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WebEx Broadcast



Note this presentation was updated on **12/03/2019**.  
Impacted slides are number 26 and 28.

# Energy Market Opportunity Costs

*For Oil and Dual-Fuel Resources with Intertemporal Production Limitations*

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# Topics

- Opportunity Cost Overview
- Opportunity Cost Methodology
- Simple Example
- Key Takeaways
- Opportunity Cost – Internal Market Monitor



# Acronyms

Acronym	Description
CAMS	Customer Asset Management System
DAM	day-ahead market
IMM	Internal Market Monitor
IMMAC	Internal Market Monitor Asset Characteristics
LMP	locational marginal price
OC	opportunity cost
O&M	operation & maintenance

# Opportunity Cost Overview

- ❖ *Introduction*
- ❖ *What is an Opportunity Cost?*
- ❖ *Why Calculate Opportunity Cost?*
- ❖ *How Will ISO Calculate an Estimated Opportunity Cost?*
- ❖ *What Input Assumptions Are Used?*

# Introduction

- Starting around December 1, ISO New England will be calculating an estimated daily opportunity cost for oil and dual-fuel generators
- Intended audience:
  - Lead participants for oil-fired and dual-fuel generators
  - Back-office personnel responsible for:
    - Formulating offer strategy
    - Submitting generator offers into eMarket



# What Are Limited-Fuel Opportunity Costs?

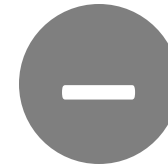
Reduction in maximum **net revenue** over a specific time horizon associated with a 1 MWh reduction in available fuel supply

- Opportunity cost horizon = seven days

**Net  
Revenue**



**Energy Revenue**  
(i.e., LMP x MWh)



**Cost of Production**  
(i.e., fuel cost, emission allowance costs, and variable operation & maintenance [O&M])

# Why Calculate Opportunity Costs?

Generator offer prices that reflect opportunity costs help the market **preserve a limited fuel supply** for the hours when fuel will be:

- Most valuable
- Most useful



# How Will ISO Calculate Estimated Opportunity Costs?

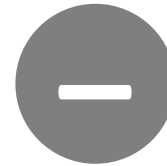
Using a seven-day independent forecast of energy market locational marginal prices (LMPs), estimates of future fuel prices, and generator's current fuel inventory, ISO estimates maximum net revenue that can be produced in two different situations:

- A. With generator's available fuel supply (assuming no replenishment during seven-day horizon)
- B. When fuel supply is reduced by 1 MWh

**Daily  
Estimated  
Opportunity  
Cost**



**A. Max net revenue produced  
with generator's available  
fuel supply**



**B. Max net revenue produced  
when fuel supply is  
reduced by 1 MWh**



# What Input Assumptions Are Used?

*Spanning Rolling Seven-Day Opportunity Cost Horizon*

- Hourly (zonal) electricity price projections
  - Seven-day independent forecast of energy market LMPs
- Daily fuel spot-price projections
  - Algonquin (non-G)
  - Oil (#2, #6 1% S, #6 0.3% S, Jet (kerosene))
- Emission allowance prices (SO<sub>2</sub>, NOX, and RGGI CO<sub>2</sub>)
- Temperature forecast
- Generator operating characteristics
  - (EcoMin, EcoMax, Minimum Run Time, etc.)
- Generator's current fuel inventory



# Opportunity Cost Methodology

- ❖ *Methodology*
- ❖ *Initial Roll-Out Limitations*

# Methodology

**Objective:** Find the reduction in maximum net revenue that results from a 1 MWh reduction in fuel supply

**Method:** Determine the generation schedule that produces the maximum net revenue over a rolling seven-day horizon while accounting for the generator's limitations:

- Fuel supply limitations
- Generator operating characteristics

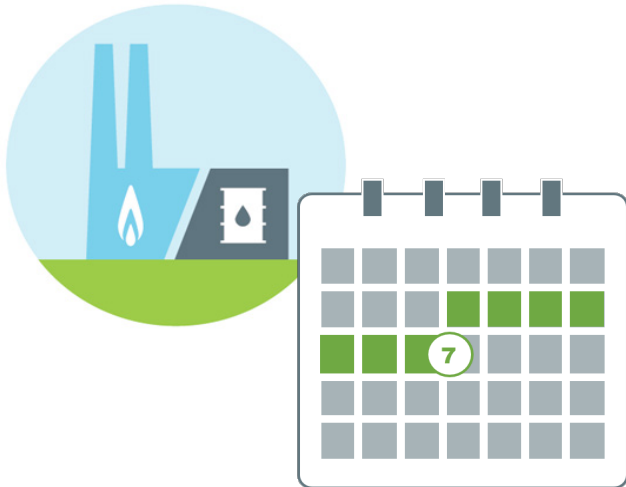
Simple problems, such as the upcoming example, can be solved by visual inspection; realistic situations are more complex and are solved by the ISO using an optimization model



# Limited Rollout, Future Enhancements

At this time, estimated opportunity costs will be calculated:

- For oil-fired and dual-fuel generators
- For a rolling seven-day horizon



Future enhancements planned to accommodate opportunity costs:

- For any resource with quantifiable intertemporal limits on total energy generation that can be tracked and modeled by the ISO
  - Excludes intermittent resources with use-it-or-lose-it energy sources, which have no intertemporal limits
    - Wind and run-of-river hydro
    - These resources will always have a \$0/MWh opportunity cost
- On horizons up to 12 months

# Simple Example

*How Opportunity Costs Are Calculated and Help Find Best Use for Limited Fuel*



Examples used in this presentation are for illustrative purposes only.

# Example Assumptions

- Example looks at a single two-day horizon
- In actual practice, opportunity costs are:
  - Estimated over seven-day horizon
  - Recalculated daily as seven-day forecast is updated
- In this example, generator:
  - Runs on oil
  - Always dispatched at EcoMax (assuming sufficient fuel)
  - Has eight hours of fuel for next two days
  - Assumed to have no replenishment (even if generator has fuel-delivery planned)
  - Must run at least three hours at a time when dispatched

Operation and Fuel Inputs	Value
EcoMax	100 MW
Minimum Run Time	3 Hours
Fuel Replacement Cost	\$57/MWh
Initial Fuel Inventory	800 MWh

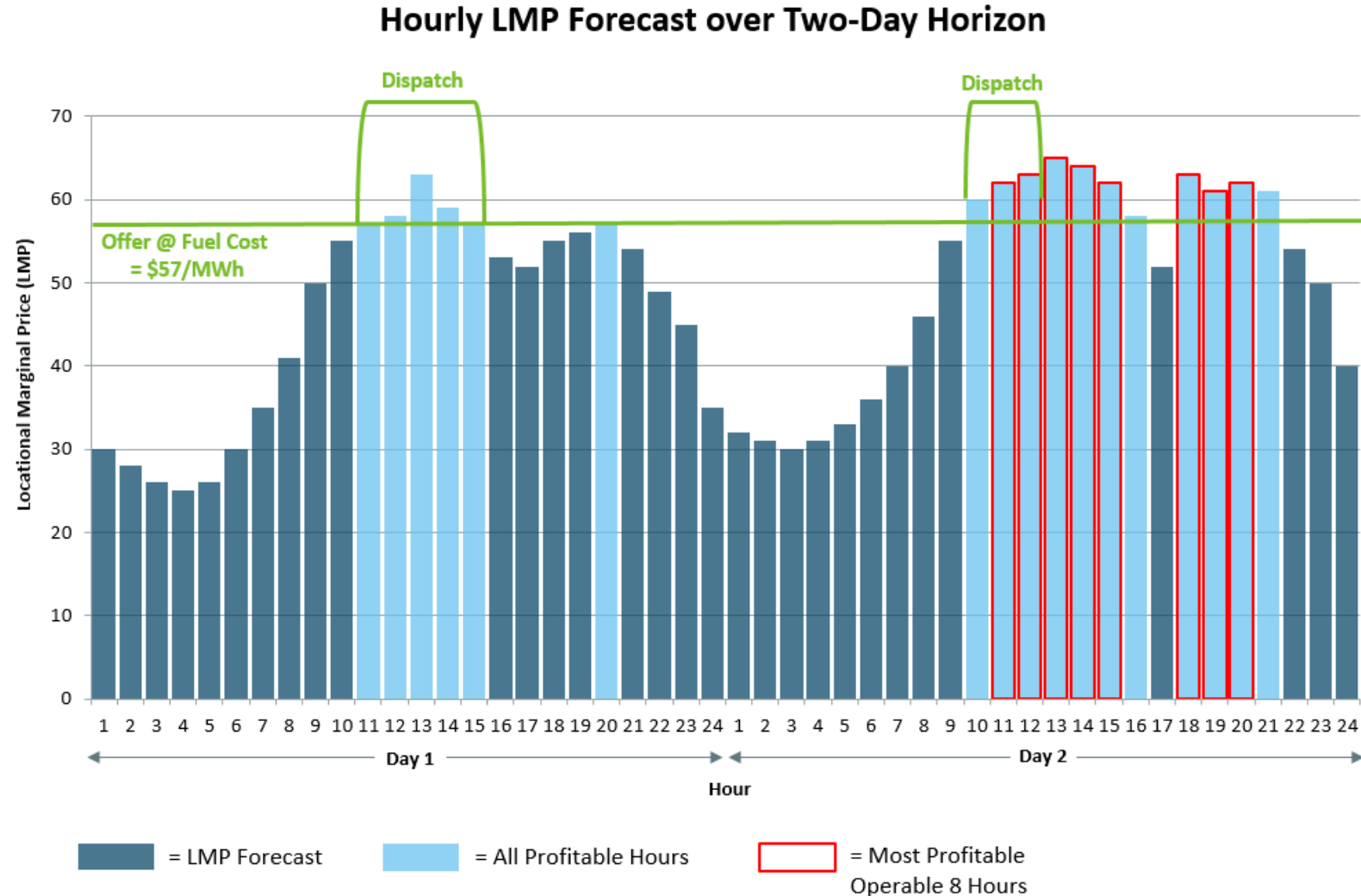
# Example: What Happens If Generator Offers on Fuel Costs Only?

Generator is dispatched  
whenever  $LMP \geq \text{offer price}$

At offer of **\$57/MWh** (fuel cost):

- Five hours of dispatch on Day 1;  
three on Day 2
- Only two hours of dispatch  
during most profitable period

**Result: All fuel is consumed  
before reaching the most  
profitable hours in Day 2**



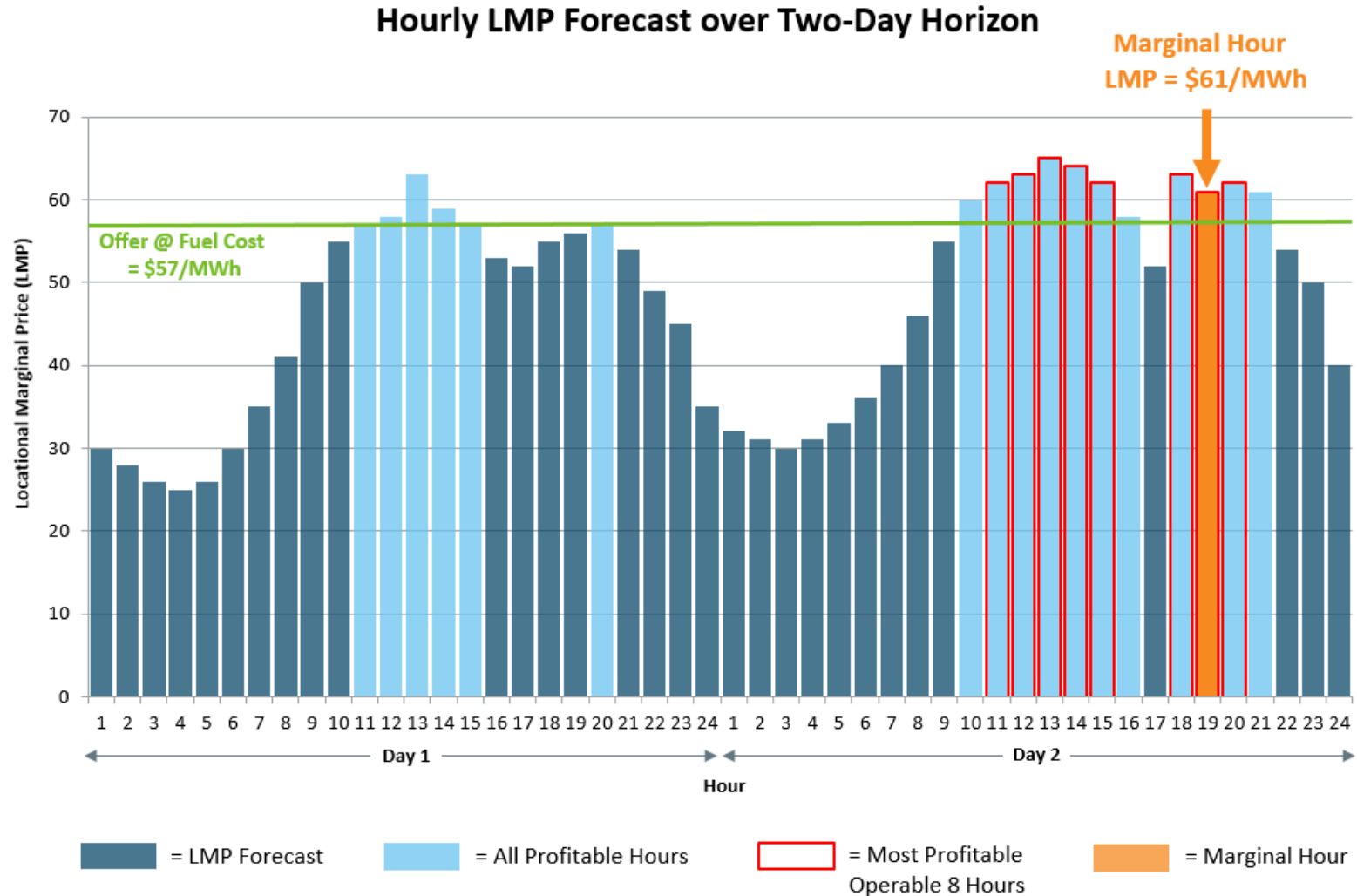
# Example: Which Hours Produce Maximum Net Revenue?

Maximum net revenue produced if generator is dispatched to run on most profitable operable eight hours of Day 2

- Recall three-hour min run time

Day 2, Hour 19 is **marginal hour**

- When generator would choose to reduce output if it had 1 MWh less fuel
- Lowest LMP during most profitable period





# Example: What is Generator's Opportunity Cost?

Opportunity cost is reduction in net revenue from 1 MWh less fuel:

Marginal hour LMP =

\$61/MWh

Fuel cost =

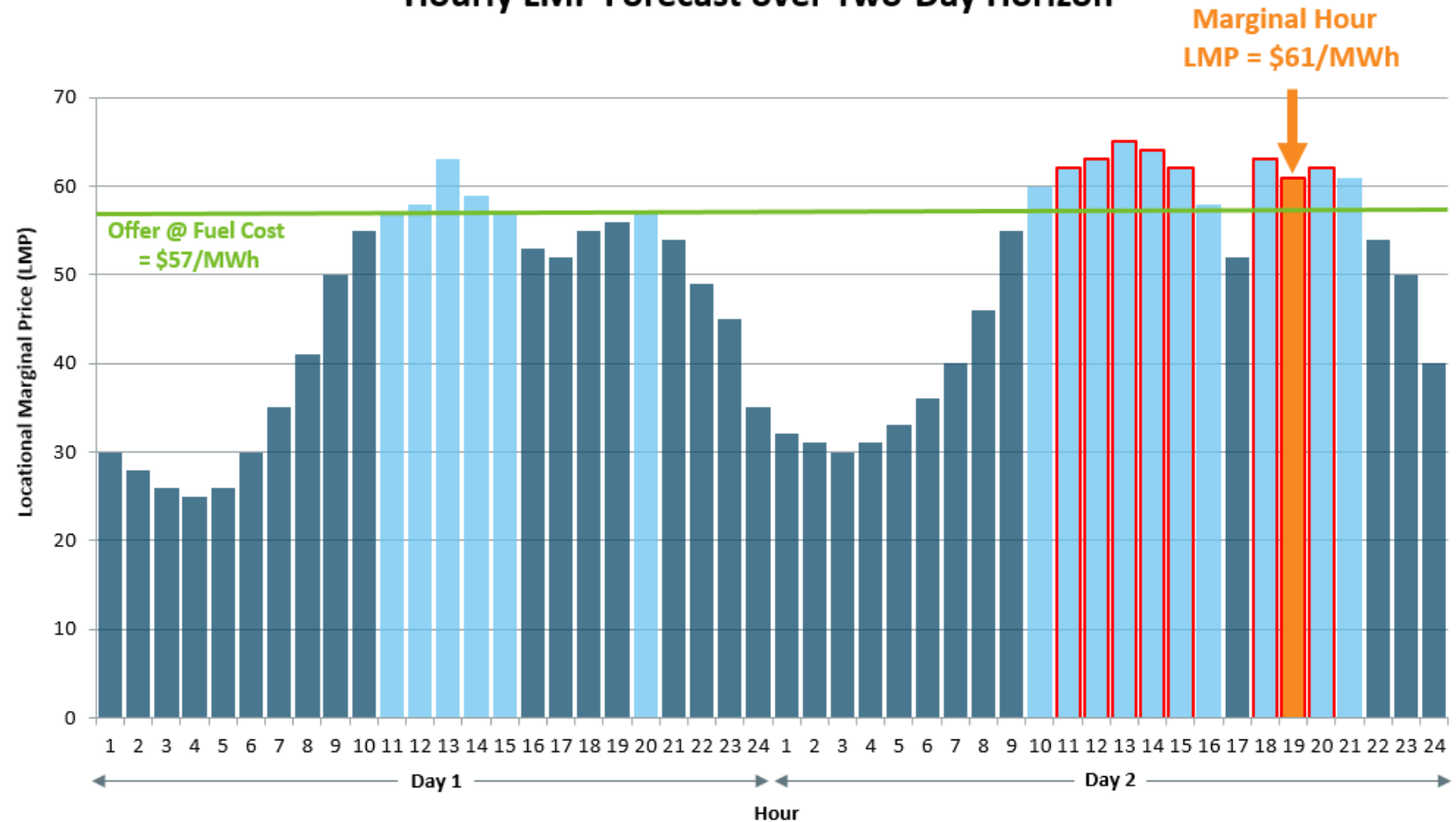
\$57/MWh

Opportunity cost

\$ 4/MWh

(net revenue change)

Hourly LMP Forecast over Two-Day Horizon



■ = LMP Forecast

■ = All Profitable Hours

□ = Most Profitable Operable 8 Hours

■ = Marginal Hour

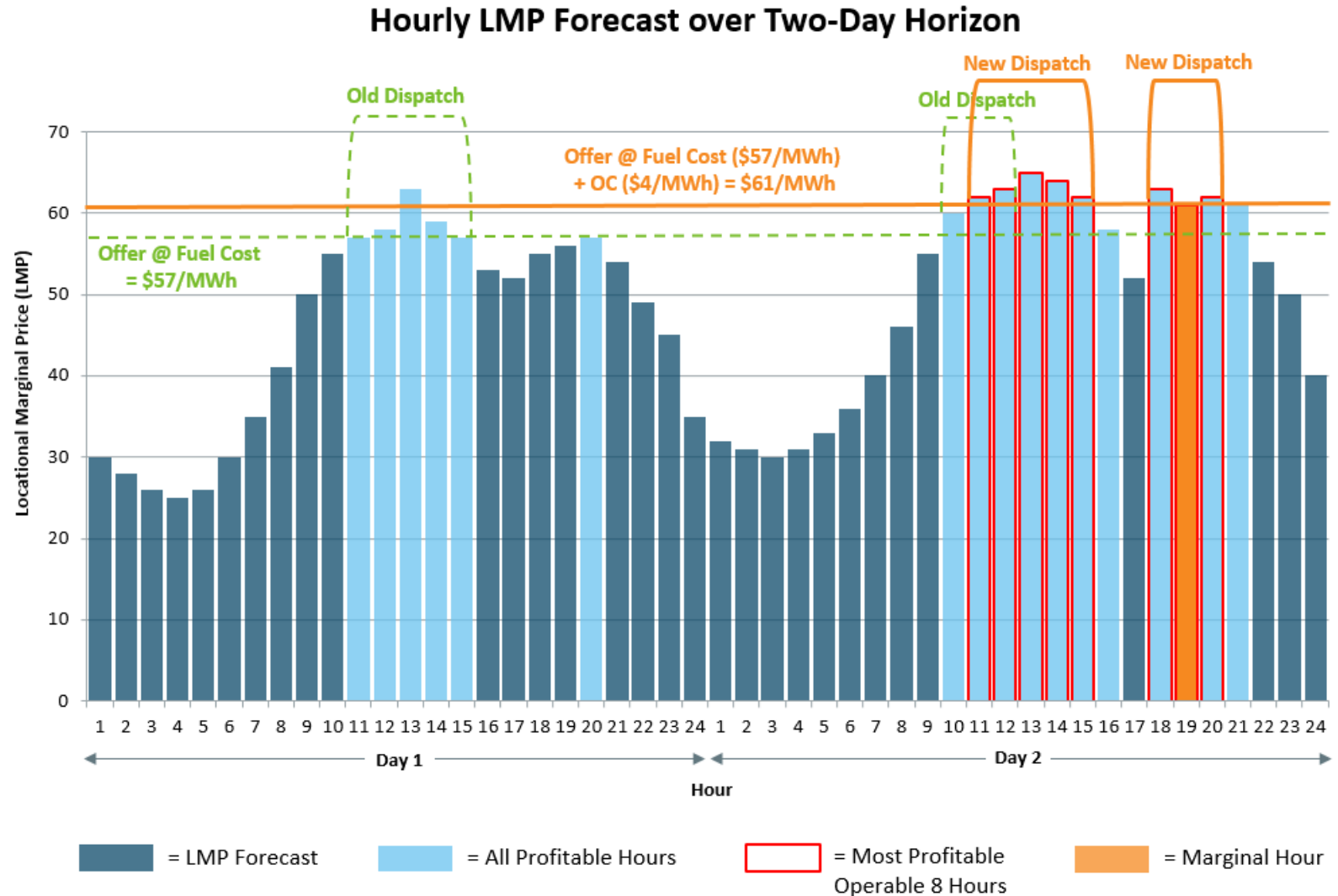
# Example: What Happens If Offer Includes Opportunity Cost Adder?

At offer of **\$61/MWh**

(\$57/MWh fuel cost + \$4/MWh opportunity cost):

- Dispatch shifts to higher-priced hours on Day 2
- More profitable overall
  - Despite generator missing out on one high-priced hour
- Helps conserve fuel

**Result: Limited fuel preserved for use in more valuable hours**



# Key Takeaways

# Opportunity Cost Adders Make Most Cost-Effective Use of Limited Resources

Including fuel costs plus opportunity costs in generator offers tends to preserve limited fuel for dispatch in higher-priced hours

- Higher LMPs typically reflect stressed system conditions and/or higher demand



# Points to Keep in Mind



- ISO actually calculates hourly opportunity cost estimates
- ISO publishes a daily opportunity cost estimate = maximum of hourly opportunity cost estimates for the day
  - Hourly opportunity cost estimate will change as real-time hours pass and fuel is consumed
    - Hourly opportunity cost estimates will tend to increase over the course of the day
- Generator will have a \$0/MWh opportunity cost adder if it either:
  - Is never in merit over seven-day horizon
  - Has sufficient fuel inventory to run every profitable hour
  - Has no way to store input energy supply for future use (for example, wind)
- Generator using full opportunity cost adder may not be dispatched during some profitable hours
  - [See simple example on slide 13](#)



# Questions?



# Opportunity Cost – Internal Market Monitor

- ❖ Tariff Allows for Opportunity Costs – Section III.A.7.5.1
- ❖ Overview
- ❖ Implementation
- ❖ Opportunity Cost Calculation Steps
- ❖ Future Enhancements
- ❖ Frequently Asked Questions (FAQ)
- ❖ Resources on ISO New England Website

# Tariff Allows for Opportunity Costs – Section III.A.7.5.1.

## ***III.A.7.5.1. Estimation of Incremental Operating Cost***

*The Internal Market Monitor's determination of a Resource's marginal costs shall include an assessment of the Resource's incremental operating costs in accordance with the following formulas,*

*Incremental Energy:*

*(incremental heat rate \* fuel costs) + (emissions rate \* emissions allowance price) + variable operating and maintenance costs + opportunity costs.*

*Opportunity costs may include, but are not limited to, economic costs associated with complying with:*

- (a) emissions limits;*
- (b) water storage limits; and,*
- (c) other operating permits that limit production of energy.*





# Overview

- No requirement for participant to include opportunity cost as part of their three-part offer
  - Used by IMM to calculate reference levels
  - Reference levels are used to evaluate competitiveness of generator's offer
- Participants can use IMM's estimated opportunity costs or determine their own opportunity costs
  - Participant methodology must be analytically supported and vetted ahead of time by IMM
- Other physical/financial parameters changes will continue to be monitored to determine whether the generator's offer is competitive
  - For example, minimum run time and start-up costs
- Introduction of opportunity cost does not change offer submission process



# Implementation

## Timing

- Opportunity cost are updated and visible by 9:00 a.m. for day-ahead market (DAM)
- Any real-time market (RTM) updates will be posted at 18:30
- A time stamp field will indicate the time and date of the last update
- Implementation date is anticipated to be December 3, 2019, and will run daily

## Where to find estimated opportunity costs

- **Customer Asset Management System (CMS)**

> **IMMAC** tab > **Fuel Index** tab

- Ask your [Security Administrator \(SA\)](#) to assign you rights

Customer and Asset Management System

IMMAC

Asset Search Change Request Search Bulk Upload Reference Tables Contact Us Database: Development

Asset details as of 11/07/2019

As Of: 11/07/2019 Asset ID: Asset Name: Short Name: Effective: 09/01/2019 Asset Status: ACTIVE Lead Participant (ID): Last Updated: 06/28/2019 Updated By:

☐ Dispatchable ☒ Intermittent

Basic Fuel Index Configuration Threshold Attachments CR History Contacts Fuel Sequence

Fuel Indexes	Premium (\$/mmBTU):*	Default Premium (\$/mmBTU):*	Opportunity Cost (\$/MWh):*	Fuel Price Override (\$/mmBTU):*	Multiplier:*	NOX (lbs/mmBTU):*	SO2 (lbs/mmBTU):*	CO2 (lbs/mmBTU):*	Carbon Permit Price:
MA_natgas6	3.160	0.000	5.63	0.00	0.000	0.000000	0.000000	159.436200	0.000000

Calculated Opportunity Cost (\$/MWh): 6.47

Calculated Opportunity Cost Timestamp: 11/21/2019 11:07:34 am

Emission Restrictions:

Participant Editable Opportunity Cost

ISO Calculated Opportunity Cost

Internal Market Monitor Asset Characteristics (IMMAC) values are used in the calculation of IMM reference levels

Comments:

Change Log



Slide 26 was updated on 12/03/2019.

# Opportunity Cost Calculation Steps

## 1. Calculate opportunity cost

- [Use previous input assumptions](#)
- Inputs into optimization model evaluated to determine marginal hour
- Marginal hour used to evaluate whether an opportunity cost exists
  - Opportunity cost, in many cases, will be equal to the difference (minimum of \$0) between the marginal hour and the variable cost of production for that hour

## 2. Upload opportunity cost to IMMAC database for viewing by 9:00 a.m.

- For Massachusetts generators, the published opportunity cost will include Massachusetts emissions value as well

## 3. Reference levels will reflect opportunity cost for DAM



# Frequently Asked Questions (FAQ)

Question	Answer
Does opportunity cost apply to day-ahead and real-time reference levels?	<b>Yes</b>
Will IMM use a participant's internally-developed methodology to estimate opportunity cost?	<b>Maybe</b> , if the participant's opportunity cost is greater than the ISO calculated value, it will be used in reference level calculations
Can I switch between an internally-developed methodology and the ISO's approach?	<b>No</b> , the software selects the higher of the internally developed, or the ISO calculated opportunity cost
Do I have to include the calculated opportunity cost when submitting my offers?	<b>No</b> , but be aware when making offers, the ISO calculated opportunity cost may increase the reference level value
Do I need special rights to view the opportunity cost in IMM?	<b>No</b> , not if you have viewer rights to IMM



*Slide 26 was updated on 12/03/2019.*

# Summary

- Participants are encouraged to incorporate estimated opportunity costs in energy market offers, but use of opportunity costs is not required
- Opportunity costs for oil and dual fuel units will be updated daily by 9:00 a.m.
  - **Anticipated** *Go-Live* is around December 1, 2018
- Opportunity costs will be included in reference prices calculated by Internal Market Monitor for each generator
- Future enhancements will allow ISO to estimate opportunity costs for any resource with any inter-temporal limitation on energy production over a 12-month horizon, as long as the limitation can be documented, quantified, tracked and modeled by the ISO



# Internal Market Monitor Contact Information

For opportunity cost calculation questions, email the Internal Market Monitor at [IMM@ISO-NE.com](mailto:IMM@ISO-NE.com)



# Resources on ISO New England Website

- [Opportunity Costs and Energy Market Offers \(Phase 1\): ISO's Proposal to Estimate Opportunity Costs for Oil and Dual-Fuel Resources with Inter-temporal Production Limitations](#)  
(September 12-13, 2018, Presentation to NEPOOL Markets Committee)
- [Opportunity Costs and Energy Market Offers \(Phase 1\): ISO's Proposal to Estimate Opportunity Costs for Oil and Dual-Fuel Resources with Inter-temporal Production Limitations](#)  
(October 9-10, 2018, Presentation to NEPOOL Markets Committee)
  - Related materials:
    - [Energy Market Opportunity Costs for Oil and Dual-Fuel Resources with Inter-temporal Production Limitations](#)  
(October 9, 2018, Memo to NEPOOL Markets Committee)
    - [Natural Gas Price Forecast Method for Energy Market Opportunity Costs](#)  
(October 9, 2018, Memo to NEPOOL Markets Committee)



## Resources on ISO New England Website, *continued*

- [Opportunity Costs and Energy Market Offers \(Phase 1\): ISO's Proposal to Estimate Opportunity Costs for Oil and Dual-Fuel Resources with Inter-temporal Production Limitations](#)  
(November 7-8, 2018, Presentation to NEPOOL Markets Committee)
  - Related materials:
    - [Efficiency and Market Power in Opportunity Cost Modeling](#)  
(November 2, 2018, Memo to NEPOOL Markets Committee)
- [Internal Market Monitor Asset Characteristics \(IMACC\) User Interface](#) (webinar recording)
- [Internal Market Monitor Energy Market Mitigation Overview](#) (e-learning)





# Providers of Information Used in Opportunity Cost Model

- Intercontinental Exchange ([www.theice.com](http://www.theice.com)) – gas price data
- Argus Media ([www.argusmedia.com](http://www.argusmedia.com)) – oil price data
- PRT, Inc. (<http://www.prt-inc.com/forecast/NE.html>) – LMP forecast



# Customer Support Information

## Methods for Contacting Customer Support

[Ask ISO](#) (preferred)

- Self-service interface for submitting inquiries
- Recommended browsers are Google Chrome and Mozilla Firefox
- For more information, see the [Ask ISO User Guide](#)



Email [custserv@iso-ne.com](mailto:custserv@iso-ne.com)

### Phone

- (413) 540-4220
- (833) 248-4220

**Inquiries will be responded to during business hours (Monday through Friday; 8:00 a.m. to 5:00 p.m.)**

**Outside of regular business hours, the pager (877) 226-4814 may be used for emergency inquiries**



# Questions?



# Evaluation