Generator Interconnection and Deliverability Study Methodologies Training

December 4, 2012
Overview

- Background
  - FERC Order 2003
  - CPUC Resource Adequacy Proceeding
  - NERC Planning Standards
- Reliability Assessments
- Purpose of generation deliverability assessment
- Generation deliverability assessment methodology
- Import Deliverability
- Deliverability Assessment Tools
FERC Order 2003 Provides Two Interconnection Services

• Energy Resource Interconnection Service (ERIS)
  – Can compete in the market against other generators
  – The ISO calls this service Energy Only Deliverability Status (EODS)

• Network Resource Interconnection Service (NRIS)
  – Meets generation capacity planning requirements while satisfying regional reliability criteria (FERC Order 2003 Paragraphs 768, 769 and Appendix C)
  – The ISO calls this service Full Capacity Deliverability Status (FCDS)
Energy Only Deliverability Status

- ERIS would allow the Interconnection Customer to connect its Generating Facility to the Transmission System and be eligible to deliver its output using the existing capacity of the Transmission System on an "as available" basis. In an area with a bid-based energy market ERIS would allow the Interconnection Customer to place a bid to sell into the market and the Generating Facility would be dispatched if the bid is accepted. (FERC Order 2003 Paragraph 753)
Full Capacity Deliverability Status

• Network Upgrades required under NRIS integrate the Generating Facility into the Transmission System in a manner that ensures that aggregate generation can meet aggregate load while satisfying regional reliability criteria and generation capacity planning requirements. (FERC Order 2003 Paragraph 769)

• CPUC Decision D.04-10-035 adopted the CAISO’s proposal for a baseline analysis to determine deliverability of qualifying resources. The CAISO published a preliminary deliverability baseline analysis report and conducted a stakeholder meeting in May 2005, after the Phase 2 workshops were concluded. (CPUC Decision D.05-10-042)
Order 2003 Required FCDS Studies to be the same for all resources

- NRIS entitles the Generating Facility to be treated in the same manner as the Transmission Provider's own resources for purposes of assessing whether aggregate supply is sufficient to meet aggregate load within the Transmission Provider's Control Area, or other area customarily used for generation capacity planning. (FERC Order 2003 Paragraph 768)

- In 2005 the ISO demonstrated through a stakeholder process that all existing resources could meet its deliverability assessment methodology. In a couple of locations minor upgrades such as wave trap replacements were required.
The Interconnection Study for NRIS shall assure that Large Generating Facility's interconnection is studied at peak load, under a variety of severely stressed conditions, to determine whether, with the Large Generating Facility at full output, the aggregate of generation in the local area can be delivered to the aggregate of load on the Transmission Provider’s Transmission System, consistent with the Transmission Provider’s reliability criteria and procedures. [LGIP, FERC Order 2003, Appendix C LGIP Section 3.2.2.2]
Applicable NERC Reliability Standards

- FAC 002 Coordination of Plans For New Generation, Transmission, and End-User Facilities
  - assessment must include steady-state, short-circuit, and dynamics studies as necessary to evaluate system performance under both normal and contingency conditions in accordance with Reliability Standards TPL-001-0, TPL-002-0, and TPL-003-0.
- TPL 002 requires single contingency analysis
- TPL 003 requires common mode N-2 contingency analysis and bus outages
Applicable NERC Reliability Standards

• FAC 010 System Operating Limits Methodology for the Planning Horizon
  – Starting with all Facilities in service and following any of the multiple Contingencies identified in Reliability Standard TPL-003 the system shall demonstrate transient, dynamic and voltage stability; all Facilities shall be operating within their Facility Ratings and within their thermal, voltage and stability limits; and Cascading or uncontrolled separation shall not occur.

• TPL 003 requires reliable system performance following common mode N-2 contingency analysis and bus outages
Mitigation Measures

- EODS generation can compete with generation in the local area.
  - Therefore congestion management is an acceptable mitigation measure
- FCDS generation must be deliverable along with the other FCDS generation in the local area.
  - Therefore congestion management curtailment of FCDS generation is not an acceptable mitigation measure in the deliverability study
Energy Only Deliverability Status Interconnection Study

• The CAISO and PTO perform short circuit and stability analyses to identify the Reliability Network Upgrades needed to interconnect the Generating Facilities to the CAISO Controlled Grid.

• Power flow analyses is also performed to identify Reliability Criteria violations that must be mitigated by Reliability Network Upgrades because congestion management would not be effective.
Full Capacity Deliverability Status Interconnection Study

- Same studies as for EODS Interconnection Study
- Deliverability Assessment
- On Peak Deliverability Assessment Methodology
The Purpose of the Deliverability Assessment

- CAISO generation interconnection procedures
  - GIP Section 6.5.2.1 describes the parameters of a deliverability assessment
  - ISO Deliverability study methodology was provided to FERC as the specific steps, and assumptions that the ISO will use in the performance of deliverability assessments

- Resource Adequacy deliverability requirements
  - CPUC generally adopted ISO deliverability study methodology for resource counting purposes

- Deliverability does NOT ensure dispatch:
  - Deliverability does not mean 100% congestion elimination for all load levels.
The Purpose of the Deliverability Assessment

• The CAISO offers two basic levels of interconnection service
  – Base level Interconnection Service for reliable interconnection and (EODS)
  – A higher level of Interconnection Service to ensure that generation capacity can be counted for resource adequacy planning purposes (FCDS)
  – The Deliverability Assessment determines the Network Facility upgrades needed to obtain the higher level of service
Overview
- How We Got to this Point -

- 2004/2005 - ISO proposes generation deliverability methodology to CPUC for Resource Adequacy purposes and to FERC for generation interconnection purposes

- 2005 – ISO completes Phase I Baseline Generation Deliverability assessment of all generation expected to be in operation during summer 2006

- 2005 - CPUC and FERC generally approve methodology for use in Resource Adequacy and Generation Interconnection processes

- 2006 - ISO begins applying deliverability methodology to new generation projects in the generation interconnection queue
Baseline Study
- The Bottom Line -

The Phase I Baseline Generation and Import deliverability study confirmed that:

- historical summer peak imports levels are deliverable
- existing generating units in the ISO Control Area are deliverable.
A deliverability assessment is applied to existing and planned generation located in the control area.

- Phase I baseline study covered all generation expected to be in operation in 2006.

Developed from PJM Methodology (MISO uses a similar methodology)

Peak load conditions

Aggregate of generation can be transferred to aggregate of the ISO Control Area Load
Study Methodology

- Capacity resources within a given sub-area must be able to be exported to other parts of the Control Area experiencing a resource shortage due to forced generation outages.
Reserve Shortage in California

* Summer Peak Load  
* Power Plants Forced out  

*** SCENARIO 1 ***

- All available generation capacity in the CAISO control area is dispatched to avoid interrupting customer service.
- All generation in Pocket 1 is available and needs to be dispatched at full output to serve all customers in the CAISO control area.
• All generation in Pocket 2 is available and needs to be dispatched at full output to serve all customers in the CAISO control area.

• The deliverability assessment methodology is designed to ensure that available generation in the various generation pockets, for all reasonable generation availability scenarios, will not be constrained by transmission limitations during resource shortages.

Reserve Shortage in California

* Summer Peak Load
* Power Plants Forced out
*** SCENARIO 2 ***

Generation forced out
Generation Pocket 2
Generation Pocket Analysis

- The location of units forced out and causing reserve margin shortage in Scenarios 1 and 2 does not significantly change the loadings on constrained transmission lines associated with the generation pocket.

- The units forced out in Scenarios 1 and 2 are outside of the generation pocket study area, so their status and dispatch levels, in aggregate, do not significantly impact the study area.

- The hundreds of thousands of generation forced outage scenarios can be sufficiently represented by evenly distributing the forced outages across the system.
Overview of Test Procedure

1. Build power flow base case model
   - Create base case generation dispatch

2. Create study groups around each line and transformer and analyze them individually

3. Identify overloaded lines and transformers constraining generation capacity and the units that are constrained.
Elaborating on the Base Case Dispatch

- Dispatching generation in the base case essentially means that we evenly distribute the available generation.
  - Since all available capacity is needed, it is all dispatched close to its maximum capacity without consideration of cost.
  - For cluster studies, generation in the queue is grouped into geographic groups and a base case is built for each group with generation in that group dispatched close to its maximum capacity.

- Base case values also represent approximate dispatch of generation outside of the study groups during the analysis.

- Generation inside of the study group is increased during the study.
Study Groups Are Created Around Each Line and Transformer

- Each transmission line and transformer is analyzed individually.
- A study area is established for each line and transformer that includes all generation with a 5% distribution factor or greater on the particular line or transformer.
- Capacity generation dispatch inside the study group is maximized to determine the maximum potential loading on the line or transformer.
- Generation outside the study group is proportionally decreased to balance the load and resources.
- This process is intended to test the ability of resources inside of the study group to be dispatched at full output when various resources outside of the study group are unavailable.
Example Generation Deliverability Test Study Group for Gregg-Borden 230 kV line

Line outage

Line overload

Deliverability Assessment Methodology
Deliverability of Imports -- Assumptions

- California is dependent on imports to satisfy its resource requirements.
- Imported resources in the resource plans of all LSEs need to be assessed by the ISO to ensure that they can be simultaneously accommodated on the transmission grid.
- When relying on imports to meet reserve margin requirements, LSEs with the assistance of the ISO should demonstrate that their imports are deliverable from the tie point to aggregate load on the ISO System using a deliverability test procedure similar to the generation deliverability test.
Deliverability of Imports and Internal Generation – Assumptions

- Assessing the deliverability of imports and generation simultaneously will ensure that any interaction between the deliverability of imports and generation is considered.

- This can be done by modeling import capacity to be used for resource adequacy planning purposes as the starting point for import assumptions in the internal generation deliverability analysis.

- The initial import capacity is based on historical data during summer peak load and high import conditions.
Network model and Generation Capacity Study – Assumptions

- A network model of the ISO Controlled Grid modeling the five year planning case is used for cluster studies.

- Existing generation capacity is based on Net Qualifying Capacity posted on ISO website

- Intermittent generation is tested at 20%(high level) and 50%(low level) exceedance level during summer peak load hours (12:00 to 6:00, May-Sept)
  - High level is used if generation pocket consists of only wind or only solar generation
  - Low level is used if generation pocket consists of mix of conventional and intermittent generation
  - Ensures that diversity adder is based on deliverable amounts
  - Ensures compensation for unavailable generation amounts
QC of wind and solar resources is based on an exceedance methodology
QC of wind and solar includes diversity adder

- Wind 1: 8 MW
- Wind 2: 11 MW
- Wind 1+2: 33 MW
Diversity adder counts production levels higher than NQC

This hour is in the 70% exceedance data set
Deliverability testing levels

- 20% exceedance level
- 50% exceedance level
- Diversity adder values
- NQC
Deliverability testing levels

- **20% exceedance level**
- **50% exceedance level**

- Compensates for unavailable generation
- Unavailable generation

Available generation
Import, Load and Contingency Study -- Assumptions

- Imports modeled in the cluster base case are the same import levels used for RA purposes:
  - Summer peak load, maximum import conditions
  - by tie point

- The 2010, 1 in 5 peak load forecast for the ISO Control Area was modeled in the base case.

- All NERC Category B and selected Category C contingencies were analyzed while applying the study methodology:
  - Category C.5 (double circuit towerlines)
  - Common mode contingencies on the 500 kV system
  - Category C contingencies identified in reliability study that can be mitigated with congestion management
Deliverability Study Tools
Deliverability Study Tools

- The tools used for this study automatically adjust the generation dispatch to identify where the combined output from resources can cause overloads on transmission facilities.

- For the identified overload, the following key information is reported by the tools as a part of study results:
  - Facilities that could be overloaded.
  - Contingencies that cause the overload.
  - Resources that contribute to the overload.
Deliverability Study Tools (Cont)

- In this study, a DC powerflow screening tool is used first and then an AC powerflow is used to further analyze the potential problems identified during the screening analysis.

- The generation dispatch and contingency combination require the optimization and linearized power flow solution techniques available in MUST in order screen the combinations and identify the potential problem scenarios.

- The DC analysis screens all cases and selects only the cases with the potential to cause overloads.
Deliverability Study Tools (Cont)

- AC Analysis: Verification process to confirm the identified overloads.

- Then AC analysis re-simulate each scenario using AC power flow and confirm the overload.
  - In addition, specific procedures in the study methodology are applied e.g. limit the number of resources moved inside each gen pocket to 20 units
  - The amount of generation increased is generally limited to 1500 MW
  - These procedures primarily limit the total amount of generation increase in the Gen pocket to a reasonable level.
DC Screening (MUST)

- Overloaded Facilities
- Contingency details
- Resources that contribute to the overloads

Apply Specific Methodology (EPCL)

- Limit generation increase based on methodology
- Verify scenarios that the overload could occur within limits of methodology using AC power flow
- Report loading on the overloaded facilities
- Report resources contributing to the overload

Based on DC power flow, determine potential problems that could occur along with the information of generators that cause/exacerbate the problems.

Simulates each scenario based on the information obtained from MUST using AC power flow (contingency and resource dispatches). Report only the cases which are constrained within the parameters of the methodology.
## Appendix B

### Phase II A Baseline Deliverability Study Preliminary Rev1, PGE NERC Category A

Header of each page indicates the area of the limiting facilities and performance level of the contingencies that cause the overload

### Facilities that could be overloaded (bottleneck) and their ratings

* = 0% Deliverable  
** = Partially Deliverable

### List of resources inside each gen pocket

### Bus Numbers of the resources

### Bus Names

### Rated Voltage of each bus

### Resource ID in power flow

### Resource Status

1 = Online  
0 = Offline

### Maximum Capacity

### Distribution Factor

### Area Number

### Zone Number

### Dispatch Level (Deliverable capacity level for units with **)

### Flow Impact = (DFAX * Pmax) / Rating of the facility

---

<table>
<thead>
<tr>
<th>BUS NO-</th>
<th>NAME-</th>
<th>-KV-</th>
<th>ID</th>
<th>ST</th>
<th>GEN</th>
<th>PMAX-A</th>
<th>DFA</th>
<th>FLW IMPCT</th>
<th>OWND</th>
<th>Q No</th>
</tr>
</thead>
<tbody>
<tr>
<td>34605</td>
<td>PO429</td>
<td>13.8</td>
<td>1</td>
<td>1</td>
<td>108.2</td>
<td>108.2</td>
<td>30</td>
<td>0.1423</td>
<td>0.0572</td>
<td>1</td>
</tr>
<tr>
<td>34605</td>
<td>PO429</td>
<td>13.8</td>
<td>2</td>
<td>1</td>
<td>108.2</td>
<td>108.2</td>
<td>30</td>
<td>0.1423</td>
<td>0.0572</td>
<td>1</td>
</tr>
<tr>
<td>34684</td>
<td>HELMS 3</td>
<td>18</td>
<td>1</td>
<td>1</td>
<td>404</td>
<td>404</td>
<td>30</td>
<td>0.1482</td>
<td>0.2226</td>
<td>390</td>
</tr>
<tr>
<td>34682</td>
<td>HELMS 2</td>
<td>18</td>
<td>1</td>
<td>1</td>
<td>404</td>
<td>404</td>
<td>30</td>
<td>0.1482</td>
<td>0.2226</td>
<td>390</td>
</tr>
<tr>
<td>34600</td>
<td>HELMS 1</td>
<td>18</td>
<td>1</td>
<td>1</td>
<td>404</td>
<td>404</td>
<td>30</td>
<td>0.1482</td>
<td>0.2226</td>
<td>390</td>
</tr>
<tr>
<td>34583</td>
<td>HELMS 1</td>
<td>18</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>180</td>
<td>30</td>
<td>0.0502</td>
<td>0.0336</td>
<td>1</td>
</tr>
<tr>
<td>34582</td>
<td>HELMS 1</td>
<td>15</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>180</td>
<td>30</td>
<td>0.0502</td>
<td>0.0336</td>
<td>1</td>
</tr>
<tr>
<td>34581</td>
<td>HELMS 1</td>
<td>15</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>180</td>
<td>30</td>
<td>0.0502</td>
<td>0.0336</td>
<td>1</td>
</tr>
<tr>
<td>34667</td>
<td>PO418GT4</td>
<td>13.8</td>
<td>4</td>
<td>1</td>
<td>88.8</td>
<td>88.8</td>
<td>30</td>
<td>0.0521</td>
<td>0.0172</td>
<td>1</td>
</tr>
<tr>
<td>34665</td>
<td>PO418GT3</td>
<td>13.8</td>
<td>3</td>
<td>1</td>
<td>88.8</td>
<td>88.8</td>
<td>30</td>
<td>0.0521</td>
<td>0.0172</td>
<td>1</td>
</tr>
<tr>
<td>34663</td>
<td>PO418GT2</td>
<td>13.8</td>
<td>2</td>
<td>1</td>
<td>88.8</td>
<td>88.8</td>
<td>30</td>
<td>0.0521</td>
<td>0.0172</td>
<td>1</td>
</tr>
<tr>
<td>34661</td>
<td>PO418GT1</td>
<td>13.8</td>
<td>1</td>
<td>1</td>
<td>88.8</td>
<td>88.8</td>
<td>30</td>
<td>0.0521</td>
<td>0.0172</td>
<td>1</td>
</tr>
<tr>
<td>34485</td>
<td>FRESNOWW</td>
<td>12.5</td>
<td>1</td>
<td>1</td>
<td>9</td>
<td>9</td>
<td>30</td>
<td>0.1167</td>
<td>0.0039</td>
<td>390</td>
</tr>
<tr>
<td>34539</td>
<td>GWF_G1</td>
<td>13.8</td>
<td>1</td>
<td>1</td>
<td>45.3</td>
<td>45.3</td>
<td>30</td>
<td>0.0539</td>
<td>0.0091</td>
<td>390</td>
</tr>
<tr>
<td>34541</td>
<td>GWF_G2</td>
<td>13.8</td>
<td>1</td>
<td>1</td>
<td>45.1</td>
<td>45.1</td>
<td>30</td>
<td>0.0539</td>
<td>0.0091</td>
<td>390</td>
</tr>
<tr>
<td>34431</td>
<td>GWF_HEP1</td>
<td>13.8</td>
<td>1</td>
<td>1</td>
<td>40</td>
<td>40</td>
<td>30</td>
<td>0.053</td>
<td>0.0079</td>
<td>380</td>
</tr>
<tr>
<td>34624</td>
<td>BALCH 1</td>
<td>13.2</td>
<td>1</td>
<td>1</td>
<td>34</td>
<td>34</td>
<td>30</td>
<td>0.0616</td>
<td>0.0078</td>
<td>380</td>
</tr>
<tr>
<td>34433</td>
<td>GWF_HEP2</td>
<td>13.8</td>
<td>1</td>
<td>1</td>
<td>39.1</td>
<td>39.1</td>
<td>30</td>
<td>0.053</td>
<td>0.0077</td>
<td>380</td>
</tr>
<tr>
<td>34672</td>
<td>KRCDPCT2</td>
<td>13.8</td>
<td>1</td>
<td>1</td>
<td>56</td>
<td>56</td>
<td>30</td>
<td>0.0573</td>
<td>0.0119</td>
<td>380</td>
</tr>
<tr>
<td>34671</td>
<td>KRCDPCT1</td>
<td>13.8</td>
<td>1</td>
<td>1</td>
<td>56</td>
<td>56</td>
<td>30</td>
<td>0.0573</td>
<td>0.0119</td>
<td>380</td>
</tr>
<tr>
<td>34642</td>
<td>KINGSBUR</td>
<td>9.1</td>
<td>1</td>
<td>1</td>
<td>35.3</td>
<td>35.3</td>
<td>30</td>
<td>0.0523</td>
<td>0.0069</td>
<td>380</td>
</tr>
<tr>
<td>34641</td>
<td>LTR_PWR</td>
<td>9.1</td>
<td>1</td>
<td>1</td>
<td>26.4</td>
<td>26.4</td>
<td>30</td>
<td>0.007</td>
<td>0.0069</td>
<td>380</td>
</tr>
</tbody>
</table>
Concluding Comments

- The CAISO assesses deliverability through three distinct assessments:
  - Deliverability of generation to the aggregate of load;
  - Deliverability of imports; and
  - Local capacity requirements

- All three of these assessment methodologies have been accepted by the CPUC and FERC

- The ISO has demonstrated using its generation deliverability assessment that the currently planned transmission system can accommodate more generation than what is needed to meet the State’s 33% RPS requirement by 2020

- However, the deliverability assessment is for resource adequacy planning and does not guarantee that there will not be any congestion