I. Introduction

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Energy storage systems (storage or ESS) are crucial to enabling the transition to a clean energy economy and a low-carbon grid. Storage is unique from other types of distributed energy resources (DERs) in several respects that present both challenges and opportunities in how storage systems are interconnected and operated. Although many jurisdictions are taking steps toward integrating storage, substantial technical and regulatory barriers remain to the rapid integration of ESS onto the grid, including and especially related to interconnection.

Well-designed interconnection rules that effectively address the unique operating capabilities and benefits of storage are essential to the rapid and cost-efficient integration of storage onto the grid in a safe and reliable manner. The Building a Technically Reliable Interconnection Evolution for Storage (BATRIES) project provides recommended solutions and resources for eight critical storage interconnection barriers, to enable safer, more cost-effective, and efficient grid integration of storage in this *Toolkit and Guidance for the Interconnection of Energy Storage and Solar-Plus-Storage* (Toolkit).

A growing number of states have adopted ambitious climate and clean energy mandates, from renewable generation and electrification targets to greenhouse gas reduction goals.[2] At the same time, residential, commercial, and industrial customers[3] are investing in storage for the economic and environmental benefits it provides.[4]

As renewable energy deployment grows both in front of and behind the meter, individual customers and electric distribution system operators are likely to increasingly rely on storage for the energy management services it provides. For example, storage paired with solar can enable managed import and export. This can have benefits for both the customer and the grid. Better timing of the use of distributed resources can minimize the cost of solar interconnection by reducing the need for grid upgrades.[5] Utility-scale storage can support resource management in states with high wind and solar penetration by mitigating the intermittency of renewable generation.[6] New federal policies are also likely to incentivize the increased adoption of storage, particularly through the Federal Energy Regulatory Commission (FERC) Order 2222, which is intended to pave the way for

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[2] *See, e.g.*, National Conference of State Legislatures, *State Renewable Portfolio Standards and Goals* (last accessed November 15, 2021), https://www.ncsl.org/research/energy/renewable-portfolio-standards.aspx.

[3] For ease of reference, this document sometimes uses the broad term “interconnection customers.”

[4] U.S. Energy Information Administration, *Battery Storage in the United States: An Update on Market Trends* (Aug. 2021), https://www.eia.gov/analysis/studies/electricity/batterystorage/pdf/battery_storage_2021.pdf. For solar-plus-storage data, *see* Galen Barbose, Salma Elmallah, and Will Gorman, *Behind-the-Meter Solar+Storage: Market Data and Trends*, Lawrence Berkeley National Laboratory (July 2021), https://eta-publications.lbl.gov/sites/default/files/btm_solarstorage_trends_final.pdf.

[5] *See*, *e.g.*, Thomas Bowen and Carishma Gokhale-Welch, *Behind-the-Meter Battery Energy Storage: Frequently Asked Questions*, National Renewable Energy Laboratory (Aug. 2021), pp. 2-4, https://www.nrel.gov/docs/fy21osti/79393.pdf.

[6] *Id*.

aggregated DERs—including storage—on the distribution system to compete in wholesale markets.[7]

Storage differs from other types of DERs, such as solar and wind generation, in several key aspects that shape the way it is interconnected to, and operated on, the grid. For example, storage can serve as both generation and load, either discharging to or charging from the grid or a paired solar system or other generation source. In addition, storage systems can be designed to control when and how much they export to, or import from, the grid, and thus can provide cost and energy management benefits to customers and the grid. These operating capabilities make storage a valuable asset, and also introduce complexities in the interconnection process as regulators must strike a balance between maximizing the energy and economic benefits of storage from a customer perspective, and the need to maintain safe and reliable service from a utility perspective.

In addition, storage has an important role to play in enabling states to achieve their climate and energy goals and more efficient operation of the grid. Behind-the-meter storage can increase resilience and reduce energy costs for customers; allow utilities to defer infrastructure investments necessary to serve peak demand; and support the integration of more renewable energy resources, such as by providing frequency regulation and mitigating the variable output of renewables.[8]

In response, several states have updated, or are currently in the process of updating, their DER interconnection rules to include storage and to enable its more time- and cost-efficient integration onto the grid, which is critical for scaling storage deployment. To date, Arizona, California, Colorado, the District of Columbia, Hawaii, Maryland, Minnesota, Nevada, New York, North Carolina, and Virginia have DER interconnection rules that facilitate the interconnection of ESS.[9] As of December 2021, Illinois, Massachusetts, Maine, and New

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[7] Federal Energy Regulatory Commission, Docket No. RM18-9-000, Order No. 2222, Participation of Distributed Energy Resource Aggregations in Markets Operated by Regional Transmission Organizations and Independent System Operators (September 17, 2020), https://www.ferc.gov/sites/default/files/2020-09/E-1_0.pdf. *See also* Docket No. RM18-9-000, Order No. 2222-A, Order Addressing Arguments Raised on Rehearing, Setting Aside Prior Order in Part, and Clarifying Order in Part (March 18, 2021), https://www.ferc.gov/media/e-1-rm18-9-002, and Order No. 2222-B, Order Addressing Arguments Raised on Rehearing, Setting Aside in Part and Clarifying in Part Prior Order (June 17, 2021), https://cms.ferc.gov/media/e-4-061721.

[8] International Renewable Energy Agency, *Behind-the-Meter Batteries: Innovation Landscape Brief* (2019), pp. 10-13, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Sep/IRENA_BTM_Batteries_2019.pdf.

[9] AZ Administrative Code § R14-2 (Feb. 25, 2020); CA Pub. Util. Comm., Southern California Edison, Rule 21; DC Mun. Regs. tit. 15, chapter 40 (Jan. 25, 2019); HI Pub. Util. Comm., Rules 22-24 (Feb. 20, 2018); Code MD Regs. 20.50.09 (April 20, 2020); MN Pub. Util. Comm., Dkt. E-999/CI-16-521, Order Establishing Updated Interconnection Process and Standard Interconnection Agreement, Attachment: Minnesota Distributed Energy Resources Interconnection Process (August 13, 2018) (MN DIP); NV Pub. Util. Comm., Dkt 17-06014, NV Power Co. Rule 15 (April 11, 2018); NY Pub. Service Comm., 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 (March 2021); NC Util. Comm., Dkt. E-100, Sub 101, North Carolina Interconnection Procedures (Aug. 20, 2021), https://desitecoreprod-cd.azureedge.net/_/media/pdfs/for-your-home/212287/ncip-approved-oct-15-2020.pdf?la=en&rev=cd85b126dd0345019917e2464beb861b; 20 VA Admin. Code 5-314 (Oct. 15, 2020).

Mexico are in the process of revising their interconnection rules to facilitate the interconnection of ESS.[10]

Interconnection procedures serve as the "rules of the road" for DER integration onto the electric grid. They include rules relating to the process, cost, and timeline for interconnection, and can include related documents, such as template forms and applications. The procedures for distribution grids are typically spelled out in rules or tariffs approved by state public utility commissions (PUCs). In developing their interconnection procedures, many states have relied on one of two model rules: the *Federal Energy Regulatory Commission's (FERC) Small Generator Interconnection Procedures (SGIP)*, and the Interstate Renewable Energy Council's (IREC) Model Interconnection Procedures (IREC 2019 Model). In addition to these resources, state interconnection procedures may also reference technical interconnection standards, including, but not limited to the Institute of Electric and Electronic Engineers' 1547-2018 standard (IEEE 1547-2018™), *IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power System Interfaces*.

The design of interconnection procedures can have a significant impact on the efficiency and cost-effectiveness of DER integration, including project viability.[11] Interconnection procedures that are not tailored to the jurisdiction's DER market conditions—such as when the speed of DER deployment outstrips the ability of utilities to keep pace with processing applications or the ability of the grid to accommodate higher penetrations of DERs—can result in significant queue backlogs or grid upgrade fees that are too high for the market to bear. On the other hand, interconnection procedures that are designed to successfully meet the demands of the DER market can facilitate the more rapid and efficient integration of DERs.

While a number of states have taken initial steps to ease the path for storage interconnection, the majority of PUCs and utilities have yet to reform their interconnection rules to be inclusive of storage. The process of revising interconnection rules and tariffs is, more often than not, lengthy and resource-intensive, and requires a high level of procedural and technical expertise. The challenge is compounded by the fact that technical standards applicable to storage continue to evolve, and many of the solutions to ease storage interconnection involve cutting-edge practices and procedures that have not yet been widely adopted. In short, there is a pressing need for guidance and

[10] CO Pub. Util. Comm., Dkt. 21I-0321E, Investigation Into the Interconnection of Distributed Energy Resources (July 12, 2021); IL Com. Comm, Dkt. 10-0700. Second Notice Order (Aug. 12, 2021) (proposing to revise IL Admin. Code tit. 83, § 466); MA Dept. of Pub. Util., Dkt. D.P.U. 19-55, Massachusetts Joint Stakeholders consensus revisions to the Standards for Interconnection of Distributed Generation tariff ("DG Interconnection Tariff") to address the interconnection of energy storage systems (Feb. 26, 2020); NM Pub. Reg. Comm., Dkt. 21-00266-UT, Rulemaking to Repeal and Replace Commission Rule 17.9.568 NMAC, Interconnection Standards for Electric Utilities, and the Associated Interconnection Manual (De. 2021).

[11] *See*, *e.g.*, Ivan Penn, *Old Power Gear Is Slowing Use of Clean Energy and Electric Cars*, New York Times (Oct. 8, 2021), https://www.nytimes.com/2021/10/28/business/energy-environment/electric-grid-overload-solar-ev.html.

implementable resources on storage interconnection that regulators, utilities, and other stakeholders can use to update their respective state interconnection procedures.

The BATRIES project helps to explain the challenges and presents solutions to several key technical and regulatory barriers to the interconnection of storage on the distribution system.[12] BATRIES is a three-year effort funded by the U.S. Department of Energy's Solar Energy Technologies Office. It brings together stakeholders from all relevant interest groups, including storage and DER developers, utilities, state regulatory commissions and staff, national research laboratories, and storage technology manufacturers to identify the critical challenges to ESS interconnection and present effective solutions as part of this *Toolkit and Guidance for the Interconnection of Energy Storage and Solar-Plus-Storage* (Toolkit).

BATRIES is led by the Interstate Renewable Energy Council (IREC), in collaboration with a team of partners—collectively, the Storage Interconnection Committee (STORIC), which includes:[13]

- Electric Power Research Institute (EPRI)
- Solar Energy Industries Association (SEIA)
- California Solar & Storage Association (CALSSA)
- New Hampshire Electric Cooperative, Inc. (NHEC)
- PacifiCorp
- Shute, Mihaly & Weinberger, LLP

Working collaboratively, and with input from external stakeholders representing PUC regulatory staff, utilities, developers, and DER associations,[14] STORIC developed an initial list of nearly forty storage interconnection challenges that encompasses technical, financing, and procedural issues. To develop a prioritized list of barriers that the BATRIES project could address within the project resources and timeframe, STORIC undertook a screening process that evaluated the initial set of barriers through several lenses, including whether other stakeholders are already working toward developing solutions on the issues; whether solutions would result in reduced costs and time for storage interconnection in furtherance of the project's objectives; and whether the issues represent a timely challenge that regulators, utilities, and developers are currently facing (as compared to a theoretical barrier that could pose a challenge in the more distant future).

[12] The BATRIES project is focused on distribution-interconnected storage, whether ESS is interconnected in front of or behind the meter, and irrespective of system size. BATRIES does not address transmission interconnection issues.

[13] Note: The Energy Storage Association (ESA) was a partner on the BATRIES project through December 2021, before merging with the American Clean Power Association (ACP) in January 2022. ACP is not a BATRIES partner.

[14] STORIC hosted two half-day workshops and made several presentations to gather input from stakeholders, and solicited peer review from subject matter experts of the proposed barriers to include in the Toolkit. A more detailed description of the stakeholder engagement process can be found in BATRIES Storage Interconnection Committee, *Roadmap for the Development of a Toolkit & Guidance for the Interconnection of Energy Storage and Solar-Plus-Storage* (March 2022), p. 7, https://energystorageinterconnection.org/roadmap-for-the-development-of-a-toolkit--guidance-for-the-interconnection-of-energy-storage-and-solar-plus-storage/.

As a result, STORIC identified the following eight priority storage interconnection barriers, which are included in the Toolkit:

- Lack of inclusion of storage in interconnection rules, and the lack of clarity as to whether and how existing interconnection rules (and related documents, such as application forms and agreements) apply to storage systems (Chapter II)
- Lack of inclusion of acceptable methods that can be used for controlling export of limited-and non-export systems in interconnection rules (Chapter III)
- Evaluation of non- and limited-export systems based on unrealistic operating assumptions that lead to overestimated grid impacts (Chapter IV)
- Lack of clarity regarding the impacts of inadvertent export from limited- and non-export systems and the lack of a uniform specification for export control equipment response times to address inadvertent export (Chapter V)
- Lack of information about the distribution grid and its constraints that can inform where and how to interconnect storage (Chapter VI)
- Lack of ability to make system design changes (other than downsizing the system) to address grid impacts and avoid upgrades during the interconnection review process (Chapter VII)
- States that have not incorporated updated standards into their interconnection procedures and technical requirements (Chapter VIII)
- Lack of defined rules and processes for the evaluation of operating schedules (Chapter IX)

The above eight barriers were selected based upon the collective experience of STORIC members who have engaged on these issues within regulatory proceedings and research and development contexts, and with input from external subject matter experts based on their own on-the-ground experience. The barriers are all at play within regulatory proceedings across the U.S., as further described in the Toolkit chapters below, highlighting the need for guidance and resources for regulators, developers, and utilities.

There are many more storage interconnection challenges than the BATRIES project could address within the project timeframe and resources.[15] To facilitate the future development of solutions related to barriers not included in BATRIES, the project team provides a list of the unaddressed barriers in Appendix A for consideration by other stakeholders.

[15] For example, based on the scoping work described above, the project team identified interconnection challenges associated with non- and limited-export as being high priority. As such, while there can also be challenges with interconnecting non-importing projects, the project team focused on developing recommendations related to requirements for and evaluation of non- and limited-export systems.

The recommendations included in the Toolkit are focused on storage interconnected to radial distribution systems,[16] whether ESS is interconnected in front of or behind the meter, and generally irrespective of system size (though the chapters below note instances in which specific discussions or recommendations have more limited applicability). Recommendations are designed for use in interconnection procedures for the distribution system. Nationally, interconnection standards are quite consistent structurally, with most following the structures of either the FERC's SGIP or IREC's Model Interconnection Procedures. These two models utilize a largely parallel structure and have similar interconnection screens and technical requirements. In order to develop model language for interconnection standards that can be adopted by states across the country, BATRIES generally uses the language from FERC SGIP to illustrate recommended revisions.[17] These recommendations should be easy to translate to other rules that utilize different formats.

Energy storage is a critical piece of the clean energy puzzle and solutions for enabling the more rapid and efficient integration of storage will continue to develop. The BATRIES project team looks forward to continuing dialogue with stakeholders on the storage interconnection barriers included in the Toolkit as well as the evolving universe of other storage interconnection challenges and opportunities.

Toolkit Quick Reference Guide

Chapter II - Updating Interconnection Procedures to Be Inclusive of Storage: Provides recommendations on how to ensure interconnection rules apply to ESS and recommends definitions for key terms that will be needed for ESS interconnection review.

Chapter III - Requirements for Limited- and Non-Export Controls: Includes recommendations for including defined acceptable export controls that maintain safety and reliability in interconnection procedures.

Chapter IV - Evaluation of Non-Export and Limited-Export Systems During the Screening or Study Process: Offers recommendations on how interconnection screening and study processes can be updated to recognize export controls.

Chapter V - Defining How to Address Inadvertent Export: Surveys how current standards treat inadvertent export and details the results of research conducted to test its potential grid impacts.

[16] Some recommendations may also apply to networked distribution systems. However, due to the technical differences between radial and networked systems, and the fact that radial systems prevail in the U.S., the project team focused primarily on radial systems.

[17] Note that BATRIES is not focused on recommending revisions to SGIP itself; rather it uses SGIP as a common reference point for model language that could be folded into individual states' interconnection standards.

Chapter VI - Improving Grid Transparency Through Hosting Capacity Analyses and Other Tools: Discusses how grid transparency tools, such as pre-application reports and hosting capacity maps, can help improve interconnection of DERs by assisting with good site selection and project design.

Chapter VII - Pathways to Allow for System Design Changes During the Interconnection Review Process to Mitigate the Need for Upgrades: Includes recommendations on how rule language can be revised to accommodate ESS project modifications during the interconnection process.

Chapter VIII - Incorporating Updated Interconnection Standards Into Interconnection Procedures: Provides recommendations on how to incorporate technical standards, such as the suite of IEEE 1547 standards, into interconnection procedures.

Chapter IX - Defining Rules and Processes for the Evaluation of Operating Schedules: Discusses what steps need to be taken to allow devices to reliably control import and export according to a schedule.

How To Use the Toolkit to Address Challenges

The Toolkit is meant to assist state regulators, utilities, and other stakeholders in addressing interconnection barriers related to the above topics. The recommendations and model language provided in the Toolkit can be used in regulatory proceedings and working groups to update interconnection procedures and practices to account for ESS and its unique capabilities on the grid. In its recommended model language revisions, the Toolkit uses FERC SGIP as a starting point (and provides model language for related forms, such as interconnection application forms that customers may complete in online portals), but states should easily be able to incorporate any changes into their own interconnection rules—whether they are based on FERC SGIP, IREC's 2019 Model Rules, or any other model language.

Recommended model language is presented in *italics*. Entirely new model language (*i.e.*, not revisions to existing text) is presented only in *italics*. Revisions to existing model language are presented in ~~strikethrough~~ (for deletions) and underline (for additions).

Note that terms and definitions are sometimes repeated throughout chapters of the Toolkit for readers who may wish to read a particular chapter without reviewing the prior chapters.

Considerations for States or Utilities Experiencing Lower Energy Storage Market Penetration or With More Limited Resources for DER-Related Investments

The solutions provided in the Toolkit are intended to have broad applicability, but some may be less applicable in jurisdictions that have limited storage market penetration (or prospects for near-term market growth), or for utilities with fewer resources to invest in the staffing, information technology, or other tools necessary for deploying the solutions (*e.g.*, smaller municipal or cooperative utilities). In such instances, regulators and utilities can prioritize the Toolkit solutions as follows:

- Start by reviewing Chapters II, III, and IV to understand how to enable the full capabilities of ESS and how to screen for inadvertent export impacts. (Chapter V provides more information on inadvertent export.)
- Pursuant to Chapter VI, consider whether any of the recommended grid transparency tools align with both the needs of interconnection applicants and the utility's resources and capabilities. Review Chapter VIII to understand how updated technical standards can enable additional ESS functionalities and maximize the benefits to both customers and grid operators.

A. Key Features of Energy Storage Systems That Impact Interconnection Review

To understand why each of the topics in the Toolkit chapters have been identified as barriers to the safe, reliable, and efficient interconnection of ESS, it is important to explain some of key features of ESS that distinguish it from the DERs that have historically been interconnected to the distribution system. This brief introduction to these concepts will assist in navigating the Toolkit.

1. Understanding ESS System Capabilities and Behavior

Perhaps the single most defining feature of ESS, whether installed alone or co-located with another DER, is that it offers a level of control that was not often available or utilized by other DERs. ESS can control how much power is exported to the grid (or imported from the grid or a co-located DER) at any one time. ESS can act as a purely non-exporting resource, a full-export resource, or a limited-export resource that limits export to a specified magnitude that may be less than the total amount of power the resource is theoretically capable of exporting at any one time. In addition to introducing greater levels of control over the *magnitude* of import and export, ESS can also control *when* a DER system imports or exports power. For example, an ESS may be able to limit export during periods of low demand or excess generation and instead ramp up export during periods of peak demand or low generation. If properly evaluated in screens and studies, such control flexibility can better serve energy needs while also allowing more DERs to interconnect without triggering the need for upgrades.

To illustrate this more specifically, it is helpful to consider just one example of how ESS systems may be used in balance with other DERs on the grid. In some areas of utility grids across the country, there is starting to be abundant solar energy produced during the middle of the afternoon—enough that at some times during the year there may be more energy than demand. Inversely, there are also certain periods of the day when there is insufficient clean energy being produced to serve load, particularly in the early evening hours when solar is no longer generating, but demand on the system remains relatively high. ESS can play an important role during these periods by importing (or storing) power during those periods of abundance. This can be done by charging from an onsite solar system, causing the solar system to cease export of all or some of its energy while the ESS charges. Or the ESS can charge from the grid itself, essentially utilizing the excess solar energy being produced elsewhere on the system. Then, when the grid conditions shift and more energy is once again needed to serve demand, the ESS can discharge power either onto the grid, or to serve onsite load such that the overall energy demand on the grid is reduced. This behavior can also be optimized in response to seasonal variations in peak demand.

While this example illustrates the significant flexibility benefits that ESS can add to the distribution system, the manner in which any one ESS will be operated depends on a variety of factors including market conditions, rate structures, and grid constraints and opportunities. In addition to external energy market factors, behind-the-meter systems are also designed to serve specific customer needs. The fixed rates or market signals that DER systems may be responding to are typically designed to incentivize the export of energy when it is needed the most and to deter energy export when there is less demand. And, the amount of energy needed (*i.e.*, the peak and minimum load) often closely aligns with when a feeder or substation will experience technical constraints (*i.e.*, if there is low load, less generation can be accommodated without triggering a thermal or voltage constraint than would be the case during a period of higher load). However, rates and market signals are rarely crafted on a feeder or substation basis. Thus, each location will have unique characteristics that may mean that grid constraints do not necessarily correspond neatly to the rate or market incentives that ESS may be responding to.

Hence, the purpose of the interconnection review process is to evaluate the grid conditions at the particular Point of Interconnection[18] for each project to determine whether the proposed DER will require grid upgrades in order to operate without causing reliability impacts to the distribution system. This review is largely independent from the rate structure or market program that a DER may be participating in. Whether a proposed project will require upgrades depends upon how and when it will be operated as well as the particular grid conditions at the proposed Point of Interconnection.

2. Changing Existing Interconnection Assumptions

Presently, most interconnection rules permit, or even require, utilities to evaluate ESS assuming that the full nameplate capacity of ESS will be exported at all times, and that ESS co-located with solar will simultaneously export at all times. These assumptions are extreme for a number of reasons. First, storage will never export continuously (*i.e.*, never ceasing to export during its operation) because it has to be charged at some point. Second, while customers often prefer to have flexibility to operate when and how they choose,

[18] Point of Interconnection, as defined similarly to SGIP, is the point where the Interconnection Facilities connect with the Distribution Provider's Distribution System. This is also referred to as the Point of Common Coupling (PCC) in technical standards like IEEE 1547.

there are currently no known reasons for a customer or system owner to choose to operate a system in that manner. Absent a rate structure that is intended to encourage maximum export, there would be little reason to do so in order to serve customer load onsite, and the distribution upgrade costs alone would be a significant deterrent. However, despite the practical reasons why this behavior is unlikely, utilities need evidence of a reliable physical solution that prevents this behavior in order to alter their interconnection review practices and to avoid overassessment of impacts.

The good news is that there are multiple methods available to reliably control export such that a project can safely be evaluated as either a non-export (zero export) or limited-export (maximum export value) project:[19]

- A non-export ESS[20] is one that implements advanced controls to forbid itself from exporting to the grid. It may be charged either by onsite generation (*e.g.*, solar) or from the grid. A non-exporting system may be utilized to meet tariff compliance (such as net energy metering, or NEM) or to align with interconnection pathways for non-exporting systems.

- A limited-export ESS is one that implements controls to set maximum export power to a specified magnitude lower than the full nameplate capacity. Such a system can export to the grid and can serve onsite load during discharging. While charging, either the grid or onsite generator can power the ESS. Depending on the intended use case and how much backfeed the grid can accommodate, the system is designed to allow a certain level of export.

As noted above, interconnection review has typically been conducted assuming that the proposed project will be exporting its entire potential output 24 hours a day, 365 days of the year, or that it will not be exporting power at all. Some state interconnection procedures, such as those in Arizona, California, Hawaii, Illinois, Iowa, Maryland, and Nevada have long recognized the existence of non-exporting systems and have provided for a slightly different, and typically more efficient, review process for non-export systems.[21] However, FERC SGIP and states that have followed that model, such as North Carolina and Ohio, typically have no mention of non-exporting systems or guidance for how they should be reviewed.

Over time, interconnection procedures have started to acknowledge that solar systems are incapable of producing power when the sun is not shining, and interconnection review in some places has thus recognized that output will differ between day and night. However, the assessment usually relies on a set of fixed hourly assumptions (*i.e.*, solar production

[19] When referring to both non-export and limited-export systems in this document, we use the term “export-controlled.”

[20] Non-export ESS is also referred to as “Import Only Mode” in the UL 1741 Certification Requirement Decision for Power Control Systems. As defined there, the “ESS may import active power from the Area EPS for charging purposes but shall not export active power from the ESS to the Area EPS.”

[21] AZ Administrative Code § R14-2-2623(B); CA Pub. Util. Comm., Southern California Edison, Rule 21, § G.1.i (Screen I); HI Pub. Util. Comm., Rule 22; IL Admin. Code tit. 83, § 466.80(c); Iowa Admin. Code r. 199.45.7(3); Code MD Regs. 20.50.09.11(C)-(D); NV Pub. Util. Comm., Dkt 17-06014, NV Power Co. Rule 15 § I.

from 10 am to 4 pm).[22] Furthermore, the concept of a limited-export system (*i.e.*, one that uses software or hardware to limit export to a non-zero value) is new and has only begun to be recognized by interconnection procedures in the last few years as interest in ESS capabilities has grown.

Since the controllable nature of ESS is critical to its ability to provide energy services, meet customer needs, and avoid or mitigate grid impacts, interconnection procedures will need to include greater recognition of export control in the screening and study process. Without this capability, ESS will be assumed to create grid impacts that might be avoided, which will increase the cost of ESS deployment and also increase the cost of other DERs that could rely on ESS to help mitigate grid impacts. This Toolkit focuses on the technical standards and procedural modifications that are necessary for interconnection rules to evolve to align with ESS capabilities while also ensuring safety and reliability.

[22] See, *e.g.*, MN Pub. Util. Comm., Dkt. E-999/CI-16-521, Order Establishing Updated Interconnection Process and Standard Interconnection Agreement, Attachment: Minnesota Distributed Energy Resources Interconnection Process, § 3.4.4.1.1 (Aug. 13, 2018) (MN DIP) ("Solar photovoltaic (PV) generation systems with no battery storage use daytime minimum load (i.e., 10 a.m. to 4 p.m. for fixed panel systems and 8 a.m. to 6 p.m. for PV systems utilizing tracking systems), while all other generation uses absolute minimum load.").