WHITE PAPER

Wind-to-Solar Conversion

Interconnection Queue Generator Modifications

Considerations for Mid-Queue Generator Modifications

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Abstract

The interconnection application process for transmission operators, as regulated by the Federal Energy Regulatory Commission (FERC), generally takes between two and three years to complete from Sargent & Lundy's experience. With the economics of renewable technologies continuously changing, developers may look to repurpose existing interconnection applications with more optimal generation technologies without requiring the assignment of a new interconnection queue number.

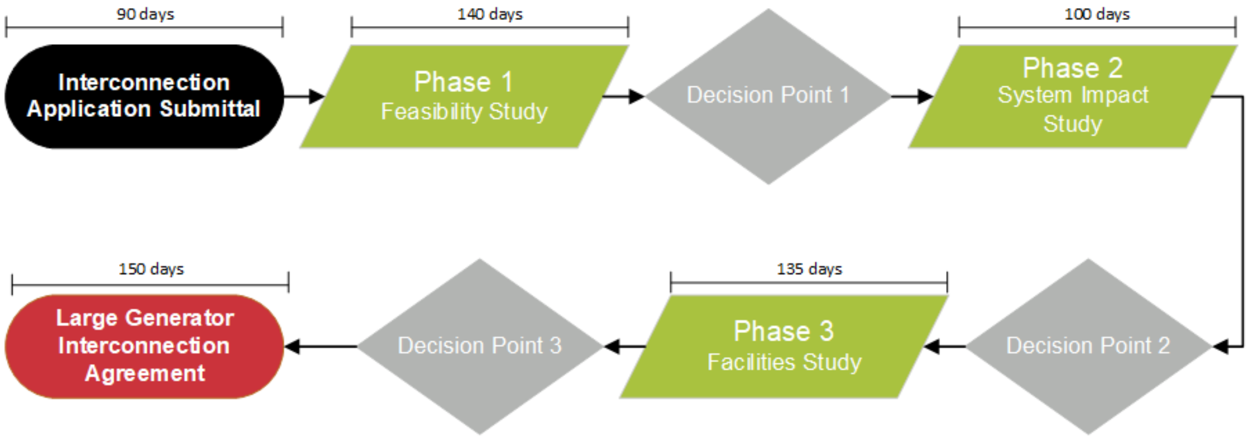
This white paper highlights the insights and considerations that Sargent & Lundy has identified during our engineering support of mid-queue, wind-to-solar generator changes in compliance with FERC Order 845. The goal is to assist owners, developers, and engineers in the efficient development and execution of an interconnection application while incorporating technoeconomic advancements made during the interconnection process. Although FERC Order 845 provides guidance on incorporating non-material changes into an interconnection application, it is the responsibility of the interconnection customer to demonstrate to the independent system operator (ISO) that proposed changes result in "equal or better" electrical performance for the transmission system.

Our insights and findings are based on our work in Midcontinent Independent System Operator (MISO) territory but are generally representative of any ISO territory under FERC regulation.

Introduction

New generation projects greater than 20 MW being constructed within an independent system operator (ISO) territory regulated by the Federal Energy Regulatory Commission (FERC) must submit into and complete the applicable ISO interconnection queue process before connecting to the transmission system. The general process is a three-phased approach that entails the completion of a feasibility study, impact study, and facilities study by the ISO before the execution of a large generator interconnection agreement (LGIA). Sargent & Lundy frequently performs these studies on behalf of developers using Transmission Adequacy & Reliability Assessment (TARA) software.

Figure 1 — Generic Interconnection Process



Upon submittal of an interconnection application, the interconnection customer is assigned an interconnection queue position number. Interconnection applications are processed in the order in which the interconnection queue numbers are assigned. Once assigned an interconnection queue position, interconnection customers are limited in the changes that can be made to the interconnection application. Any changes to the application that are considered material changes and have an impact on the electrical performance of the transmission system require the interconnection customer to be assigned a new interconnection queue position and restart the interconnection process.

The duration needed to complete the interconnection process requires developers to submit interconnection applications long before the expected commercial operation date (COD) of the project. With the rapid changes in power generation technology and economics, particularly for renewable generation, a developer may determine that an existing interconnection application is no longer an optimal project. FERC Order 845 provides a process by which a developer can make changes to an existing interconnection queue application, such as capacity or fuel type, without requiring the assignment of a new interconnection queue position number. This can be advantageous to developers whose projects are dependent on federal regulations or who have submitted into a queue with a technology that is no longer optimal.

Interconnection Queue Generator Modifications

Regulatory Filings

FERC Orders 845 and 845-A

FERC Order 845 was issued on April 19, 2018 in response to the electric power industry's numerous changes since the issuance of FERC Order 2003. FERC Order 2003 required public utilities that own, control, or operate facilities for transmitting electric energy in interstate commerce to file revised open-access transmission tariffs containing standard generator interconnection procedures and a standard agreement. FERC subsequently issued FERC 845-A on February 21, 2019 with additional clarifications and determinations.

FERC Order 845 changes were due to factors such as the economics of new power generation (driven by sustained low natural gas prices), technological advances, and federal and state policies. With the implementation of FERC Order 845, interconnection customers can make certain generator changes during the interconnection queue process, provided that the changes result in "equal or better" electrical performance. These technological advancements include a fuel change (i.e., wind to solar PV). Leveraging the ability for mid-queue generator changes allows interconnection customers to maximize project economics without impacting the project timeline by being forced to accept a new queue position for changes to a proposed project's technical characteristics.

Each ISO has its own guidelines and standards for allowing and accepting technological advancements compliant with FERC Order 845. The ISO-specific guidelines are generally outlined in each ISO's open-access transmission tariff (OATT). In all cases, it is the responsibility of the interconnection customer to demonstrate that changes to the technical characteristics of the project result in "equal or better" electrical performance to retain the project's interconnection queue position.

Reasons for Generator Modifications

Tax Credits

United States federal tax credits have been key drivers behind the growth of utility-scale wind and solar projects. These federal tax credits include the Business Energy Investment Tax Credit (ITC) and the Renewable Energy Production Tax Credit (PTC). The ITC is often utilized by solar projects; onshore wind projects have historically relied on the PTC. Changes in the relative values of these tax credits in the near term are expected to drive a shift from wind to solar project development.

Expiring Wind Production Tax Credits

The PTC is a per-kilowatt-hour (per-kWh) tax credit that accrues to the project owner over a 10-year period based on the amount of energy produced by the project. Eligibility of the PTC tax credit is based on the date when the project commences construction or the year in which 5% of the total capital cost for the project has been spent and construction has begun (known as safe harboring). The 10-year timeline starts from the time the project is placed in service.

The value of the PTC is based on the year in which construction commences or equipment is safe harbored, as shown in Table 1.[1]

Table 1 — PTC Schedule

Construction Begins / Equipment Safe Harbored	Estimated PTC	Placed-in-Service Date
After Dec. 31, 2016	1.9 cents/kWh	Dec. 31, 2021
By Dec. 31, 2017	1.8 cents/kWh	Dec. 31, 2022
By Dec. 31, 2018	1.4 cents/kWh	Dec. 31, 2022
By Dec. 31, 2019	1.0 cent/kWh	Dec. 31, 2023
By Dec. 31, 2021	1.5 cents/kWh	Dec. 31, 2025

After commencing construction by the deadline noted in Table 1, projects have four years to begin producing electricity. On May 27, 2020, the Internal Revenue Service (IRS) issued Notice 2020-41, providing a one-year extension to qualifying projects that began construction in 2016 or 2017. IRS Notice 2020-41 provides a five-year construction window to provide relief related to the effects of the COVID-19 pandemic. The Consolidated Appropriations Act of 2021, enacted on December 27, 2020, further extends the PTC deadlines,[2] as reflected in Table 1 for placed-in-service dates prior to 2026.

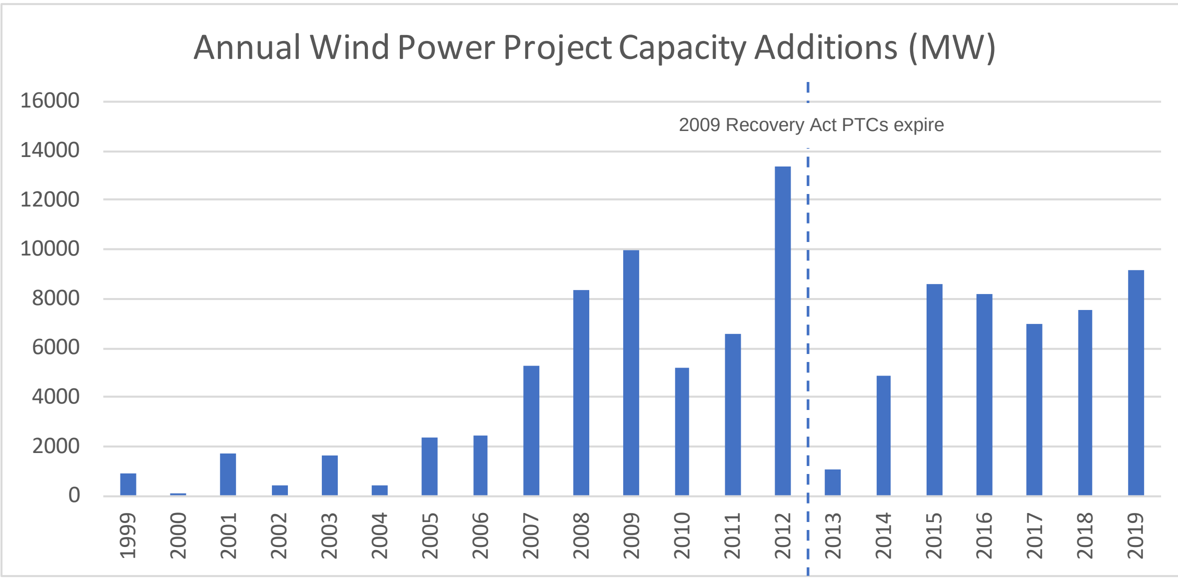
While the possibility of legislative changes remains, the current PTC schedule is set to sunset on wind projects with construction and development activities commencing after the end of 2021. Historically, the wind industry has responded to the prospect of declining tax incentives by curtailing new capacity additions,[3] as shown in Figure 2. The American Recovery and Reinvestment Act of 2009 (2009 Recovery Act) extended wind PTCs through the end of 2012. The expiration of the PTCs and legislative uncertainty resulted in a sharp decline of wind capacity installations the following year.

[1] https://www.energy.gov/sites/prod/files/2020/02/f71/weto-funding-factsheet-2020.pdf

[2] https://home.kpmg/us/en/home/insights/2020/12/tnf-favorable-tax-provisions-renewable-energy-industry-enacted.html

[3] AWEA WPA Annual Report, 2019

Figure 2 — United States Wind Capacity Additions by Year



The scheduled expiration of wind PTCs has historically led to decreases in wind project development.

Solar Investment Tax Credits

The ITC is a tax credit that can be claimed on federal corporate income taxes for a certain percentage of the cost of a solar system that is placed in service during the tax year. The ITC is calculated by multiplying the applicable tax credit percentage (10–30%) by the tax basis, which is the amount invested in eligible property.

Table 2[4] details the applicable ITC percentage based on construction commencement and placed-in-service date.

Table 2 — ITC Schedule

Construction Begins	Estimated PTC	Placed-in-Service Date
by Dec. 31, 2019	30%	by Dec. 31, 2023
by Dec. 31, 2020	26%	by Dec. 31, 2023
by Dec. 31, 2021	22%	by Dec. 31, 2023
after Jan. 1, 2022	10%	after Jan. 1, 2024

Additionally, a solar system that is eligible for the ITC can also use an accelerated depreciation corporate deduction to provide additional incentive for solar development.

[4] Guide to the Federal Investment Tax Credit for Commercial Solar Photovoltaics, US Department of Energy, January 2020

While the tax incentives available for wind projects are scheduled to sunset, the tax incentives available for solar projects are not. For this reason, project sponsors can reasonably be expected to transition from wind to solar project development as a result of the changing landscape of tax incentives.

Costs

Sargent & Lundy has aggregated data from the constructed renewable energy projects we have supported over the last decade, including capital costs, operation and maintenance (O&M) costs, and the tax and economic factors that influence the cost for wind and solar energy. The predominate tax factor is the tax credits (production or investment), which is outlined in the “Tax Credits” section herein. Additional factors that significantly contribute to the cost of renewable energy are the capital and the O&M costs. While project costs within each technology are highly project-specific, a general comparison between wind and solar can be made.

Wind Costs

In Sargent & Lundy’s experience, wind projects in the United States can expect total capital costs to be approximately $1300–1400 per kilowatt (kW) of installed alternating current (AC) capacity and the average total O&M over the life of the project to be between $38/kW and $45/kW. The largest factor that leads to variation of the capital cost of a wind project is the turbine technology used; it makes up approximately 60–65% of the capital costs. The largest factor that leads to a variation of the O&M cost of a wind project is whether the project owner self-performs the maintenance or hires an independent service provider.

The levelized cost of electricity (LCOE) is the measure of a break-even point at which a project must sell its generated power to cover all annual and overnight expenses. Considering capital and O&M costs, typical energy generation, and industry-standard financial and economic assumptions, the LCOE for wind projects ranges from approximately $20 to $35 per megawatt (MW) while taking advantage of the full wind production tax credits. Without the tax credits, the LCOE for wind would range from approximately $35/MW to $55/MW. The general trends within the wind industry (lower costs, higher production, etc.) are lowering LCOE values approximately 5–10% annually.

Solar Costs

In general, solar photovoltaic (PV) projects in the United States can expect total capital costs to be approximately $1000–1200/kW of installed AC capacity and the average total O&M over the life of the project to be between $22/kW and $31/kW. The largest factors that lead to a variation of the capital cost of a solar project are the module and racking technologies used and the project capacity. The choice of these technologies and the project capacity impact typical civil and structural expenses from both direct material cost and economies of scale respectively. The largest factors that lead to a variation of the O&M costs of a solar project are typically location-specific (i.e., module cleaning requirements, vegetation management requirements, land lease costs, etc.).

Considering capital and O&M costs, typical energy generation, and industry-standard financial and economic assumptions, the LCOE for solar PV projects ranges from approximately $20/MW to $35/MW while taking advantage of the full solar investment tax credit. Without the tax credit, solar LCOE would range from approximately $30/MW to $50/MW. The general trends within the solar PV industry (lower costs, higher production, etc.) are lowering LCOE values approximately 20% annually, with decreases as high as 30% in some markets.

The trends for both costs and incentives within the wind and solar industry indicate that the solar LCOE will soon drop below that of wind. Because of this projection, many developers may want to change their generators while maintaining their position in the interconnection queue.

Non-Material Change Study

To proceed with a generator change, the ISO may require the completion of a non-material change study to show that a generator change results in "equal or better" performance than the original generator. Nearly all ISOs in the United States have some form of this requirement. Sargent & Lundy has performed non-material change studies, with our most recent experience in Midcontinent Independent System Operator (MISO) territory.

MISO technology modification rules are outlined in Section 4.4 of Attachment X[5] (Generator Interconnection Procedures). Interconnection customers can maintain their project's interconnection queue position following a change in generation technology so long as the developer submits a detailed technical analysis demonstrating that the modification is not a material modification. The detailed analysis shall include steady-state (thermal/voltage), reactive power, short-circuit/fault duty, and stability analyses unless the transmission provider deems one or more of them unnecessary based on the nature of the change requested. The following factors determine whether the proposed change is a material modification:

- Any change in expected output of the generating facility that is higher than what was studied in the interconnection process, unless control equipment is employed to limit the injection at the point of interconnection (POI) to the level of interconnection service originally requested
- An increase in short-circuit current that degrades transmission system reliability
- Angular stability performance and dynamic response that degrades transmission system reliability
- Violation of steady-state thermal or voltage limits caused by the planned change utilizing the same criteria consistent with the interconnection system impact study

Short-Circuit Studies

To evaluate the short-circuit impact of the proposed interconnection application modification, a short-circuit modeling study can be performed. Short-circuit models are obtained from the ISO; they are typically in ASPEN Oneliner format and are the same models used in the initial short-circuit evaluation of the project. With the equivalent short-circuit model updated to the specification of the modification, the short-circuit results are compared to pre- and post-modification. If no new short-circuit over-duties are identified, the change is not considered a material modification.

Additionally, if the modification results in use of a technology with a lower ceiling for fault contribution, justification can be made on these grounds rather than the need for a full short-circuit analysis.

Dynamic Modeling

To evaluate the angular stability performance and dynamic response of the modification, the dynamics package is obtained from the ISO. In the case of MISO, these files are in DSATools Transient Security

[5] https://www.misoenergy.org/api/documents/getbyname/Attachment%20X.pdf

Assessment Tool (TSAT) format; they may be in other formats, such as PSS/E, for other ISOs. This package includes design-basis dynamic contingency events. The dynamic events are simulated for both the current project design as well as post-modification to observe the post-event angular stability and dynamic response. If stability is maintained, the change is not considered a material modification.

Steady-State Modeling

In a steady-state analysis, the steady-state thermal and voltage performance of the modification is evaluated. While a technology change may result in no net change to project generation size, unique ISO and transmission owner rules may apply for each technology. For instance, in MISO's summer peak evaluation, wind is dispatched at 15.6% of the interconnection service request; in the shoulder peak case, it is dispatched at 100%. This differs from solar, where it is dispatched at 100% in the summer peak case and 50% in the shoulder peak case. The relevant power flow study cases are obtained from the ISO. These include all design-basis contingency event definitions. The modification is studied using an ISO-specific TARA contingency analysis program, and the original case results are compared against the modification. If no new violations are observed, the change is not considered a material modification.

Summary

The interconnection application process for transmission operators, as regulated by FERC, generally takes between two and three years to complete from Sargent & Lundy's experience. With the economics of renewable technologies continuously changing, developers may look to repurpose existing interconnection applications to utilize more optimal generation technologies without requiring the assignment of a new interconnection queue number. The benefits of this include:

- Utilizing optimal generator technology
- Changing the fuel type (e.g., wind to solar) to take advantage of current tax credits
- Maintaining project schedule

Each ISO has a process outlined for implementing FERC Order 845. Generally, in all cases it falls on the interconnection customer to demonstrate that the proposed modifications to the interconnection application result in "equal or better" electrical performance for the transmission system. A non-material change study can be performed, which includes:

- Short-circuit studies
- Dynamic modeling
- Steady-state modeling

Combined, these studies are generally sufficient to demonstrate that the proposed changes to the interconnection application result in "equal or better" electrical performance for the transmission system.

About Sargent & Lundy

Sargent & Lundy is one of the oldest and most experienced full-service architect engineering firms in the world. Founded in 1891, the firm is a global leader in power and energy with expertise in grid modernization, renewable energy, energy storage, nuclear power, and fossil fuels. Sargent & Lundy delivers comprehensive project services—from consulting, design, and implementation to construction management, commissioning, and operations/maintenance—with an emphasis on quality and safety. The firm serves public and private sector clients in the power and energy, gas distribution, industrial, and government sectors.

Sargent & Lundy's roles on electric power generation projects include full-design architect-engineer, owner's engineer, lender's independent engineer/technical advisor, and consultant. Our services include specialized technical advisory and consulting services to complete engineering and program management, encompassing procurement, construction management, technology transfer, and assistance with construction. Sargent & Lundy provides professional consulting, engineering, and design services throughout the lifecycle of power generation, transmission, and energy storage projects, from project concept and development, through detailed design and procurement, to construction and operation.

The Sargent & Lundy Electrical Analytical Group (EAD) consists of a team of specialists with advanced degrees in power systems engineering. Sargent & Lundy's EAD group has extensive experience related to transmission system planning and interconnection studies both for steady-state load flow/contingency analysis, and transient stability analysis. Our EAD group also has extensive experience with the development of steady-state and dynamic facility models in PSS/E for submission to system operators for many different types, including offshore wind, onshore wind, solar, and large-scale grid connected battery energy storage facilities, in addition to natural gas and coal fired power plants and nuclear power plants. Our EAD group is experienced in the development of scripts for automation of PSS/E runs using both IDEV and Python scripting methods. In addition to the steady-state and frequency domain dynamic analysis, our EAD group also performs advanced time-domain transient analysis.

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