# MISO Hourly Scheduling Rules

PJM Interconnection - Generator Offer Flexibility Senior Task Force

June 19, 2015

# Overview

**Purpose**

- Discuss MISO' hourly Generation Offer structure/capability
- Reference:
    - Energy and Operating Reserve Markets Business Practices Manual BPM-002-r14
    - https://www.misoenergy.org/Library/BusinessPracticesManuals/Pages/BusinessPracticesManuals.aspx

# Exhibit 4-10: Generation Resource and DRR-Type II Economic Data Summary

| Generation and DRR-Type II Offer Data | Units | Day-Ahead Schedule Offer | Real-Time Schedule Offer | Notes |
|---|---|---|---|---|
| **Economic Offer Data** | | | | |
| Energy Offer Curve | MW, $/MWh | Hourly | Hourly | |
| No-Load Offer | $/hr | Hourly | Hourly | 4 |
| Regulating Reserve Capacity Offer | $/MWh | Hourly | Hourly | 1 |
| Regulating Reserve Mileage Offer | $/MW | Hourly | Hourly | 1 |
| Spinning Reserve Offer | $/MWh | Hourly | Hourly | 1 |
| On-Line Supplemental Reserve Offer | $/MWh | Hourly | Hourly | 1,2 |
| Off-Line Supplemental Reserve Offer | $/MWh | Hourly | Hourly | 3 |
| Hot Start-Up Offer | $ | Daily | Daily | 4 |
| Intermediate Start-Up Offer | $ | Daily | Daily | 4 |
| Cold Start-Up Offer | $ | Daily | Daily | 4 |
| Self-Scheduled Regulation | MW | Hourly | Hourly | 1 |
| Self-Scheduled Spinning Reserve | MW | Hourly | Hourly | 1 |
| Self-Scheduled On-Line Supplemental Reserve | MW | Hourly | Hourly | 1,2 |
| Self-Schedule Off-Line Supplemental Reserve | MW | Hourly | Hourly | 3 |
| Self-Scheduled Energy | MW | Hourly | Hourly | |

Note 1: If qualified
Note 2: If not Spin Qualified
Note 3: Quick-Start Resources only
Note 4: Default Offers are used if no values are submitted for Energy and Operating Reserve Markets

# Exhibit 4-10A: Generation Resource and DRR-Type II Operating Parameter Data Summary

| Generation and DRR-Type II Offer Data | Units | Day-Ahead Schedule Offer | Real-Time Schedule Offer | Notes |
|---|---|---|---|---|
| **Commitment Operating Parameter Offer Data** | | | | |
| Hot Notification Time | hh:mm | Hourly | Hourly | |
| Hot Start-Up Time | hh:mm | Hourly | Hourly | |
| Hot to Intermediate Time | hh:mm | Daily | Daily | |
| Intermediate Notification Time | hh:mm | Hourly | Hourly | |
| Intermediate Start-Up Time | hh:mm | Hourly | Hourly | |
| Hot to Cold Time | hh:mm | Daily | Daily | |
| Cold Notification Time | hh:mm | Hourly | Hourly | |
| Cold Start-Up Time | hh:mm | Hourly | Hourly | |
| Maximum Daily Starts | Integer | Daily | Daily | |
| Maximum Daily Energy | MWh | Daily | Daily | |
| Minimum Run Time | hh:mm | Daily | Daily | |
| Maximum Run Time | hh:mm | Daily | Daily | |
| Minimum Down Time | hh:mm | Daily | Daily | |
| Commitment Status | Select | Hourly | Hourly | 1 |
| Maximum Daily Regulation Up Deployment | MWh | NA | Daily | 9 |
| Maximum Daily Regulation Down Deployment | MWh | NA | Daily | 9 |
| Maximum Daily Contingency Reserve Deployment | MWh | NA | Daily | 9 |

| Dispatch Operating Parameter Offer Data | | | | |
|---|---|---|---|---|
| Hourly Economic Minimum Limit | MW | Hourly | Hourly | 1 |
| Hourly Economic Maximum Limit | MW | Hourly | Hourly | 1,5 |
| Hourly Regulation Minimum Limit | MW | Hourly | Hourly | 1,6 |
| Hourly Regulation Maximum Limit | MW | Hourly | Hourly | 1,6 |
| Hourly Emergency Minimum Limit | MW | Hourly | Hourly | 1 |
| Hourly Emergency Maximum Limit | MW | Hourly | Hourly | 1,5 |
| Maximum Off-Line Response Limit | MW | Hourly | Hourly | 1,4,6,8 |
| Energy Dispatch Status | Select | Hourly | Hourly | 1 |
| Regulating Reserve Dispatch Status | Select | Hourly | Hourly | 1,6 |
| Spinning Reserve Dispatch Status | Select | Hourly | Hourly | 1,6 |
| On-line Supplemental Reserve Dispatch Status | Select | Hourly | Hourly | 1,6 |
| Off-line Supplemental Reserve Dispatch Status | Select | Hourly | Hourly | 1,4,6 |
| Hourly Single-Directional-Down Ramp Rate | MW/min | N/A | Hourly | 1,3 |
| Hourly Single-Directional-Up Ramp Rate | MW/min | N/A | Hourly | 1,3 |
| Hourly Bi-Directional Ramp Rate | MW/min | N/A | Hourly | 1,3 |
| Hourly Ramp Rate | MW/min | Hourly | Hourly | 1,2,3 |
| Single-Directional-Down Ramp Rate Curve | MW/min | N/A | Hourly | 3 |
| Single-Directional-Up Ramp Rate Curve | MW/min | N/A | Hourly | 3 |
| Bi-Directional Ramp Rate Curve | MW/min | N/A | Hourly | 3 |
| Combined Cycle Status | Select | Daily | Daily | |
| Forecast Maximum Limit | MW | Rolling 5-Min | Real-Time | 7 |

# Day-Ahead Resource Offer Parameter Hierarchy

Resources provide default parameters indicating the capabilities of the unit

- Initial parameters are provided during registration
- Default Day-Ahead Resource Parameters are updated through the market systems

Hourly Day-Ahead Offer Parameters override...
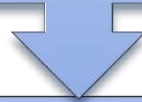
Default Day-Ahead Offer Parameters

# Day-Ahead Unit Limits – Hourly Dispatch Limits

## Emergency – Minimum and Maximum

• Levels the unit can produce and maintain stable operations under Emergency conditions and it may vary each hour

## Economic – Minimum and Maximum

• Output level limits from the unit under non-Emergency conditions
• Normal operation of the unit and it may vary each hour

## Regulation – Minimum and Maximum

• Minimum and maximum operating levels for a Resource that can provide Regulation and it may vary each hour

**Emergency Maximum**

**Economic Maximum**

**Regulation Maximum**

**Regulation Minimum**

**Economic Minimum**

**Emergency Minimum**

**Off-line**
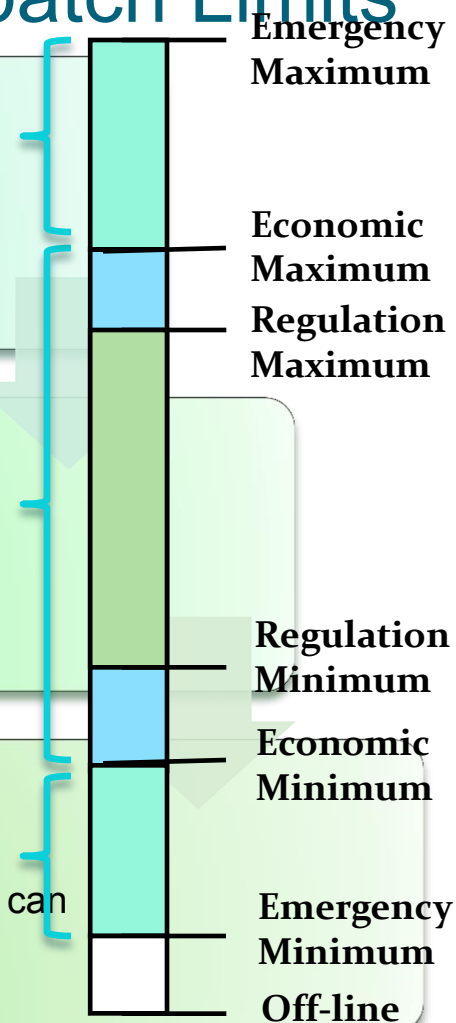
# Day-Ahead Unit Limits – Runtimes, Starts, and Notification Times

Submitted on a daily and hourly basis
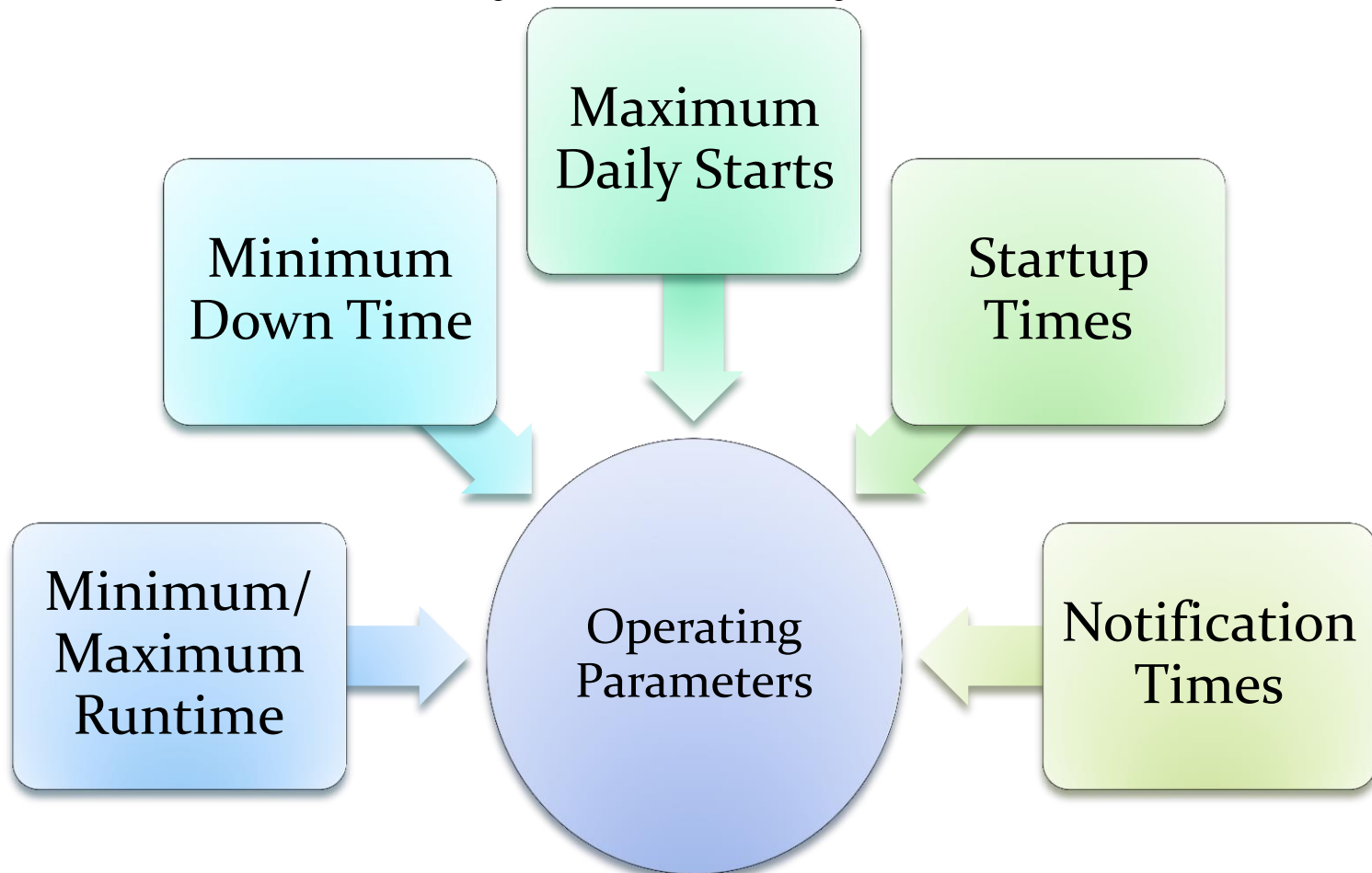
# Day-Ahead Start Up and No Load Costs

Part of the default offer, but can be overridden in the Day-Ahead Schedule Offer.  (Also applies to the Real-Time Schedule Offer)

| Start-Up Costs | • Cost to startup the unit based on the unit status (cold, intermediate or hot) and the commitment start time<br>• Designated on a daily basis |
|---|---|
| No Load Costs | • Cost associated with operating a unit at zero output<br>• Designated on an hourly basis. |

# Day-Ahead Resource Offer Commitment Status

All Schedule Offers for generation resources have an associated offer commitment status that impacts the considerations made regarding unit commitment

| | |
|---|---|
| **Outage** | • Resource is not available for commitment because the resource is on a planned or forced outage |
| **Emergency** | • Resource is available for commitment in emergency situations only |
| **Economic** | • Resource is available for commitment by MISO |
| **Must-Run (self-commit)** | • Resource as committed per MP request and may be available for dispatch by MISO |
| **Not Participating** | • Resource will not participate in the E&OR Markets but is otherwise available |

# Day-Ahead Resource Energy Offer Dispatch Status

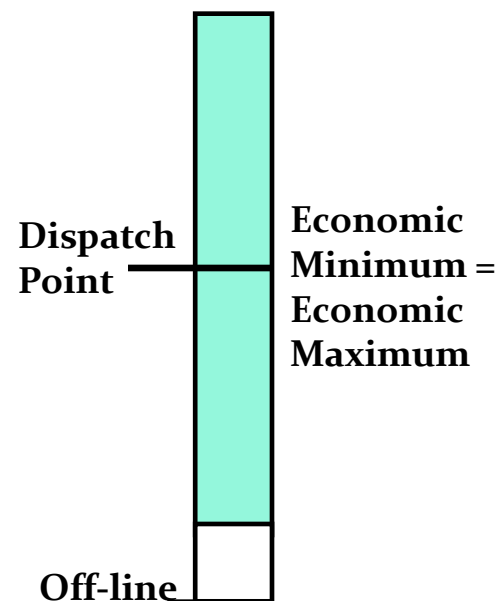Each generation resource can designate a dispatch status on an hourly basis

**Economic**

Respond according to economics

**Self-Schedule**

Price-taker up to the Self-Scheduled output level

Two dispatch status options are valid for Energy

# Day-Ahead Self-Schedule Offer for Energy

**Dispatch Point**

**Economic Minimum = Economic Maximum**

**Off-line**

**Example of Self-Schedule in Whole**

**Self-Schedule in whole**

- Submit Economic Minimum equal to Economic Maximum
- Submit Commitment Status of "Must Run"
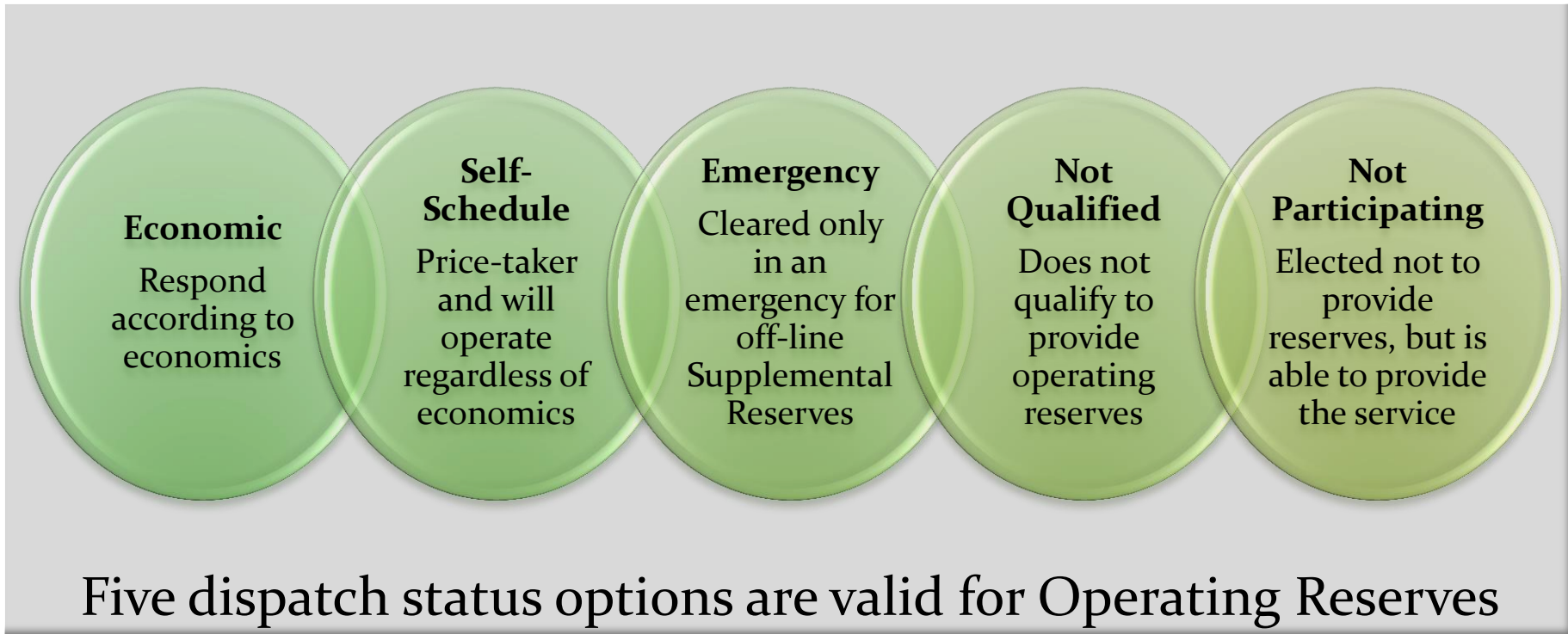
**Self-Schedule in part**

- Different Economic Minimum/ Maximum values provides a band for economic dispatch
- Self-Schedule in part is a price taker up to Self-Schedule MW Amount
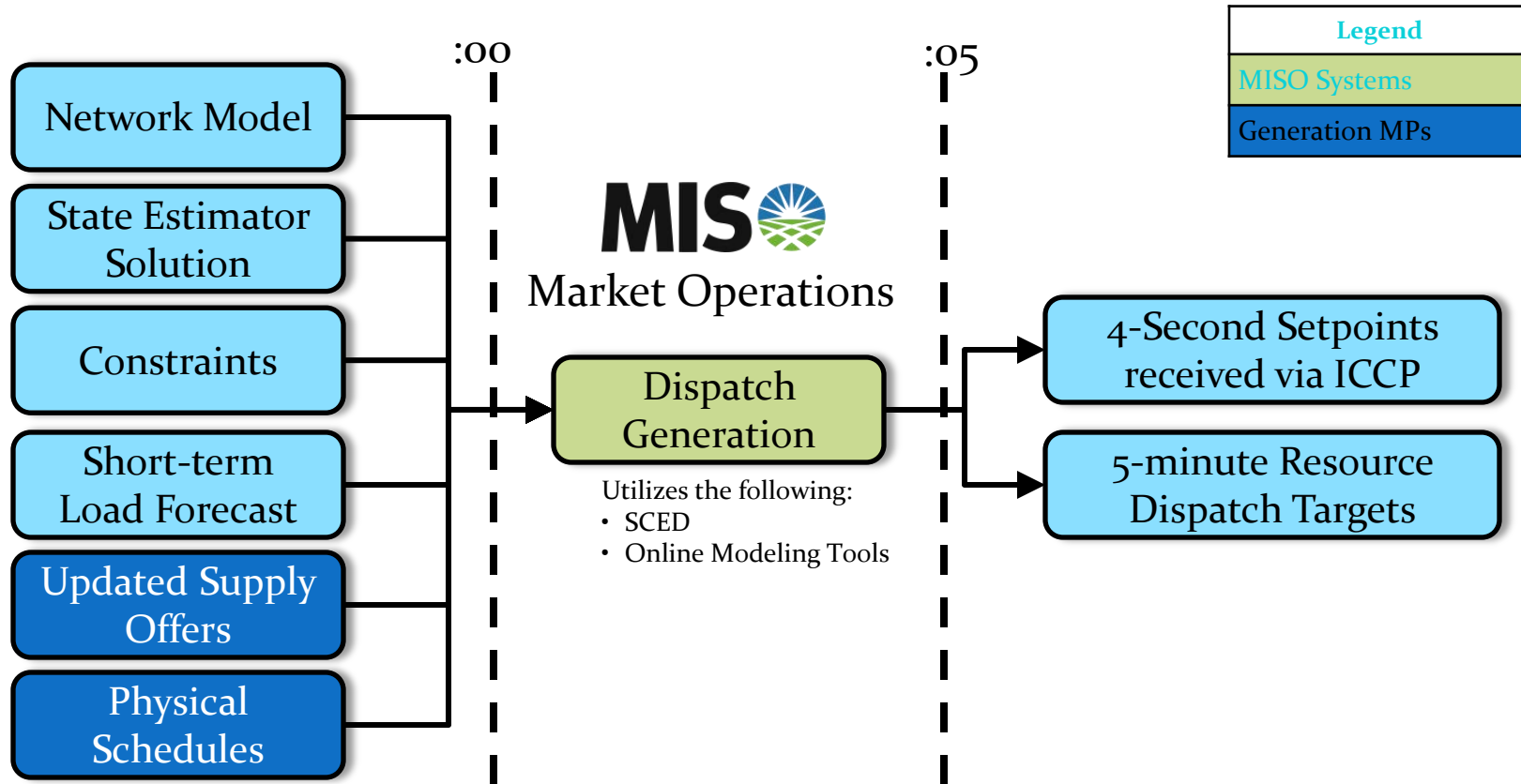- Submit Commitment Status of "Must Run"

**Economic Maximum**

**Economic Dispatch Range**

**Self-Schedule MW Amount**

**Self-Schedule Range**

**Economic Minimum**

**Off-line**
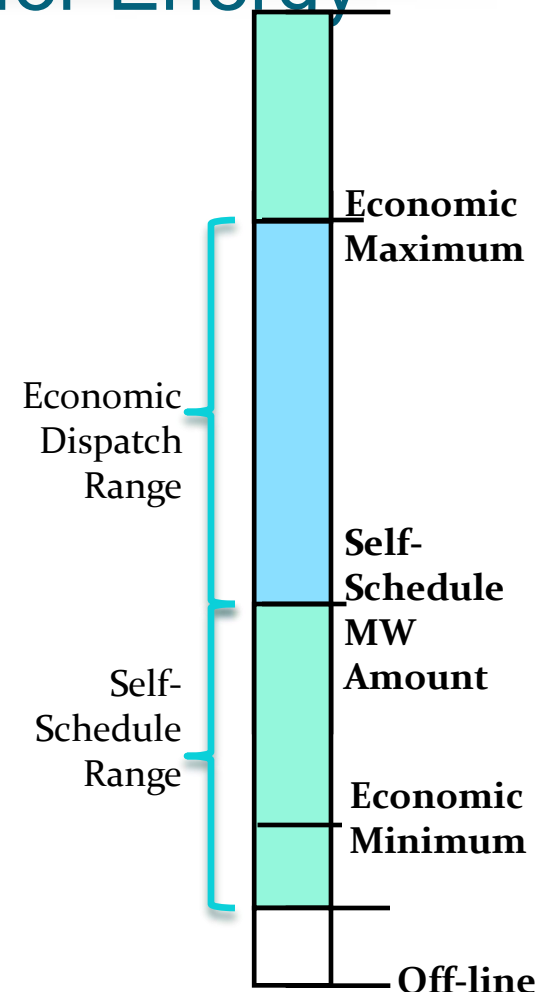
**Example of Self-Schedule in Part**

# Day-Ahead Operating Reserves Offer Dispatch Status

## Each generation resource can designate a dispatch status on an hourly basis

**Economic**
Respond according to economics

**Self-Schedule**
Price-taker and will operate regardless of economics

**Emergency**
Cleared only in an emergency for off-line Supplemental Reserves

**Not Qualified**
Does not qualify to provide operating reserves

**Not Participating**
Elected not to provide reserves, but is able to provide the service

Five dispatch status options are valid for Operating Reserves

# Real-Time Market addresses actual system conditions



| Legend | | |
|---|---|---|
| MISO Systems | | |
| Generation MPs | | |

Network Model

State Estimator Solution

Constraints

Short-term Load Forecast

Updated Supply Offers

Physical Schedules

:00

:05

**MIS** Market Operations

Dispatch Generation

Utilizes the following:
- SCED
- Online Modeling Tools

4-Second Setpoints received via ICCP

5-minute Resource Dispatch Targets
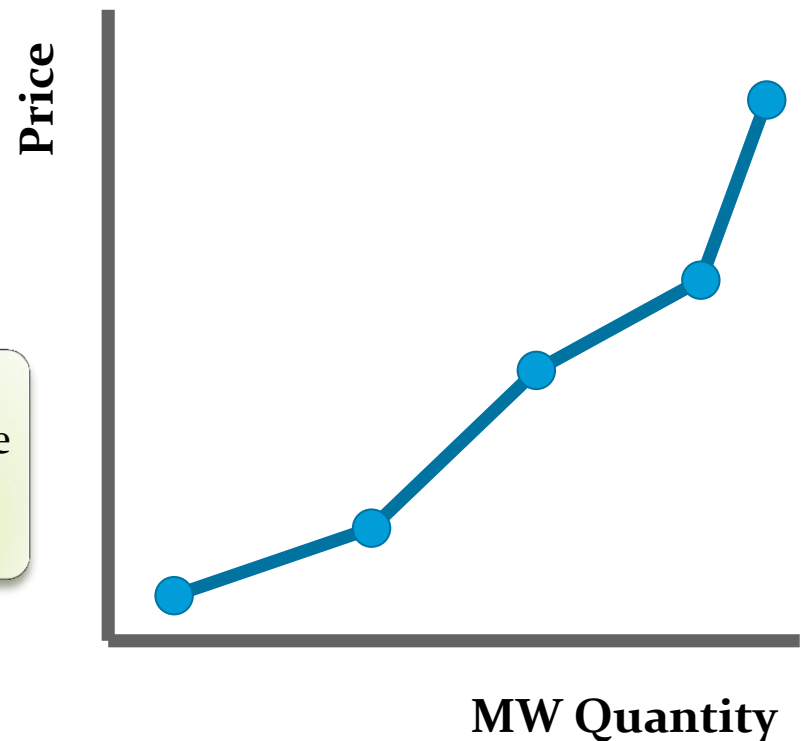
- Real-Time Market closes 30 minutes before the Operating Hour
- Energy and Operating Reserves are cleared in the Real-Time
- SCED runs every 5 minutes to set setpoints for the next dispatch interval
- Dispatch instructions are communicated to the MP at RT-5 minutes
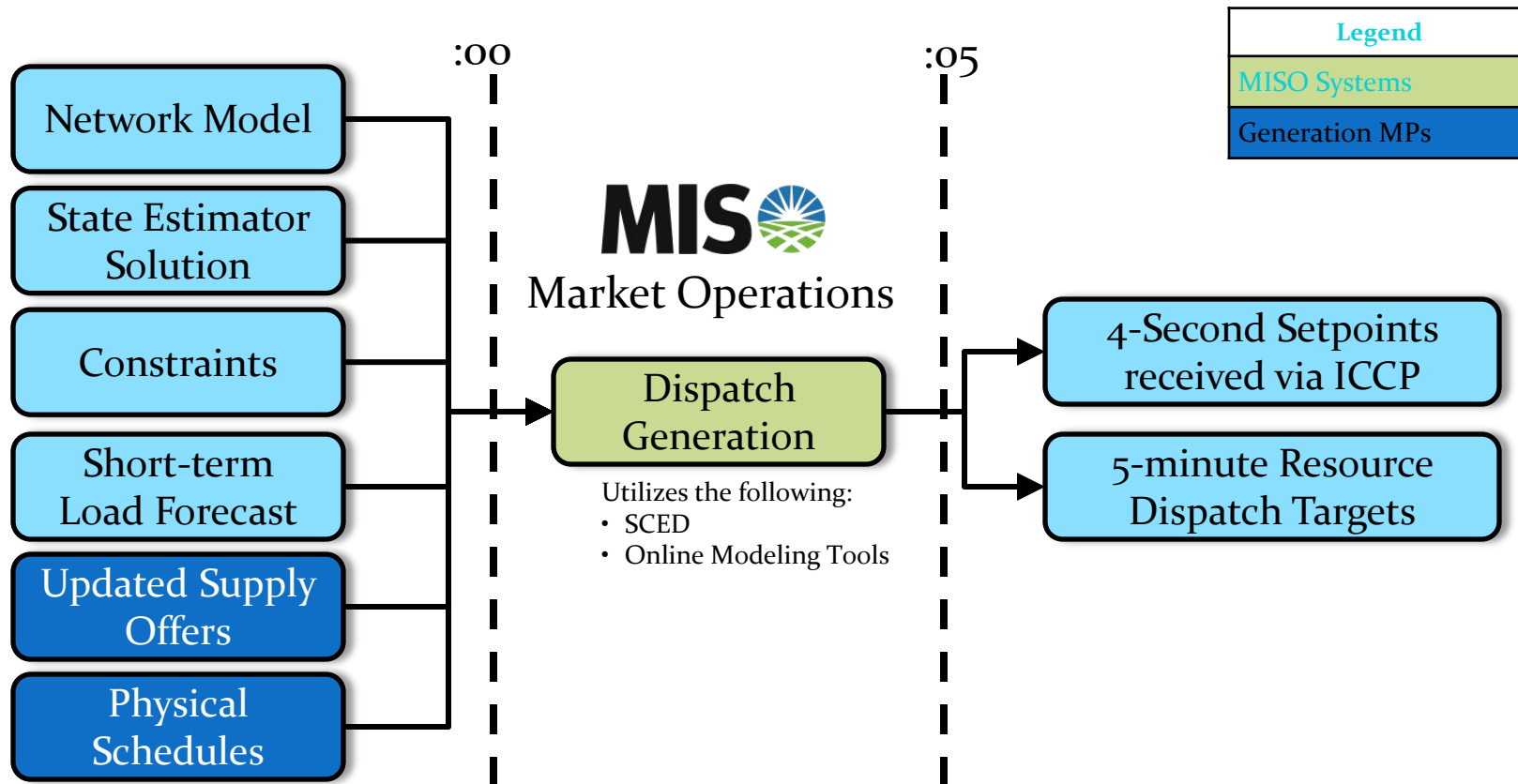
# Updated Real-Time Energy Offers

Resources may submit an updated offer to sell energy to the market in the Real-Time
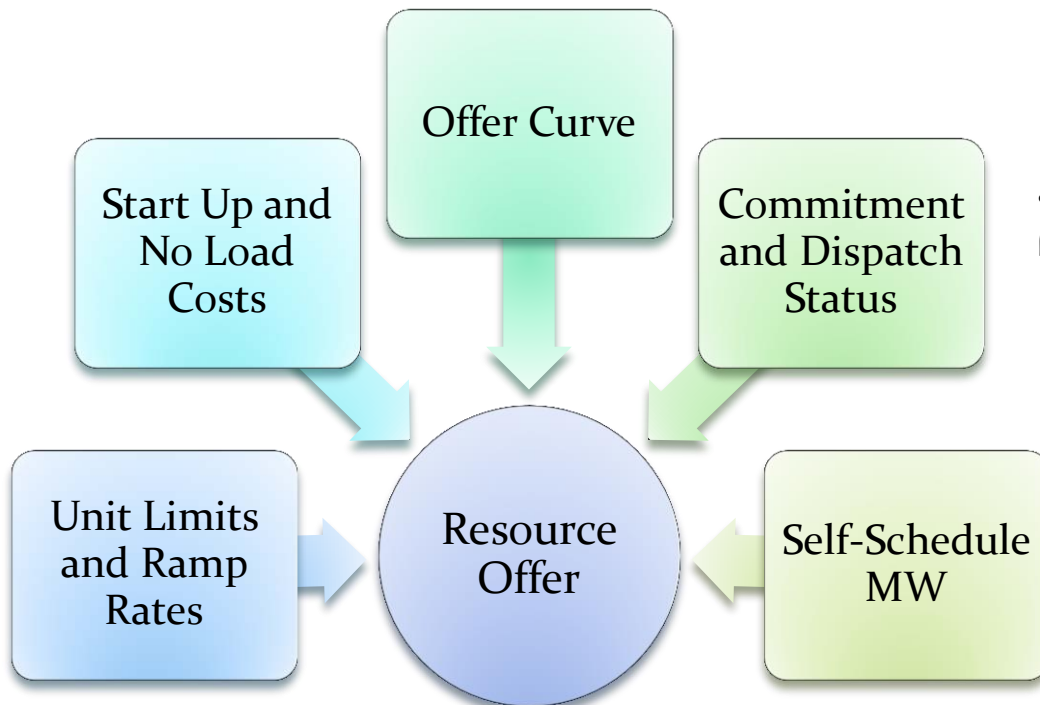
**Real-Time Energy Offer Curve $ / MWh**

Offer Curve

Start Up and No Load Costs

Commitment and Dispatch Status

Unit Limits and Ramp Rates

Resource Offer

Self-Schedule MW

**Price**

**MW Quantity**

- Real-Time Market addresses actual system conditions



Legend
- MISO Systems
- Generation MPs

:00 :05

Network Model
State Estimator Solution
Constraints
Short-term Load Forecast
Updated Supply Offers
Physical Schedules

**MISO** Market Operations

Dispatch Generation

Utilizes the following:
- SCED
- Online Modeling Tools

4-Second Setpoints received via ICCP

5-minute Resource Dispatch Targets

- Real-Time Market closes 30 minutes before the Operating Hour
- Energy and Operating Reserves are cleared in the Real-Time
- SCED runs every 5 minutes to set setpoints for the next dispatch interval
- Dispatch instructions are communicated to the MP at RT-5 minutes

# Real-Time Market: Updated Energy Offers

**Real-Time Market Resource Offers**

- In the Real-Time Market, Resource Offers can be submitted that differ from the Day-Ahead Resource Offers
- MPs with Generation Resources can modify Energy Offers for the capacity that has not yet been dispatched, but is available during the Operating Day
- Resources within the Market Footprint can participate in the Real-Time Market by submitting Resource Offers provided they can respond to 5-minute Dispatch Setpoint Instructions. These Resources are dispatchable

**Real-Time Resource Offers**

- May be submitted in the Real-Time Markets only at the registered CPNode location of that Resource
- Must be submitted at least 30 minutes prior to the Operating Hour
- Must reflect the actual known physical capabilities and characteristics of the Resource
- Must promptly notify the MISO Real-Time Operators of any changes to the availability of its Resource as soon as possible, but no later than 30 minutes after the changes have occurred

**Real-Time Resource Offers include:**

- Min/Max Limits – 3 sets of limits – Emergency, Economic, Regulation
- Unit Capabilities
  - Ramp Rates
  - Start Up/No Load
- Offer Curve – Up to 10 $/MW pairs, slope or block, monotonically increasing
- Commitment Status – Outage, Emergency, Economic, Must-Run, Not Participating
- Dispatch Status – Economic, Self-Schedule

**Real-Time Schedule Offers Carry Over**

- It should be noted that Real-Time schedule offers carry over to the Real-Time offer for the following operating day, unless updates are made. This includes unit parameters, status parameters, schedule offers and self-schedule quantities. This is true regardless of whether the Default Offer Parameter(s) or the Hourly Offer Parameters are in use.