United States Environmental Protection Agency

RE-Powering America's Land Initiative

# INTERCONNECTION

## Plugging RE-Powering Sites Into the Electric Grid

October 2019

**Explore important interconnection factors:**

- **Proximity**
- **System Types**
- **Costs**
- **Anticipating the Process**

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# Interconnection

## Plugging RE-Powering Sites Into the Electric Grid

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## Plugging RE-Powering Sites Into the Electric Grid

## 1. What Is Interconnection and Why Is It Important for RE-Powering Sites?

EPA's RE-Powering America's Land Initiative encourages the reuse of formerly contaminated lands, landfills, and mine sites for renewable energy development, when such development is aligned with a community's vision for the site. Renewable energy development on these properties requires interconnection, a multistep technical, administrative, and financial process that enables a renewable (or conventional) energy generator to interconnect to the electric grid and supply power.

Interconnection costs and development timelines can vary tremendously between projects—even between projects that are seemingly very similar. The potential uncertainty and variability of interconnection costs and timelines can become a deciding factor to the viability of a project. Renewable energy project developers bear the primary responsibility for guiding their projects through the interconnection process, but it is important for RE-Powering site owners, responsible parties, and other stakeholders interested in sustainable site reuse to understand the interconnection process and the factors that can delay or accelerate it.

This discussion paper provides RE-Powering stakeholders with information for efficiently proceeding through the interconnection process for renewable energy projects connecting to the electric transmission and distribution systems.

## 2. Interconnection Advantages

The prior uses of the brownfield, Superfund,[1] mining, and landfill sites that are the focus of the RE-Powering Initiative may have rendered them unsuitable for most redevelopment options. But they can offer several distinct advantages over greenfield sites for renewable power development, including lower land acquisition costs, site exclusivity,[2] expedited permitting, special tax incentives, and the availability of existing infrastructure that would otherwise be very costly to construct.

This infrastructure may include:

- Proximity to existing transmission or distribution electricity lines, as well as substations
- Road, rail, or water access (critical for renewable project construction and regular maintenance of projects)
- Water supply infrastructure (critical for certain renewable energy projects, such as concentrating solar power, biomass, and geothermal technologies)

[1] EPA's Superfund program is responsible for cleaning up some of the nation's most contaminated land and responding to environmental emergencies, oil spills, and natural disasters. Learn more at https://www.epa.gov/superfund.
[2] Generation interconnection processes can require evidence of site exclusivity, or exclusive site control by the project developer, for the purposes of renewable development. This can be obtained from a lease, purchase agreement, or option to buy or lease. Due to the history of designation and remediation at RE-Powering sites, establishing site exclusivity should be more straightforward than for many greenfield renewable sites that may cross property boundaries and never have been part of an integrated permitting or regulatory process.

- Physical security that can protect renewable energy assets
- Existing buildings, which can facilitate renewable energy transactions behind the customer meter that typically obtain retail rates for the power produced

RE-Powering sites with some or all of these features may offer meaningfully lower costs and complexity for renewable energy development and boost prospects for a smooth interconnection process.

## 3. Types of Interconnections

Electricity is delivered from generators to consumers via transmission and distribution networks. Transmission networks are operated by a regional transmission organization (RTO), independent system operator (ISO), or non-RTO/ISO operator such as a utility.[3] Transmission networks consist of high-voltage power lines (typically transmitting 100 kilovolts [kV] or more) designed to carry power efficiently over long distances. Distribution networks, operated exclusively by utilities, deliver power at lower voltages (typically transmitting 37 kV or less) and over shorter distances to the consumer. Generators may interconnect with the electrical system at either the distribution or transmission level, as described in **Figure 1**.

Interconnection information on many of the transmission systems that operate across the U.S. is provided in **Appendix A**.

### A RE-Powering Site With Interconnection Advantages

The former Bethlehem Steel Plant in Lackawanna, New York, is a RE-Powering site that was developed in multiple stages for the 35 MW Steel Winds (wind power) and 4 MW Steel Sun (solar) projects. The availability of existing electric infrastructure (including an on-site utility substation)[a] was an important, positive factor that allowed such a large volume of renewable generation to be safely and reliably interconnected with the power grid.[b]

[a] A substation is an electrical facility that steps up or down the voltage to either supply power to consumers or export power back to the electric grid.

[b] EPA, *Steel Winds, Lackawanna, New York: Development of Wind Power Facility Helps Revitalize Rust Belt City*, https://www.epa.gov/sites/production/files/2015-04/documents/success_steelwinds_ny.pdf [accessed September 2019], and The Buffalo News, *"Steel Sun" Project Would Add Solar Panels Near Wind Turbines at Former Bethlehem Site in Lackawanna*, July 13, 2014 http://buffalonews.com/2014/07/13/steel-sun-project-would-add-solar-panels-near-wind-turbines-at-former-bethlehem-steel-site-in-lackawanna/ [accessed September 2019].

[3] RTOs and ISOs are functionally similar entities responsible for transmission planning, operations, and the use of an electric grid on a regional and interregional basis. A map of RTO/ISO regions is available from the Federal Energy Regulatory Commission at https://www.ferc.gov/industries/electric/indus-act/rto.asp [accessed September 2019].

**Figure 1: Types of Distribution and Transmission Interconnections**

| Type of Interconnection | Typical Interconnection Voltage[4] | Typical Project Generation Capacity (AC)[5] | Primary Electricity Markets[6] |
|---|---|---|---|
| Distribution export: Direct connection[7] | 4 kV–37 kV<br>Some 60 kV–115 kV | 50 kilowatts (kW)–5 megawatts (MW) | Wholesale markets under Federal Energy Regulatory Commission (FERC) jurisdiction and/or retail markets under state utility commission, municipal, or cooperative jurisdiction |
| Distribution: Net metered[8] | 4 kV–37 kV<br>Some 60 kV–115 kV | 1 kW–2 MW | Retail markets under state utility commission, municipal, or cooperative jurisdiction |
| Distribution: Virtual net metered and community renewables[9] | Usually<br>4 kV–37 kV<br>Some 60 kV–115 kV | 20 kW–5 MW | Retail markets under state utility commission, municipal, or cooperative jurisdiction; sometimes direct connection to a utility |
| Transmission | Some 60 kV–115 kV<br>220 kV–765 kV | > 5 MW | Wholesale markets under FERC jurisdiction |

[4] Voltage is the characteristic of an electric system that makes electricity move through transmission and distribution lines. It is typically measured in kV across the transmission and distribution grid.

[5] Capacity is the maximum power a generator can produce, commonly measured in kilowatts (kW) and megawatts (MW). 1 MW = 1,000 kW. For interconnection purposes, capacity is typically expressed in alternating current (AC). The AC capacity of a solar photovoltaic (PV) project will generally be 15% to 35% less than its direct current (DC) capacity, depending on how the project is configured.

[6] Wholesale markets are regulated by FERC and provide access to a variety of local and regional customers. Retail markets are under the purview of state utility regulatory commissions (for investor-owned utilities), the municipal government (for municipal utilities), or an oversight board (for electric cooperatives) and allow access to local utility markets. The retail prices of electricity are often higher than wholesale prices due to additional charges, such as local distribution and pertinent taxes. In some cases, even projects that are interconnected as net energy metered, virtual net metered, or community renewables may participate in some wholesale markets. However, wholesale markets would not commonly be the only revenue source for such projects.

[7] Distribution interconnection projects with "direct connection" typically do not interact with retail (electricity end-user) facilities or electricity bills.

[8] Net metering is a mechanism that allows behind-the-meter (i.e., residential, commercial, industrial, and institutional) generation projects to sell the power they generate in excess of their meter's requirements back to the grid. This mechanism determines the compensation for the excess power sales.

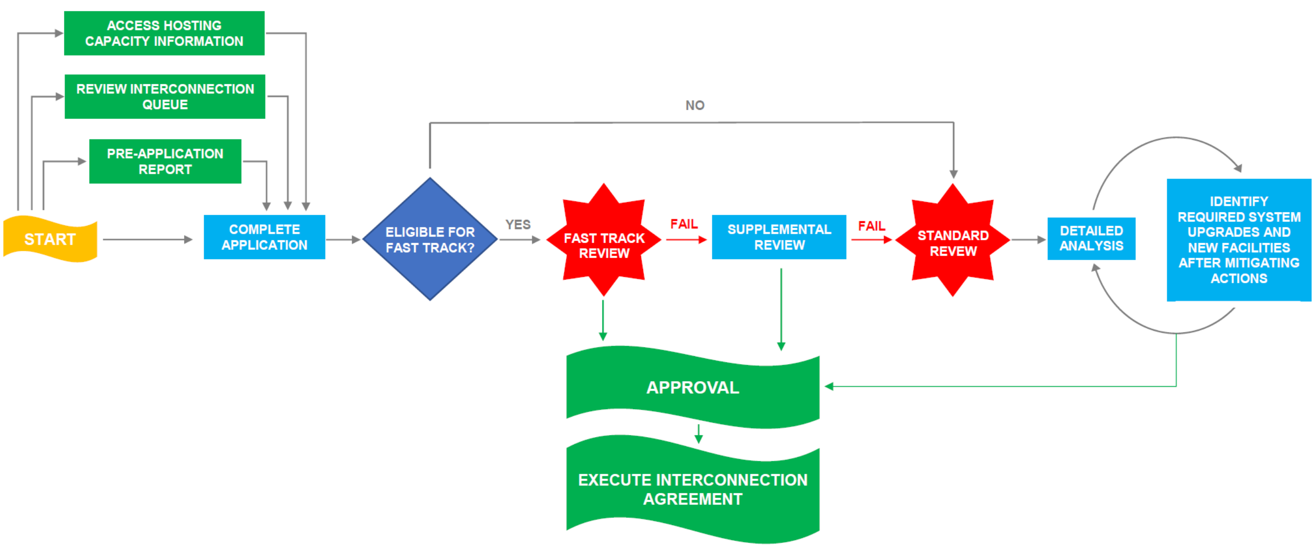
[9] Virtual net metering (also called meter aggregation) is a mechanism for allocating net metering credits to utility electricity customers that are not directly connected to an on-site generation project. Community renewable programs (usually focused on solar) also allocate off-site renewable production to customers. Each utility with virtual net metering or community renewables programs will have specific rules on customer eligibility and electricity allocations. Because virtual net metering and community solar projects are often between 500 kW and 5 MW in capacity, they align well with the renewable potential of RE-Powering sites. The RE-Powering program published a discussion paper on community solar, available at: https://www.epa.gov/sites/production/files/2016-12/documents/epa_repowering_community_solar_discussion_paper_final_120716_508.pdf [accessed September 2019].

## 4. Interconnection Review Process

When individual interconnection applications are evaluated, statewide regulatory policies can have substantial impacts on the cost, duration, and complexity of the process. For example, many states limit the maximum capacity of generators that can net meter (sell excess power not consumed on-site to the grid).[10] Some states provide streamlined interconnection processes for systems below a certain capacity threshold or that pass certain analytic tests or "screens."

Although interconnection review processes can differ depending upon the state, as well as the utility and RTO/ISO, most processes include the broad steps depicted in **Figure 2**.

**Figure 2: The Interconnection Review Process[11]**




[10] The Database of State Incentives for Renewables & Efficiency® (DSIRE®) provides descriptions of net metering policies in each state and summary maps of national policies. See, for example, *Customer Credits for Monthly Net Excess Generation (NEG) Under Net Metering*, https://www.dsireusa.org/resources/detailed-summary-maps [accessed September 2019]. DSIRE® is operated by the NC Clean Energy Technology Center at North Carolina State University and is funded by the U.S. Department of Energy (DOE).
[11] This figure is adapted from the Office of Energy Efficiency and Renewable Energy, DOE, *On the Path to SunShot – Interconnection Process*, http://energy.gov/eere/sunshot/downloads/path-sunshot-interconnection-process [accessed September 2019].

This section describes seven of the general steps depicted in Figure 2 and explains what developers of projects at RE-Powering sites can expect to provide and receive during each step.

### *Seven Interconnection Steps*

1. ***Request a pre-application report.*** At the developer's request, the transmission or distribution system operator may provide a pre-application report detailing a variety of information relevant to the proposed generation project. This may include information about the substation and voltage available at the proposed point of interconnection (POI), the closest feeders,[12] the circuit distance between the project and POI, any capacity estimates of relevant line sections, and the availability of three-phase electric power (a common method of alternating-current electric power generation, transmission, and distribution).[13] The pre-application report, which typically has a fee of between $300 and $1,300,[14] allows the developer to assess the project's interconnection prospects and risks before filing an actual interconnection application. Pre-application reports are often available within two to four weeks of request and payment.[15] A representative list of the data fields in a pre-application report is shown in **Figure 3**.

2. **Review the interconnection queue.** At approximately the same time as when the developer reviews the pre-application report, it will typically attempt to gather information on all other generation projects that a transmission or distribution system operator is considering for interconnection at the same POI as the developer's project. The first-to-last order of projects seeking to interconnect at a POI is called the "interconnection queue." Queue information may include the size and type of each project and where each project stands in the review process.

[12] Feeders or "circuits" are distribution lines that transport power from a substation to consumer facilities.
[13] While many utilities and other system operators offer pre-application reports, not all do. A sample pre-application report request from the utility Southern California Edison is available at *Rule 21 – Optional Pre-Application Report Request*, https://www1.sce.com/nrc/AboutSCE/regulatory/Openaccess/forms/FORM_Rule21_PreApplicationRequest_Form_19-922.pdf [accessed September 2019].
[14] For example, Pacific Gas and Electric (PG&E) in California has reports that range from $300 to $1,325, and Central Hudson Gas & Electric in New York has a report fee of $750, consistent with New York State interconnection requirements. In New York, the pre-application report fee is applied to the cost of the interconnection application itself if an application is filed promptly after receipt of the pre-application report. See *PG&E's Pre-Application Report Request*, https://www.pge.com/includes/docs/pdfs/mybusiness/save/solar/Pre_App.pdf [accessed September 2019]; and Central Hudson Gas & Electric, *Distributed Generation FAQ*, https://www.cenhud.com/dg/dg-faq#6afce7e913b66510VgnVCM1000001600020aRCRD [accessed September 2019].
[15] FERC's model interconnection standards require utilities to provide pre-application reports within 20 business days. See FERC, *Small Generator Interconnection Agreements and Procedures*, November 22, 2013, page 34, https://www.ferc.gov/whats-new/comm-meet/2013/112113/E-1.pdf [accessed September 2019]. For investor-owned utilities in New York State, the pre-application reports must be provided to developers within 10 business days. See New York State Public Service Commission (NYSPSC), *New York State Standardized Interconnection Requirements and Application Process for New Distributed Generators and Energy Storage Systems 5 MW or Less Connected in Parallel With Utility Distribution Systems*, October 2018, page 9, http://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/dcf68efca391ad6085257687006f396b/$FILE/October%20SIR%20Appendix%20A%20-%20Final%2010-3-18.pdf [accessed September 2019].

**Figure 3: Components of Pre-Application Report for Distributed Generation of 5 MW or Less in New York State[16]**

| Project Data Provided to Utility With Pre-Application Request | |
|---|---|
| Customer name (and date of pre-application request) | Distributed generation fuel source/configuration |
| Location of project (address and/or global positioning satellite [GPS] coordinates) | Proposed project size in kW-AC |
| Distribution generation technology type | |
| **Pre-Application Report Data Elements Provided Back to the Applicant** | |
| Operating voltage of closest distribution line | Approximate distance (miles) between serving substation and project site |
| Phasing at site | Number of substation banks |
| Approximate distance to 3-phase (if only 1 or 2 phases nearby) | Total substation bank capacity (MW) |
| Circuit capacity (MW) | Total substation peak load (MW) |
| Fault current availability, if readily obtained | Aggregate existing distributed generation on the circuit (kW) |
| Circuit peak load for the previous calendar year | Aggregate queued distributed generation on the circuit (kW) |
| Circuit minimum load for the previous calendar year | |

3. **Access hosting capacity information.** When possible, the developer also could obtain free information about the hosting capacity of the distribution circuit. Hosting capacity maps, an example of which is in **Appendix B**, give developers a good indication of how far their projects are from the closest distribution infrastructure and how much new generation capacity might be accommodated at various nearby locations on a distribution system. This information will give the developer insight into whether the interconnection review process might be delayed and whether costly system upgrades are likely. In addition to obtaining a pre-application report, analyzing any available hosting capacity data, and reviewing the interconnection

[16] Appendix D: Pre-Application Report for the Connection of Parallel Generation Equipment to the Utility Distribution System of the NYSPSC, *Standardized Interconnection Requirements and Application Process for New Distributed Generators and Energy Storage Systems 5 MW or Less Connected in Parallel With Utility Distribution Systems*, October 2018, PDF page 61, http://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/dcf68efca391ad6085257687006f396b/$FILE/October%20SIR%20Appendix%20A%20-%20Final%2010-3-18.pdf [accessed September 2019]. SCE and the other two California investor-owned utilities also offer a presentation on *How to Read a Pre-Application Report* at https://www.pge.com/includes/docs/pdfs/b2b/newgenerator/retailgenerators/Pre-ApplicationReport.pdf [accessed September 2019].

queue, developers should conduct detailed technical due diligence on potential projects. Additional technical due diligence on interconnections can be conducted by reviewing prior interconnection studies from nearby sites, researching land use permits and right of way processes from local and state agencies, and seeking guidance from renewable energy installation firms experienced in the local market.

4. **Complete the interconnection application.** Assuming the developer's review of the pre-application report, interconnection queue, and hosting capacity data does not dissuade it from pursuing the project further, the developer will next complete an interconnection application. Applications may require detailed technical information about the project, including its generator type, proposed interconnection type and location, and documentation that the developer has appropriate land use rights as well as appropriate licenses or certificates to participate in the renewable energy industry in the jurisdiction.

5. **Request a streamlined interconnection review (fast tracking).** Many utilities have fast track processes for generation projects of 5 MW or less in capacity, *if they meet certain requirements that expedite interconnection review while protecting against negative grid impacts*.[17] Fast tracking can substantially reduce the time, often by eight or more weeks, and complexity of interconnection processes for qualifying generation projects. In jurisdictions that have adopted FERC model standards, meeting the criteria presented in **Figure 4** provides potential fast track eligibility for inverter-based projects.[18] More than 80% of completed RE-Powering projects are 5 MW or less in capacity and, therefore, may be candidates for fast track review in certain jurisdictions.[19]

**Figure 4: Fast Track Capacity Eligibility for Inverter-Based Systems Under FERC Model Standards[20]**

| Line Voltage | Eligibility Regardless of Location | Eligibility on a Mainline and Within 2.5 Electrical Circuit Miles of a Substation |
|---|---|---|
| < 5 kV | ≤ 500 kW | ≤ 500 kW |
| ≥ 5 kV and < 15 kV | ≤ 2 MW | ≤ 3 MW |
| ≥ 15 kV and < 30 kV | ≤ 3 MW | ≤ 4 MW |
| ≥ 30 kV and ≤ 69 kV | ≤ 4 MW | ≤ 5 MW |

[17] Fast track eligibility is often determined by a combination of renewable project capacity, distance from the project to the nearest substation, and voltage and available capacity of the transmission or distribution facility to which the project is seeking to interconnect. Potential negative grid impacts include voltage, thermal, protection, and other power quality violations.
[18] Inverters convert the variable direct current (DC) output of PV into an alternating current (AC) frequency that can be fed into building electricity use or the commercial electrical grid.
[19] These data are calculated from the list of completed projects in the RE-Powering America's Land Initiative's *Project Tracking Matrix*, published in January 2019, https://www.epa.gov/sites/production/files/2019-02/documents/re_tracking_matrix_508_final_013119a.pdf [accessed September 2019].
[20] FERC, *Small Generator Interconnection Procedures (SGIP)*, August 27, 2018, pages 7–8, https://www.ferc.gov/industries/electric/indus-act/gi/small-gen/sm-gen-procedures.pdf [accessed September 2019].

6. **Request a standard review.** If a renewable project either does not qualify for fast track review, or qualifies but fails fast track analytic screens, it will need to proceed through the standard interconnection process. This involves the transmission or distribution system operator performing detailed computer simulations of how electricity would flow from the proposed project through all relevant components of its system. The simulations are intended to reveal new facilities and upgrades needed to maintain system safety and reliability under all conditions and to produce project cost estimates.

   If new facilities or system upgrades are required, the transmission or distribution operator will provide the developer with cost estimates to implement the necessary system enhancements. Such costs are borne by the proposed project or shared with other projects, depending on how the grid operator manages group studies and interconnection queues.

   The renewable developer can request that utilities provide further details on technical requirements and costs and may redesign its project accordingly to reduce interconnection costs. The developer may also be able to use a dispute resolution processes (e.g., with access to an independent engineer or other arbitrator) to address remaining concerns.

7. **Execute the interconnection agreement after project approval.** If the developer decides to move forward with the project, it will execute an interconnection agreement with the transmission or distribution grid operator that details the responsibilities of each party.

## 5. Interconnection Costs

As previously noted, developers are typically responsible for all costs incurred for interconnection reviews, as well as for the material and labor costs for new transmission or distribution facilities and grid upgrades required to physically connect the generator to the grid. Below, the costs of an interconnection review or "study" are described first, followed by the typically much larger material and labor costs of interconnection.

The costs of an interconnection review will vary widely, depending upon factors such as project size and location, position in the interconnection queue, interconnection voltage, and eligibility for fast tracking. Smaller distribution-level projects eligible for fast tracking may only pay study fees of $2,500 or less,[21] while the fee for a standard interconnection review of proposed transmission projects greater than 20 MW can often exceed $150,000.[22]

[21] For example, see Southern California Edison, *Rule 21: Generating Facility Interconnections*, Section E.2, Effective June 8, 2017, https://library.sce.com/content/dam/sce-doclib/public/regulatory/tariff/electric/rules/ELECTRIC_RULES_21.pdf [accessed September 2019].

[22] For example, see California ISO, *Appendix DD: Generation Interconnection and Deliverability Allocation Procedures*, Section 3.5.1, April 1, 2019, http://www.caiso.com/Documents/AppendixDD-GeneratorInterconnection-DeliverabilityAllocationProcedures-asof-Apr1-2019.pdf#search=appendix%20dd [accessed September 2019].

For projects on distribution systems, the total cost of interconnection itself will depend on the utility's requirements (monitoring and control equipment, system protection devices, etc.) and the cost of mitigating system violations identified by the utility. In Xcel Energy Minnesota's popular community solar program, typical interconnection costs range widely from $2,000 to $150,000 for projects between 250 kW and 1 MW in capacity, and from $5,000 to $1 million for projects larger than 1 MW.[23]

The actual project interconnection costs required to maintain grid safety and reliability are primarily driven by the grid impact studies performed during the standard review process and can vary significantly based on the common cost drivers such as project size, interconnection options, findings from the impact study process, and applicable utility tariff rules.

Some transmission operators, such as California ISO, provide interconnection unit cost guides for use in estimating the cost of facilities required to interconnect generation. Selected data from that cost guide are summarized in the text box on the prior page.

Project-level data on the estimated interconnection costs of RE-Powering projects can also be obtained in some cases from the grid operator, such as from PJM for the Mid-Atlantic and Ohio Valley transmission

**Transmission Interconnection Per Unit Cost Guide**

California ISO's annual per unit cost guide for transmission upgrades is particularly useful both because more than one-third of all U.S. solar generation projects and 9% of all renewable energy capacity of RE-Powering projects are in California,[c] and because the data are a good reference point for the rest of the nation. The estimated interconnection costs range from $0.9 million to $2.5 million per mile to "reconductor" a typical 69-kV single circuit line to upgrade its carrying capability. New substation equipment can range from $12.5 million for a 69-kV substation to $15 million for a 230-kV substation for a single existing transmission line. These cost estimates for transmission lines are based on flat land and rural settings and do not reflect permitting and right-of-way costs. Transmission line costs can vary significantly due to other factors, such as the type of terrain (cost multiplier of 1.3 for hilly terrain) and population density (cost multiplier of 1.5 for urban populations).[d]

[c] U.S. solar generation data from Solar Energy Industries Association, https://www.seia.org/states-map; and RE-Powering program data from https://www.epa.gov/sites/production/files/2019-02/documents/re_tracking_matrix_508_final_013119a.pdf [both accessed September 2019].

[d] See *PG&E 2019 Final Per Unit Cost Guide* at https://www.caiso.com/informed/Pages/StakeholderProcesses/ParticipatingTransmissionOwnerPerUnitCosts.aspx [accessed September 2019].

[23] Xcel Energy Minnesota, *Solar*Rewards® Community® - Engineering Frequently Asked Questions*, updated January 31, 2017, https://www.xcelenergy.com/staticfiles/xe-responsive/Admin/Managed%20Documents%20&%20PDFs/MN-SRC-Engineering-FAQs.pdf [accessed September 2019].

system.[24] For example, interconnection system impact studies for three RE-Powering solar projects in New Jersey show interconnection cost estimates of:

- Hackensack Brownfield: Up to 1.1 $MW_{AC}$ project with cost estimate of $182,900[25]
- Brick Township Landfill Superfund: Up to 5 $MW_{AC}$ project with cost estimate of $291,077[26]
- Kinsley Landfill: Up to 5 $MW_{AC}$ project with cost estimate of $865,019[27]

Note that all of these interconnections are within the same transmission operator's territory and still vary significantly in their costs per unit of solar capacity. This variation in interconnection costs is driven by multiple factors, including length and complexity of electricity line extensions and system upgrades required.

**Scituate Solar Landfill Project: Interconnection Success Story**

The town of Scituate, Massachusetts, investigated the potential for a 3 MW solar project on a closed landfill, to complement a wind project on a nearby wastewater plant facility. The initial interconnection cost estimate for the solar project was $900,000, due to utility concerns about the volume of variable renewable power at the POI from this proposed solar project and an existing wind project. That cost would have compromised the economics of the project.

However, the developer worked with National Renewable Energy Laboratory data and the utility to conduct follow-up technical studies to show how timing of wind and solar power production would be largely complementary. That analysis reduced utility interconnection concerns and ultimately resulted in a successful interconnection outcome with much lower upgrade costs.[e] This exemplifies the benefits of RE-Powering parties viewing interconnection reviews as an interactive process.

[e] EPA, *An Old New England Town Lights the Way With Solar*, https://www.epa.gov/sites/production/files/2015-04/documents/scituate_landfill_case_study.pdf [accessed September 2019].

[24] PJM, *New Services Queue*, https://www.pjm.com/planning/services-requests/interconnection-queues.aspx [accessed September 2019].
[25] PJM, *Generator Interconnection Request Queue X1-072, Hackensack (Solar for All) 4kV, Feasibility/Impact Report*, July 2011, http://pjm.com/pub/planning/project-queues/impact_studies/x1072_imp.pdf [accessed June 2019]. Final (actual) interconnection costs from invoices to project developers do not appear to be published by PJM, which is the reason that estimated costs are shown here.
[26] PJM, *Generation Interconnection Combined Feasibility/System Impact Study Report for PJM Generation Interconnection Request Queue Position Y2-051, Brick-Lanes Mill 34.5kV*, January 2013, http://pjm.com/pub/planning/project-queues/impact_studies/y2051_imp.pdf [accessed September 2019]. EPA published a case study of this solar project: EPA, *Brick Township Goes Solar: Redevelopment of a Superfund Site*, https://semspub.epa.gov/work/02/372924.pdf [accessed September 2019].
[27] PJM, *Generation Interconnection System Impact Study Report for PJM Generation Interconnection Request Queue Position Y2-081, Deptford (Kinsley Solar) 13kV*, December 2013, http://pjm.com/pub/planning/project-queues/impact_studies/y2081_imp.pdf [accessed September 2019]. This development is likely connected to or dependent on another adjacent or nearby solar project as referenced by a note on page 3 of the study: "If previous solar projects are not completed, the cost for feeder metering could increase…"

## 6. Tips to Minimize Interconnection Costs and Delays

As RE-Powering stakeholders support developers in navigating the interconnection process, below are 10 tips to improve outcomes.

1. **Explore any freely available online interconnection resources** (e.g., interconnection queues and hosting capacity maps of utilities).
2. **Request a pre-application report** early in project planning.
3. **Come prepared with relevant information.**[28,29]
4. **Stick to mandated interconnection timelines** (an application can be rejected for non-compliance).
5. **Align external approvals** (e.g., easements, conditional use permits) with interconnection timelines to keep the project on track.
6. **Obtain an independent expert's engineering review** if the interconnection upgrade cost seems unreasonable.
7. **Appeal if you receive late, incomplete, or questionable feedback** from the utility or ISO/RTO.[30]
8. **Point out special project design aspects**, such as inverter features to control output from solar PV projects, which may mitigate potentially adverse grid impacts.
9. **Be open to modifying your project** to make it more interconnection-friendly (e.g., by reducing generation capacity to eliminate the need for costly system upgrades).
10. **Constructively engage with all stakeholders**. A successful interconnection process requires frequent and close coordination between all stakeholders. Engaging with utilities as project partners can be especially effective. This coordination begins with the pre-application process and continues through the initial commercial operation of the project. Common opportunities for engagement include:
    - Scoping meetings after submitting the interconnection application

[28] Most utilities also have a list of documentation that developers must submit for transmission and distribution interconnections. These documents typically include the interconnection application, detailed site plans with the location of all relevant equipment, a certificate of electrical inspection, proof of insurance, and a one-line diagram. In power engineering, a one-line or single-line diagram shows the arrangement and connection of various equipment.

[29] For a distribution utility example of required documentation, see Appendix F: Application Package Checklist of the NYSPSC, *Standardized Interconnection Requirements and Application Process for New Distributed Generators and Energy Storage Systems 5 MW or Less Connected in Parallel with Utility Distribution Systems*, October 2018, PDF page 64, http://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/dcf68efca391ad6085257687006f396b/$FILE/October%20SIR%20Appendix%20A%20-%20Final%2010-3-18.pdf [accessed September 2019]. For a transmission operator example, see the list of resources the California ISO requests to begin an application: *ISO Interconnection Request*, https://www.caiso.com/planning/Pages/GeneratorInterconnection/InterconnectionRequest/Default.aspx [accessed September 2019].

[30] Additionally, some jurisdictions have dispute resolution processes requiring that grid operators provide additional technical information to the disputing party to justify proposed interconnection costs.

- Results meetings after interconnection screenings or computer simulations
- Contract negotiations when finalizing the interconnection agreement
- Project testing prior to commercial operation

## 7. Conclusion and Key Takeaways

By understanding the factors that influence interconnection costs and review cycles, RE-Powering site owners, responsible parties, state and local government agencies, and other stakeholders will be in a better position to (i) understand which sites have the best opportunities for development, (ii) support developers through the interconnection process at high-potential sites, and (iii) avoid spending time and resources on sites with low potential. The important interconnection factors considered in this paper include:

- Distance to the nearest transmission or distribution system point of interconnection
- Distinctions between transmission and distribution systems
- The generation capacity of a renewable project affecting transmission and distribution operator evaluations of project impacts on their grids
- Hosting capacity, pre-application reports, and other ways of estimating the ability of existing grid infrastructure to accommodate more generation without costly upgrades
- Access to fast track interconnection review processes for small to mid-sized projects meeting certain conditions
- The wide range of interconnection costs for new facilities and system upgrades on distribution or transmission systems that may be required
- The benefits of being proactive and organized in approaching interconnection applications
- The interactive nature of many interconnection reviews

Developers bear the ultimate responsibility for submitting the interconnection application and engaging with the transmission or distribution grid operator. Developers must ensure that the project details are properly conveyed, that the project design is optimized to minimize interconnection costs and shorten development timelines, and that viable RE-Powering sites have the best opportunity for renewable energy deployment. With this information, RE-Powering stakeholders can support the project developers during this process.

## 8. More Information

EPA offers a comprehensive list of resources for developers to learn more about its RE-Powering America's Land Initiative. The RE-Powering Mapper database offers a list of potential redevelopment sites, noting proximity of electrical infrastructure, site access, and other information. Visit https://www.epa.gov/re-powering to learn more. Also, EPA has a network of RE-Powering contacts across its regional offices (visit https://www.epa.gov/re-powering/forms/contact-us-about-re-powering-americas-land).

Additional information sources specific to interconnections are provided below.

### Interconnection Process Overviews

Midwest ISO Generator Interconnection Process (flow chart):
https://cdn.misoenergy.org/GI%20Process%20Flow%20Diagram106549.pdf

California ISO Interconnection Timeline and Process:
http://www.caiso.com/Documents/2-2018Studies-StudyResults-ProjectCostResponsibility.pdf

Southern California Edison Fast Track Interconnection Process:
https://www.energy-exchange.com/wp-content/uploads/T11S6_Giannotti.pdf (pages 28-31)

### Interconnection Applications and Data Forms

California ISO Interconnection Request:
http://www.caiso.com/Documents/IRandStudyAgreement26Feb2019FINAL.docx

### Interconnection Agreements

Many jurisdictions and utilities base their interconnection agreements on versions of the following FERC materials:

FERC Standard Interconnection Agreements & Procedures for Small Generators:
https://www.ferc.gov/industries/electric/indus-act/gi/small-gen.asp

FERC Standard Interconnection Agreements & Procedures for Large Generators:
https://www.ferc.gov/industries/electric/indus-act/gi/stnd-gen.asp

### Miscellaneous Information on Interconnection

EPA Toolbox for Renewable Energy Project Development – *Solar Interconnection Standards & Policies:* https://www.epa.gov/repowertoolbox/solar-interconnection-standards-policies

# Appendix A: Interconnection Queue Information for Selected U.S. Wholesale Electricity Markets

**Figure 5: Region-Specific Data on Queues to Interconnect Generators to Wholesale Electricity Markets**

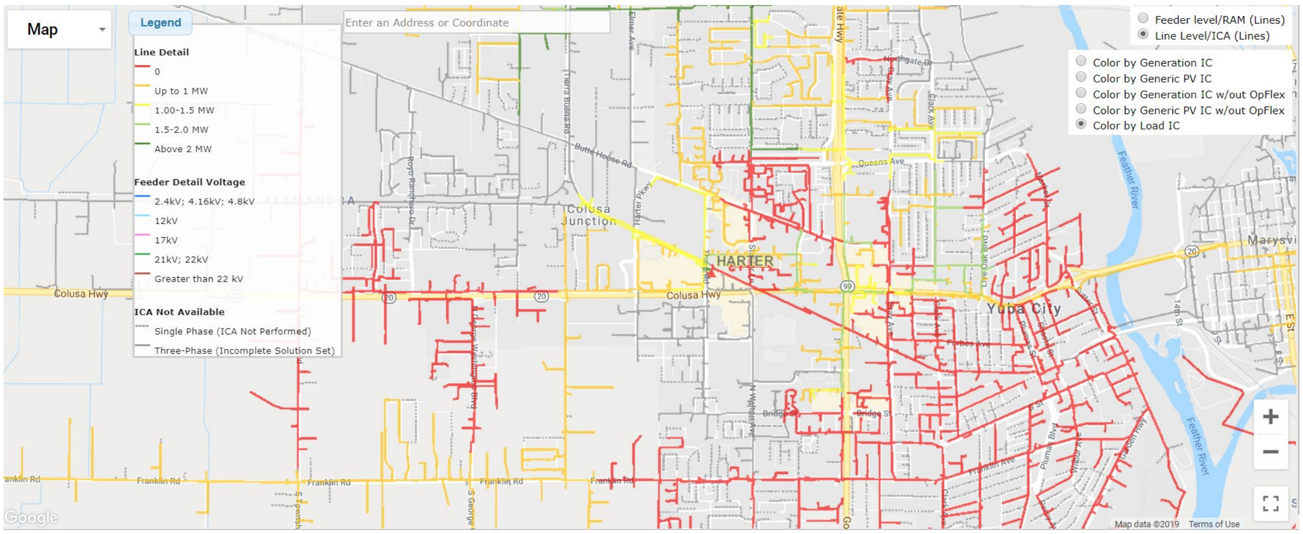
| States | ISO or RTO (Transmission Operator) or Utility | Resource Name | Types of Data Available With Resource | Website Link |
|---|---|---|---|---|
| CA | California ISO (CAISO) - Transmission Operator | Resource Interconnection Management System | • Queue Position<br>• Request Date<br>• Application Status<br>• Study Process<br>• Generation/Fuel Type<br>• MW<br>• Utility<br>• Section or Transmission Line<br>• Projected Service Date | CAISO Resource Interconnection Management System (Queue):<br><br>https://rimspub.caiso.com/rims5/logon.do |
| CA | Southern California Edison (SCE) - Utility | Wholesale Distribution Access Tariff (WDAT) Queue | • Request Date<br>• Application Status<br>• Technology*<br>• Type/Fuel Facility<br>• Summer/Winter MW<br>• Exports<br>• County<br>• Substation and Circuit<br>• Proposed Online Date<br>• Study Availability<br>• Interconnection Process Type* | SCE WDAT & Rule 21 Interconnection Queue:<br><br>https://www.sce.com/nrc/aboutsce/regulatory/openaccess/wdat/wdat_queue.xls |
| CA | Pacific Gas and Electric (PG&E) - Utility | Wholesale Distribution Access Tariff (WDAT) Queue | | PG&E WDAT Interconnection Queue:<br><br>https://www.pge.com/pge_global/common/word_xls/for-our-business-partners/interconnection-renewables/energy-transmission-and-storage/wholesale-generator-interconnection/PublicQueueInterconnection.xls |
| CA | San Diego Gas & Electric (SDG&E) - Utility | Wholesale Distribution Access Tariff (WDAT) Queue | | SDG&E WDAT Interconnection Queue:<br><br>https://www.sdge.com/sites/default/files/documents/SDGE%20WDAT%20%26%20Rule%2021%20Generation%20Interconnection%20Queue%2005-20-19.pdf |
| TX | Electric Reliability Council of Texas (ERCOT) – Transmission Operator | Transmission Project Information Tracking | • Project Number/Name<br>• Queue Position<br>• Request Date<br>• Project Description<br>• Location<br>• Application Status<br>• Projected Service Date<br>• Service Level<br>• Circuit Miles<br>• Autotransformer Capacity | ERCOT Planning - Transmission Project Information Tracking:<br><br>http://www.ercot.com/gridinfo/planning<br><br>http://www.ercot.com/content/wcm/key_documents_lists/89026/ERCOT_February_TPIT_No_Cost_020119.xlsx |
| AR, KS, LA, MN, MO, MT, ND, NE, | Southwest Power Pool – | Generation Interconnection | • Interconnection Number<br>• Nearest Town/ State<br>• Projected Service Date<br>• Capacity | Southwest Power Pool Generation Interconnection Active Requests: |

| States | ISO or RTO (Transmission Operator) or Utility | Resource Name | Types of Data Available With Resource | Website Link |
|---|---|---|---|---|
| NM, OK, SD, TX, WY | Transmission Operator | Active Requests | • Summer/Winter MW<br>• Service Type<br>• Generation Type<br>• Substation or Line<br>• Status<br>• Studies (Feasibility/Impact) | http://opsportal.spp.org/Studies/GIActive |
| AR, IL, IN, IA, KS, KY, LA, MI, MN, MS, MO, MT, NE, NC, ND, OH, PA, SD, TX, WI, WY | Midwest ISO (MISO) – Transmission Operator | Interconnection Queue | • Project Number<br>• Queue Date<br>• Transmission Owner<br>• County/State<br>• Summer/Winter MW<br>• Projected Service Date<br>• Facility/Fuel Type<br>• Study/Request Status<br>• Studies (Feasibility/Impact) | MISO Interconnection Queue:<br>https://www.misoenergy.org/planning/generator-interconnection/GI_Queue |
| DC, DE, IL, IN, KY, MD, MI, NC, NJ, OH, PA, VA, WV | PJM – Transmission Operator | Generation Queues | • Queue Number<br>• Project Name<br>• Capacity<br>• Status<br>• Projected Service Date<br>• Fuel Type<br>• State<br>• Studies (Feasibility/Impact)<br>• Transmission Owner | PJM Generation Queues:<br>https://www.pjm.com/planning/services-requests/interconnection-queues.aspx |
| New York | New York ISO (NYISO) – Transmission Operator | Interconnection Queue | • Queue Position<br>• Developer Name<br>• Project Name<br>• Date of Request<br>• Summer/Winter MW<br>• Type/Fuel<br>• Location<br>• Interconnection Point<br>• Utility<br>• Studies<br>• Projected Service Date | NYISO Interconnection Queue:<br>https://www.nyiso.com/interconnections |
| CT, MA, ME, NH, RI, VT | ISO New England – Transmission Operator | Interconnection Request Queue | • Project Type<br>• Location by State, County, and Zone<br>• Interconnection Point<br>• Fuel Type & Renewable Sources<br>• Proposed Net Change in MW and Network Resource Capability | ISO New England Interconnection Request Queue:<br>https://www.iso-ne.com/system-planning/transmission-planning/interconnection-request-queue |

*Not provided by all utilities

# Appendix B: Example Hosting Capacity Map

**Figure 6: Hosting Capacity Map From the California Utility Pacific Gas and Electric[31]**




[31] Pacific Gas and Electric Company, *View the Integration Capacity Analysis Map*, https://www.pge.com/en_US/for-our-business-partners/distribution-resource-planning/distribution-resource-planning-data-portal.page [accessed September 2019].