Staff Technical Conference on Increasing Real-Time and Day-Ahead Market Efficiency through Improved Software

Prepared Remarks of

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In 1995 FERC began the process of identifying ancillary services. At that time I said, that despite the plethora of identified services, that we could only measure two items in real-time, active power and reactive power. We may have thirty-one ways to package these two items, but there were still only two items that we could measure.[1] Now over fifteen years later, we have many more services that are being offered by utilities, ISOs, independent generators, and marketers, but we still only have two items that we can measure in real-time, active power and reactive power.

The subject of this staff technical conference is increasing real-time market efficiency. Achieving real-time market efficiencies within a control area requires real-time markets within, between, and among control areas. Currently we do not have those real-time markets for metered flows between and among control areas, resulting in what I call tie-riding freeloaders.[2] The generic, less caustic, term, one used by this Commission, is freerider.[3]

[1] See "Thirty-One Flavors or Two Flavors Packaged Thirty-One Ways: Unbundling Electricity Service" *The National Regulatory Research Institute Quarterly Bulletin*, Summer 1996. This article originally appeared as comments titled "31 Flavors or Two Flavors Packaged 31 Ways," *Promoting Wholesale Competition Through Open Access Non-discriminatory Transmission Services by Public Utilities,* FERC Docket RM95-8-000, 1995 November 2.

[2] See "Tie Riding Freeloaders--The True Impediment to Transmission Access," *Public Utilities Fortnightly,* 1989 December 21.

[3] See for example "Letter order accepting ISO New England Inc's et al 1/26/11 submittal of revised tariff sections, effective 6/1/11 under ER11-2755," dated 2011 March 18; "Order granting in part and denying in part rehearing re Midwest Independent Transmission System Operator, Inc under ER08-394. Dissent in part of Commissioner Wellinghoff," dated 2008 October 20; and, "Motion to Intervene and Comments of the Dominion Companies under ER08-394," dated 2008 January 28. "Freerider" also sometimes appears as "free-rider." "Tie-riding freeloaders" is more obviously related to electric utilities than is the more generic "freerider."

Without a real-time physical market between and among control areas there is a tendency to disrespect the network. The most telling illustration of this disrespecting of the network is a graph I had a correspondent produce showing histograms of system frequency in India. The first graph is of system frequency in the Southern Region of India for January 2002.[4] I point out that the modal frequency on the graph is 48 Hertz on a system that nominally operates at 50 Hertz. A year later, India implemented a real-time physical market for its control areas. The second graph is of system frequency for the same region of India for January 2003, only twelve months after the first graph. I point out that with a real-time physical market between and among control areas that the modal frequency on the graph is now 49.85 Hertz, much closer to where system frequency in India is supposed to be. Over 90% of the gap has been closed. The third slide superimposes the two graphs, to show the contrast between the two situations, as well as for August 2004, when the modal value on the graph is 50.00 Hertz. The fourth slide shows similar information for each of the 32 months from January 2002 through August 2004. India's real-time physical market created respect for the system, where before there had been disrespect.

In North America the disrespect for the system has been most strongly shown in the operation of the transmission system.

- The most infamous example was Enron in 2000/2001. Enron bought cheap electricity in Northern California and sold it at a high price in Southern California using a contract path through Oregon, Nevada, and Arizona. The lack of real-time physical markets at the various control area borders helped Enron pocket a lot of cash by avoiding a contract across Path 15 while contributing to the overload of Path 15.
- A current and continuing example is the Lake Erie doughnut. The overloaded path is generally within New York State. In recent years, electricity has been purchased near Niagara Falls and sold into New York City with a contract path through Ontario, Michigan, Ohio, and Pennsylvania.[5] Eleven years ago I told a NERC working group that such shenanigans could be avoided if NERC had a requirement for control areas to have in place mechanisms to cash out physical imbalances geographically. In my presentation to NERC I gave the example of the Lake Erie doughnut.[6]

I note that a real time market means that utilities will be more cognizant of the unscheduled flows on their power lines, since unscheduled flows of electricity would then impact cash flow of the enterprise. Accountants will always spend money for cash registers even if they begrudge the engineers the cost of other aspects of the Smart Grid. In regard to the 2003 blackout, how

[4] All graphics are inserted at the end of this document.

[5] See "Report of New York Independent System Operator, Inc., submits additional loop flow-related analysis and data supporting studies under ER08-1281," dated 2011 February 28.

[6] See "Wide Open Load Following," Presentation on Loop Flow to NERC Control Area Criteria Task Force, Albuquerque, New Mexico, 2000 February 14/15.

might Ohio Edison responded differently if its accountants were also looking at the flows on the overloaded transmission lines? How should Ontario Hydro have been compensated for bearing the insult to its system of the power surges across it as the lights began to go out?

Without a physical real-time market between and among control areas any real-time market within the control area becomes a profit center for the control area, besides making the control area a tie-riding freeloader. Profit centers within a control area are not bad. However, a recent report by Federal government labs has been using the lack of real-time markets within control areas to justify not requiring wind and other non-dispatchable resources to buy sufficient ancillary services to fulfill the contractual commitments that they make to deliver electricity pursuant to a specific load profile.[7] Forcing control areas to participate in physical real-time markets with the other control areas will allow control areas to enforce schedule commitments on a real-time basis.

A physical real-time market between and among control areas was implemented in 2002/2003 in India. Physical imbalances, called Unscheduled Interchange (UI), are bought and sold every fifteen minutes with the price determined by the concurrent system frequency. The frequency histograms on the screen come from before and after the implementation of this physical real-time market between and among control areas. The technology used in India for measuring the Unscheduled Interchange was specified in the 1990s. I note that in North America the standard period for reading interchange meters is four seconds, not fifteen minutes, and phasor technology allows meters to be read accurately up to thirty times a second.

We do have unscheduled interchange in North America. The market monitor's report for PJM, in whose footprint sits this FERC office building, shows that during the first quarter of 2011, PJM had a physical imbalance (which the report calls system inadvertent) with its neighbors of 137 GWH out[8]. This 137 GWH is a net of an unknown unscheduled interchange out minus an unknown unscheduled interchange in. Further the value of this net PJM imbalance is unknown.

One valuation of the PJM imbalance could treat the energy as dump power, electricity that was surplus and needed to be disposed off. In ERCOT, dump power often was valued at a negative price of $35/MWH. Alternatively, the valuation could treat the energy as being very dear to the

[7] See "Comment on 'Air Emissions Due to Wind and Solar Power'" by Andrew Mills and Ryan Wiser, Energy Analysis Department, Lawrence Berkeley National Laboratory, Berkeley, California 94720; Michael Milligan, National Renewable Energy Laboratory, Golden, Colorado 80401; and Mark O'Malley, School of Electrical, Electronic and Mechanical Engineering, University College Dublin, Dublin 4, Ireland, *Environmental Science & Technology* / Vol. 43, No. 15, 2009. The original article was by Warren Katzenstein and Jay Apt, Carnegie Mellon Electricity Industry Center, Tepper School of Business, and Department of Engineering and Public Policy, 254 Posner Hall, Carnegie Mellon University, Pittsburgh, Pennsylvania 15213.

[8] http://www.pjm.com/~/media/documents/reports/state-of-market/2011/2011q1-som-pjm.ashx, p 105.

parties and have a positive value of $500/MWH. Under these two pricing scenarios (and the prices are not extreme prices), PJM could owe the rest of the grid $4,795,000 in dumping fees for those three months or could be owed $68,500,000 for assistance provided. The actual valuation of PJM's quarterly imbalance would depend on the operation of a physical real-time market with the other control areas in the Eastern Interconnection. And since the 137 GWH is a net of some amount of unscheduled interchange versus some amount of unscheduled interchange out, the answer will not be as simple as multiplying some average price times 137 GWH.

India uses system frequency as the primary driver for pricing physical imbalances. System frequency is the horizontal axis in my graphs. North America experiences much smaller system frequency excursions than does India. However, system frequency is still important in North America for determining area control error (ACE) and for controlling generators during a shortage or surplus condition. NERC's Time Error Correction Elimination Field Trial identified 4,234 minutes over the last five years when the Eastern Interconnection experienced frequencies that were below 59.95 Hertz.[9] System frequency can be used as an independent variable in setting the price for physical imbalances between and among control areas, as India does. For real-time physical markets within a control area, the appropriate independent variable is ACE.

The North American interconnections have tighter standards for system frequency than does India. Also, the North American interconnections have greater swings in the financial markets associated with the price of electricity than does India. As a result, the frequency based formula for pricing physical imbalances should be steeper than the mechanism used in India. I have often suggested an exponential formula based on the frequency error and its calcula.[10] My study of pricing in ERCOT during April 2009[11] led me to realize that any imbalance pricing mechanism must permit negative prices. Thus, though an exponential change in prices might be appropriate for extreme shortages of electricity, some other formula must be used for extreme gluts.[12]

The real-time physical market must have prices that are geographically differentiated. I described previously in regard both to ENRON and to the Lake Erie doughnut the effect on transmission lines. The geographic price differentiation should reflect both marginal energy losses and transmission constraints.

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[9] See http://www.nerc.com/page.php?cid=6|386

[10] See ibidem for a discussion of the integral of frequency error. The derivative of frequency error may also be desirable in establishing the pricing formula for physical imbalances.

[11] "Renewable Electric Power—Too Much of a Good Thing: Looking At ERCOT," *Dialogue*, United States Association for Energy Economics, 2009 August.

[12] "A Pricing Mechanism To Facilitate Entry Into The FCAS Market: Comments Of Mark B. Lively, Utility Economic Engineers," *Investigation Of Hydro Tasmania's Pricing Policies In The Provision Of Raise Contingency Frequency Control Ancillary Services To Meet The Tasmanian Local Requirement,* Office of the Tasmanian Economic Regulator, 2010 July 9.

The inclusion of real time transmission constraints in determining the geographic differentiation of prices for a real-time physical market will improve the reaction to TLR calls. A TLR would suppress prices on one side of the constraint and increases prices on the other side of the constraint, for all variations from schedule. If deviations from schedule have led to the TLR call, then a real-time physical market within the control areas will encourage generation and load to eliminate those variations. A real-time physical market within the control areas will also encourage generation and load to vary from their schedules in ways that will reduce the need for the TLR, providing income to the party at variance in a good way. I note that most utility imbalance systems automatically penalize all variances from schedule, whether that variance is helping or hurting the operation of the network. A real-time physical market within the control areas will reward any variations by generation and load that help the system.

I started these remarks by saying we can measure two items in real time, active power and reactive power. Many people have addressed the market for active power. Few people address the market for reactive power. I will do so only briefly.

First, I note that India has a real-time market for reactive power, with the price based on voltage conditions. Second, I note that reactive power does not "travel well." When reactive power does travel, reactive power will unnecessarily contribute to active power losses and voltage excursions. Accordingly, I believe that local voltage is an appropriate index for varying the price for reactive power, but the real-time pricing of reactive power needs to be more dynamic than has been implemented in India. For instance, the price for reactive power should also reflect the local price for active power. In addition, the shape of the reactive power pricing curve needs to reflect the competing concepts of leading and lagging power.[13] I have previously made presentations on reactive power pricing to FERC staff as part of its investigation into the issue and am willing to do so again.

I thank FERC staff for the opportunity to speak and for your attention to my presentation.

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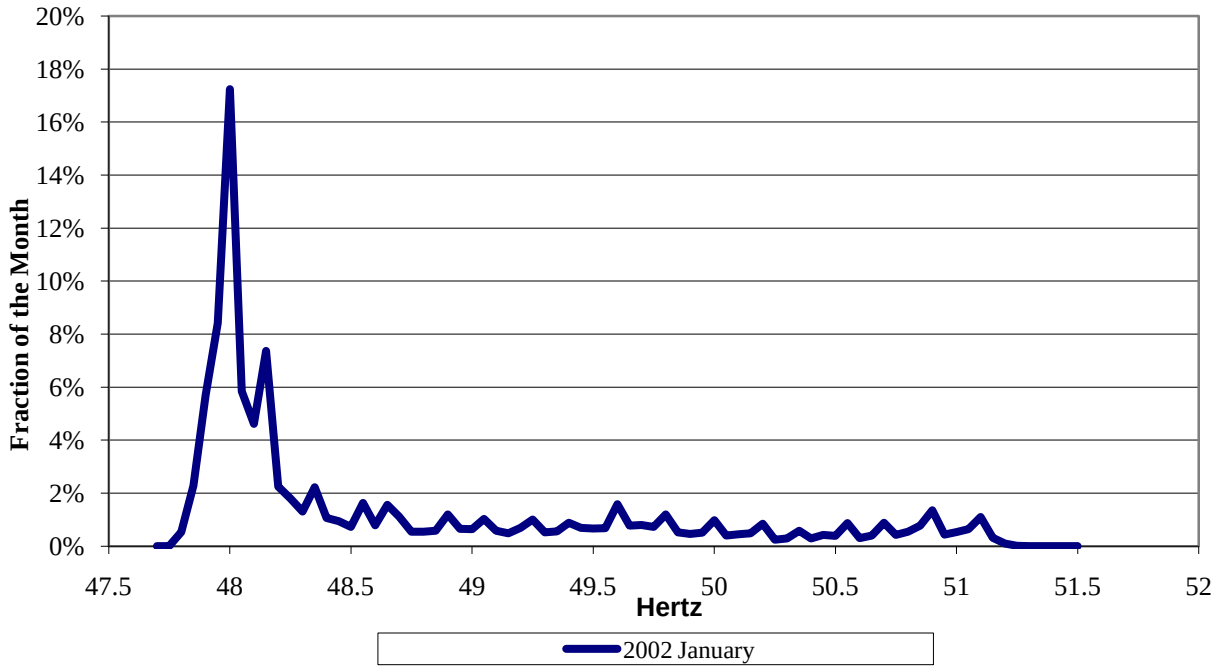
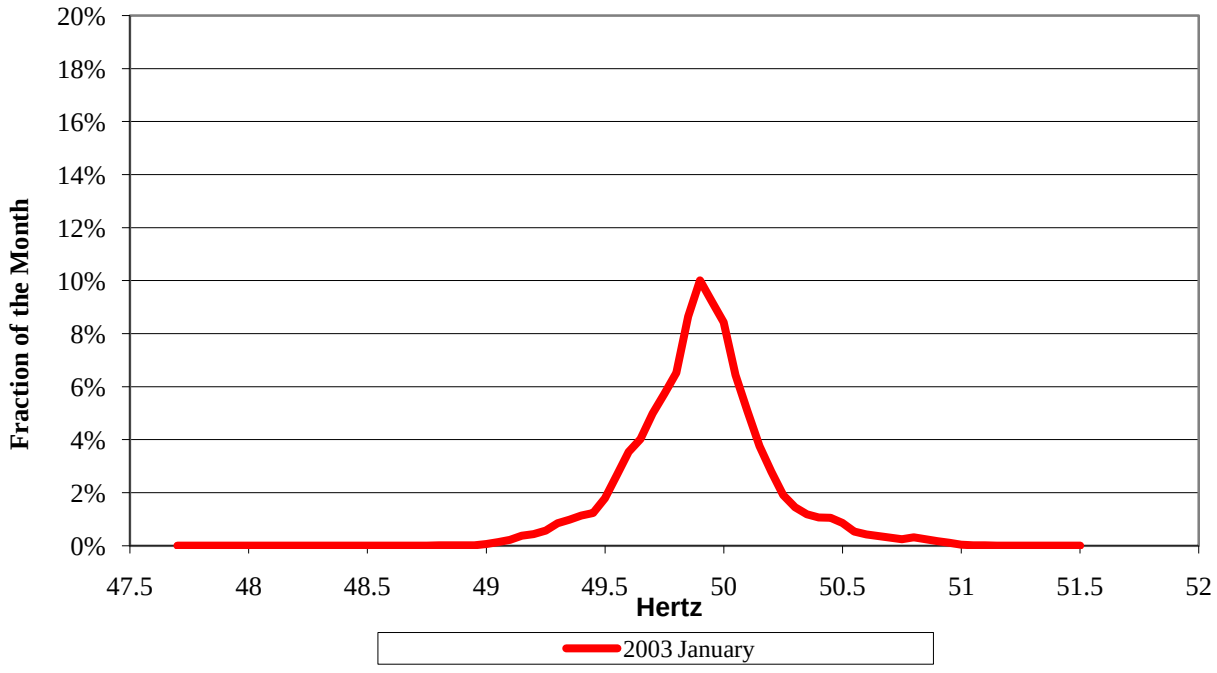
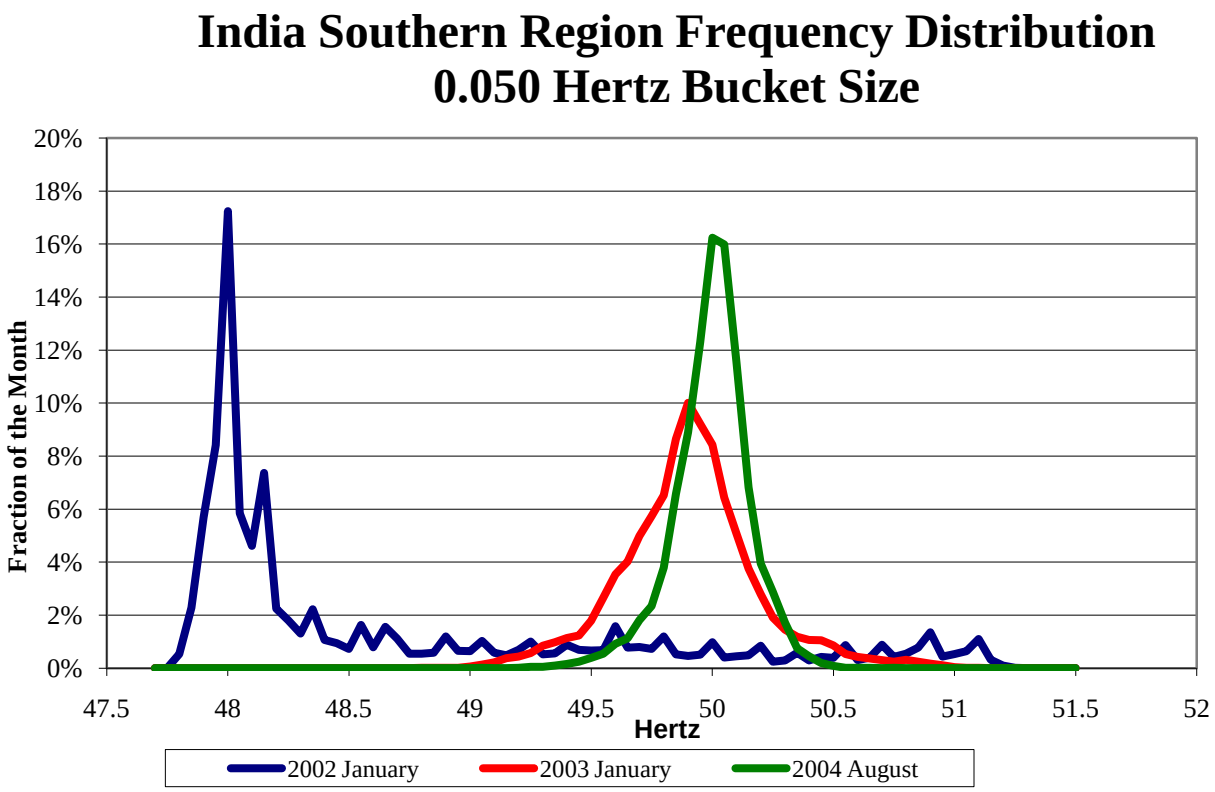
[13] See "Constructing a Competitive Distribution Market in Reactive Power: Comments of Mark B. Lively to the Office of Gas and Electricity Markets," 2005 December 15.

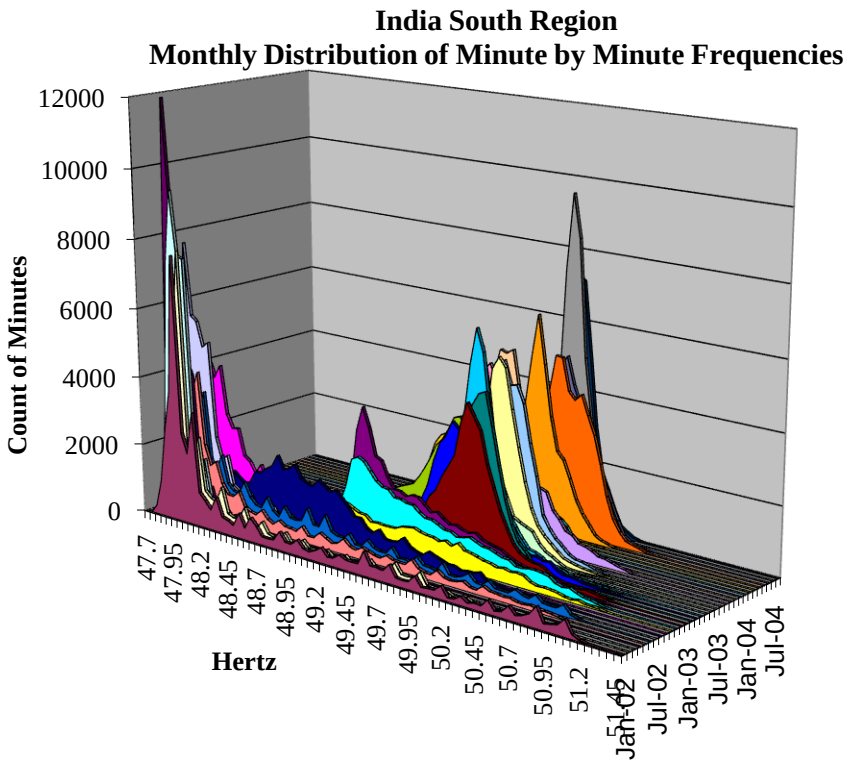
India Southern Region Frequency Distribution
0.050 Hertz Bucket Size



India Southern Region Frequency Distribution
0.050 Hertz Bucket Size




India Southern Region Frequency Distribution
0.050 Hertz Bucket Size
Fraction of the Month
20%
18%
16%
14%
12%
10%
8%
6%
4%
2%
0%
47.5
48
48.5
49
49.5
50
50.5
51
51.5
52
Hertz
2002 January
2003 January
2004 August


India South Region
Monthly Distribution of Minute by Minute Frequencies
Count of Minutes
12000
10000
8000
6000
4000
2000
0
47.7
47.95
48.2
48.45
48.7
48.95
49.2
49.45
49.7
49.95
50.2
50.45
50.7
50.95
51.2
51.45
Hertz
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04