

# Important Concepts from Price Formation Education Session 1: Economic Dispatch

## 1. *Electricity Market Overview*

Unit Commitment determines which units to turn on and when based on forecasted load and other requirements. Unit commitment is then fixed in economic dispatch. Economic dispatch determines the megawatt output for each resource that is online. Locational prices are determined by solving the economic dispatch.

### Energy Market Offers

Energy Market offers have three components:

- **Startup cost:** The cost to start a unit from shutdown conditions
- **Incremental energy cost:** The variable operating cost incurred for every megawatt hour generated. This cost is non-decreasing
- **No-load cost:** The cost to operate a resource in the inefficient portion of the energy offer curve

### Locational Marginal Pricing

The locational marginal price (LMP) reflects the incremental cost of supplying the next megawatt of load at a particular location while satisfying all operational constraints. LMP includes only the incremental energy cost but does not include no-load cost or start-up cost.

### Uplift

Uplift includes make-whole payments and lost opportunity cost. Make-whole payments occur when a resource's revenue cannot cover its total offer costs. Lost opportunity cost occurs when a resource is dispatched by the RTO/ISO away from its profit-maximizing dispatch point. Uplift costs are unavoidable, as they are often due to restrictions and non-convexities inherent in the market framework. Uplift is non-transparent to the market. Only the market participant receiving uplift payments has visibility of those payments.

### Unit Commitment

Unit commitment determines when to turn resources on and off and is the least-expensive way of supplying forecasted load in the system, often over an extended time. Prices are not determined by unit commitment.

### Economic Dispatch

Economic dispatch determines the least-expensive way to supply load and defines the output of all online units to keep the system in balance. Prices are determined by solving economic dispatch but start-up and no-load costs are not considered, as they become constants.

## 2. Marginal Pricing

A resource is marginal when it supplies the next megawatt of generation or demand reduction to meet load or to control a transmission constraint. Due to inflexibilities and restrictions, LMPs do not always increase as load increases.

## 3. Fast-Start Pricing and Comparison of RTO/ISO Approaches

Definitions of fast-start resources vary across RTOs/ISOs, but in general, they can start up quickly and have shorter minimum run times than other resources. However, the operating characteristics of fast-start resources often prevent them from setting price. In 2016, FERC asked RTOs/ISOs to improve price formation by enabling fast-start resources to set price more often and reflect the cost of fast-start deployment through transparent price signals.

### PJM Combustion Turbine Special Pricing Treatment

More than 12 years ago, PJM implemented special pricing treatment to allow block-loaded combustion turbine resources to set price. Combustion turbines are usually offered as inflexible, which means they cannot set price naturally. PJM relaxes the economic minimum values for block-loaded combustion turbines that are eligible to set price by 20 percent. The wider the relaxed dispatchable range, the better chance a resource has to set price.

### California Independent System Operator (CAISO) Fast-Start Resources

CAISO has special pricing treatment for committed constrained output generators. Resources must elect constrained output generator status, then when committed in the Day-Ahead Market, the economic minimum for these resources is relaxed to zero in the dispatch and pricing processes. However, in the Real-Time Market, the economic minimum for these resources is relaxed to zero only in the pricing process. The constrained output generator's submitted energy offer is replaced by a calculated energy bid that includes no-load costs, but not start-up costs.

### ISO New England Fast-Start Resources

ISO New England employs special pricing treatment for fast-start resources in real time. Fast-start resources are defined as resources with start-up times that do not exceed 30 minutes. There are separate dispatch and pricing runs. In the pricing run, the fast-start resource economic minimums are relaxed to zero. Start-up costs are amortized over economic maximum and minimum run time, and no-load costs are amortized over economic maximum and added into energy offers for all online hours. Lost opportunity cost is paid when dispatch signals are not profit maximizing.

### MidContinent ISO (MISO) Fast Start Resources

MISO has special pricing treatment for one-hour fast-start resources with separate runs for dispatch and pricing. If a committed one-hour resource is qualified for special pricing treatment then it is allowed to be partially committed (integer relaxation) in the pricing run. In effect, economic minimums are relaxed to zero megawatts and commitment costs are amortized over economic maximum and added to energy offers for qualified resources.

### New York ISO (NYISO) Fast Start-Resources

New York ISO allows special pricing treatment for block-loaded resources, with separate runs for dispatch and pricing. In the dispatch run, 10-minute offline resources less than 80 MW have their economic minimum relaxed to zero. In the pricing run,

committed block-loaded resources have their economic minimums relaxed to zero and are allowed to set price. In addition, 10-minute offline resources less than 80 MW have their economic minimum relaxed to zero and commitment costs are amortized over the economic maximum and added to energy offers.