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PJM/MISO Joint and Common Market Capacity Deliverability

PJM Fact Finding #2

PJM Capacity Import Limit Methodology

PJM Planning Division
White Paper
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PREFACE

On April 22, 2014 the Federal Energy Regulatory Commission (FERC) approved revisions to PJM's Reliability Assurance Agreement ("RAA") and Open Access Transmission Tariff ("Tariff") to recognize limits on the amount of capacity from external resources that can be reliably imported into PJM. Similar to the existing manner in which PJM recognizes practical limits on capacity transfers between locational deliverability areas (LDAs) *internal* to PJM, known as Capacity Transfer Emergency Limits ("CETLs"), the approved Tariff revisions now also incorporate a methodology to determine practical limits on capacity transfers across *external* PJM interfaces for each forward capacity delivery year. And, just as internal CETL values can change each year, these external limits can as well. Known as Capacity Import Limits (CILs), PJM will begin employing these parameters as part of the next Base Residual Auction to be conducted in May, 2014. This white paper describes the methodology by which PJM determines CILs.

1. Introduction

Since RPM's inception in 2007, forward auctions have recognized locational constraints that limit the delivery of capacity *within* PJM. To date, however, the RPM auctions have not recognized the locational constraints that limit the delivery of capacity to PJM from areas *outside* PJM. The intent of RPM is to promote reliability by identifying and pricing physical attributes of the system making the cost of those physical limitations apparent to the market. Until now, PJM's Tariff-authorized auction parameters did not account for the risk that an external resource may be prevented from providing power to PJM at critical times by curtailments of firm transmission by third-party systems over which PJM has no control.

Growing Curtailment Risk

PJM forward auctions have seen a substantial increase in the quantity of capacity offered from external generation — up by 80% in one year alone and more than tripling since 2008. Notably, PJM has also experienced curtailment of firm transmission by surrounding systems numerous times in the past few years (several times each month, on average). Because sellers can submit capacity offers to PJM from

external generation resources that, at the time of the offer, lack firm transmission on the necessary path, the risk exists that PJM or external transmission systems may not have sufficient capability, absent transmission upgrades, to accommodate those capacity offers. Transmission capability is finite[1]. Moreover, the risk that the existing transmission system will not be able to accommodate all capacity commitments reliably increases as more offers, particularly those without firm transmission service, are submitted and cleared.

PJM's procedures for reviewing and approving firm transmission requests do not directly address the risk that firm transmission can be curtailed by third-party systems. However, given the implications for resource adequacy it is important for PJM to consider and attempt to mitigate the risk that a capacity resource, on which loads depend for service during peak periods or emergencies, will not be delivered because transmission service was curtailed. Since its inception, PJM has addressed import limits only by reviewing requests for firm transmission service into PJM. But transmission requests may not be resolved until long after the external resource offers and clears an RPM auction. And, while PJM has entered into various agreements with its neighbors that make important strides regarding inter-regional scheduling and dispatch to manage congestion, PJM's firm transmission studies do not completely mitigate the risk that external systems managing their own congestion will affect deliverability of power to PJM load.

Consequently, an external resource that clears an RPM auction, but fails to secure firm transmission on satisfactory terms, will not qualify as available to PJM in the Delivery Year as a capacity resource. External resources that do not reflect the cost of delivering capacity into PJM can suppress capacity prices and induce physical resources to retire. Over-commitment of external resources that cannot be delivered into PJM affects both short-term and long-term reliability by inflating the supply of resources in the Base Residual Auction. In the short-term, commitment of resources above deliverable levels can directly displace marginal resources for which Reliability Pricing Model capacity payments might make the difference between remaining in service or retiring. In the long-term, market participants seeking to develop truly committed resources similarly will receive inaccurate price signals and may cancel or defer development plans. In addition, price suppression and retirement of physical internal resources

[1] While physical limits on import capability plainly exist, under current market rules these limits are not considered at the time offers are submitted into the capacity auctions. PJM regularly tests the capability of the transmission system to confirm PJM can receive a Capacity Benefit Margin ("CBM") of 3500 MW from external systems, but that value is only for *emergency assistance* from neighbors that is *above and beyond* the capacity resources—including external capacity resources—otherwise committed to PJM through the RPM auctions.

can cause a net loss of installed physical capacity due to resources retiring, while external resources that cleared the auction but later do not obtain firm service never become PJM resources.

CILs Mitigate Curtailment Risk

CILs address curtailment risk imposed by adjoining, third-party systems, by confronting the unrealistic assumption that external system operators will always redispatch generation in order to preserve, rather than curtail, firm transmission for external capacity. Curtailment risk highlights the fact that firm transmission service simply is not the equivalent of an electrical connection to an external resource, one that is "pseudo tied." Pseudo-tied units are treated like internal generation, subject to redispatch and locational pricing and are not subject to NERC TLR-5 curtailments[2]. External capacity can only and fairly be considered a true internal capacity equivalent when under the control of the same system operator. But, when a resource remains under the operational control of an external system, curtailment risk remains.

CILs help mitigate curtailment risk given that firm transmission service is used to deliver capacity resources on which loads depend under peak load, emergency system conditions. Indeed, incorporating CILs in RPM auctions is analogous to CETLs within PJM that address the transmission system's ability to move capacity from generation to load within PJM. CILs provide a quantification of the constraints on the system's ability to import capacity from areas *external* to PJM.

2. Defining Limits on Capacity Resource Imports

CILs establish reliability limits on capacity resource imports applied by PJM in RPM auctions. Much of the methodology discussed below focuses on how PJM determines the overall level of capacity deliveries that the transmission system could reliably support before NERC reliability criteria violations are encountered. However, the CIL is not that overall limit established by that analysis. Rather, the CIL is the portion of the overall limit that remains available to import capacity resources after CBM is deducted from the overall limit. The difference between the overall limit and CBM – the CIL - is the

[2] NERC Transmission Loading Relief (TLR) Level 5 is invoked to curtail firm transactions to alleviate identified flowgate constraints.

level of transmission system capability that can be used to import external capacity resources committed in PJM RPM Auctions.

Reliability Studies Establish CILs

Essentially, this overall CIL+CBM limit is the maximum transfer amount that could be delivered into PJM without violating reliability criteria on relevant facilities inside or outside PJM that have an electrically significant response to those transfers. The transfer analysis is modeled under "capacity emergency conditions," similar to the types of conditions used to set internal CETL values. Doing so dictates many of the conditions and assumptions embedded in power flow analysis modeling: system load levels, the availability or lack of availability of generation resources and operating procedures invoked.

The CIL definition casts a wide net for monitored facilities those that the planning staff review to ascertain the existence of NERC reliability criteria violations. The scope includes PJM and the other systems with which it interconnects such that the analysis of facilities – typically at 100kV and above - considers much of the North American Eastern Interconnection (based on comprehensive models that PJM has developed over the years in coordination with its neighbors and regional planning groups).

Monitored facilities must have "an electrically significant response" to power flows caused by importing capacity across an external interface. PJM determines "significant response" in terms of distribution factors ("DFAX"), expressed as percentages. DFAX represents the portion of a transfer of energy that will flow across a particular transmission facility or group of transmission facilities from a defined source to a defined sink. PJM presently employs a three percent DFAX. [3]

3. Using Adjoining Systems as Source Zones

[3] The Eastern Interconnection Reliability Assessment Group (ERAG) also used a three percent minimum distribution factor in its 2018 Summer Transmission System Assessment.

PJM's border with external systems extends over two thousand miles, and includes interconnections with systems of diverse load and topological system characteristics. Adjoining systems include the New York ISO, the Midcontinent Independent System Operator, Inc. (which will now include the Entergy system), the Tennessee Valley Authority (TVA), and Duke Energy Carolinas/Duke Energy Progress. PJM's CIL methodology recognizes this breadth and diversity in two ways:

i. flows between and among different external systems will allow an increase in the total quantity of capacity that PJM can import simultaneously from all external areas; and

ii. flows across specific portions of PJM's interface with external systems might encounter binding constraints before aggregate flows across PJM's overall external interface encounter binding constraints.

PJM has developed "source zones" to implement these principles. Source zones are groupings of one or more balancing authority areas that permit planning analyses to reflect the fact that when one system enters an emergency condition, it can usually rely on support from surrounding systems. For initial implementation of CILs, PJM has identified five such external source zone, shown on **Map 1:**

1) *Northern Zone:* NYISO & ISONE

2) *Western Tier 1 Zone:* MISO East, MISO West & OVEC

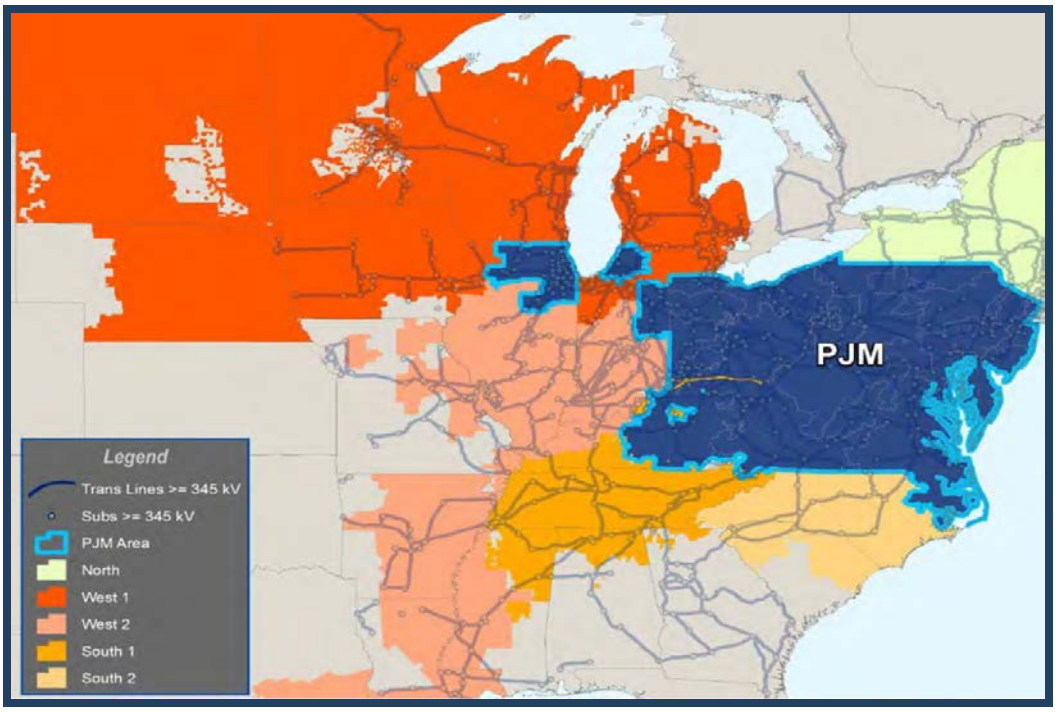
3) *Western Tier 2 Zone:* MISO Central & MISO South

4) *Southern Tier 1 Zone:* TVA & LGEE

5) *Southern Tier 2 Zone:* VACAR (non-PJM portions)

PJM may encounter the need to modify these zones periodically based on changing system characteristics, operational data or changes in RTO/ISO membership.

Map 1: CIL Source Zones



Disaggregating the "world" outside PJM into source zones allows planning analyses to reflect one of the most fundamental advantages of interregional coordination: when one system enters an emergency condition, it usually can rely on support from surrounding systems that are not experiencing the same level of system stress.

PJM's Capacity Import Limit analysis cannot assume that external flows will be optimized at a nodal level to avoid curtailment of firm transmission into PJM. Rather, CIL analysis confronts the reliability risk that an external system will curtail firm transmission service rather than redispatch generation to preserve Capacity Resource deliveries. PJM cannot direct the operation of those external generation resources.

But, PJM can reasonably assume that the various system operators will coordinate by adjusting aggregate flows between and among their systems to lend assistance to a system facing emergency conditions. Indeed, ignoring that neighboring systems would offer emergency assistance through such flow adjustments would be unreasonable. The CIL determination method therefore appropriately assumes that source zones will adjust their flows with PJM and with each other by the amount needed to maximize the overall PJM's overall import limit: CIL+CBM. Such adjustments mean that the total amount of capacity that PJM can import before a reliability criteria violation is encountered is higher than it would be if PJM assumed no such flow adjustments among source zones. Source zones enable PJM to recognize finite transmission system limitations on capacity imports at a level more specific than just employing one, single 'world' value comprising all external areas immediately adjoining PJM's two-thousand-mile-plus border. This approach more closely approximates how PJM presently determines whether specific external generation resources are deliverable to PJM as capacity. A unit-specific external generation resource has a specific location, and PJM evaluates a requested transfer of power and energy from that source and location into the PJM Region. While it is not feasible to set a CIL value on an individual resource basis at the time of the BRA, the CIL methodology recognizes constraints that can exist for five defined zones along PJM's l interface with adjoining systems.

4. Reliability Study Procedure

The CIL reliability study procedure establishes the amount of power that can be reliably transferred to PJM from the five external source zones, defined above. PJM begins with a system power flow model based on the latest summer peak for the applicable delivery year. This case reflects the amount of confirmed Network External Designated Transmission Service, and FERC filed grandfathered transmission agreements.

PJM Dispatch

PJM dispatch reflects generation deficiency conditions independent of source zones. Source zones are modeled to reflect normal operating conditions, able to supply PJM with power up to the lower of CIL or the limit of their respective, available reserves. PJM load and that in external zones is initially modeled at a 50/50 peak load forecast level. Load in PJM is further reduced by the amount of forecasted energy efficiency. The amount of reserves considered available from any adjacent non-PJM

area may be adjusted to reflect historical data. Redispatch and implementation of load management schemes are not considered as part of this study.

Power Flow Analysis

PJM scales load uniformly down at a constant power factor in source zones and scales PJM generation down uniformly to simulate power imported from external resources. In order to exclude transmission facilities from the monitored list which are not significantly affected by the increase in import power from the external resources, PJM employs an outage transfer distribution factor cutoff of three percent based on the source zones supplying the resources. Transfers from each source zone are optimized by scaling load uniformly in each zone independently to maximize transfers into PJM.

All Eastern Interconnection BES facilities 100 kV and above are monitored for thermal overloads All PJM BES facilities and selected non-PJM BES facilities are monitored for voltage magnitude and voltage drop reliability criteria violations. PJM internal BES single contingency events and selected non-PJM BES contingency events are simulated as part of power flow analysis. The following operating procedures are employed as necessary:

i. Adjustments of Phase Angle Regulators (PARS) which PJM or PJM member companies control (within existing agreements for emergency operation)

ii. The activation of any approved PJM or PJM member company operating procedure (procedure descriptions are available in Manual 3.)

The "simultaneous" PJM CIL equals the aggregate power transfer into PJM, region-wide, at the point where any increase in this MW transfer would cause a reliability criteria violation, less the applicable PJM CBM. A similar approach is employed to determine the non-simultaneous maximum power transfer from each source zone into PJM. **Table 1** shows example simultaneous and source zone CIL calculations using a 2018 study year transmission planning model. The CIL value along the entire border is a simultaneous limit which PJM determines by optimizing flows among PJM and all source zones. The sum of the maximum imports taken from each source zone individually, though, differ from that simultaneous PJM-wide value. Given their respective, different system characteristics and likelihood of peaking at different times, PJM reliability analyses identify the first limiting reliability criteria violation encountered for each source zone, known as the First Contingency Total Transfer

Capability (FCTTC). The individual zone FCTTCs will always sum to a value greater than the simultaneous, region-wide FCTTC. A portion of the CBM is allocated to each of the five source zones as described below.

Table 1: CIL Calculation Example

	Simultaneous	North	West 1	West 2	South 1	South 2
FCITC	9700	2500	3600	1200	2000	3900
CBM*	3500	902	1299	433	722	1407
FCITC - CBM	6200	1598	2301	767	1278	2493

5. Allocation of CBM to Determine Source-Zone Limits

PJM subtracts CBM from the overall, simultaneous level of capacity imports that the transmission system can support. Accordingly, when determining a CIL for each of the five source zones, PJM must allocate a portion of the CBM value to each solely for the purpose of setting the CIL for each source zone. Nothing changes the full 3,500 MW CBM PJM uses in determining Installed Reserve Margin (IRM) each year.

The subtraction of CBM recognizes an important distinction between PJM's simultaneous CIL along PJM's entire border and individual external source zone CILs. PJM allocates CBM to each source zone based on the ratio of the maximum import quantity from each such source zone divided by the PJM total maximum import quantity. In short, CBM is allocated to each source zone based on its respective FCTTC divided by the PJM simultaneous FCTTC.

Use of Source Zones in RPM Auctions

Just like the intra-PJM locational CETL constraints PJM is introducing simultaneous as well as five individual source zone CILs as input parameter constraints beginning with the May 2014 RPM Auction. When any of the CIL constraints bind in an auction, the result will be conceptually the same as when a CETL constraint binds for capacity transfers into an LDA. If the region-wide constraint binds, the

auction algorithm will clear the lowest price set of external resource offers that does not sum to more than the limit. Similarly, if a source-zone CIL binds, the auction algorithm will continue to accept external offers from other source zones, but will clear only the lowest-cost set of offers across the constrained interface with the relevant source zone that is within the limit quantity for that source zone.