dispatchable power*** includes: Nuclear, Natural gas-fired and Import supply
- Plants adjusted on-demand
- VRE is "must-take" ***non-dispatchable*** supply

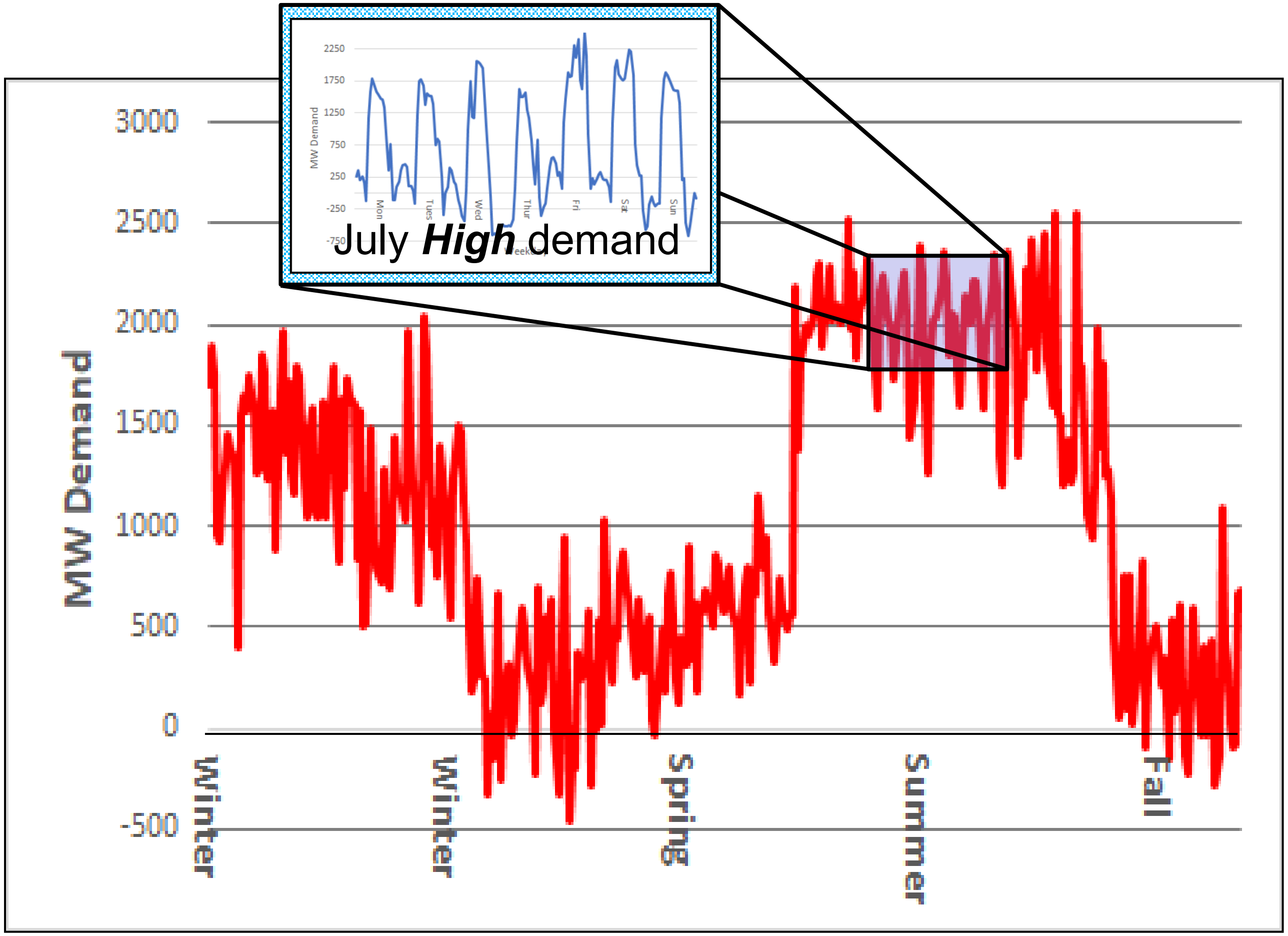
Credit: adapted from https://www.mitsubishielectric.com/news/2016/pdf/0303-b.pdf

Dispatchable Power *Challenges*

- Operator must integrate output of both dispatchable generating plants, ESS, DR plus non-dispatchable VRE
  - Dispatching will typically involve conflicting factors ***i.e.*** range of possible outcomes that meet similar goals
  - ***Key challenges*** include tradeoffs among: Forecast Error; Supply Variability; Supply Reserve; and Cost of Operation
  - Operator will leverage a variety of performance metrics* to assemble a "Dispatch Stack" of power sources
  - Operator refers to autonomous controls with manual override

***Metrics**: MW, MWh, MW/Minute, $/MW

Net Demand Determines Outcomes…

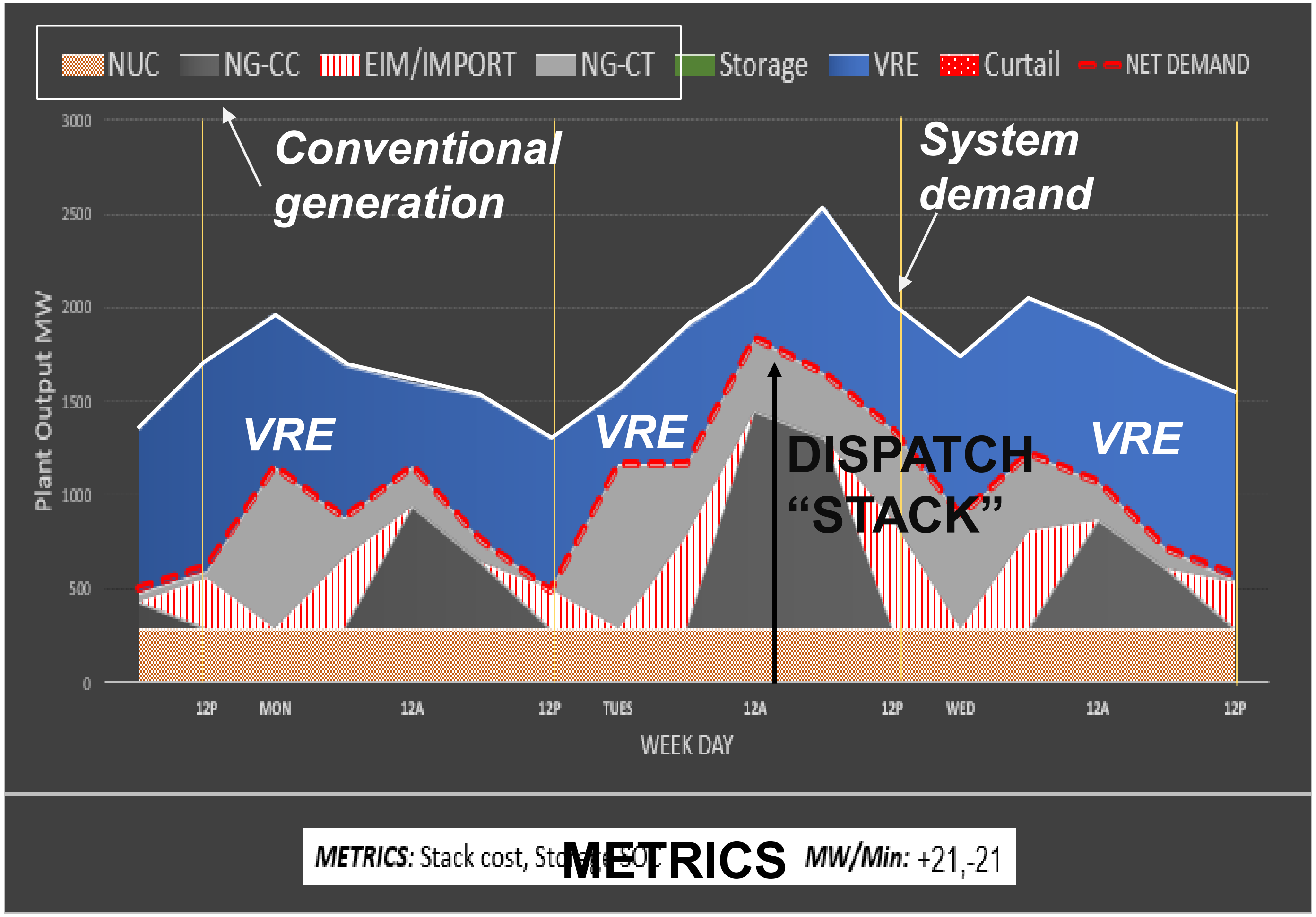


- ***Net Demand equals*** System demand ***minus*** VRE supply
- No export power ***or*** in-state demand above 2030 RPS
- ***Under direct control*** of grid operators

Ref. Appendix A-2, "New Mexico In-state Energy Storage" NM RETA report, Sept. 2022

Summary Panels (Examples)

- Simulated dispatch for three high-demand days in July, 2030
- Mimic historic generation patterns and operating rules
- Centralized control of state's grid



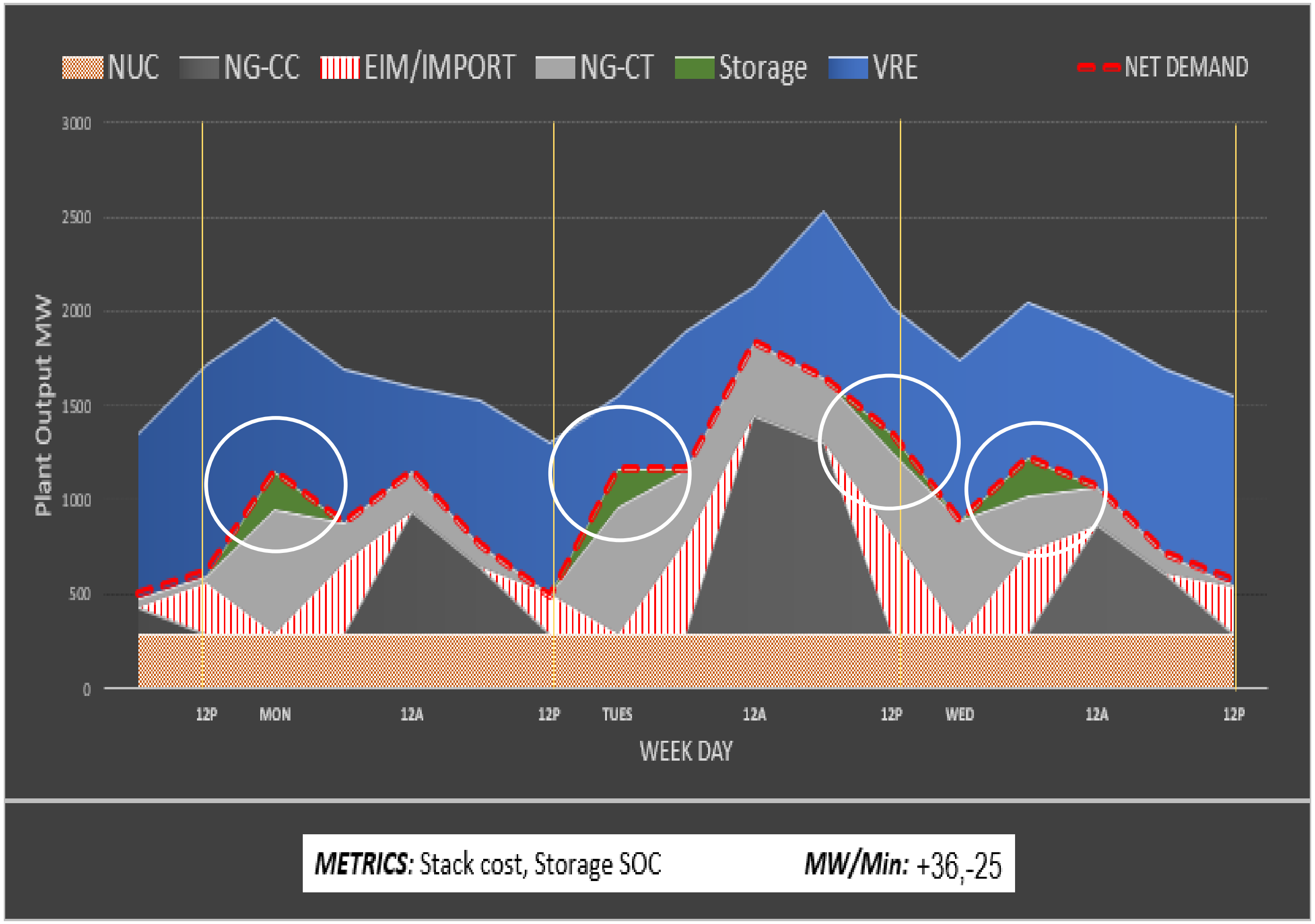
Metric: Forecast Error

- ***Forecasting*** is used by operators to estimate short-term grid quantities over periods of minutes-hours-days
  - A common measure of forecast (supply) error is ***+/-MW megawatts***
  - In this example, the VRE forecast is biased towards over-estimating available supply, on average, about 15%
  - A ***Wind-dominated system*** may incur higher forecast errors
  - Summary panels highlight the impact of supply forecast errors on ***ESS discharge***

Ref. Projected 2030 Wind/Solar fractions 60%/40%; see Section 3.3, "New Mexico Renewable Energy Transmission and Storage Study: Update of Key Findings" NM RETA report, Feb. 2022

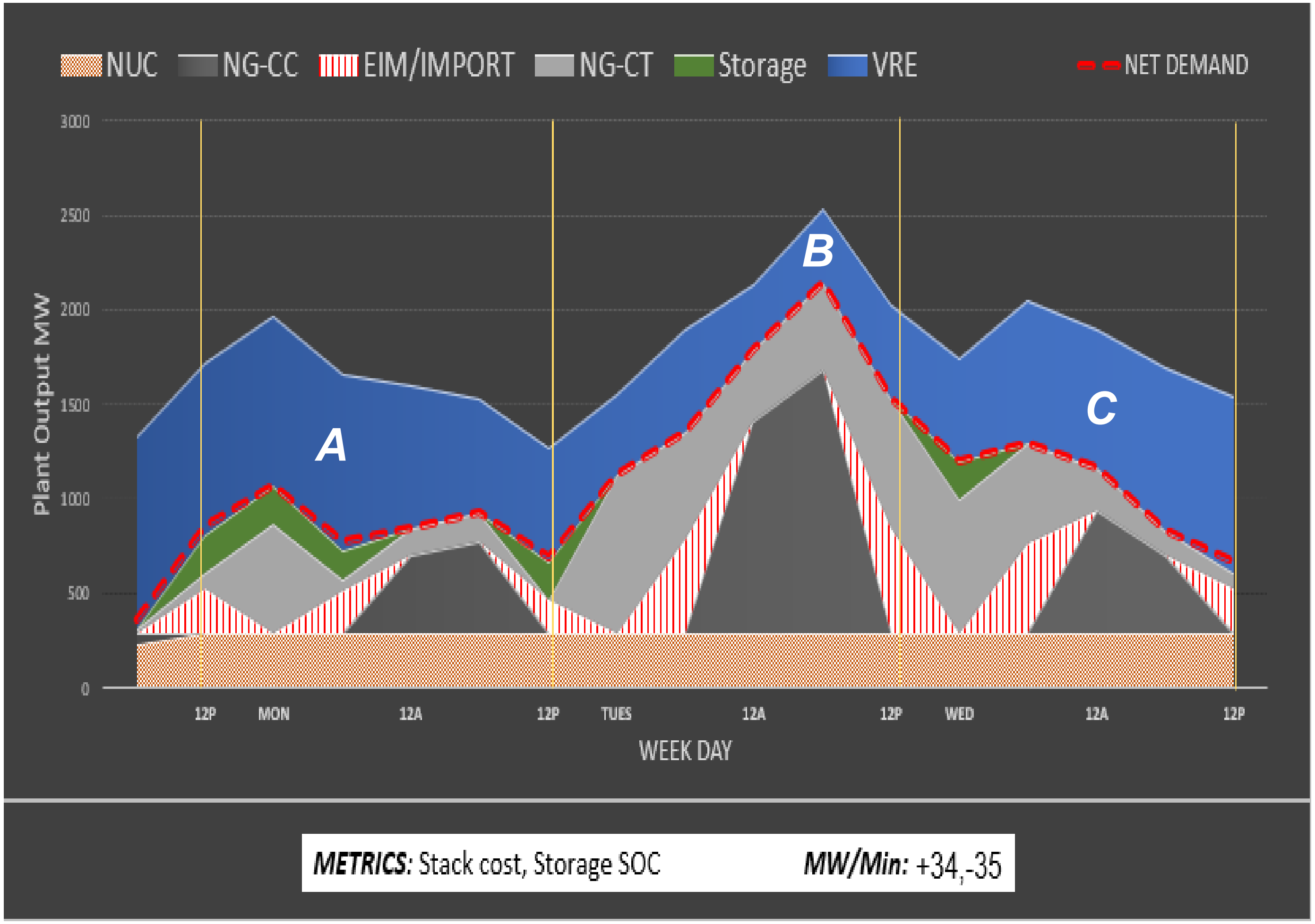
Storage Discharge- No Forecast Error

- Operator's ***perfect*** 1-hour ahead VRE supply forecast
- ***Events:*** (highlighted) Natural-gas fired plants displaced through ***ESS "Arbitrage"***



Storage Discharge- Forecast Error

- Operator's ***imperfect*** 1-hour ahead forecast: ***A,C*** over-supply; ***B*** under-supply
- Discharged MWh varies ***30% or more*** from prior example



Pre- and Post-Dispatch

- ***400 MW*** storage capacity utilized for Arbitrage

No Forecast Error

- Over ***6,300 MWh displaced*** during storage re-dispatch
- Over 30% decrease in ***Stack cost*** due to reduced gas-fired plant output
- Discharge coincides with pattern of net demand ***variability***

Forecast Error

- Over ***3,200 MWh displaced*** during storage re-dispatch
- Less than 15% decrease in ***Stack cost*** (proportional to plant displacement)
- Forecast error yields large change in ESS discharge

Takeaways: Dispatchable Power

- Simulations highlight the importance of ***dispatch flexibility***

- Storage and Curtailment will become key operator tools for managing future grid operation
- Dispatching will typically require ***a tradeoff among conflicting factors*** *i.e.* range of possible outcomes that meet similar goals
- ***Key Challenges*** include: Forecast Error; Supply Variability; Supply Reserve; and Cost of Operation
- Operator must integrate output of both dispatchable generating plants, ESS, DR plus non-dispatchable VRE

Study URL- NMRETA website

https://nmreta.com/wp-content/uploads/2022/10/RETA-Energy-Storage_-0922.pdf

SUPPLEMENT

- Cost Performance

Cost Performance

- Simulation incorporates conventional plant running costs
  - ***Fixed*** cost per MWh for NUC, NG-CC, NG-GT and EIM supply sources
  - ***Variable*** cost per MWh for CURTAIL and ESS options
  - Minimize aggregate cost of dispatch stack $/MWh

Supply Source	Cost Per MWh
NUC Nuclear	$40
NG-CC Nat Gas	$70
CURTAIL	$60
EIM/IMPORT	$60
NG-GT Nat Gas	$160
ESS Storage	$200

- ESS cost per MWh quantified by a Time-of-Use rate proxy (PNM 35B), charged off-peak and discharged on-peak

Metric: Supply Variability

- ***Variability*** may become problematic with larger fractions of VRE supply
  - A common measure of variability is ***ramp rate*** +/-***MW per minute***
  - Compensated by dispatching supply over two time frames: <u>Regulation </u>(less than 15 minutes) and <u>Load Following </u>(part-hours to days)
  - Allowable Nuclear ramps are ***1% or less*** of rated capacity per minute, Natural Gas ramps are usually ***25% or less*** of rated capacity per minute