OFFICE OF UTILITIES REGULATION
Regulating Utilities for the Benefit of All

USAID
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PREPARATION AND PROMULGATION OF ELECTRICITY SECTOR CODES

Dispatch Code

Work Shop 2

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Contents

BACKGROUND

The Electricity Act 2015 (EA2015) establishes the following:

Single Buyer – means the licensee whose license obligates it to purchase electricity generated by independent power producers and persons having net billing arrangements.

System – with respect to electricity, means the physically connected generation, generation, transmission and distribution facilities operated under the central management of the system operator.

System Operator – means the licensee holding the dispatch license that is a ring fenced department within the Single Buyer.

Dispatch Activities – means the activities involved in the central management and direction of generating plants and other sources of supply to the system in order to achieve the optimal safety, reliability and economic supply of electricity.

Dispatch Code – means the rules made by the Office, with the approval of the Minister, to govern dispatch activities.

BACKGROUND 2

The EA2015 includes the following conditions related to dispatch activities:

STRUCTURE

1. The System Operator shall separate dispatch activities from Transmission, Generation, Distribution and Supply activities.

2. Discrete System Operator department with separate staff to do dispatch activities. Head to report to board of the System Operator.

BACKGROUND 3

The EA2015 includes the following conditions related to dispatch:

Merit Order

1. Merit Order System to be defined in the Generation Code as per Second Schedule (Item 1)

2. Licensee to schedule and issue direct instructions for dispatch in accordance with a merit order system of available generation sets of each authorized electricity operator required or agreed to be subject to such schedule and instructions

3. Generation Licensee to comply with all directions from System Operator or face a breach

BACKGROUND 4

The EA 2015 Second Schedule establishes the following conditions related to dispatching:

Licensee to schedule and issue instructions for dispatch of available generation sets :

- Based on **Equal Incremental Cost** principle
- In ascending order of **marginal cost** in respect of an hour
- To the extent allowed by **transmission operating constraints**
- That will take into account **electricity delivered into or out of the System**, from or to other sources.
- That will aggregate and **be sufficient to match** at all times (as far as possible in view of the available of Gen sets) **demand forecast**.
- That will take into account **information provided by authorized electricity operators**
- That will take into account the need for an **appropriate margin of reserve** for security operation.

BACKGROUND 5

The EA 2015 Second Schedule establishes the following conditions related to dispatching:

- subject to **forecasted demand (including transmission and distribution losses).**
- subject to **economic and technical constraints imposed** from time to time on the system or any part thereof.
- subject to the **dynamic operating characteristics** of available gen sets.
- subject to **other matters** provided for in the **Gen Code**.

BACKGROUND 6

The EA2015 includes the following conditions related to dispatch:

Monitoring, Reporting and Auditing

1. Office to **monitor Dispatch Activities** to ensure Second Schedule defined Merit Order is being complied with.

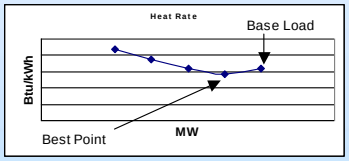
2. System Operator to establish technical arrangement **to give real time access** to Office, Minister and IPP's with real time information concerning dispatch activities.

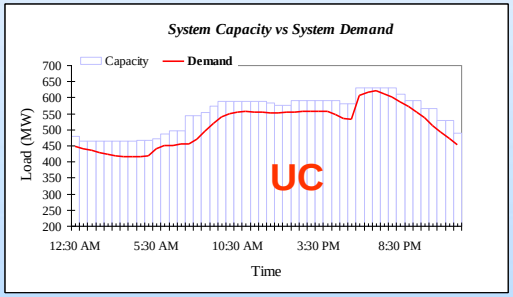
3. Generation Licensee to **comply with all directions from System Operator** or face a breach

4. Office to cause **independent audit of dispatch** activities at least annually
   - System Operator **to facilitate the Audit**
   - System Operator **to provide information requested by the auditor** to allow him to complete the audit in a reasonable timeframe.

5. System Operator to ensure that **dispatch activities information is shared with all generations** licensees whose generation capacity is in the dispatch activities, except where it is not relevant to them.

What is dispatch?





GENERATORS

	MERIT ORDER	UNIT NAME	CAPACITY (MW)	MERIT ORDER COST (US$/MWH)
BASELOAD	1	Hydro & Wind	21	
	2	Jamalcoa	11	78
	3	RF1	18	108
	4	RF2	18	110
	5	JPPC	60	111
	6	JEP	124	123
	7	OH4	69	135
	8	OH3	65	141
	9	HB6	69	141
INTERMEDIAT	10	BOCC	114	166
	11	OH2	60	175
	12	OH1	30	178
PEAKING	13	GT 11	20	186
	14	GT 12	38	226
	15	GT 13	38	229
	16	GT 10	33	278
	17	GT 3	22	294
	18	GT 9	20	296
	19	GT 5	22	317
	20	GT 7	14	336
	21	GT 8	14	341
	22	GT 6	14	352

ED

•50 HZ (AGC)

•30MW RESERVE

GRID NETWORK

GRID CONTROL

LOAD

L_1

L_2

L_3

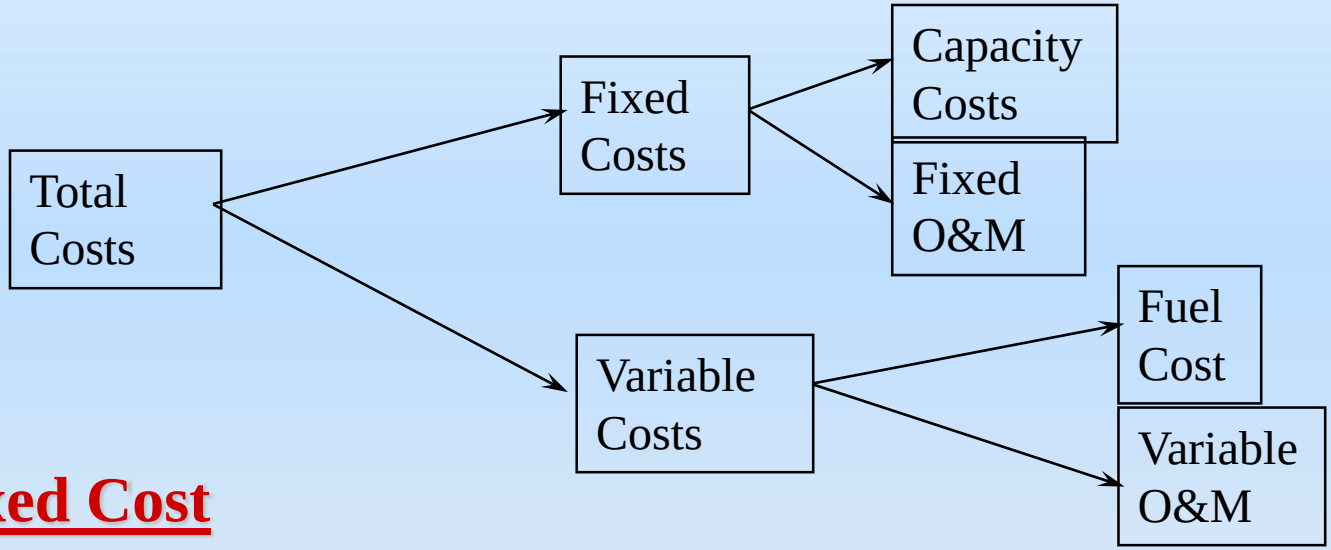
L_{15}

L_N

1 MW

GENERATING UNIT'S COSTS

Generating Unit Costs are broadly divided into fixed and variable costs



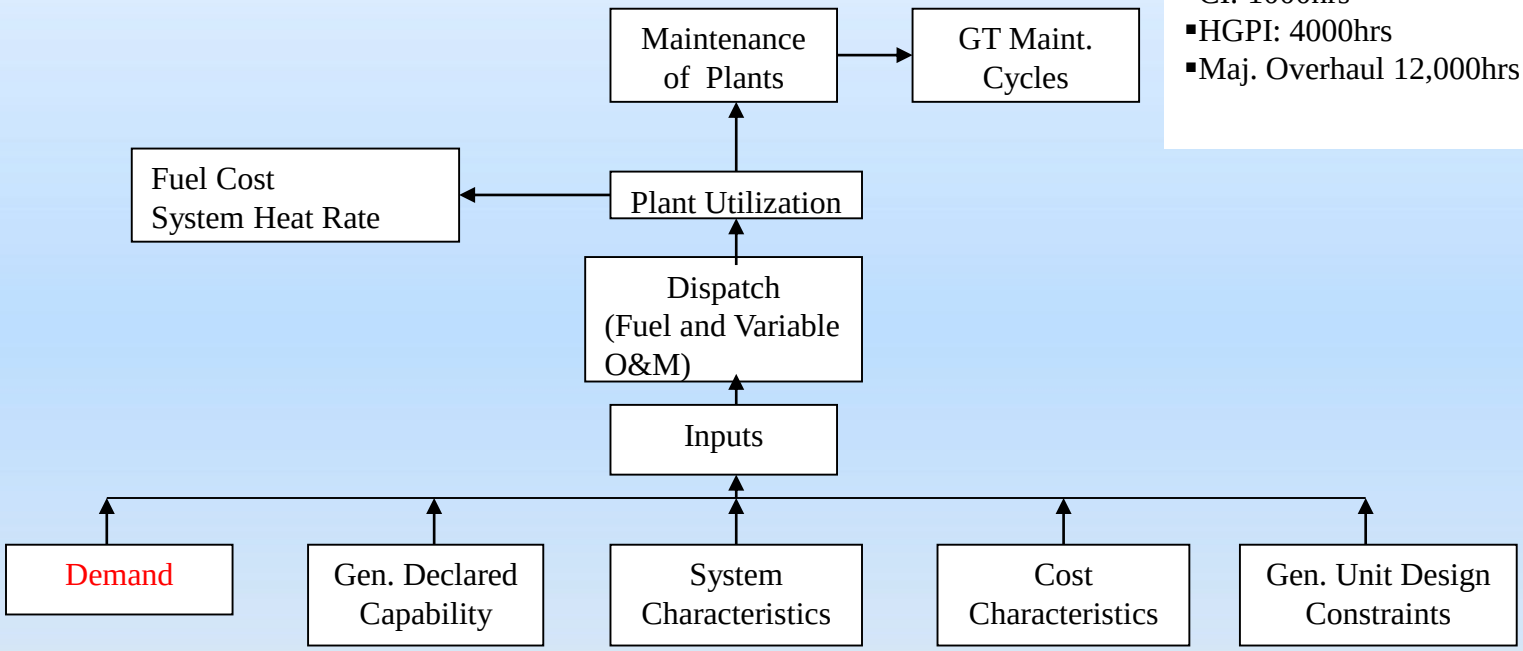
Fixed Cost

- Fixed Costs are costs incurred as a result of a capital investment over the lifetime of the investment
- These costs are invariable with respect to the amount of electricity produced, transmitted or used
- Consists of Capacity Cost and Fixed Operation and Maintenance Costs

Variable Costs

- These costs vary with respect to the amount of energy generated
- Consists of Fuel Cost (majority) and Variable Operation and Maintenance Costs
- Generating Units are economically dispatched in order to optimize & minimize their variable operating cost

DISPATCH CYCLE



- CI: 1000hrs
- HGPI: 4000hrs
- Maj. Overhaul 12,000hrs

- Availability
- Heat Rate
- MCR
- FOR (# of Trips)

- System Security

- O&M
- Fuel Prices

- Cycling Capability
- Min. Load
- Environmental Dispatch
- Ramp Rate
- Min. Up/down time (GT starts)
- Spinning Reserve Criteria

Dispatching Methodology

- **Unit Commitment** (UC) program is used to determine the schedule of adding & removing generators from the grid in order to minimize variable operating cost for the period.
  - Dynamic Programming Method is used.
  - Off-line optimization (typically 30 – 60 minutes intervals)

- **Economic Dispatching** is the process used to optimize and minimize the variable operating cost of units synchronized to the grid.
  - Equal Incremental Cost Principle is used.
  - This principle requires that the generator that can serve the next increment of demand at least cost is dispatched next.
  - Incremental Cost is derived from equations using a unit's heat rate data and fuel cost.
  - Typically Updates in 5 – 6 minutes intervals

- **Automatic Generation Control**
  - Updates in 5 – 6 seconds intervals

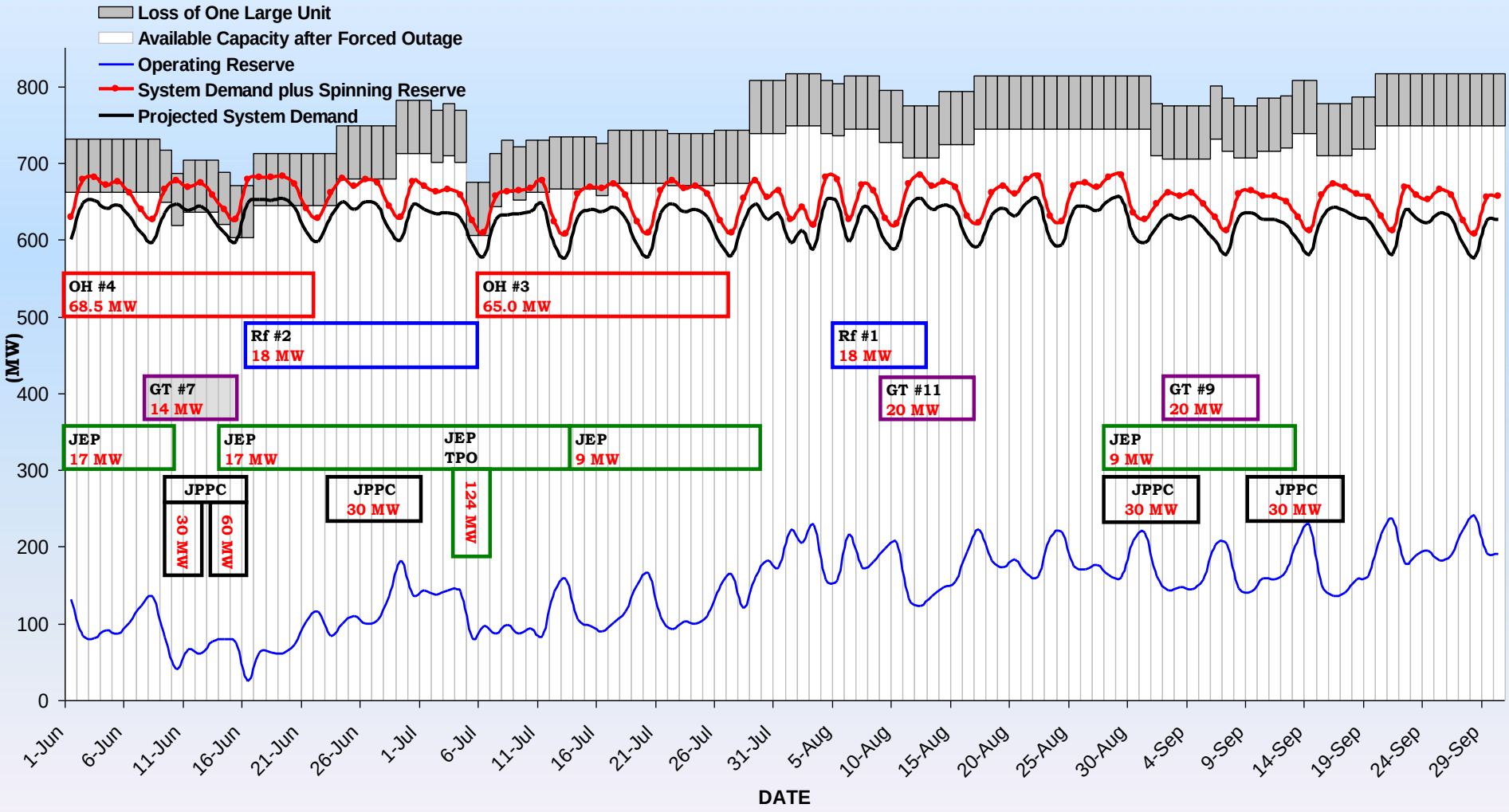
UNIT MODELS - ECONOMIC

- Thermal Plants
  - These units are modeled using their thermal characteristic in terms of heat rate (tested or guaranteed), fuel price and contractual O&M price (along with consideration for operational constraints)
- Purchase Arrangements
  - Typically provides a price ($/MWh) for energy provided. This type of model does not require specific information on the heat rate, fuel price or O&M
- Renewables
  - Typically modeled using energy price

INFLUENCE OF POWER GENERATING TECHNOLOGIES ON DISPATCH

- Dispatchable
  - These are technologies which by virtue of their design and/or use, are able to respond to requested changes in output
- Non-Dispatchable
  - These are technologies which by virtue of their design, energy source and/or use, are unable to respond to requested changes in output
- Must-Run
  - This characteristic is designated to account for technical constraints of generating units on the system

Typical Operations Profile



JPS DISPATCH PROCESS - PLANNING

- Annual Budgets are prepared from simulations for every day of the year utilizing annual maintenance plans, demand forecasts and fuel price projections
- Weekly outage requests are submitted by JPS and IPP units based on their annual schedules
- These outages are evaluated on the similar criteria of safety, system security and economics e.g. the effect of an outage on the system cost, or will this outage affect another outage already in progress on the T&D
- Load forecasting
  - Similar day load forecasting is done
- Unit Commitment
  - Day ahead Resource Scheduling and Unit Commitment
- A Daily Load Forecast and Unit Commitment Schedule is sent to the Control Room for execution

JPS DISPATCH PROCESS - EXECUTION

- Reviews Load Forecast and Unit Commitment Schedule periodically during shift and update as required
- System Operator uses unit commitment and economic dispatch software package to execute dispatch
- Manages critical system parameters such as MW, MVAR, Frequency & Voltage within prescribed tolerances
  - Evaluates specific scenario & contingencies based on safety and system security
  - Issue dispatch instructions to individual plants based on ED recommendations, subject to the above
  - Modify and or update execution strategy as appropriate
- JPS Provides daily dispatch data to the OUR

DISPATCH SHORT TERM OPERATIONAL PLANNING

The Short Term Dispatch Operations Planning is concerned with:

Dispatch Data Registration

Demand Forecasting

Merit Order Calculation and Reporting

Operating Margin;

Unit Commitment Forecasting and Reporting

Economic Dispatch Forecasting and Reporting

Heat Rate Policy (Development and Testing Schedule)

Dispatcher Training (Simulator setup and use)

DISPATCH SHORT TERM OPERATIONAL PLANNING

Dispatch Data Registration

Within the Data Categories and Stages in Registration each item of data is allocated to four categories:

1. Operational Data as required by the Dispatch Code.
2. Data Required for Demand Forecasting
3. Data required in accordance with the Merit Order requirements.
4. Design Data for Generator modelling for system simulations

DISPATCH SHORT TERM OPERATIONAL PLANNING

Demand Forecasting

Users on the Transmission System to provide Demand (MW and Mvar).

Phase	Applicable Parties	Forecast Data	Time period for which forecast data is required
Operational Planning 2 Years ahead (End of January each Year)	All Distribution System Users with Demands in excess of 5MVA	Hourly forecast of Active and Reactive Demand	For Day of Users Max Demand, Day of System Peak and Day of System Minimum
	Users whose actions, in the opinion of System Operator, can have an effect on the stability of the System	Active and Reactive Demand	At specified times each week in the forecast period as identified by the System Operator in advance. The times shall be identified in 1hour periods for each week.
PROGRAMMING PHASE 1 - 8 Weeks (By 10:00am each Friday)	All Users who forecast Demand changes in excess of 5MVA in any 1 hour period	Active and Reactive Demands	Any hour where the User forecasts a Demand change in excess of 5MVA for the period.
Control Phase 0 24hrs Commencing 00:00	all identified Users with Demand changes in excess of 5MVA in any 1 hour period	Active and Reactive Demands	Any hour where the Users forecasts a Demand change in excess of 5MVA for the period.

DISPATCH SHORT TERM OPERATIONAL PLANNING

Variable Resource Power Plant (VRPP) Forecasting

VRPP on the Transmission to provide quality resource forecast using industry proven methods

- Medium Term Forecast – rolling hourly forecast for the next 168hrs (7 days)
- Short Term Forecast – System Operator can request rolling five minute resource forecast for the next 6 hours

Embedded Generator Forecasting

Applies to Generators on the Distribution System not subject to central dispatch.

- System Operator to specify need where it reasonably determines that their output could affect demand forecasting

DISPATCH SHORT TERM OPERATIONAL PLANNING

System Operator and User Forecasts

The following factors should be taken into account:

- Historic Demand Data and trends
- Weather forecasts
- Incidence of major events or activities
- Generating Unit active power generation forecasts or schedules
- Demand transfers
- Interconnection with adjacent Connection Points
- Planned Demand reduction (e.g. block load shedding)
- Any other factor reasonably considered necessary that may impact the Demand forecast.

DISPATCH SHORT TERM OPERATIONAL PLANNING

Outage Planning

Generation Outage Planning:

1. The System Operator shall develop overall **generation maintenance plans for three (3) Years** in advance**. Three year plan becomes operational plan over time**
2. Generators are required to **submit on or before July 1st** of each Year a rolling three (3) Year plan for the scheduled maintenance requirement beginning in January of the following Year.
3. The System Operator shall **obtain Scheduling information from Generators for Embedded Generating Plant** not subject to Central Dispatch where it considers it appropriate and relevant.
4. The Scheduling information shall specify the following on an individual Generating Unit basis:
   - **the period the unit is required**
   - **the planned half-hourly output**
   - any other information the System Operator reasonably considers necessary
5. The System Operator shall endeavour to **schedule Outages in a non-discriminatory manner** as far as System security constraints allow.
6. System Operator and Generator shall make best efforts to ensure that **interconnection are maintained with the Generating Unit**.

DISPATCH SHORT TERM OPERATIONAL PLANNING

Operating Margin

1. The Operating Margin comprises **Contingency Reserve** plus **Operating Reserve**.

2. **Contingency Reserve** is the margin of Generation Capacity required in the period from 24 hours ahead down to real time.

   - provided by Generating Units which must be held available to Synchronize within a defined timescale.

   - Set by System Operator considering
     - Availability and historical reliability of Generating Units;
     - Notified Risks of Trip of Generating Units
     - Demand forecasting uncertainties

DISPATCH SHORT TERM OPERATIONAL PLANNING

Operating Margin

1. **Operating Reserve** provides spare Generation Capacity for Frequency control in real time (Spinning Reserve) and quick time contingency (10_minutes Reserve)'

2. The System Operator shall determine the amount of Spinning Reserve and 10 Minute Reserve to ensure System security.

3. The System Operator Operating Reserve policy shall consideration factors which including:
   - the magnitude of the **largest MW infeed** from Generating Units
   - the **predicted Frequency drop** following loss of the largest infeed as may be determined through simulation using a dynamic model.
   - the extent to which **Demand Control** can be implemented
   - the **cost of** providing Operating **Reserve** at any point in time
   - **ambient weather conditions** directly or indirectly affecting Generating Unit and/or Transmission System reliability.
   - Variability of **intermittent renewable generation**

DISPATCH SHORT TERM OPERATIONAL PLANNING

Merit Order System

1. The System Operator shall establish a **Merit Order** based on the real or contracted **Variable Operating Cost.**

2. The Variable Cost of each Generating Unit or Complex is the sum of the Variable Operating & Maintenance Cost (VOM) and the Fuel Cost.

3. In mathematical form:

Merit Order Cost ($/MWh) = Fuel Cost ($/MBTU) x Full Load Heat Rate (MBTU/MWh) + VOM ($/MWh)

- This information allows the System Operator to rank the Generating Units in the order of their Full Load Point cost of operation.

- The commitment and de-commitment of units shall be guided by parameters including load, available units, **the Merit Order Ranking** and the forecasted duration.

- **Dispatch level** of each Unit or Complex shall be determined by the application of the **equal incremental cost principles** in Economic Dispatch.

DISPATCH SHORT TERM OPERATIONAL PLANNING

Merit Order Reporting

1. The System Operator shall **notify the Generator as to the relative position** of its dispatchable Generating Unit(s) in the Merit Order in terms of ranking number each Week.

2. The System Operator shall **notify the OUR of the daily revised Unit Commitment Schedule and the actual dispatch** for the prior twenty four (24) hours.

3. Units that have been declared based on their contract, as **Take-As-Available, are not influenced by the merit order and equal incremental cost** optimization processes.

DISPATCH SHORT TERM OPERATIONAL PLANNING

Merit Order and Dispatch Input Updating

1. **Fuel Data and Variable O&M data** updated with latest available information based on procurement cycle and contractual agreements.

2. Merit Order to be **declared Monthly** and updated as data changes. Must be declared 24 hrs before use.

3. **Heat Rate data** derived from guaranteed contractual heat rate information for IPP's or test information for other thermal plants.
   - Heat Rate test to be conducted at least twice annually
   - Test to be done at a minimum four (4) MW output levels

4. System Operator to monitor and determine re-test in accordance with JPS Heat Rate Testing Policy.

DISPATCH SHORT TERM OPERATIONAL PLANNING

Unit Commitment Scheduling and Dispatch

In the preparation of Unit Commitment and Dispatch Schedule, the System Operator shall take into consideration the following factors:

- forecasted **Demand** and geographical Demand distribution
- each Generator's declaration of each **Generating Unit(s) MW capability** and availability
- Generator's contracted **operating characteristics**
- contracted and **declared Heat Rate** curve or point
- **fuel prices** and constraints
- System **reserve requirements**
- System **Stability implications**, frequency and voltage control
- System constraints.

This schedule shall be prepared for the following Week and revised on a daily basis

DISPATCH SHORT TERM OPERATIONAL PLANNING

Dispatcher Training Simulator

1. The System Operator shall maintain a functional Dispatcher Training Simulator (DTS).

2. The System Operator shall request and Generators shall **provide all the modelling data** required from each Generator

3. The Dispatcher Training Simulator shall be used
   - to evaluate the historical performance of the system
   - to validate historical actions taken
   - to train System operators in the management and control of the System.
   - to guide the development of any new Operating Policy and Procedure

4. The DTS used to **test the adequacy** of the System Operator's System **Restoration Procedures.**

DISPATCH Execution

Dispatch for Operations (Execution):

This section of the Dispatch Code covers the following areas:

- SCADA System Real Time Update (demand and generator availability and capability)
- Unit Commitment and Dispatch Real Time Update
- Non-Dispatchable (VRPP) monitoring and management
- Generator Outage Execution
- Generating Unit synchronization
- Frequency (AGC) and Voltage Control
- Reserve Margin Monitoring and Control
- Dispatch Deviation Tracking and Reporting
- After the Fact (AFE) Variance Analysis and Reporting
- Safety Co-ordination
- Contingency Planning;

DISPATCH Execution

UNIT COMMITMENT AND DISPATCH REAL TIME UPDATE

Dispatch Instructions:

- Real Power (MW) dispatch shall be **based on an Equal Incremental Cost principle** to minimize the variable operating cost.
- Dispatch Instructions are **normally given on a half hourly basis** or anytime that is warranted by the operational requirements of the System.
- **Reactive Power (MVAR)** is **dispatched at the discretion** of System Control Engineer to maintain the System Voltage within the tolerable limits.
- Generating Units operate at 0.85 pf but could be required to operate at as low as 0.8 pf and **can be requested to absorb reactive power .**
- Non-Dispatchable Generating Units shall operate as agreed upon between the System Operator and the Generator.
- The Generator shall **communicate** with the System Control Engineer **on matters of switching and Synchronization**

DISPATCH Execution

Frequency and Voltage Control

The **System Control Engineer** shall be **responsible** for issuing any instruction necessary to:

- Maintain the **voltage** on the Transmission System in accordance with the **normal operational limits of +/- 5%.**
- Maintain, or enable others to maintain, the **voltage of supply to consumers within the limits of +/- 5%** of the Nominal Operating Voltages.
- Supply the Reactive Power requirements of the System as economically as possible.
- Maintain **frequency** within the limits of **50 Hz +/- 0.2 Hz**.
- Designate Generating Units to operate in Dispatch or Spinning Reserve mode

DISPATCH Execution

Frequency and Voltage Control

The **Generator** shall be **responsible** for :

- Ensuring that the Generating Unit's mode of operation is as designated by the System Control Engineer.
- Ensuring that Generating Units operate in the required control mode.
- Ensuring that Generating Unit(s) automatic voltage regulators are in service continuously.
- Communicating any unusual voltage, frequency or dynamic disturbances occurring upon any Generating Unit.
- In the event of a sudden change in System Voltage, act according to System Operator instructions unless plant at risk.

DISPATCH Execution

Dispatch Deviation Tracking and Reporting

1. The System Operator shall **keep a record all dispatch instructions** and the compliance of each Generator with the instructions received.

2. Each Generator shall **keep a record all dispatch instructions received** and their level of compliance.

3. **Dispatch Deviation shall be calculated** by the System Operator for all Dispatchable Generators.

This information shall be **used to calculate the dispatch deviation penalties** for Generators which have a dispatch deviation penalty as part of their Power Purchase Agreement (PPA).

DISPATCH Execution

After-the-fact Evaluation

1. The System Operator shall perform simulations to determine the actual dispatch performance for each day.

2. The System Operator shall do a daily comparison of the Planned Unit Commitment and Dispatch with the Actual Unit Commitment and Dispatch Achieved.

3. The System Operator shall provide a Dispatch Variance Report to the OUR for each Day. This report should identify and quantify as best as possible the contributing factors to dispatch variance.

4. The System Operator must provide adequate explanation of all variances from the planned dispatch. Explanatory factors shall include
   - changes to Generator Capability, Availability and Efficiency
   - System Stability and Security
   - Frequency
   - Demand.

DISPATCH Execution

After-the-fact Evaluation

1. All **non-compliance with the required Merit Order dispatch shall be communicated** in writing by the OUR to the System Operator **within 3 months**.

2. The **System Operator** shall **keep a record all dispatch instructions and the compliance** of each Generator with the instructions received.

3. The OUR shall ensure that an **independent audit of the Dispatch** process is conducted annually.

4. All **Generators are required to keep a record of their dispatch performance** and shall provide reports to the OUR upon request.

5. Generators are also required to take all steps to facilitate and comply with the information requirements of the OUR commissioned annual Dispatch audit.

Key Issues and Next Steps

ISSUES

1. Real time access to dispatch

Next Steps

1. Receive, Review and include stakeholders comments