

## **Generation Connection Process - North American vs Australian Experience**

**M. HEIDARI, J. JIANG, J. TAILOR, T. ABDEL-GALIL**  
**SNC Lavalin Inc**  
**Canada**

### **SUMMARY**

This paper presents a summary of our recent experience with interconnection processes in North America (specifically with NYISO in New York) and Australia (specifically with AEMO in Victoria). The paper provides an overview of the connection application steps for both regions and highlights the main differences between the two (specifically in terms of large generator interconnection procedures). The paper mainly focuses on the interconnection studies required during the interconnection application process, roles and responsibilities of stakeholders i.e. the independent system operator (ISO), the connecting transmission facility owner (TFO), the developer, and consultants during the studies phase, and it discusses how they affect the overall connection process.

### **KEYWORDS**

Generator, Interconnection, NYISO, AEMO

## 1 INTRODUCTION

Non-utility generation has a long history around the world. In North America, the concept of non-utility generators (NUGs) or independent power producers (IPPs) goes back to 1970s. In 1978, the Congress passed the US Public Utility Regulatory Policies Act (PURPA), which established a class of non-utility generators, called Qualifying Facilities (QF), which were permitted to produce power for resale [1].

Nowadays, IPPs can compete for supplying power and energy and access to the transmission network in most modern countries. Depending on their size, these power producers could connect to the power system at the transmission or distribution levels, and they can provide active power as well as ancillary services such as inertia, reactive power support etc. They also perform a critical role in system reliability and security. Independent system operators (ISOs), however, still have the role of supervising the electricity market and they are responsible to ensure that the power system reliability remains at an acceptable level under all conditions. As a result, IPPs need to go through a connection application process before they can connect to a power system to ensure that the system operator requirements are met, and the reliability and the security of the power system has not negatively compromised.

This paper presents a summary of our recent experience with interconnection processes (specifically larger generator interconnection procedures) in North America (specifically with NYISO in New York) and Australia (specifically with AEMO in Victoria). Section (2) of the paper provides an overview of the connection application steps for NYISO, section (3) of the paper provides an overview of the interconnection procedures in Australia (with AEMO), section (4) discusses some of the differences between the two regions, finally conclusions are presented in section (5).

Please note that the paper does not intend to provide the details of the interconnection procedures in the above regions, and it merely provides high-level overviews of our understanding of required procedures at the time of writing this paper. Readers should refer to the most recent rules, regulations, and procedures of the appropriate authorities to obtain up-to-date and accurate information.

## 2 OVERVIEW OF THE INTERCONNECTION PROCEDURES WITH NYISO

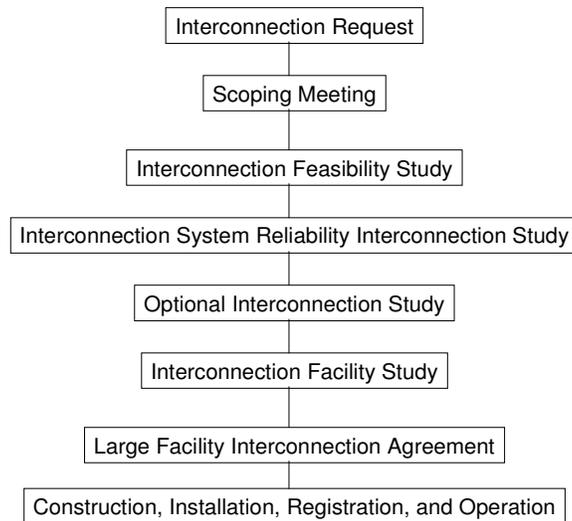
NYISO has different procedures for larger and small generator interconnections, and usually the procedures for small generator interconnections are simpler than the procedures for large generator interconnections. The focus of this paper is on larger new generator interconnections and the procedures described here are based on [2]. Although for the exact definition of large generator one should refer to the appropriate NYISO manual at the time, generally speaking new generators larger than 20MW should go through the large generator interconnection procedures. The overall steps of the procedure are shown in Figure 1.

The first step of an interconnection is to submit an interconnection request. Upon receipt of a new Large Facility Interconnection Request (LFIR), NYISO performs a number of initial processing steps, and assigns the new LFIR a Queue Position based on the date and sequence it was received.

After the initial processing has been completed, NYISO holds a Scoping Meeting with the developer and the connecting transmission owner (CTO). The purpose of the Scoping Meeting is to discuss the interconnection options for the proposed project and identify the potential feasible Points of Interconnection (POIs).

The next main step in the interconnection procedures is the interconnection feasibility study (FES). The purpose of the feasibility study is to develop a conceptual design for the proposed interconnection, evaluate the impact of the project on the pre-existing electric system around the POI, preliminarily identify the CTO attachment facilities (CTOAFs) and any system upgrade facilities (SUFs) that would be required to interconnect the project to the system, and develop estimates of the cost and time to construct the required facilities. Please note that the parties (i.e., NYISO, CTO and the developer) may decide to forego the feasibility study and proceed directly to a system reliability impact study (SRIS). Upon completion of the feasibility study, a SRIS should be performed. The purpose of the SRIS are to: evaluate the impact of the project on the system (in more depth than the feasibility study and based on the conceptual interconnection design from the feasibility study), re-evaluate and revise the list of

CTOAFs and SUFs identified in the feasibility study, and re-evaluate and revise the estimates of the cost and time to construct the required facilities. If the feasibility study was not performed, the SRIS would be the first study for the project, and the SRIS scope would include development of the conceptual design for the proposed interconnection.



**Figure 1 main steps of a large generator interconnections procedures**

Optional studies could be done as per the developer request. Although during the feasibility study, one or more alternative POI(s) could be evaluated, the Developer must specify which POI is to be evaluated in the SRIS, and only one POI may be evaluated in the SRIS. However, if the Developer wishes to evaluate alternative POI(s) at the SRIS step of the interconnection process, the Developer may request a reasonable number of Optional Interconnection Studies (OISs) to be performed concurrently with the SRIS.

After completion of the SRIS, the next main step is the Facilities Study, which is performed under the umbrella of the NYISO Class Year Facilities Study process. The Class Year Facilities Study (CYFS) is conducted for a set of projects that have met the eligibility requirements for entry into a Class Year. The CYFS consists of several separate studies grouped into two general “Parts”. Part 1 studies mainly identify the required CTOAFs and local SUFs involved in the direct connection of the Project to the pre-existing electric system. Part 2 studies include the Annual Transmission Baseline Assessment (ATBA), the Annual Transmission Reliability Assessment (ATRA), and the Class Year Deliverability Study. In summary, these studies are performed to obtain estimation of cost and time to construct SUFs required for all the projects involved in the CYFS collectively, and also to determine the cost allocation among the CY developers.

According to [2], generally speaking, NYISO has overall responsibility for the performance of all interconnection studies under the LFIP. However, NYISO may request the CTO to perform all or portions of a study, or to utilize a third party (e.g., an engineering consultant) to perform all or portions of a study. For example, NYISO usually seeks the assistance of the CTOs for much of the “Part 1 Studies” in CYFS. The CTOs may opt to use consultants for some of this work. If a CTO prefers, NYISO may hire a consultant to perform this work. Also according to [2], the developer may hire a consultant to perform the analytical portion of the feasibility and SRIS studies.

Once all the studies are completed and the required approvals are obtained, a large generator interconnection agreement can be signed. After execution of the Interconnection Agreement, the developer may proceed with detailed engineering, construction, installation, registration, testing, and operation of the project.

### 3 OVERVIEW OF THE INTERCONNECTION PROCEDURES WITH AEMO

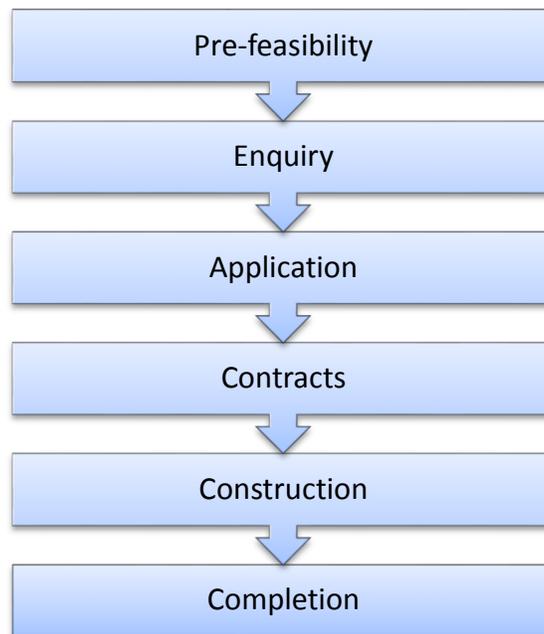
In Australia, a Connection Applicant wishing to connect a facility to the National Electricity Market (NEM) must communicate with the connecting Network Service Provider (NSP). The connecting NSP manages the connection process and is the main point of contact for the Connection Applicant.

Across the NEM, Australia Electricity Market Operator (AEMO)'s role is to assess and negotiate performance standards that could affect power system security. AEMO is also involved in assessing simulation models of power system plant and associated control systems, and commissioning and post-commissioning activities.

In the State of Victoria, AEMO has additional responsibilities. The transmission network is a Declared Shared Network (DSN) and AEMO has been delegated certain functions performed in other parts of the NEM by the connecting NSP in processing connections to the Victorian transmission network.

The focus of this paper is on connection process with AEMO and the procedures described are based on Victorian Transmission Connections – Process Overview,

(<https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Network-connections/Victoria-transmission-connections---process-overview>). The overall steps of the procedure are shown in Figure 2.



**Figure 2 Connection Application – Process Overview**

The first step of the connection process is the Pre-feasibility. Applicants consider the feasibility of their project and begin discussions with the connecting Network Service Provider (NSP), landowners and relevant government authorities. NSPs usually refer to this phase as preliminary enquiry or pre-feasibility. AEMO's role is to provide transmission network data and other information if requested. At the end of the Pre-feasibility, a connection enquiry is prepared.

Upon the completion of Pre-feasibility, the Applicant submits the connection enquiry to the connecting NSP to determine the most suitable point of connection, information required to submit an application and establish the scope and estimate of any required connection assets. Upon the receipt of connection enquiry, NSP undertakes a Preliminary Impact Assessment (PIA) and consults AEMO. AEMO's role is to receive enquiry, coordinate response, and provide transmission network data if requested. At the end of Enquiry, NSP provides an enquiry response to the Applicant.

Next main step is the application. The Applicant submits an application to the NSP. During this step, the Applicant engages consultant to prepare the connection application including preparation of connection study report, completion of Generator Performance Standard (GPS), Releasable User Guide (RUG), computer models and other information. NSP receives and reviews the application, consults AEMO and confirms the ability to meet performance requirements for registration. AEMO's role is to receive and coordinate assessment of application. At the end of this stage, AEMO responds to the NSP and the NSP responds to the Applicant.

After the completion of Application, AEMO prepares an offer for connection. Then a connection agreement (contract) is finalized. The next step is the construction. The Applicant completes and implements designs, prepares commissioning programs, and finalises supporting information. At the commissioning stage, developers have to undertake a rigorous testing regime (often referred to as 'R2' testing) of the installed facility to demonstrate validity of the software models of generating system submitted at the GPS stage. The testing at R2 stage is followed by tweaking of model parameters such that the simulated response matches the measured response from field tests. This part is akin to NERC MOD standard tests that are prevalent in North America. AEMO's role is to review construction progress reports, facilitate resolution of any technical issues, and receive and review updated data and other information from the Applicant. Final step is completion. This phase involves finalization of market registration and commissioning of the facility, involving both AEMO and NSP. The time of the whole connection process depends on various factors such as project size, degree of technical difficulty, negotiation, etc.

## 4 TECHNICAL REQUIREMENTS

### 4.1 Main Technical Requirements by AEMO

There are detailed technical requirements by AEMO for new generating system (GS). Following are high level description of the main requirements. For complete list of requirements and their details, refer to the latest version of the National Electricity Rules (<https://www.aemc.gov.au/regulation/energy-rules/national-electricity-rules/current>).

- **Reactive Power Capability:** This requirement is concerned with the capability of a GS to deliver reactive power at its connection point, which assists in the maintenance of a suitable power system voltage profile. Root Mean Squared (RMS) simulation is required to demonstrate the compliance.
- **Response to Frequency Disturbance:** These technical requirements consider the response of the GS to frequency disturbances at the connection point, and the conditions for which they must remain connected. Both RMS and Electromagnetic Transient (EMT) simulations are required to demonstrate the compliance.
- **Response to Voltage Disturbance:** These technical requirements consider the response of a GS to voltage disturbances at the connection point, and the conditions for which they do (and do not) remain connected. Both RMS and EMT simulations are required to demonstrate the compliance.
- **Generating system response to disturbances following contingency events:** This includes a requirement that a GS remain in operation following the occurrence of both nearby faults and remote faults, or operational loss of power system elements, external to the GS. Both RMS and EMT simulations are required to demonstrate the compliance.
- **Impact on network capability:** These technical requirements consider the impact of the GS on inter-regional and intra-regional transfer capability. Both RMS and EMT simulations are required to demonstrate the compliance.
- **Frequency Control:** These technical requirements consider the performance of the frequency control system and the ability of the GS to increase or decrease its active power output in response to a power system frequency event. Both RMS and EMT simulations are required to demonstrate the compliance.

- Voltage and reactive power control: These technical requirements consider the performance of the voltage, power factor and reactive power control system, and the ability of the GS to increase or decrease its reactive power output in response to a power system incident and to support network voltage through changes in the control system reference points. Both RMS and EMT simulations are required to demonstrate the compliance.
- Active Power Control: These technical requirements consider the ability of a GS to increase or decrease its active power transfer in response to a dispatch instruction from AEMO.
- Fault Current: These technical requirements consider the fault current contribution of a GS to the connecting network, and the fault current withstand of the GS and those circuit breakers used to isolate it from the network. Both RMS and EMT simulations are required to demonstrate the expected current contribution.

#### **4.2 Main Technical Requirements by NYISO**

NYISO has different procedures for small [6] and large [5] interconnections. Also, the procedures differ for Capacity Resource Interconnection Service (“CRIS”) and Energy Resource Interconnection Service (“ERIS”). This section mainly intended to provide a general understanding of the types of studies that are needed for an interconnection study in New York. The readers should refer to the latest version of the NYISO tariff for the full details. Generally speaking NYISO planning is based on the following standards and guidelines [7]:

- NERC principles and guides
- Principles and standards for planning the bulk electric systems of the NPCC; and Transmission planning criteria, methods and procedures described in the FERC Form No. 715-Annual Transmission Planning and Evaluation Report for the NPCC Region
- NYSRC Reliability Rules including Local Reliability Rules.

In a typical System Reliability Impact Study, the following items need to be addressed [2]:

- Impact on Base System Conditions
  - This involves steady state analysis of the system to assess the impact of the proposed project on base system conditions (generation dispatch, power flows, voltage, equipment loadings, etc.)
- Impact on System Performance and Transfer limits: This involves several studies including:
  - Thermal Analysis
    - Assessment of the impact of the project on normal and emergency thermal transfer limits.
  - Voltage Analysis
    - Assessment of the impact of the project on system voltage performance and voltage-based transfer limits if more limiting than the emergency thermal transfer limits
  - Stability Analysis
    - Assessment of the impact of the project on system stability performance and stability-based transfer limits if more limiting than the emergency thermal transfer limits or voltage-based transfer limits.
- Impact on Fault Duties
  - This involves fault analysis to assess the impact of the proposed project on the fault levels in the area.

## **5 COMPARISON OF NYISO AND AEMO APPROACHES**

Based the experiences with NYISO and AEMO it seems that the major steps to be taken in both regions are similar. For example, the SRIS required by NYISO is mostly covered by the connection

study that is required by AEMO. However, there are some minor differences that are highlighted in this section.

### **5.1 *Involvement of Developer***

Although NYISO allows the developer to hire a consultant for the analytical portions of the feasibility study and the system reliability impact study, generally speaking NYISO is the responsible party for performing the connection studies, and most of the time NYISO (CTO, or their consultants) perform a major portion of the required studies. On the other hand, in Australia, a big portion of the connection studies is conducted by the developer (or its consultants), and the developer usually ensures that the proposed interconnection meets the AEMO requirements (as defined in National Electricity Rules (NER) [3]) before they submit their application to AEMO. While ideally both of these approaches work well, our recent experience revealed a number of advantages and disadvantages for each the approaches.

The main advantage of the approach taken by NYISO is the high level of efficiency in conducting the studies. Since NYISO (CTO, or their consultants) perform the required studies for several interconnection requests every year, they become highly familiar with the process, which enables them to conduct the studies efficiently and quickly. Also repetition of a similar set of studies several times every year, allows NYISO to invest in automation tools for the connection studies, which in-turn can accelerate the study procedures even further. The downside of the NYISO approach is the fact that NYISO usually does not have a deep knowledge of the developer equipment and design. Although NYISO provides several communication channels, certain details may not be fully transferred between the developer engineering team and the NYISO study team, which reduces their ability to fully optimize the plant design.

On the other hand, under AEMO approach, the developer (or its consultants) is the main responsible party for performing the required connection studies. The system operator defines three levels of system access standards i.e. automatic, negotiated, and minimum. If a developer can demonstrate that it meets the automatic access standard for a system performance criterion, then it automatically passes the requirements of that clause. If a developer cannot meet the automatic access standard, but can demonstrate that it meets the minimum access standard for a system performance criterion, it can negotiate with the system operator to identify if the access standard can be relaxed (negotiated) without affecting the overall system reliability and security. Finally if the developer cannot meet the minimum access standard for any of the clauses, its application will be rejected. Since the developer is usually very familiar with the capabilities of its equipment and flexibilities in their design, this approach enable the developer to propose an optimized size and design for its plant. Also, since the developer performs a big portion of the studies, it usually assesses the feasibility of proposing an economical design that meets the NER requirements, and it may not proceed with the application, if the developer concludes that an economical design is not feasible. This will significantly reduce the burden on AEMO, and enables it to review the applications it receives more thoroughly. The downside with the AEMO approach is that usually the developer does not perform many connection studies per year; therefore, the developer should go through a learning curve every time it needs to conduct a connection study.

### **5.2 *Electromagnetic Transient Simulations***

Another difference that was observed between NYISO and AEMO was the level of electromagnetic transient studies required during the connection studies. While NYISO usually does not require a significant level of EMT studies, AEMO requires a considerable portion of the studies to be verified in an EMT simulation program [4]. Requirements for EMT simulations significantly increases the required efforts and complexity of the connection studies. However, EMT studies can identify issues that may not be detected with traditional transient stability programs. This is especially important for weak sections of the network.

## 6 CONCLUSIONS

The paper summarized our recent experience with interconnection procedures in North America (specifically with NYISO) and Australia (specifically with AEMO in Victoria). Although the main components of the interconnection studies in both regions are similar; there are few differences between the two processes.

One of the major differences between NYISO application process and AEMO application process is the level of the developer involvement in the connection studies. Although NYISO allows the developer to perform the analytical portion of the system studies, usually a big portion of the connection studies are performed by the NYISO itself (CTO or their consultants). On the other hand, in Australia, usually a big portion of the connection studies is carried out by the developer (or its consultants), and the system operator will only review and assess the sufficiency and validity of the studies. While the North American approach provides a high level of efficiency (as the system operator is completely familiar with the system and the required study steps), it reduces the ability of the developer to do a thorough design optimization. On the other hand in Australia, the system operator defines three levels of system access standards i.e. automatic, negotiated, and minimum. The developer is responsible to demonstrate that it meets the required access standard levels. This approach allows the developer to optimize the plant size and design and prioritize various aspects of its plant specifications.

Another noticeable different between the NYISO and AEMO procedures is the level of EMT studies required for the connection studies. While NYISO usually does not require a significant level of EMT studies, AEMO requires a considerable portion of the studies to be verified in an EMT simulation program. Requirements for EMT simulations significantly increases the required efforts and complexity of the connection studies. However, EMT studies can identify issues that may not be detected with traditional transient stability programs. This is especially important for weak sections of the network.

## BIBLIOGRAPHY

- [1] “The Public Utility Regulatory Policies Act (PURPA)”, Pub.L. 95–617, 92 Stat. 3117, enacted November 9, 1978
- [2] NYISO, "Transmission Expansion and Interconnection Manual", Version: 3.0, Effective Date: 06/30/2017
- [3] AEMC, "National Electricity Rules Version 121", 2 May 2019
- [4] AEMO – Network Development, "Access Standard Assessment Guide", January 2019
- [5] New York Independent System Operator, Inc. - NYISO Tariffs - Open Access Transmission Tariff (OATT) - 30 OATT Attachment X – “Standard Large Facility Interconnection Procedures”, Effective Date: 6/30/2010
- [6] New York Independent System Operator, Inc. - NYISO Tariffs - Open Access Transmission Tariff (OATT) - 30 OATT Attachment Z – “Small Generator Interconnection Procedures”, Effective Date: 6/30/2010
- [7] New York Independent System Operator, Inc. - NYISO Tariffs - Open Access Transmission Tariff (OATT) - 10 OATT Attachment D – “Methodology For Completing a System Impact Study, Transmission Service Study, or Network Integration Transmission Service Study”, Effective Date: 4/1/2016
- [8] New York State Reliability Council, "Reliability Rules & Compliance Manual", For Planning and Operating the New York State Power System, Version 44, April 11, 2019