Stakeholder Education
Fuel Requirements for Black Start Resources

Operating Committee Special Session

January 8, 2019

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Agenda – Stakeholder Education

- Fuel Requirements for Black Start Resources vs. Fuel Security
- Black Start Basics
- Black Start Resource Fuel Requirements
- Natural Gas Terminology
- Fuel Supply Status for Existing Black Start Resources
- Black Start Testing Requirements
- Existing Compensation Mechanisms for Black Start Resources

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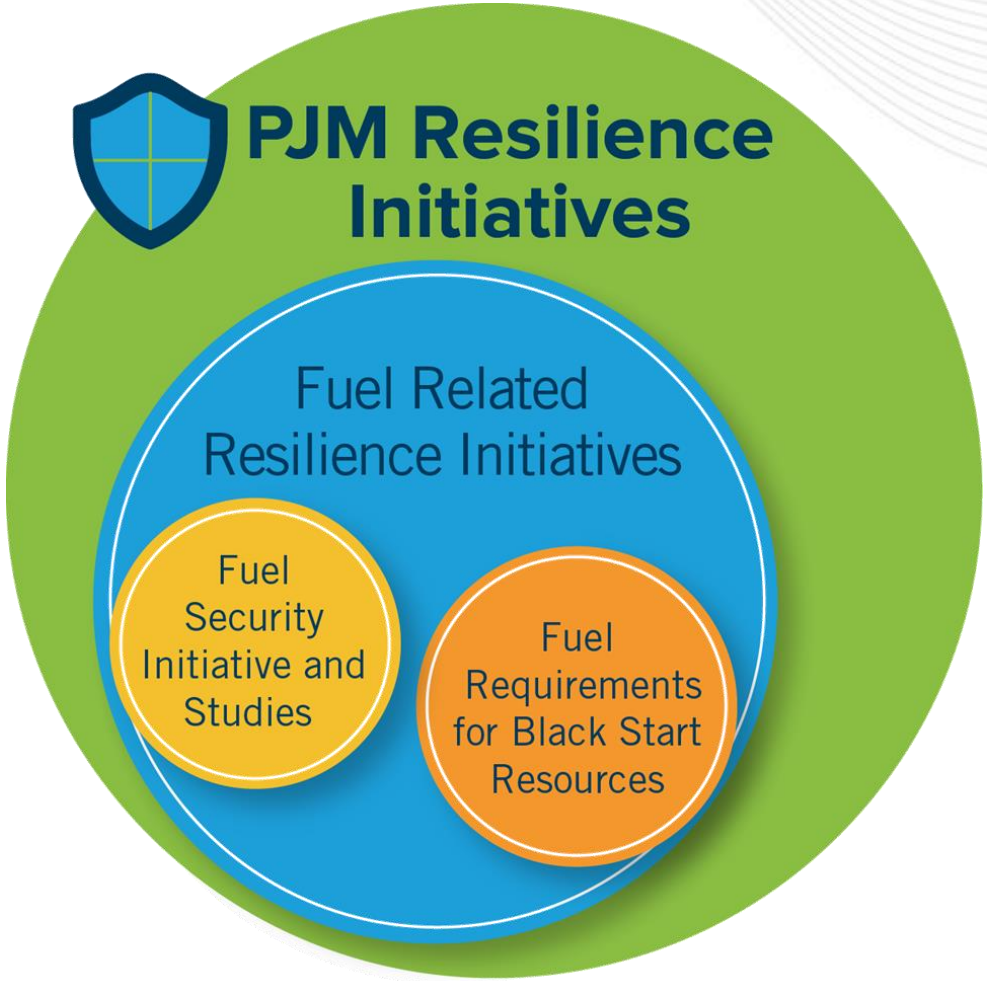
Fuel Requirements for Black Start Resources vs. Fuel Security



- The ongoing Fuel Security Initiative is working to address fuel needs for units across the RTO during extreme but plausible, longer duration events.
- The Fuel Requirements for Black Start Resources process is solely addressing units that provide Black Start Service and focused on system restoration.

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Black Start Basics /
Black Start Resource Fuel Requirements

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- ***What is black start?*** If power is lost throughout the entire PJM area, black start units are designated resources that are able to restore electricity to the grid without using an outside electrical supply

- Applicable Tariff provisions and PJM Manual references for Black Start Service:
  - OATT Schedule 6A
  - Manual 12, Section 4.6
  - Manual 14D, Section 10.0
  - Manual 27, Section 7.0
  - Manual 36, Attachment A

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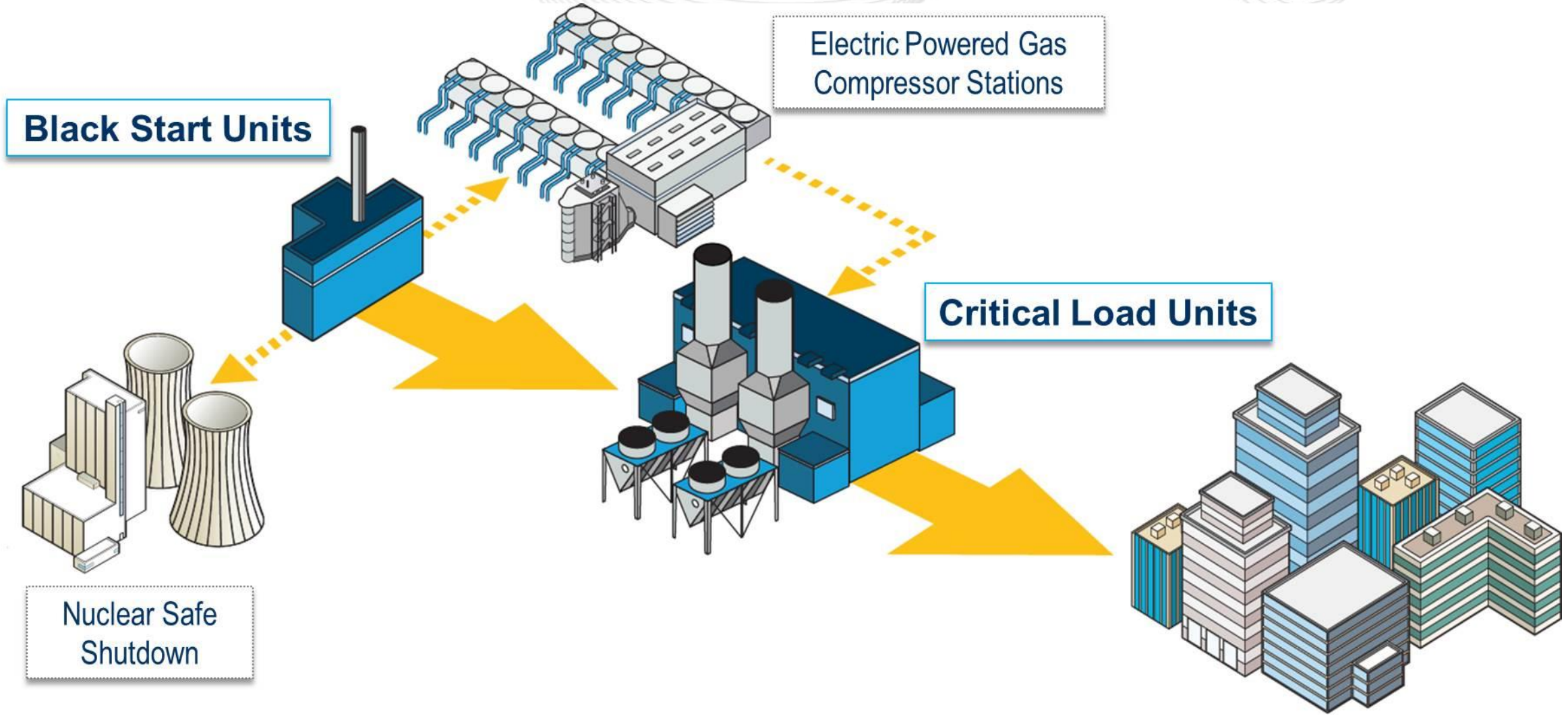
How Black Start Units are Used



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PJM Black Start / Critical Load

- Black Start units:
  - Ability to self start / close to a dead bus within 3 hours
  - Provide power to serve critical loads

- PJM Critical Load Criteria:
  - Units with a hot start time of 4 hours or less
  - Nuclear safe shutdown loads
  - Critical gas infrastructure

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Current PJM Black Start Fuel Requirements

- PJM OATT Schedule 6A (Section 18 - Fuel Storage Costs)
  - Run hours shall be at least 16 hours or as defined by the Transmission Owner restoration plan, whichever is less.
- PJM Manual 36 (Attachment 'A' - Minimum Critical Black Start Requirement)
  - Black Start Resource Operators must maintain fuel to allow for 16 hours of run time or as defined by the Transmission Owner restoration plan, whichever is less. PJM and Transmission Owners must be notified if a Black Start resource fuel level falls below these values.
- PJM Manual 14D (Section 7.1.6 – Black Start)
  - Black Start unit operators shall not permit their fuel inventory fall below 10 hours, if they do PJM must be notified and the resource must be placed in Max Emergency.

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Current PJM Black Start Fuel Requirements

- PJM Manual 14-D, Section 10, Black Start Generation Procurement
  - Fuel assurance considerations in RFP evaluation process:
    - Can unit start on both primary or secondary fuel alone?
    - Is start-up fuel required before running on primary or alternate fuel?
    - Special switching requirements / unit restrictions in order to move from primary to alternate fuel (or vice versa)
    - Onsite fuel storage
    - Primary firm gas transportation contract vs. secondary firm or interruptible gas contracts; single vs. multiple gas pipeline access.

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Other ISO/RTO Black Start Unit Fuel Requirements

- ISONE
  - Fuel supply independent of other BS resource's requirements
  - Allow unit to run at full capacity as follows:
    - 2 hours for renewables, including hydro
    - 12 hours for all other fuel types
- NYISO
  - Requirements vary based on Transmission Owner local procedures

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Other ISO/RTO Black Start Unit Fuel Requirements

- MISO
  - Must have an adequate inventory of fuel supply to accomplish the goals of the Transmission Operator's System Restoration Plan
- CAISO
  - Each Black Start Generating Unit must be capable of sustaining its output for a minimum period of 12 hours from the time when it first starts delivering Energy

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FERC-NERC-Regional Entity Joint Review of Restoration and Recovery Plans: Blackstart Resources Availability

- Issued May, 2018 – Update to report issued in 2016
- Conclusions included:
  - Reliance on a single fuel blackstart resource without fuel storage capacity or firm fuel arrangements may cause issues during a restoration event
- Recommendations included:
  - Mitigating risks associated with the reliance on a single fuel
  - Single fuel dependent blackstart generator owners develop alternative fuel capability or coordinate with their fuel providers to mitigate this risk

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FERC-NERC-Regional Entity Joint Review of Restoration and Recovery Plans: Blackstart Resources Availability

- Recommendations (continued):
    - This could include firm contracts with specifications to ensure that fuel supplies to the blackstart generating units are unimpeded during a restoration event.
  - Blackstart resource owners to work with their regulators as necessary, to develop alternative solutions to address potential fuel constraints.
  - Consider further study of the adequacy of compensation for blackstart and other resources supporting system restoration.
- Full Report

  https://www.ferc.gov/legal/staff-reports/2018/bsr-report.pdf

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Natural Gas Terminology

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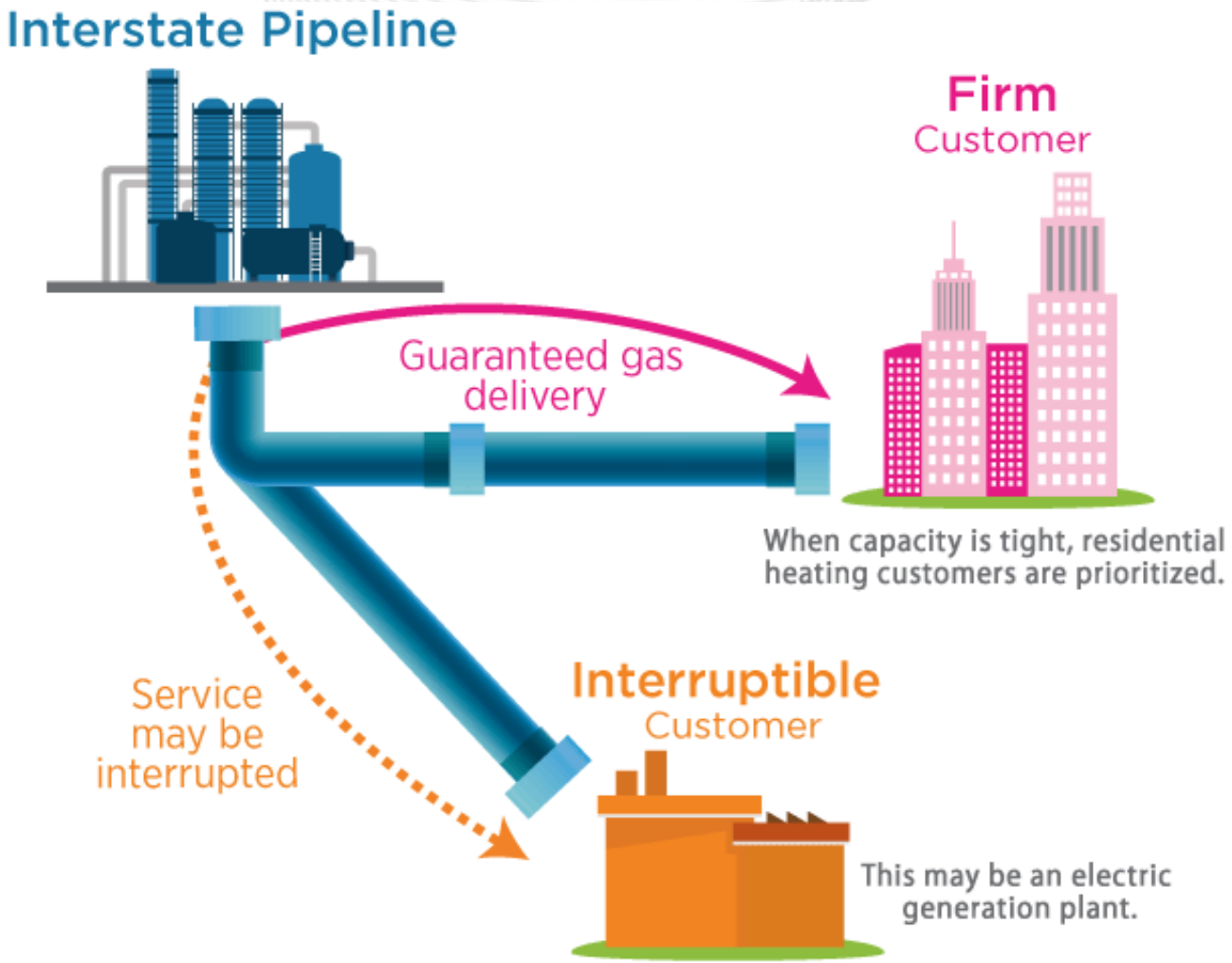
Natural Gas Terminology



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High Level View of Natural Gas Capacity Market

Pipelines

- Sells firm capacity contracts to gas traders and LDCs in primary market

Primary Market

LDC/Marketer

- Purchases firm capacity contract from pipeline in primary market
- Release unused firm capacity to shippers in secondary market

Secondary Market

Gas Shippers

- Purchase released capacity from firm contract holders in secondary market (or purchase IT directly from pipeline)

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Secondary Market:

The market for firm transportation capacity when the original owner is not using it.

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Capacity Release:

A mechanism by which holders of firm interstate transportation capacity can relinquish their rights to utilize the firm capacity to other parties that are interested in obtaining the right to use that capacity for a specific price, for a given period of time and under a specifically identified set of conditions. The firm transportation rights may include transmission capacity and/or storage capacity

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Primary Firm Pipeline Capacity:

All pipeline contracts contain primary receipt and delivery points. If the capacity is released, and the primary receipt and delivery points remain unchanged, the pipeline transportation capacity retains the primary firm scheduling priority.

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Secondary Firm Pipeline Capacity:

All pipeline contracts contain primary receipt and delivery points. If pipeline capacity is released and the primary receipt and/or primary delivery points are modified, the pipeline transportation capacity is classified as ‘secondary’ and is scheduled after primary firm pipeline capacity, but before interruptible pipeline capacity.

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Fuel and Non-Fuel Consumable Supply Status for Existing Black Start Resources

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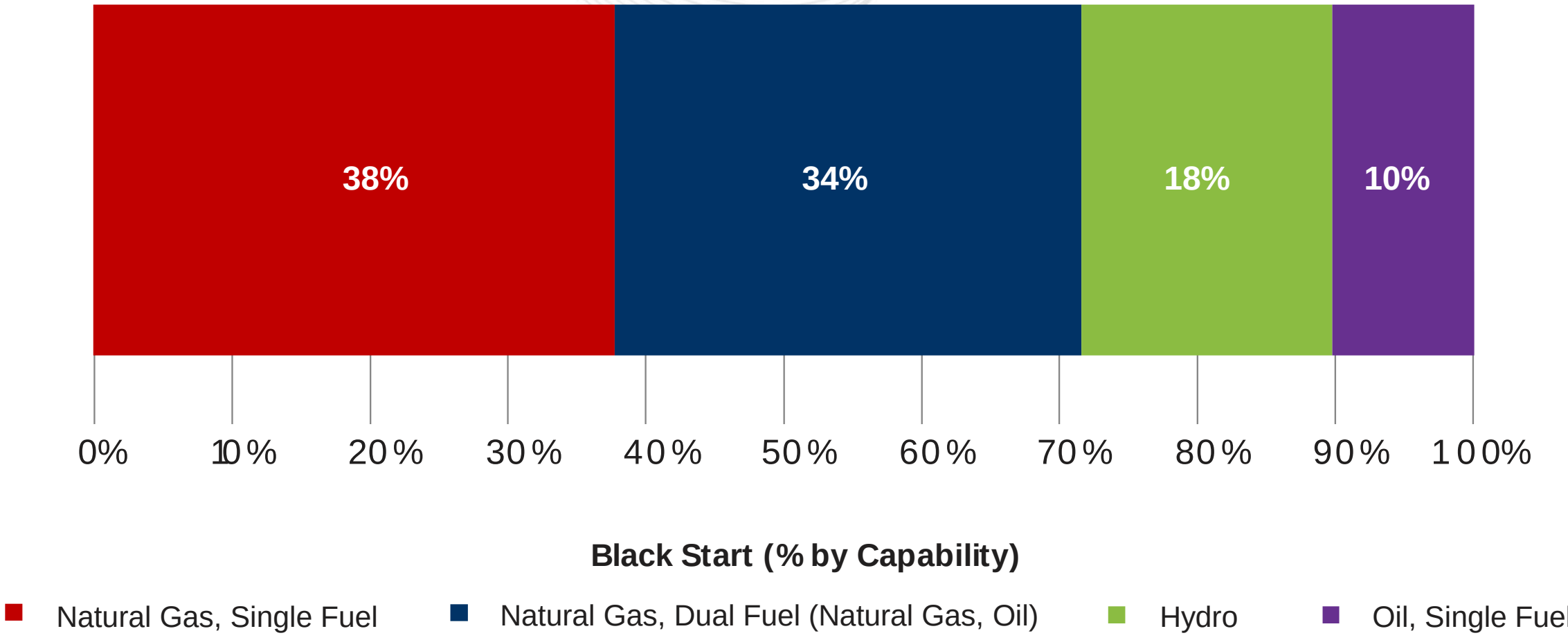
Black Start Resources Fuel Breakdown



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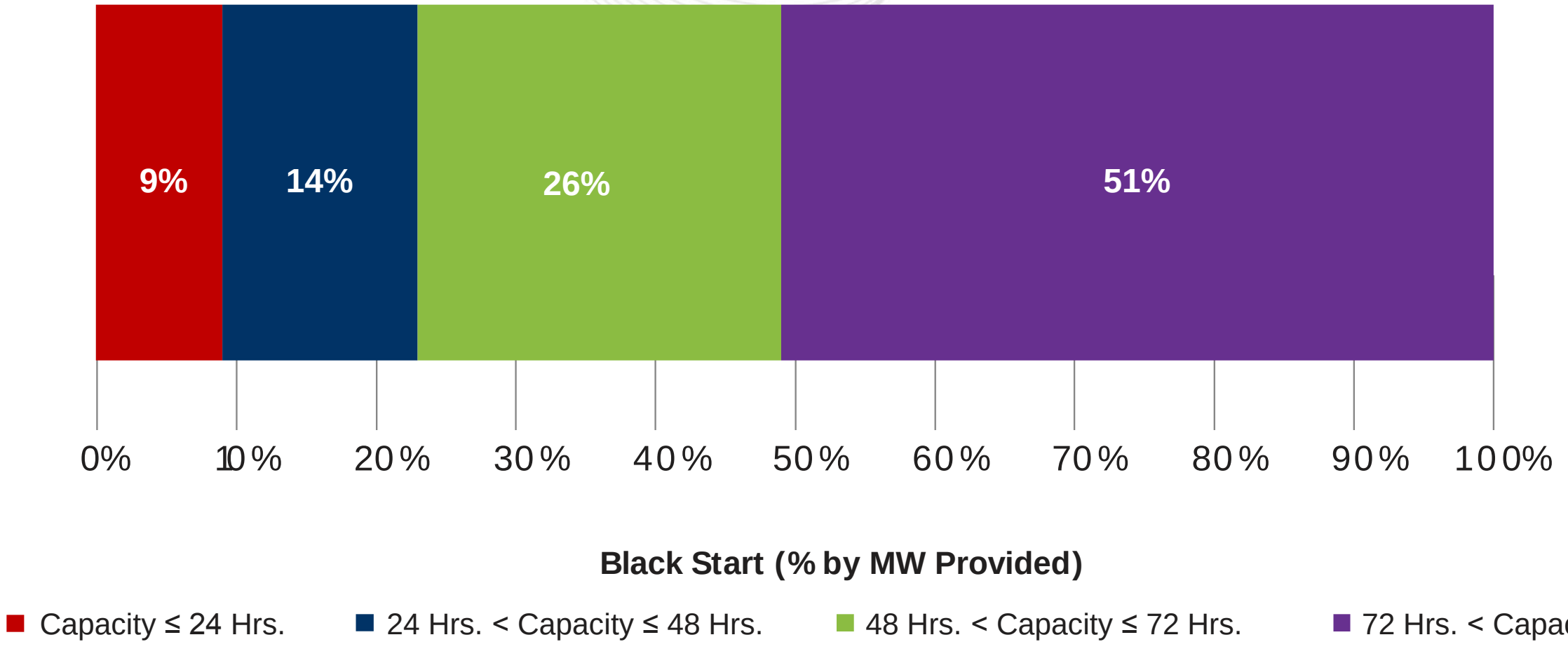
Oil Black Start Resources Fuel Storage Capacity



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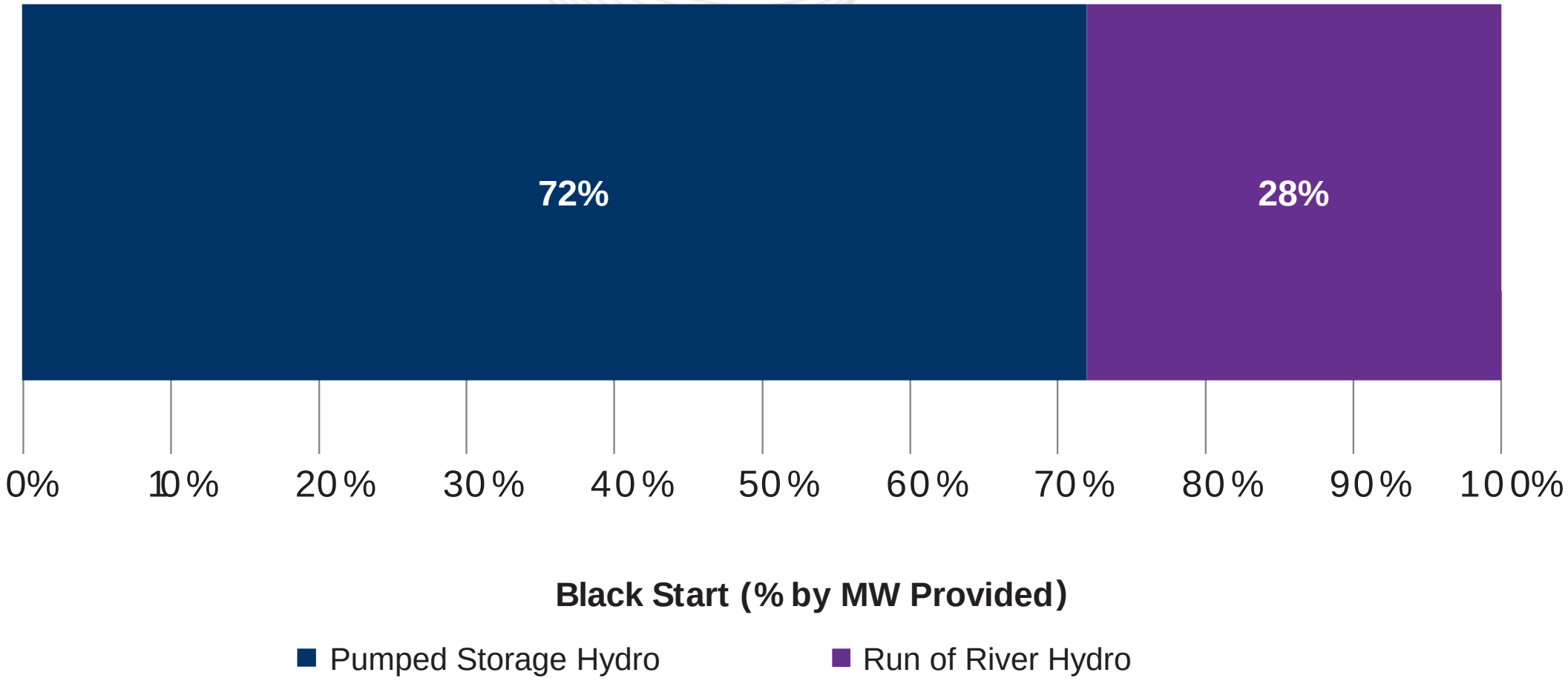
Hydro Black Start Resources Detail



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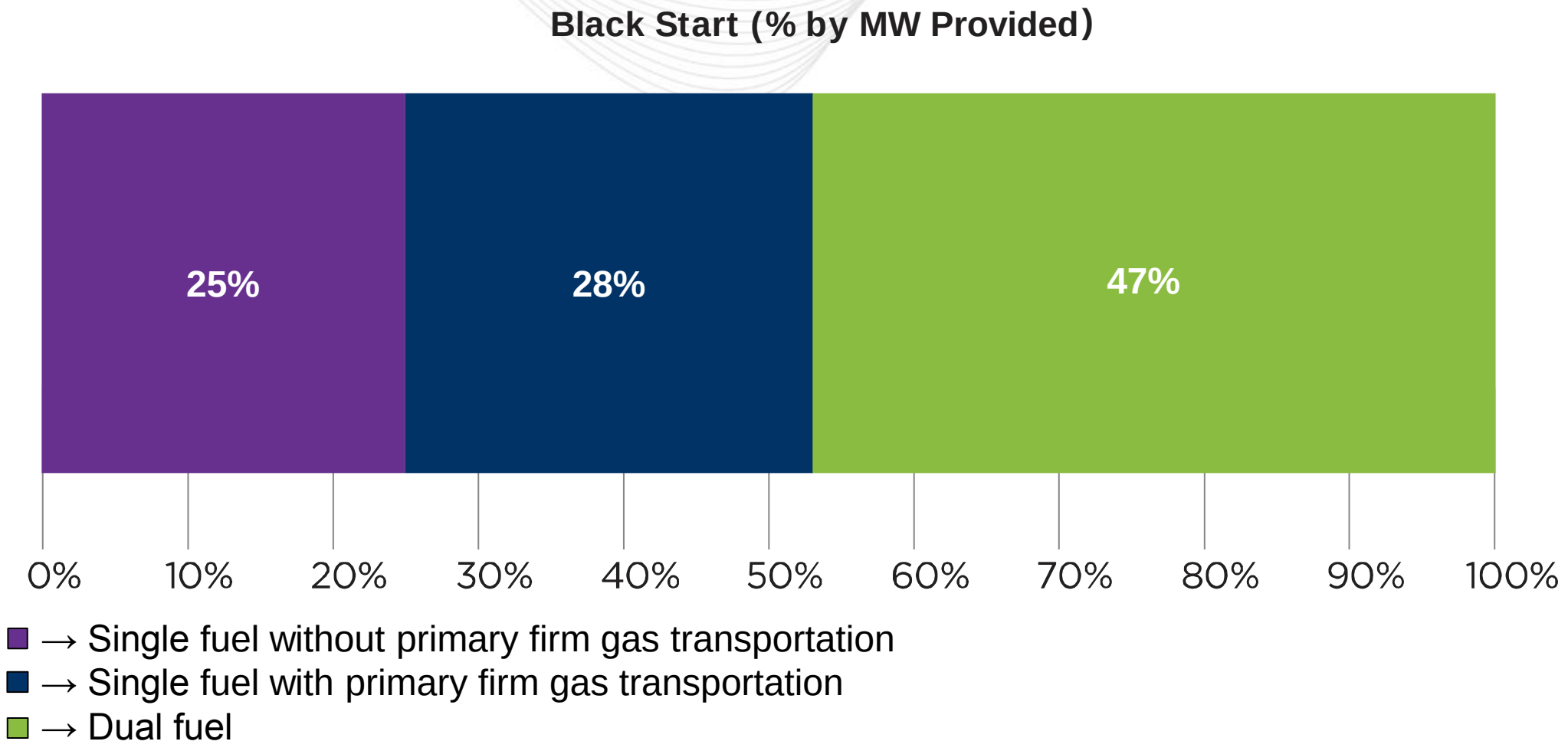
Natural Gas Black Start Resources Detail



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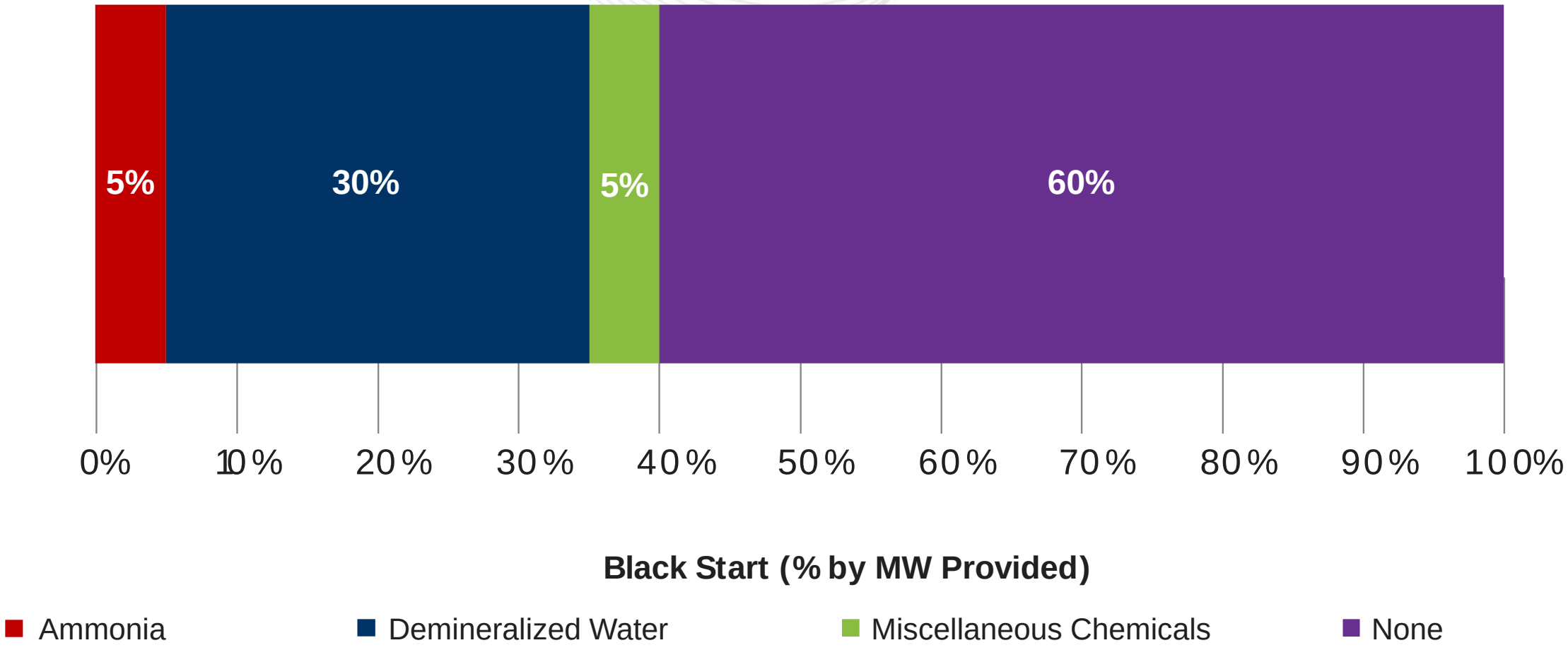
Operationally Limiting Non-Fuel Consumables



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PJM Black Start Testing Requirements

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Black Start Testing

- Every Black Start Critical resource shall be tested to verify that it can be started and operated without being connected to the PJM power system
  - Testing is required to be performed annually to confirm the resource's black start capability
  - A successful test is required, on a 13-month rolling basis, for the resources to continue receiving black start revenues
  - Black Start testing is scheduled at the discretion of the generator owner, however, prescheduled with PJM prior to the test.
  - A Black Start test report form should be filled out and submitted for all testing performed (pass or fail)

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Black Start Testing Compensation

- Compensation for energy output delivered to the system is provided for the unit's minimum run time at the higher of the unit's cost-capped offer or real-time LMP, plus start-up and no-load cost

- Compensation when closing to a dead bus includes a start cost plus one hour of No-Load

- Two Black Start test attempts are allowed to be compensated

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Black Start Testing Requirements

- Annual tests includes testing the unit:
  - can start when requested from a “blackout” state
  - has the ability to close unit onto a dead bus within 3 hours of the request to start
    - physically closing the generator breaker connected to a dead bus
    - simulate closure to a dead bus by physically closing the generator breaker to a live bus

THE BLACK START TEST DISPLAYED THE ABILITY TO …	ACTUAL EQUIPMENT TEST SUCCESS	SIMULATED EQUIPMENT TEST SUCCESS	ITEM NOT TESTED	TESTING FAILED
… START WITHOUT POWER				
… CLOSE INTO A DE-ENERGIZED BUS				
… OPERATE AT REDUCED LEVELS WHEN DISCONNECTED FROM THE GRID				
… MAINTAIN FREQUENCY UNDER VARYING LOAD … (For a Period of at least thirty minutes)				
… MAINTAIN VOLTAGE UNDER VARYING LOAD … (For a Period of at least thirty minutes)				
… MAINTAIN BLACKSTART RATED OUTPUT FOR DURATION MATCHING LCC RESTORATION REQ				

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Black Start Testing Requirements

- Annual tests includes testing the unit:
  - Operates at reduced levels when disconnected from the grid
    - removing the unit from the grid while the unit is running (ALR units only)
  - can maintain frequency and voltage under varying load
    - picking up an isolated block of load or house load
    - If closing to a dead bus, producing VARS when the unit is synchronized & perform governor testing

THE BLACK START TEST DISPLAYED THE ABILITY TO …	ACTUAL EQUIPMENT TEST SUCCESS	SIMULATED EQUIPMENT TEST SUCCESS	ITEM NOT TESTED	TESTING FAILED
… START WITHOUT POWER				
… CLOSE INTO A DE-ENERGIZED BUS				
… OPERATE AT REDUCED LEVELS WHEN DISCONNECTED FROM THE GRID				
… MAINTAIN FREQUENCY UNDER VARYING LOAD … (For a Period of at least thirty minutes)				
… MAINTAIN VOLTAGE UNDER VARYING LOAD … (For a Period of at least thirty minutes)				
… MAINTAIN BLACKSTART RATED OUTPUT FOR DURATION MATCHING LCC RESTORATION REQ				

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Black Start Testing Requirements

- The company must maintain black start procedures for each unit and ensure personnel are familiar with procedures

- In addition to black start unit testing:
  - Test of all communication circuits.
  - Test features unique to each facility that relate to Black Start Service.

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Failed Test

- If a unit fails a black start test, the unit is given a ten day grace period within which it may retest without financial penalty.
  - Following the grace period monthly black start revenues will be forfeited from the time of the first day of the month in which the unsuccessful test occurred until the first day of the first month after the unit successfully passes a black start test.

- If a unit fails to submit a black start test within the 13 month rolling window PJM will consider this a failed test and black start revenues will be forfeited

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Black Start Service Compensation

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Generator's Annual Black Start Service Revenue Requirement

- A generator's Annual Black Start Service Requirement is the amount of compensation a black start unit receives per delivery year if it fulfills all the black start requirements under the tariff.
- Primary formula to calculate black start generator's Annual Black Start Service Revenue Requirement
  - PJM Tariff – SCHEDULE 6A Black Start Service Section 18

Generator's Annual Black Start Service Revenue Requirement = {(Fixed BSSC) + (Variable BSSC) + (Training Costs) + (Fuel Storage Costs)} * (1 + Z)

BSSC = Black Start Service Cost

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Fixed Black Start Service Costs (Fixed BSSC)

*{(Fixed BSSC) + (Variable BSSC) + (Training Costs) + (Fuel Storage Costs)} * (1 + Z)*

Fixed BSSC (only one of the following rates may be selected):

Rates	Black Start Required Capital Costs
Base Formula Rate (BFR)	If not requiring additional capital costs or not electing to document capital costs
Capital Cost Recovery Rate (CRR)	If recovering documented capital costs (including NERC Standard Compliance); may include FERC-approved rate if electing to recover capital costs outside tariff guidelines
Capital Recovery Rate - NERC-CIP Specific Recovery	If electing to recover only the capital costs associated with compliance to applicable mandatory NERC CIP Reliability Standards

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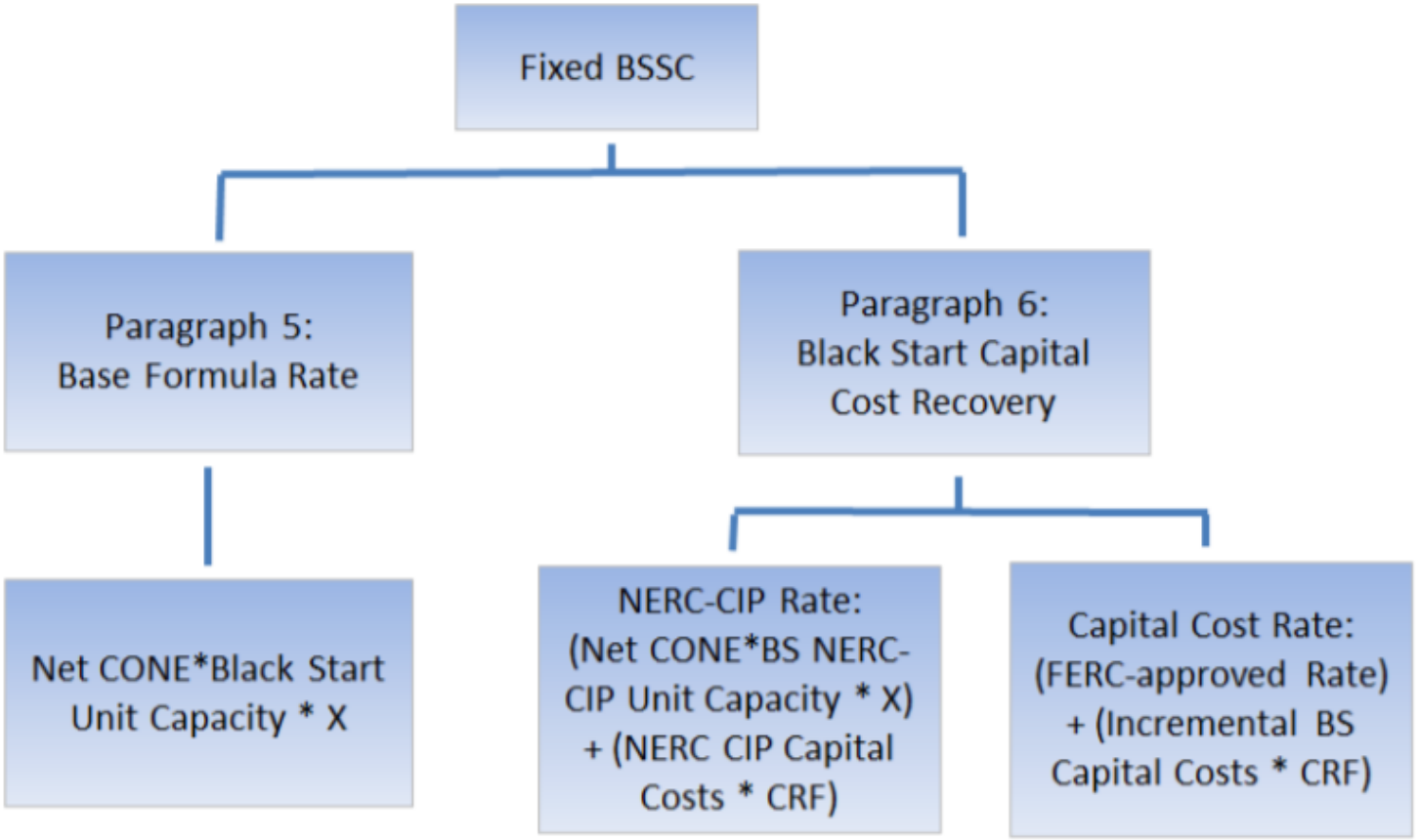
Overview of the Three Methods to Recover Fixed Black Start Costs per Schedule 6A



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Fixed BSSC, Base Formula Rate (BFR)

BFR = Net CONE * Black Start Unit Capacity * X

- Net CONE = Current installed capacity (“ICAP”) net Cost of New Entry ($/MW year) for the CONE Area where the Black Start Unit is located
- Black Start Unit Capacity = either (i) Black Start Unit’s installed capacity (MWs); or (ii) awarded MWs by the Transmission Provider
- X = Black Start Service allocation factor (Black Start Units with a commitment established under Schedule 6A section 5, X shall be .01 for Hydro units and .02 for CT units)

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Fixed BSSC, Capital Cost Recovery Rate (CRR)

CRR = (FERC-approved rate) + (Incremental Black Start Capital Costs * CRF)

- FERC approved rate = (if applicable) FERC-approved recovery of costs to provide Black Start Service
- Incremental Black Start Capital Costs = Capital costs documented by the owner or accepted by the Commission for the incremental equipment solely necessary to enable a unit to provide Black Start Service
- CRF = Levelized CRF based on the age of the Black Start Unit or the expected Capital Improvement Lifespan of the new or additional capital improvements

(next slide contains the Capital Recovery Factor table)

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Capital Recovery Factor Table

Age of Black Start Unit	Term of Black Start Commitment	Levelized CRF
1 to 5	20	0.125
6 to 10	15	0.146
11 to 15	10	0.198
16+	5	0.363

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Fixed BSSC, Capital Recovery Rate – NERC-CIP Specific Recovery

Capital Recovery Rate – NERC CIP = (Net CONE * Black Start NERC-CIP Unit Capacity * X) + (Incremental Black Start NERC-CIP Capital Costs * CRF)

- Net CONE = reference slide 5
- Black Start NERC-CIP Unit Capacity = Installed capacity (MW) capped at 100 MW for Hydro Units, or 50 MW for CT Units
- Incremental Black Start NERC-CIP Capital Costs = Capital costs documented by the owner or accepted by the Commission for the incremental equipment solely necessary to enable a Black Start Unit to maintain compliance with mandatory CIP Standards
- CRF = reference slide 6 & 7

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Variable Black Start Service Costs (BSSC)

*{(Fixed BSSC) + (Variable BSSC) + (Training Costs) + (Fuel Storage Costs)} * (1 + Z)*

Variable BSSC = Black Start Unit O&M * Y

- Black Start Unit O&M = the variable operations and maintenance costs attributable to supporting Black Start Service
  - *Variable BSSC should also include the cost to maintain compliance with NERC Reliability Standards that apply to the Black Start Unit solely on the basis of the provision of Black Start Service by Unit.*
- Y = multiplier used against the Black Start O&M cost; Y=0.01, unless a higher/lower value is supported by documentation. If a value of Y is submitted for this cost, a (1-Y) factor must be applied to the Black Start Unit's O&M costs on the unit's cost-based energy schedule

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Training

*{(Fixed BSSC) + (Variable BSSC) + (Training Costs) + (Fuel Storage Costs)} * (1 + Z)*

Training cost = 50 staff hours/year/plant * $75/hour = $3,750 year/plant

- Training cost is the cost associated for training for black start unit operations

(submitted testing records to include description of operator training and dates of training)

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Fuel Storage Costs

*{(Fixed BSSC) + (Variable BSSC) + (Training Costs) + (Fuel Storage Costs)} * (1 + Z)*

Fuel Storage Costs = {MTSL + [(# Run Hours) * (Fuel Burn Rate)]} *

(12 Month Forward Strip + Basis) * (Bond Rate)

- MTSL = Minimum Tank Suction Level, volume of fuel storage cost for Black Start Unit
  - Shall apply where no direct current pumps are available for the Black Start Unit
  - In the case where more than one Black Start Unit shares a common fuel tank, only one Black Start Unit will be eligible for recovery of this volume in its fuel storage cost calculation. The MTSL for the other Black Start Unit(s) sharing the common fuel tank shall be zero.

fuel storage costs continued on next slide

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Fuel Storage Costs continued

*{(Fixed BSSC) + (Variable BSSC) + (Training Costs) + (Fuel Storage Costs)} * (1 + Z)*

Fuel Storage Costs = {MTSL + [(# Run Hours) * (Fuel Burn Rate)]} * (12 Month Forward Strip + Basis) * (Bond Rate)

- # Run Hours = Run Hours shall be at least 16 hours or as defined by the Transmission Owner restoration plan, whichever is less
- Fuel Burn Rate = Actual fuel burn rate for the Black Start Unit
- 12 Month Forward Strip = average of forward prices for the fuel burned in the Black Start Unit traded the first business day on or following May 1

fuel storage costs continued on next slide

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Fuel Storage Costs continued

*{(Fixed BSSC) + (Variable BSSC) + (Training Costs) + (Fuel Storage Costs)} * (1 + Z)*

Fuel Storage Costs = {MTSL + [(# Run Hours) * (Fuel Burn Rate)]} *

(12 Month Forward Strip + Basis) * (Bond Rate)

- Basis = Transportation costs from the location referenced in the forward price data to the Black Start Unit plus any variable taxes
- Bond Rate = Bond Rate Value for bonds rate Baa1 by Moody's as of the first business day on or following May 1

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Z factor

*{(Fixed BSSC) + (Variable BSSC) + (Training Costs) + (Fuel Storage Costs)} * (1 + Z)*

- Z Factor = Incentive factor Black Start Units:
  - 10 percent for units on Base Formula Rate (BFR)
  - 0 percent for units on Capital Cost Recovery Rate (CRR) or NERC CIP Specific Recovery Rate

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Automatic Load Rejection (ALR) Black Start Generator

- Training Costs * (1 + Z) = 50 staff hours * $75 = $3,750
  - $3,750 * (1+.10) = $4,125 per plant per delivery year

- ALR Unit's Fuel Storage Costs are zero

For ALR units, the total annual compensation from black start is $4,125 per plant per delivery year.

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Black Start Service Credit

- Black Start Service Credits
  - Monthly credits are provided to generators based on the annual revenue requirements (June 1 – May 31)
  - Revenue requirements for jointly owned Black Start Units will be allocated to the owners based on ownership percentage
  - Monthly credit is equal to 1/12 of its annual Black Start Service revenue requirement for eligible critical Black Start Units
    - Credits are only paid if a unit meets all criteria for Black Start Service and is in good standing with the PJM testing requirements for Black Start Units
    - Monthly credits forgone due to non compliance cannot be recovered

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Black Start Service Charges

- Monthly charges are allocated to PJM customers include:
  - Pool-wide black start revenue based on the annual revenue requirements (June 1 – May 31)
    - Monthly charge is equal to 1/12 of its annual Black Start Service revenue requirement for eligible critical Black Start Units
  - Black start testing costs for critical Black Start Units
    - Requirement for testing every 13 months

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Black Start Service Charges

- Black Start service charges allocation
  - Charges are allocated to point-to-point Transmission Customers and network zonal Transmission Customers (NSPL)
  - Ratio share of charges are first calculated for point-to-point customers, remaining charges are allocated to the network customers serving load in a transmission zone
- Firm and Non-Firm Point-to-Point transmission is compared to total transmission, used to determine the adjustment factor for the ratio share
  - Usage varies month to month, around 7% of black start charges allocated to non-zone transmission

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Black Start Service Charges

- Remaining allocation to network customers serving load in that transmission zone based on their monthly network service peak load contributions.

- Network customers are allocated zonal rates and are based on Black Start Service capability in that zone
  - Revenue requirements for Black Start units designated in a TO restoration plan as critical will be allocated to that TO zone
  - Shared resources serving multiple zone will have their annual revenues allocated to the TOs by a critical load percentage share

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