Journal of Applied and Advanced Research, 2018: 3(1) 22–23
http://dx.doi.org/10.21839/jaar.2018.v3i1.128
ISSN 2519-9412 / © 2018 Phoenix Research Publishers

Review Article – Energy Trading and Marketing

A review on Locational Marginal Price (LMP) for deregulated industry

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(Received: 15-02-2018; Accepted 27-02-2018; Published Online 28-02-2018)
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Abstract

In recent years the power industry has experienced significant changes in power distribution systems primarily due to implementation of smart grid technologies and implementation of distributed generation. This paper focuses on *Locational Marginal Pricing* method which is the most effective method for determining the optimal location of generator taking consideration of the constraints like voltage limits, line flow limits, congestion of the line, line losses etc.

Keywords: Distributed generation, deregulated electricity market, locational marginal price, congestion management

Introduction

The Locational Marginal Pricing (LMP) mechanism is one of the most commonly employed tools for market settlement in the deregulated power system environment. The Locational Marginal Price (LMP) at a bus signifies the cost of supplying the next increment of load at that bus. The LMP is the sum of supplying energy marginal cost, cost of losses due to the increment and transmission congestion cost, if any, arising from the increment and congestion, if any, arising from that increment. The LMP is the true indicator of marginal pricing of energy. The calculation of LMPs implicitly involves congestion management. Compared to other approaches of congestion management, the LMP approach has found very wide acceptance throughout the world due to its inherent efficiency in the network capacity allocation. Many of the successfully running power markets like PJM, NYISO, ISO-NE, CAISO, ERCOT, MISO and NEMCO have already implemented LMP mechanism in their systems, whereas other markets are now evolving towards locational marginal pricing. The LMP mechanism was first invented by Dr. William Hogan in 1992 [1], and introduced at Pennsylvania-New Jersey-Maryland (PJM) ISO. However, the basis of the LMP mechanism is the theory of spot pricing proposed by Schweppe et al. The distinguished feature of the LMP mechanism is that the entire course of power scheduling (pool as well as bilateral transactions) is done centrally, recognizing system conditions and constraints arising thereof. The underlying principle of locational marginal pricing is that the energy price varies from one location to another location in the presence.

Literature survey

Major milestone in the LMP development of LMP markets include the following:

1992:

FERC initiates the transition to competitive bulk energy markets in the United States in a bid to ensure competitive practices and economic efficiency in the wholesale electricity market.

April,1997:

The largest centrally dispatched electricity system in the world, PJM at the time was also the first North American Market to implement LMP as a congestion management mechanism. For the previous 25 years, PJM had centrally dispatched generation based on security – constrained economic dispatch.

LMP Definition:

LMP indicates the price of electricity at a particular bus which increases with the congestion of transmission. When there is a congestion electricity prices will be higher in congested zone and zonal market clearing price or locational marginal price could be employed for representing price differentials. Accordingly LMPs would have to be forecasted for individual bus in the entire power system.LMP is the cost of supplying the next MW of load at a specific location[2].The price of producing an additional MW at a specific location in the grid is called Locational Marginal price.LMP will be same for all buses when

(a) Transmission limits are not reached.
(b) Transmission limits are not exceed.
(c) Losses are zero.

Components of LMP

Each LMP (expressed in $/ MWh) have three components:

LMP = LMPE + LMPL + LMPC[1]

Where superscripts E, L and C denote energy, losses and congestion respectively. The energy component is the same throughout (except in different islands).

LMP at any node i is given by

$$LMP_i = \lambda + \lambda * (\partial P_l / \partial P_i) + \sum_{ij=1}^{N} \mu_{Lij} * (\partial Pij / \partial P)$$

$$LMP_i = \lambda + \lambda_{L,i} + \lambda_{C,i}$$

λ Represents the marginal energy component.

$\lambda_{L,i}$ Represents the marginal loss component.

$\lambda_{C,i}$ Represents the congestion component. The energy component is the same throughout (except in different islands).

The loss component varies but is usually small. It is sometimes lumped with the congestion component, or it may disappear altogether if a lossless network model is used to compute the LMP.

The congestion component can be large, and it adds to or subtracts from the LMP, according to whether a power injection at the network point marginally increases or alleviates congestion. Each supplier of MWs to the network is paid at its LMP and each consumer of MWs from the network is charged at its LMP.

LMPs are also used to charge congestion fees for transmission usage (bilateral transfers). These fees are positive when the transfer contributes to congestion and negative when the transfer alleviates congestion.

Parameters Effecting LMPs

The factors affecting LMP values are generator bid prices, system active constraints, and system losses. If system is unconstrained and we ignore system losses, LMP values are flat throughout the network. This flat value is determined by generator bid prices only. System losses vary when delivering energy to various load locations, but they are usually small. However, it is well known that system active constraints drastically affect LMPs. The active constraints may include voltage constraints, real power flow constraints, etc. When the system is constrained, LMPs differentiate at different locations and their values reflect the increased cost to deliver energy from marginal generating units to load buses.

Key Features of LMP Markets

(1) Use Full Network Model to Operate Day-Ahead and Real-Time Key Security Constraints and Insure Grid Reliability

(2) Day-Ahead market is Financial. Meets Security Constraints and is Financially Binding

(3) Use Two-Settlement Approach. Run Separate Day-Ahead Settlement & Real-Time Settlement

Important issues in the LMP implementation

(1) Handling different infeasibilities. Determining prices when systems run out of controls and transmission constraints are violated requires special attention and must be carefully designed.

(2) Another type of infeasibility is excess of generation – total generation is greater than total load. Even when all units are dispatched down to their economic minimum, there exists still possible excess generation.

Characteristics of LMP

(1) The daily load curves have similar patterns; whereas the daily LMP curves are volatile.

(2) There are some abrupt changes in the LMP curves. The LMP and load values are low late at night.

Benefits derived from LMP

Long term benefits

LMP is a necessary step towards achieving long-term goal of wholesale electricity market i.e. Demand-responsiveness to both locational and temporal price differences**.**

Short term benefits

(1) The ability to secure effective local market power mitigation tools from FERC

(2) Reduction in undesirable trading strategies (e.g., the "dec game")

(3) Greater transparency, efficiency, and reliability in system operation

Market participants' gain

(1) The opportunity to hedge congestion costs

(2) Assurances that power/MWs are available at a given time and location

Wholesale energy market benefits include

(1) Reliability of the electric grid **-** More options for purchasing energy cost-effectively

(2) Greater transparency for regulators seeking to ensure reliability and affordability of energy.

Conclusion

LMP can be used for congestion management and it can be used for optimal location determination of generator considering the values of LMP .The security constraints of a transmission line like voltage limit, line flows, line losses etc. can also be met by LMP.

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