

Real-Time Operational Considerations



Objectives

Students will be able to:

- Identify the various conditions & considerations for operating during real-time
- Describe the process for maintaining voltage schedules & guidelines at PJM
- Identify the reporting guidelines and process for Instantaneous Reserve Check

System Dispatching in Real-Time Operations

When to Notify PJM

- Generation owners planning to run generation resources scheduled in the Day-ahead Markets are required to call the PJM Control Center at least 20 minutes prior to bringing the unit online. Generation owners of self-scheduled generation resources must also provide at least 20 minutes notice
- Generation owners must notify PJM when they are coming offline
- Any change in MW output requires notification to PJM

Unit Hourly Updates

- If the status changes during real-time (for example, the unit limits change), the Operating Company uses the Unit Hourly Updates web page to provide the updated status

Deviations from Day-ahead Market for Pool Scheduled Resources

- If a generation resource has been scheduled in the Day-ahead Market and wishes to deviate from that schedule (i.e. not run), the generation owner should contact the PJM Scheduling Coordinator to determine if this course of action is possible*
- The guideline for notifying PJM of deviations for pool scheduled resources will be the greater of the notification time plus time to start or 45 minutes

*If the PJM Scheduling Coordinator determines that the generation resource is not needed for reliability purposes for the operating day, the generation owner can decide not to run the resource and no forced outage will be incurred. The generation owner will be responsible for all imbalance and operating reserve charges

If the PJM Scheduling Coordinator determines that the resource is needed for reliability purposes, he/she will inform the generation owner. The generation owner may still elect to not run the resource, but a forced outage for the duration of the scheduled operation of the resource will be generated. The generation owner will be responsible for all imbalance and operating reserve charges

Switching Schedules

If a unit has been asked to extend its hours of operation in real time and the unit has a limited fuel supply and must utilize higher priced fuel to remain online, the participant must inform the PJM system operator of the fuel cost change by requesting the real time offer to be switched to one of the additional available schedules

- Give PJM system operator the Schedule Name and Schedule Description from Schedule Manager Page

Unit

Schedules

Dispatch Lambda

Market Results

Regulation Market

Synchronized Reserve Market

Nonsynchronized Reserve Market

DA Scheduling Reserve Market

Con Ed

Parameter Limits

Interface Pricing

Opportunity Cost Calculator

Schedule Offers

Schedule Detail

Schedule Manager

Schedule Selection

Schedule Manager

Portfolio: Unit:

Get Report

Get CSV Report

Pages: 1

Records: 1 - 3 of 3 matches.

Schedule Manager for

AddDeleteSubmit

	Schedule Name	Schedule Description	Schedule Type
<input type="checkbox"/>	SGAS	Lucky Start CT SGAS	05-Cost-PLS
<input type="checkbox"/>	CGAS	Lucky Start CT CGAS	06-Cost-PLS
<input type="checkbox"/>	KERO	Lucky Start CT Kero	11-Cost-PLS

PJM Procedure for Cost Reimbursement

Participants who have been asked by PJM to extend a unit's run time and in order to comply with that request procured higher cost fuel have until 12:00 noon on the following business day to submit an e-mail to **market_bids@pjm.com** with the following information:

- Unit Name
- Date of operation
- Time of extended operation
- ID number of new schedule
- Name of new Schedule
- Contact information (name of sender, phone, e-mail)
- Date and time of PJM Dispatch contact to generator
- Actual marginal cost of unit considering the actual cost of the fuel procured to continue operating

Unit Problems in Real-Time Operations

Unit Problems

Events that can influence Unit Operation

- Governor Control
- Blocked Governor
- AVR/PSS Out of Service
- Unable to Maintain Reactive Output

Governor Control

- Mechanism that senses machine speed and adjusts the input to the prime mover to change the mechanical power output of the machine to compensate for changes in load restoring frequency to nominal value
 - Fossil Unit: Controls the input of steam to the high pressure stage of the turbine
 - Hydroelectric Unit: Controls the flow of water into the hydraulic turbine
 - Combustion Turbine Unit: Controls the amount of fuel flow into the combustor
 - Wind Turbine: Controls the pitch of the blades

Blocked Governor

- Blocking the governor bypasses the governing feedback mechanisms maintaining the generator at a fixed output level
 - System instability can occur since fewer units will be able to respond to deviation in frequency
 - Longer period of time is needed to restore system frequency to normal

Blocked Governor

- Blocking a governor:
 - Notify PJM's Generation Dispatcher verbally of the outage
 - Create and submit an eDART ticket to notify PJM of an outage to the governor on the unit
 - Initiate the associated eDART governor ticket by submitting a "Start" time for the equipment outage
 - Update the unit parameters in eMKT
- Placing a governor in service:
 - Notify PJM's Generation Dispatcher verbally of the governor being placed into service
 - Close out the associated eDART governor ticket by submitting an "End" time for the equipment outage
 - Update the unit parameters in eMKT

Generator AVR/PSS Status Reporting

- Per NERC Standard VAR-002-2b
 - R3. Each Generator Operator shall notify its associated Transmission Operator as soon as practical, but within 30 minutes of any of the following:
 - R3.1. A status or capability change on any generator Reactive Power resource, including the status of each automatic voltage regulator and power system stabilizer and the expected duration of the change in status or capability
 - R3.2. A status or capability change on any other Reactive Power resources under the Generator Operator's control and the expected duration of the change in status or capability
- Reporting of AVR status and Reactive Capability changes accomplished via eDART generator reporting

Generator AVR/PSS Status Reporting

- PJM Manual 14-D;
 - Excluding the time period when a generator is in the startup or shutdown mode, whenever a PJM unit's Automatic Voltage Regulation (AVR) status is off (or is planned to be off), the generator's owner/operator must immediately enter a ticket via eDART. For real-time changes, the generator's owner/operator must also notify the PJM Power Dispatcher (PD) and the respective TO by phone

Generator AVR/PSS Status Reporting

- PJM Manual 14-D;
 - Generation Owners/Operators must coordinate any voltage schedule issues (including stability, automatic voltage regulator and power system stabilizer outages) with PJM and the TO. In the event that automatic voltage regulating devices are out-of-service, the Generator shall provide manual voltage regulation to maintain the prescribed voltage schedule

Generator AVR/PSS Status Reporting

- PJM Manual 14-D;
 - The Generator must notify PJM and the TO with as much lead-time as possible prior to performing all voltage regulator and power system stabilizer maintenance. Notifications of unplanned outages on automatic voltage regulators (AVR) and/or power system stabilizers (PSS) must be communicated to PJM and the TO as soon as possible but no later than within 30 minutes of the occurrence. For modeling accuracy the provision of telemetered AVR and PSS status points by Generator Operators to PJM is preferred

What Reactive Reserve information is reported?

- MOCs/GOs must report to the TO and PJM any limitation or restriction on their unit which would prevent it from being able to follow it's reactive capability curve as recorded in eDART
 - Unless an eDART ticket already exists documenting the condition
- Submit an updated capability curve via eDART

Voltage Schedules

Voltage Limits

- Established by equipment manufacturers
 - Affected Equipment
 - Motors
 - Transformers
 - Generators
 - Loads
 - Capacitors
- ANSI Standards provide basis for voltage schedules
 - 97.5% - 105.0% Normal
 - 95.0% - 105.8% Emergency
 - These limits are for customer voltage

Purpose Of PJM Voltage Limits

- Voltage limit
 - Maintain system reliability
 - High voltage limit protects equipment from damage
 - Low voltage limit protects system from voltage instability and equipment damage

High Voltage Causes

- Causes of High Voltage
 - Light loads
 - Caused by excess line capacitance
 - Voltage rise in area rather than a single bus
 - Switching in a line with high capacitive charging current
 - Reactive supplied by charging of line
 - Other
 - Voltage regulation malfunction
 - Excess VAR sources on system

Low Voltage Causes

- Causes of Low Voltage
 - Excessive VAR loading
 - Typically over an area, not a single bus
 - Voltage regulation equipment malfunction
 - Generator voltage regulator may fail
 - Transformer tap hang-up
 - Typically at a single bus, not an area
 - May result in an imbalance in MVAR flows or circulating MVAR
 - Geo-Magnetic Disturbances
 - Increased VAR requirement in system
 - Var absorption by EHV transformers

Voltage Deviations

- Consequences of deviations from voltage limits
 - High voltage
 - Light bulb life decreased
 - Electronic devices life decreased
 - Low voltage
 - Dim lights
 - Slow heating of heating devices
 - Difficulty starting motors
 - Overheating/damage to motors

Voltage Schedules

- NERC Standard VAR-001:
 - Each TOP shall:
 - Specify a voltage or reactive power schedule
 - Provide the schedule to the GOP
 - Direct them to follow it with AVR in service
 - Provide the GOP with the notification requirement for deviations from the schedule
 - Provide the criteria used to develop the schedules
- The TO/TOP Matrix identifies shared or assigned responsibilities

Voltage Schedules

- **PJM:**
 - Requires the following subset of generators to follow voltage schedules:
 - Individual generating units greater than 20 MVA
 - Generators that aggregate to 75MVA or greater that are connected to a common bus
 - Black start generators
 - Any other Generation Owners/Operators that request a voltage schedule

Voltage Schedules

- **PJM:**
 - Will define exception criteria
 - Reactive and Power Factor Schedules are considered as exceptions
 - Requires PJM Transmission Owners to notify generators in writing of TO voltage schedules or PJM default schedule
 - If the TO does not provide a TO voltage schedule to a generator in their zone they must notify PJM and PJM will notify generator in writing of PJM default voltage schedule

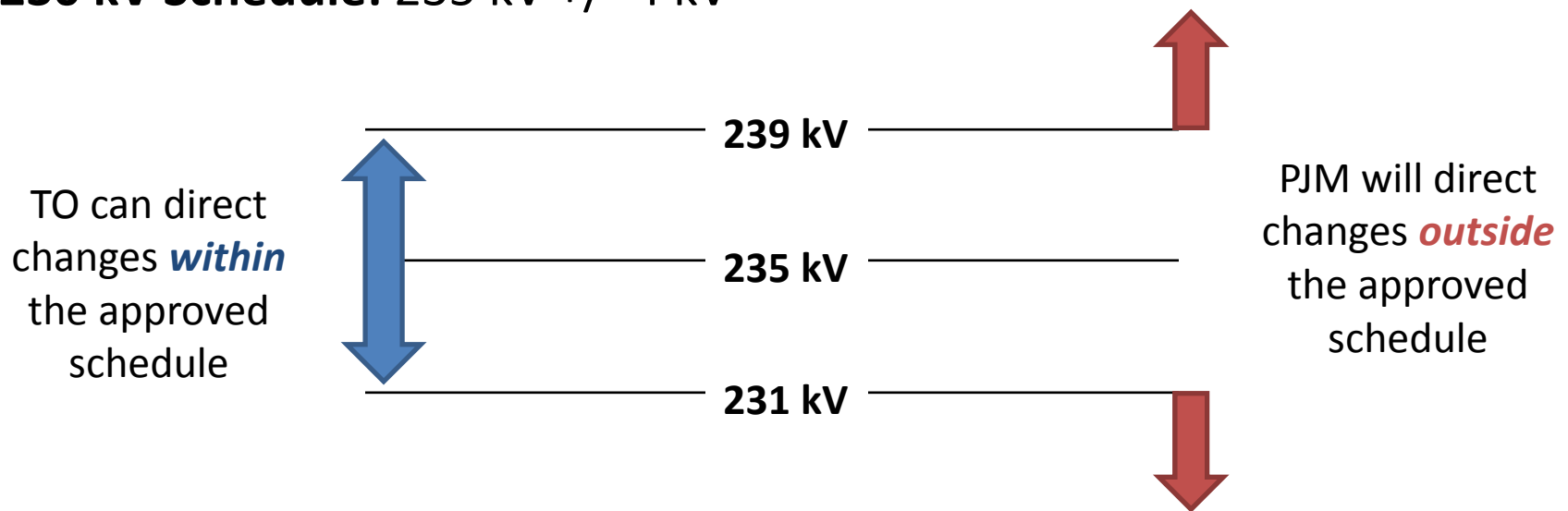
PJM Default Generator Voltage Schedules									
Voltage Level (kV)	765	500	345	230	161	138	115	69	66
Schedule (kV)	760.0	525.0	350.0	235.0	164.0	139.5	117.0	70.0	67.0
Bandwidth (+/- kV)	+/- 10.0	+/- 8.0	+/- 7.0	+/- 4.0	+/- 4.0	+/- 3.5	+/- 3.0	+/- 2.0	+/- 1.5

Voltage Schedules

- **PJM will direct:**
 - Deviations from default voltage schedules based system conditions
 - Generators to adjust voltage schedules if such a direction adversely impacts the units MW output
 - Generator to come online or remain online in the condensing or generating mode to provide voltage support
- **TO (via TO/TOP Matrix) can:**
 - Request generators to adjust MVAR output within the prescribed voltage schedule

Voltage/Schedule Adjustments

230 kV Schedule: 235 kV +/- 4 kV



Identify how generator owners are informed of their voltage schedules

- Generation Owner/Operator shall:
 - Follow the voltage schedule with the AVR in service
 - If AVR is out of service, GO/GOP must notify PJM and TO
 - Communicate voltage schedule concerns to PJM via the PJM TO for resolution
 - If there are additional reserves based on D-Curve:
 - Generator is required to notify PJM and the TO that they cannot maintain their assigned voltage schedule and provide updated D-Curve via eDART
 - If operating at full lead or full lag MVAR based on submitted D-Curve:
 - Generator is required to notify PJM and the TO that they cannot maintain their assigned voltage schedule
 - PJM will determine if MW reduction is required in order for unit to adjust MVAR output to maintain voltage schedule

Instantaneous Reserve Check (IRC)

PJM Instantaneous Reserve Check

- IRC is used to verify PJM's reserve situation
 - **ALL** generators must report their reserve information to PJM when requested
 - A minimum of one request via PJM All-Call before each daily peak
 - Usually 30 to 45 minutes prior to the peak
 - Could be more than 2 requests in a day depending on system conditions
 - Establish benchmarks which can be used to estimate reserves
 - Determine if reserve shortages exist and what if any emergency procedures should be declared

PJM Instantaneous Reserve Check

- Expectations:
 - Receive accurate member information “Instantly”
 - Data accuracy – maintain hourly updates in “eMarket”

Reporting Reserves

- The following reserve information must be submitted for each control area in which a member has generation resources located
 - Operating Reserve
 - Synchronized Reserve
 - Quick Start
 - Hydro
 - Other
 - Supplemental

Some Notes!

- Reserve quantities should reflect current regulation assignments
- If a Maximum Generation Alert is issued and Maximum Emergency Generation is called into the capacity, Emergency Maximum should be used in place of Spin Max or Economic Maximum
- TTS = Time to start
- Eco Max value used in calculations ONLY when no Spin Max value is provided

Operating Reserves

- Operating Reserves: Offline + Online
 - Offline
 - Offline = lesser of:
 - *Spin Max*
 - *Spin Ramp Rate X (30 min – TTS)*
 - *NOTE: Offline Reserve Units that have a (Notification + TTS) \leq 30 minutes should be included*
 - Online
 - Online = lesser of:
 - *Ramp rate X 30 min*
 - *Spin Max – Current MW level*

Operating Reserves Example

Gen	Fuel Type	Emerg. Min	Eco Min	Eco Max	Spin Max	Emerg Max	Current MW output	Spin Ramp Rate MW/Min	Notification &TTS
Amus	Hydro	10	15	180	190	200	80	20	10 Min
Grange	CT	0	0	600	600	600	0	10	5 Min

- Calculate the Operating Reserves for the Amus and Grange units.
 - Amus:
 - Online Unit
 - $(\text{Spin Ramp Rate} \times 30 \text{ Min}) = (20 \text{ MW} \times 30 \text{ min}) = 600 \text{ MW}$; or
 - $(\text{Spin Max} - \text{Current Output}) = (190 \text{ MW} - 80 \text{ MW}) = 110 \text{ MW}$
 - Grange:
 - Offline Unit
 - Spin Max = 600 MW; or
 - $(\text{Spin Ramp Rate} \times (30 \text{ min} - \text{TTS}))$

Synchronized Reserves

- Synchronized Reserve
 - Synch Reserve = lesser of:
 - *Spin Ramp Rate * 10 min*
 - *Spin Max – current MW level*

Synchronized Reserves Example

Gen	Fuel Type	Emerg. Min	Eco Min	Eco Max	Spin Max	Emerg Max	Current MW output	Spin Ramp Rate MW/Min	Notification &TTS
Amus	Hydro	10	15	180	190	200	80	20	10 Min
Grange	CT	0	0	600	600	600	0	10	5 Min

- Calculate the Synchronized Reserves for the Amus and Grange units.
 - Amus:
 - $(\text{Spin Ramp Rate} \times 10 \text{ Min}) = (20 \text{ MW} \times 10) = 200\text{MW}; \text{ or}$
 - $(\text{Spin Max} - \text{Current output}) = (190 \text{ MW} - 80 \text{ MW}) = 110 \text{ MW}$
 - Grange:
 - 0 MW – Offline Unit

Quick Start Reserves

- Quick Start Reserves
 - Comprised of:
 - Hydro
 - Non-Hydro
 - Quick Start Reserve = lesser of:
 - *Spin Max*
 - *Spin Ramp rate * (10 min – TTS)*

NOTE: Offline Reserve Units that have a (Notification + TTS) ≤ 10 minutes should be included

Quick Start Reserves Example

Gen	Fuel Type	Emerg. Min	Eco Min	Eco Max	Spin Max	Emerg Max	Current MW output	Spin Ramp Rate MW/Min	Notification &TTS
Amus	Hydro	10	15	180	190	200	80	20	10 Min
Grange	CT	0	0	600	600	600	0	10	5 Min

- Calculate the Quick Start Reserves for the Grange unit
 - Grange:
 - Spin Max = 600 MW
 - Spin Ramp rate * (10 min – TTS)
 - $(10 \text{ MW} \times (10 \text{ min} - 5 \text{ min})) = (10 \text{ MW} \times 5 \text{ Min}) = 50 \text{ MW}$

Supplemental Reserves

- Supplemental Reserve (formerly Secondary)

$$\text{Supplemental Reserve} = \text{Operating Reserve} - \text{Primary Reserve}$$

- Supplemental Reserve for Amus & Grange:
 - $((\text{Amus Operating} + \text{Grange Operating}) - (\text{Amus Primary} + \text{Grange Primary}))$
 - $((110 \text{ MW} + 250 \text{ MW}) - (110 \text{ MW} + 50 \text{ MW})) = (360 \text{ MW} - 160 \text{ MW}) = \mathbf{200 \text{ MW}}$

PJM Instantaneous Reserve Check

- Once data is received from Member, PJM determines:
 - PJM Operating Reserve
 - Adjusted Primary Reserve vs. requirement
 - Adjusted Synchronized Reserve vs. requirement
 - Unaccounted for capacity
 - Area Synchronized Reserve levels
- PJM compares values calculated from Member data to reserve requirements to determine deficiencies
- PJM report results to Members via eDART

PJM Instantaneous Reserve Check

- eDART is the tool used to report reserve information



The screenshot displays the PJM eDART web application. On the left sidebar, the 'Instantaneous Reserve Check' button is highlighted with a red box and a hand icon pointing to it. The main content area is titled 'IRC Company Data'. It includes fields for 'Company:', 'Request ID: 217', 'Timestamp: 07/08/2011 11:24', and 'User Name:'. Below these fields is a table titled 'Company Data' with columns for PJMCZ, Mid Atl, AP, DLCO, CE, and Western. The table contains rows for 'Operating Reserve', 'Synchronized Reserve', 'Quick Start', 'Hydro', 'Other', and 'Supplemental'. At the bottom of the form are buttons for 'Submit Form', 'Refresh', and 'Main Menu'.

	PJMCZ	Mid Atl	AP	DLCO	CE	Western
Operating Reserve		0				0
Synchronized Reserve		0				0
Quick Start						
Hydro		0				0
Other		0				0
Supplemental		0				0

PJM Instantaneous Reserve Check

- Company Input:
 - Operating Reserve
 - Synchronized Reserve
 - Quick-Start Reserve
 - Hydro
 - Non-hydro reported separately
 - Supplemental Reserve

The screenshot shows a web form titled "IRC Company Data". At the top, it displays "Company:" followed by "Request ID: 2179" and "Request Timestamp: 02/08/2011 11:24". Below this, it shows "User Name:" and "Posted Timestamp:". The main section is a table titled "Company Data" with columns for PJMCZ, Mid Atl, AP, DLCO, CE, and Western. The rows are: Operating Reserve, Synchronized Reserve, Quick Start (with sub-rows for Hydro and Other), and Supplemental. Each row has input fields for the six regions. The PJMCZ column has a dropdown menu. At the bottom, there are three buttons: "Submit Form", "Refresh", and "Main Menu".

	PJMCZ	Mid Atl	AP	DLCO	CE	Western
Operating Reserve	<input type="text"/>	0	<input type="text"/>	<input type="text"/>	<input type="text"/>	0
Synchronized Reserve	<input type="text"/>	0	<input type="text"/>	<input type="text"/>	<input type="text"/>	0
Quick Start						
Hydro	<input type="text"/>	0	<input type="text"/>	<input type="text"/>	<input type="text"/>	0
Other	<input type="text"/>	0	<input type="text"/>	<input type="text"/>	<input type="text"/>	0
Supplemental	<input type="text"/>	0	<input type="text"/>	<input type="text"/>	<input type="text"/>	0

NOTE: Reserve quantities must reflect current regulation assignments

If eDART is unavailable, the values are reported via telephone to the PJM Generation Dispatcher

PJM Instantaneous Reserve Check

- As a group, discuss consequences of not submitting IRC information or submitting incorrect IRC information
- List the reliability and economic consequences:

PJM Instantaneous Reserve Check

Control Zone	Gen	Fuel Type	Emerg. Min	Eco Min	Eco Max	Spin Max	Emerg Max	Current MW output	Ramp Rate MW/Min	Notification and TTS
AEP	Columbus	Hydro	5	10	225	230	250	0	25	5
AEP	Lexington	Fossil	200	225	700	720	750	680	8	360
AP	Bedford	CC	80	100	300	300	310	210	15	20
CE	Elmwood	Nuclear	1200	1200	1200	1200	1200	1200	5	2880
DAY	Whitehouse	Hydro	50	70	400	400	440	0	30	14
DLCO	Pleasantville	Wind	0	0	70	70	70	45	1	0
DOM	Richmond	CT	0	20	600	600	600	0	50	7
DOM	Corolla	CT	0	5	25	30	30	0	3	2
PJMCZ	Elizabeth	Fossil	100	200	590	590	600	410	20	720
PJMCZ	Lebanon	Fossil	300	400	1150	1150	1200	620	10	1200

IRC Exercise

- Given the portfolio:
 - Fill out the IRC report in eDART with the following values:
 - Operating Reserve
 - Synchronized Reserve
 - Quick Start
 - Hydro
 - Other
 - Supplemental

IRC Report

Normal Operating Day

	PJMCZ	AEP	AP	CE	Day	DLCO	DOM
Operating Reserve							
Synch Reserve							
Quick Start Hydro							
Quick Start Non-Hydro							
Supplemental							

IRC Report

Max Emergency Generation Alert issued and Max Emergency called into the capacity

	PJMCZ	AEP	AP	CE	Day	DLCO	DOM
Operating Reserve							
Synch Reserve							
Quick Start Hydro							
Quick Start Non-Hydro							
Supplemental							

Questions?

Resources and References

- PJM. (2014). *PJM Manual 14-D: Generation Operational Requirements (rev. 28)*. Retrieved from <http://www.pjm.com/~media/documents/manuals/M14D.ashx>