III. Requirements for Limited- and Non-Export Controls

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A. Introduction and Problem Statement

Storage systems have unique capabilities, such as the ability to control export to, or import from, the grid. There are multiple different methods by which ESS can manage export, including the use of traditional relays as well as Power Control Systems that have recently been refined under a common standard. However, utilities, customers, developers, manufacturers, and regulators may be unfamiliar with the currently available control technologies and methodologies for testing or verifying that Power Control Systems will operate as intended. This can result in each ESS needing a tailored screening and study assessment to interconnect (known as customized review), testing, and/or utilities overestimating system impacts if they do not have confidence in the controls used. These are significant barriers to an efficient and effective interconnection process for ESS.

Energy storage export and import can provide beneficial services to the end-use customer as well as the electric grid. These capabilities can, for example, balance power flows within system hosting capacity limits, reduce grid operational costs, and enable arbitrage for solar-plus-storage owners via self-supply. But if mismanaged or enacted at the wrong times, these same capabilities can have adverse and potentially damaging effects.

For most grid assets, relays, circuit breakers, and manual disconnect equipment have been regularly employed as protection equipment to prohibit adverse operations. However, energy storage has inherent flexibility that presents unique opportunities for departing from status quo grid integration and protection approaches. For example, ESS offers an ability to dispatch active and reactive power via a PCS, a high rate of response, and the capability to transition twice its rated power in a single step (from full import to full export or vice versa). Developing standardized methods for validating the types of export controls most suited for ESS and other DERs can help take full advantage of ESS performance while also minimizing interconnection costs. Standardized methods are also essential for ensuring that utilities can provide reliable electricity, in part, through the reliable operation of interconnected assets.

Clear identification of standardized methods of controlling export in interconnection rules also provides interconnection customers the information they need to properly design ESS projects prior to submitting interconnection applications. This regulatory certainty reduces the time and costs associated with ESS interconnection by minimizing the amount of customized review needed and by empowering customers to design projects that avoid the need for distribution upgrades.

Today, many state interconnection procedures do not yet recognize export-limiting capabilities at all, and even fewer concretely identify the acceptable methods of control. The following chapter provides background on how interconnection procedures consider export limiting today. It introduces the types of export controls that can be used and discusses, in particular, the standardization process for PCS. It then provides recommendations on incorporating guidance on export controls into interconnection procedures to minimize customized review while also ensuring export-controlled systems are safely evaluated.

Note: While this chapter discusses the requirements for limited- and non-export controls, Chapter IV discusses the screening and study process for evaluating these types of systems.

B. State Approaches to Identifying Export Control Methods

Currently, interconnection procedures in the United States generally have one of three different ways of addressing the concept of export control for storage and other DERs. First, some procedures do not recognize the concept of export limiting at all. The FERC SGIP contains little discussion or acknowledgement of non- or limited-export projects. Thus, a number of states that have followed the FERC SGIP model,[27] and several other states, do not have any process associated with reviewing non- or limited-export projects. The second group have a distinct review tier for non-exporting projects (typically Level 3), like the IREC 2019 Model. However, these rules typically do not identify what methods of controlling export are acceptable with any level of specificity.[28] Finally, the third group are those that followed the California Rule 21 model, which includes a distinct screen for non-exporting projects.[29] This screen identifies, with more detail, what methods of export control are acceptable to qualify as non-export for purposes of the screen. None of these three categories has historically included any consideration of limited-export projects.

The approach taken in California has a distinct advantage in that it is the only one that provides utilities and applicants with a clear list of the acceptable methods for controlling export. However, that list of acceptable export controls is embedded in a screen for non-exporting projects only and thus it has not provided a convenient vehicle for the incorporation of controls used for limited-export, as compared to non-export, systems.

[27] *See*, *e.g.*, 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; OH Admin. Code 4901:1-22.

[28] *See, e.g.*, IL Admin. Code tit. 83, § 466.80(c)(2) ("The distributed generation facility will use reverse power relays or other protection functions that prevent power flow onto the electric distribution system"); Admin. Code r. 199.45.7(3); ("The distributed generation facility will use reverse power relays or other protection functions that prevent power flow onto the electric distribution system. . ."; 2013 IREC 2019 Model ("An Applicant may use the Level 2 process for a Generating Facility with a Generating Capacity no greater than ten MW that uses reverse power relays, minimum import relays or other protective devices to assure that power may never be exported from the Generating Facility to the Utility.")

[29] CA Pub. Util. Comm., Southern California Edison, Rule 21 § G.1.i; NV Pub. Util. Comm., Dkt 17-06014, NV Power Co. Rule 15 § I.4.b.

The following subsection III.C provides a description of the export control methods that have been traditionally recognized in interconnection procedures and/or standards, such as those in California and Nevada.

C. Traditional Export Control Methods

Where DER systems require export limiting in order to interconnect, control has been achieved over the years in multiple ways with existing equipment, mostly only for larger systems. This is often achieved using protective relays implementing a reverse power limiting function (known as Reverse Power Protection) or minimum import function (known as Minimum Power Protection). Relays are sensing and computational devices which can signal a circuit breaker to trip based on measured quantities of voltage and current, dependent on the function(s) implemented. For a non-export system, the relay would be set to trip the circuit breaker if reverse power is sensed for longer than a short delay time or, alternatively, if import power falls below a minimum amount. A similar concept can be used for limited-export systems to trip the breaker when reverse power exceeds a certain level (known as Directional Power Protection).

DER systems which employ this type of protection to control export may have an additional control system acting internally to ensure export power does not reach the level which would cause the relay to trip. Alternatively, the systems could be designed based on an analysis of the load and generation at the site, such that export power is very unlikely to ever exceed the limit. In this case, inadvertent export (previously described in Chapter II.B.2 and Chapter III) could be introduced where some export beyond the limit occurs, but is not of sufficient duration to cause a trip. Inadvertent export would usually occur due to a fast drop in load, such as a large air conditioning unit or other large load turning off. DERs with control systems in place can recognize this violation of the export limit and respond quickly to reduce generation so export no longer exceeds the limit. Chapter V will discuss inadvertent export in more detail.

Another way to control export is by reducing the export capability of the DER via an internal setting to a value below its Nameplate Rating. Inverters typically have an ability to limit maximum output power via a settable parameter or via a firmware change, the latter typically requiring the intervention of the manufacturer. IEEE 1547-2018 has formalized this concept by allowing the changing of nameplate parameter values via configuration (known as Configured Power Rating). This optional feature can be tested with the IEEE 1547.1-2020 test procedures.[30] While limiting power via configuration settings does limit export power, it would also generally limit the ability to serve any onsite load when this limit affects the power at the inverter terminals, as is typically done today.

[30] IEEE Standard Conformance Test Procedures for Equipment Interconnecting Distributed Energy Resource with Electric Power Systems and Associated Interfaces, IEEE Std 1547.1-2020, https://standards.ieee.org/standard/1547_1-2020.html.

Another option is to use probabilistic methods to ensure export power does not exceed a limit, without the need for additional protection functions or relays. This is typically only done for non-export systems, by analyzing the load in comparison to the generation in order to have a high degree of certainty that load will always be higher than generation, usually by a wide margin (known as Relative Distributed Energy Resource Rating).

The above practices have been used in many areas of the country and around the world, but in the U.S. have thus far only been formalized in a few interconnection rules. California, Nevada, and Hawaii have for some years included a list of recognized non-export methods in interconnection rules which include relay and probabilistic methods.[31]

D. Certification Requirement Decision (CRD)

Recent efforts in California and other states have focused on expanding the acceptable methods of export control to permit the use of certified Power Control Systems for both non- and limited-export functions. These can be especially useful for smaller systems where a relay is impractical,[32] though DERs of any size might employ them.

Power Control Systems are composed of a controller, sensors, and inverters, any of which may or may not be contained in separate devices. PCS have been used to limit export to the distribution system where no export is allowed, or to limit the maximum export to a value less than the Nameplate Rating of the DER. One possible configuration of a PCS is shown in Figure 1. Here, separate PV and storage inverters are controlled by signals derived from a discrete PCS controller. As connected, the current transformer (CT) monitors the entire load, while the PCS uses the sensor information to create power setpoints for the inverter(s). In this configuration, either or both of the inverters could be controlled to an export limit, and import limiting to the storage inverter could be implemented. Other configurations with alternative connections or setups could be used to achieve different control strategies (*e.g.*, see Appendix B).

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31 California Rule 21 G.1.i; Nevada Rule 15 I.4.b; and Hawaiian Electric Rule 22 Appendix II.

32 R. Brent Alderfer, Monika M. Eldridge, and Thomas J Starrs, *Making Connections: Case Studies of Interconnection Barriers and Their Impact on Distributed Power Projects*, United States Department of Energy Distributed Power Program Office of Energy Efficiency and Renewable Energy, Office of Power Technologies (July 2000), https://www.nrel.gov/docs/fy00osti/28053.pdf.

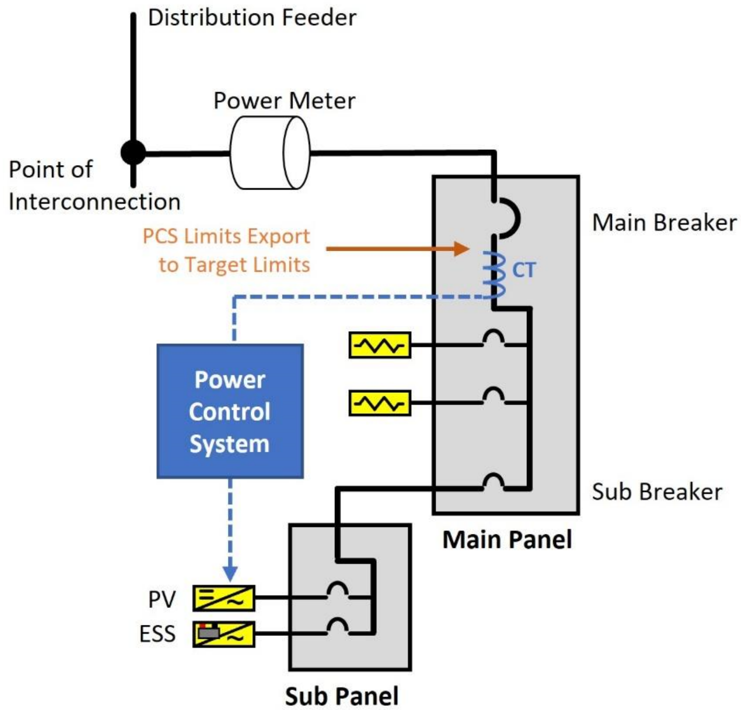

Figure 1. Local Power Control System Supporting Export Limiting (EPRI)

Storage may include PCS export or import controls in order to maintain export or import limits within distribution system constraints. Storage could also use PCS to enable it to comply with net energy metering requirements, typically when set for export only to ensure that a battery is charged entirely from solar or import only to ensure that a battery does not export for NEM credit.

Since PCS are control devices, as opposed to a signaling device which trips a circuit breaker at a definite time delay (like a relay does), their response times are characterized in terms of open loop response time (OLRT), which reflects the time for the output to reach 90% of the reduction toward the final value. PCS can introduce inadvertent export as a result of changes to load, similar to other systems, but they do not “trip” at any definite time. Though some PCS are able to respond in timeframes similar to the typical settings for reverse power relays, others are slower—while still generally being fast enough to avoid distribution system impacts such as interactions with voltage regulators.

Arizona, Colorado, Nevada, Maryland, Minnesota, and Hawaii have included provisions in interconnection rules for these types of systems, including a maximum 30 second response time,[33] but those rules largely predated any certification test protocol. The UL

[33] AZ Administrative Code § R14-2-2603(E)(4) (inadvertent export duration limited to 30 seconds); Section 4 Code of Colorado Regulations § 723-3, 3853(c)(I); HI Pub. Util. Comm., Rule 22, at Sheet 44B-1 to Sheet 44B-2 (Appendix II) (same); MN TIIR § 11.3, at p. 33 (same); NV Pub. Util. Comm., Dkt 17-06014, NV Power Co. Rule 15 § I.4(b) (same); Code MD Regs., Sec. 20.50.09.06.O(2).

Certification Requirement Decision (CRD)[34] for PCS (issued for UL 1741[35] on March 8, 2019) now defines conformance tests that allow PCS to be certified. While not yet part of the UL 1741 standard, the CRD document is required to be utilized for UL product certification programs. The tests are planned to be incorporated into the UL 1741 standard such that the CRD will no longer be needed.

The test protocol can be used to demonstrate that a PCS supports: (1) export limiting from all sources, (2) export limiting from ESS, and (3) import limiting to ESS. Additionally, unrestricted, export only, import only, and no exchange operating modes may optionally be supported by the PCS. More detail on the CRD test procedures is given in Appendix B.

E. Recommendations

1. Interconnection Procedures

As explained in Chapter III.A, the manner in which export is managed is likely to be a critical aspect of interconnection review for many ESS in the coming years. Furthermore, it is likely that a significant number of all future interconnection applications to the distribution system are going to include an energy storage component. For this reason, it is important that interconnection procedures be updated to more clearly and deliberately address what types of export controls are safe and reliable and can therefore be proposed as part of an interconnection application without triggering the need for additional customized review.

Relying on customized review of the export controls for each and every interconnection application is a significant barrier for ESS. Customized review deprives applicants of the certainty they need to design an application to meet utility and distribution system requirements from the start. Customized review also requires additional utility time and resources for each application. Most importantly, however, as discussed in the preceding sections, there are a number of export control methods that are already widely accepted for use. Those that are newer, like PCS and the configured power rating, can also be trusted because they rely on equipment whose functionality has been certified. Non-standard types of export control equipment will continue to need customized review, but it is reasonable to update interconnection procedures to identify a list of acceptable methods that can be trusted and relied upon by both the interconnection customer and the utility.

[34] CRDs are the preliminary documents developed through UL's deliberative process to inform revisions to UL's existing or future listings. They are a primary vehicle for addressing hardware or control requirements in standards. The CRD for PCS contains tests to assess a set of PCS functionalities not previously addressed in UL 1741.

[35] UL 1741 is a product safety standard that stipulates the manufacturing and product testing requirements for the design and operation of inverters, converters, controllers, and other interconnection equipment intended for DER. Solar and storage inverters, as well as other products, are listed to the safety standard UL 1741, which requires grid-interactive equipment to pass the tests in IEEE 1547.1.

A section on acceptable export control methods provides a foundation upon which other important interconnection rule and process changes can be made that ensure that ESS are screened and studied safely and efficiently. As discussed further in Chapter IV, in order to screen and/or study projects, utilities need to know, with confidence, how much the proposed project will export. In most states today, the existing approach is that the utility assumes the project will export the full nameplate (or combined nameplate) of the DER equipment. In order to evaluate a project as exporting anything less than the full combined nameplate, a utility must have clear information, and confidence, in the manner in which the DER limits export. This confidence can be achieved by providing a pre-approved list of methods which are considered acceptable.

This Toolkit recommends that interconnection procedures include a distinct section defining acceptable export methods and provides model language that states can use. The model language can be incorporated into all different styles of interconnection procedures with only minor modifications.

The model language, which is provided in the following Chapter III.E.2, accomplishes the following things:

- It establishes that if an applicant uses one of the export control methods specified in its application, then the Export Capacity specified in the application will be used by the utility for evaluation during the screening and study process. It also makes clear that the Export Capacity identified in the application will be considered a limitation in the interconnection agreement.
- It identifies six different acceptable export control methods. The methods identified are those described above in Chapter III.C and III.D and in Table 1 below. The methods are organized by whether they can be used for non-export, limited-export, or for both (as shown in the following table). Settings and response times are identified where necessary.
- It also includes a seventh export control option that allows for the use of any other method (beyond the six specifically identified methods), so long as the utility approves its use. In other words, this provision allows for customized review of any export control methods that do not meet the criteria of one of the six pre-identified acceptable methods.

Table 1. Acceptable Export Control Methods

Acceptable Export Control Methods		
	For Non-Exporting DER	For Limited-Export DER
a) Reverse Power Protection (Device 32R*)	Yes	
b) Minimum Power Protection (Device 32F*)	Yes	
c) Relative Distributed Energy Resource Rating	Yes	
d) Directional Power Protection (Device 32*)		Yes
e) Configured Power Rating		Yes
f) Limited Export Utilizing Certified PCS	Yes	Yes
g) Limited Export Using Agreed-Upon Means	Yes	Yes

* ANSI[36] device numbers are listed in parentheses, as defined by IEEE C37.2 IEEE Standard Electrical Power System Device Function Numbers, Acronyms, and Contact Designations.

2. Recommended Language

In order to recognize the controllable nature of ESS in interconnection review, PCS should be included in the list of eligible export controls, and the limits set by the PCS should be considered as enforcing the Export Capacity. Having a certified PCS allows smaller systems to incorporate a limit without an additional extensive review process. It is reasonable to require utilities to rely on the capabilities of certified devices. Some systems may be made up of components from different manufacturers, which are more challenging to certify through a Nationally Recognized Testing Laboratory (NRTL). Therefore, some allowance for non-certified PCS, which the utility agrees meets the export control requirement, should also be provided for. Assurance for non-certified systems may be provided through other utility evaluations, potentially including field testing.

The early interconnection rules incorporating PCS (such as Hawaii Rule 22 and California Rule 21) included detailed technical requirements. As of this writing, the technical requirements in those rules are now out of alignment with the way PCS is defined and tested per the UL CRD. This can be problematic for the evaluation of equipment since the

[36] The American National Standards Institute (ANSI) is a private non-profit organization that oversees the development of voluntary consensus standards for U.S. products and services. ANSI accredits standards developed by others that ensure consistency in product performance and conformance with testing protocols.

certification will not match the rule's required capabilities. To maintain alignment, most detailed technical requirements should defer to the UL CRD and UL 1741, and any high-level performance requirements in interconnection rules should align fully with the UL CRD and UL 1741.

For enabling export controls more broadly, interconnection procedures should be revised to include the following model language. For interconnection procedures based on SGIP, this section replaces SGIP Section 4.10 titled Capacity of the Small Generating Facility (section 4.10.1 would remain). In interconnection procedures that use a level-based approach (like IREC's Model), this section would fit best in a section on general requirements that applies to all projects regardless of the review level (such as section IV of IREC's 2019 Model).

*Section 4.10 – **Export Controls***

4.10.2 If a DER uses any configuration or operating mode in subsection 4.10.4 to limit the export of electrical power across the Point of Interconnection, then the Export Capacity shall be only the amount capable of being exported (not including any Inadvertent Export). To prevent impacts on system safety and reliability, any Inadvertent Export from a DER must comply with the limits identified in this Section. The Export Capacity specified by the interconnection customer in the application will subsequently be included as a limitation in the interconnection agreement.

4.10.3 An Application proposing to use a configuration or operating mode to limit the export of electrical power across the Point of Interconnection shall include proposed control and/or protection settings.

*4.10.4 **Acceptable Export Control Methods***

*4.10.4.1 **Export Control Methods for Non-Exporting DER***

*4.10.4.1.1 **Reverse Power Protection** (Device 32R)*

To limit export of power across the Point of Interconnection, a reverse power protective function is implemented using a utility grade protective relay. The default setting for this protective function shall be 0.1% (export) of the service transformer's nominal base Nameplate Rating, with a maximum 2.0 second time delay to limit Inadvertent Export.

*4.10.4.1.2 **Minimum Power Protection** (Device 32F)*

To limit export of power across the Point of Interconnection, a minimum import protective function is implemented using a utility grade protective relay. The default setting for this protective function shall be 5% (import) of the DER's total Nameplate Rating, with a maximum 2.0 second time delay to limit Inadvertent Export.

4.10.4.1.3 ***Relative Distributed Energy Resource Rating***

This option requires the DER's Nameplate Rating to be so small in comparison to its host facility's minimum load that the use of additional protective functions is not required to ensure that power will not be exported to the electric distribution system. This option requires the DER's Nameplate Rating to be no greater than 50% of the interconnection customer's verifiable minimum host load during relevant hours over the past 12 months. This option is not available for interconnections to area networks or spot networks.

4.10.4.2 ***Export Control Methods for Limited-Export DER***

4.10.4.2.1 ***Directional Power Protection*** *(Device 32)*

To limit export of power across the Point of Interconnection, a directional power protective function is implemented using a utility grade protective relay. The default setting for this protective function shall be the Export Capacity value, with a maximum 2.0 second time delay to limit Inadvertent Export.

4.10.4.2.2 ***Configured Power Rating***

A reduced output power rating utilizing the power rating configuration setting may be used to ensure the DER does not generate power beyond a certain value lower than the Nameplate Rating. The configuration setting corresponds to the active or apparent power ratings in Table 28 of IEEE Std 1547-2018, as described in subclause 10.4. A local DER communication interface is not required to utilize the configuration setting as long as it can be set by other means. The reduced power rating may be indicated by means of a Nameplate Rating replacement, a supplemental adhesive Nameplate Rating tag to indicate the reduced Nameplate Rating, or a signed attestation from the customer confirming the reduced capacity.

4.10.4.3 ***Export Control Methods for Non-Exporting DER or Limited- Export DER***

4.10.4.3.1 ***Certified Power Control Systems***

DER may use certified Power Control Systems to limit export. DER utilizing this option must use a Power Control System and inverter certified per UL 1741 by a nationally recognized testing laboratory (NRTL) with a maximum open loop response time of no more than 30 seconds to limit Inadvertent Export. NRTL testing to the UL Power Control System Certification

Requirement Decision shall be accepted until similar test procedures for power control systems are included in a standard. This option is not available for interconnections to area networks or spot networks.

4.10.4.3.2 ***Agreed-Upon Means***

DER may be designed with other control systems and/or protective functions to limit export and Inadvertent Export if mutual agreement is reached with the Distribution Provider. [37] *The limits may be based on technical limitations of the interconnection customer's equipment or the electric distribution system equipment. To ensure Inadvertent Export remains within mutually agreed-upon limits, the interconnection customer may use an uncertified Power Control System, an internal transfer relay, energy management system, or other customer facility hardware or software if approved by the Distribution Provider.*

[37] SGIP includes the term "Transmission Provider" in place of "Distribution Provider" in its model interconnection procedure language because it was adopted as a pro forma for transmission providers under FERC jurisdiction. However, states typically change it to "Distribution Provider" or another term when applicable.