Appendix I - CSF Plant Operator Guide

Effective Date: July 18, 2023

Review By Date: July 18, 2025

References:

ISO New England Inc. Transmission, Markets, and Services Tariff, Section I – General Terms and Conditions (Section I)

ISO New England Inc. Transmission, Markets, and Services Tariff, Section II – Open Access Transmission Tariff (OATT)

ISO New England Inc. Transmission, Markets, and Services Tariff, Section III – Market Rule 1 – Standard Market Design (Market Rule 1)

ISO New England Operating Procedure No.14 - Technical Requirements for Generators, Demand Response Resources, Asset Related Demands and Alternative Technology Regulation Resources (OP-14)

ISO New England Operating Procedure No. 18 - Metering and Telemetering Criteria (OP-18)

ISO New England Operating Procedure No. 18 Appendix C - Minimum Accuracy Standards for New and Upgraded Metering, Recording and Telemetering Installations And For Calibration of Existing Equipment (OP-18C)

ISO New England Operating Procedure No. 18 Appendix F - ISO Communications Front End (CFE) Interface Specifications (Confidential) (OP-18F)

Attachments:

Attachment A - CSF Configuration Diagrams

Attachment B - CSF Static Data Information Form

Attachment C - Available Energy and Available Storage Calculation Examples

Contents

1. Introduction

This Appendix I to ISO New England Operating Procedure No. 14 - Technical Requirements for Generators, Demand Response Resources, Asset Related Demands, and Alternative Technology Regulation Resources (OP-14I) establishes operating requirements for Continuous Storage Facilities (CSFs) as well as reporting requirements under which CSF Operators shall submit data to ISO New England (ISO). The submittal of such data supports the reliable and efficient integration of energy storage into the ISO Balancing Authority Area (BAA). The requirements of this OP-14I apply to all Resources registered as a CSF that are or will be:

(i) dispatched by ISO or

(ii) represented in the ISO Energy Management System (EMS).

This OP-14I also includes requirements to submit data that will be integrated into the ISO EMS in order to facilitate proper System Operator system awareness.

This OP-14I establishes data reporting and operating requirements specific to CSFs. The CSF Operator shall also comply with any other requirements that apply to CSFs under other ISO Operating Documents

2. Definitions

NOTE

Defined terms used but **not** defined in this OP-14I shall have the meanings ascribed to them in the ISO New England Transmission, Markets, and Services Tariff or the Glossary of Terms Used in North American Electric Reliability Corporation Inc. (NERC) Reliability Standards.

The following definitions are used for the purposes of this OP-14I:

Available Energy is the maximum MWh that a CSF could generate within a specified amount of time based on its current equipment status and state of charge.

Available Storage is the maximum MWh that a CSF could consume within a specified amount of time based on its current equipment status and state of charge.

CSF Operator is the Lead Market Participant (Lead MP), or its designee, who operates a CSF or reports the CSF data to ISO as required in this OP-14I.

Facility Max Reactive Lagging Capability is the maximum reactive capability in the lagging direction (i.e., VAr management that increases local voltage levels) that the CSF can supply at the Point of Interconnection given the existing voltage, in a continuous manner within one minute and maintain for at least one hour.

Facility Max Reactive Leading Capability is the maximum reactive capability in the leading direction (i.e., VAr management that decreases local voltage levels) that the CSF can absorb at the Point of Interconnection given the existing voltage, in a continuous manner within one minute and maintain for at least one hour.

3. Standard Operational Practice and Requirements

3.1 CSF Data

Unless ISO agrees to other modeling and data arrangements, CSF data (whether static or telemetered) that a CSF Operator submits in accordance with this OP-14I shall be consistent with the definition of a CSF.

3.2 Reclosing and Restarts

A CSF shall be designed and operated (including the performance of re-closings and restarts) by the CSF Operator in accordance with ISO Operating Documents, which apply to all Resources within the ISO's BAA.

If the CSF main breaker is opened (i.e., the Resource is manually or automatically disconnected from the rest of the New England Transmission System), the CSF Operator shall receive permission from ISO and the relevant LCC prior to reclosing (i.e., reconnecting to the New England Transmission System). In other words, an automatic restart of the CSF is **not** permitted following a fault to the Distribution System or Transmission System that is severe enough to disconnect the CSF (e.g., a low voltage ride-through event that is **not** "ridden-through") or following any CSF-wide out-of-service event.

3.3 Ramp Rate Limitations

Due to the very fast ramping capabilities of CSFs, there is potential for the transmission equipment to which they are interconnected to become significantly loaded or unloaded, which may lead to operational and reliability concerns. As operational experience is gained, ISO shall evaluate and has the right to implement ramp rate limitations on a CSF-specific basis, or to all CSFs in New England as warranted. Where ramp rate limitations are applied, the specific CSF limits shall be provided to the Lead MP.

4. Static Plant Data Requirements

The static plant data requirements in this section relate to the physical layout of the CSF as well as data relevant to the design and operation of the CSF. The CSF Operator shall provide this data and shall keep the data up-to-date by completing and submitting the "CSF Static Data Information Form." The "CSF Static Data Information Form" is an editable Excel workbook file that shall be requested from, and returned as a completed Excel workbook file to, the ISO at RenewableResourceInt@iso-ne.com. A sample "CSF Static Data Information Form" is included as Attachment B to this OP-14I. Instructions are included on the form for completing and submitting the required data. Attachment A to this OP-14I serves as an aid to determining the inverter grouping. Consistent with Schedules 22 and 23 of Section II of the Tariff and OP-14, the CSF Operator shall verify that the static plant data for each CSF is kept current. The CSF Operator shall communicate any material changes to the data to ISO as soon as practicable.

Static data:

1. Storage module type(s) and number(s)
2. Maximum storage nameplate capacity (in MWh to two decimal places)
3. Inverter type(s)
4. Maximum inverter nameplate capacity (in MW to two decimal places)
5. Inverter-by-inverter breakdown of relative storage MWh nameplate capacity
6. Descriptions of any permitting or administrative restrictions for the CSF or any portion of the CSF, such as requirements to reduce or to cease power production during certain hours or during certain events or weather conditions.

5. Real-Time Data Collection and Transfer

This section establishes the Real-Time operational data requirements for CSF Operators. In accordance with Table 6.1 of this OP-14I, and as detailed in Section V (Internal New England Metering And Telemetering For Dispatch, Market, And Reliability Purposes) of ISO New England Operating Procedure No. 18 - Metering and Telemetering Criteria (OP-18), data required under this Section shall be electronically and automatically transmitted by the CSF Operator to ISO. In addition, if any recommended data is provided by the CSF Operator, it shall also conform to the requirements of OP-18. Reliable integration of CSFs into the Real-Time Energy Markets is highly dependent on the availability of Real-Time power production, status, and capability data. As such, the data provided shall be highly accurate and reliable.

5.1 Required Data Collection Points

CSF Operators shall provide the Real-Time data collection points listed in Table 6.1 of this OP-14I that are identified as "Required."

Available Energy and Available Storage shall be calculated using a 15 minute, 1 hour, and 4-hour time horizon. These values should reflect the maximum energy generation and consumption capability, respectively, that could occur during these time horizons, subject to the current state of charge and taking into consideration any power restrictions due to equipment, Interconnection Agreement limits, and energy capabilities from any other on-site generation equipment (e.g. PV panels, wind turbines, etc.) See Attachment C for example calculations.

5.2 Recommended Data Collection Points

CSF Operators are requested to provide the Real-Time data collection points list in Table 6.1 of this OP-14I that are identified as “Recommended.”

If the CSF includes any solar PV and/or wind generation (i.e. the solar or wind generation is not a separately registered Resource for Real-Time Markets), static and meteorological data from OP-14 Appendix H and/or OP-14 Appendix F respectively, is requested in order to aid in the development and improvement of centralized solar and wind power forecasts.

6. Real Time Data Table

Table 6.1 Real-Time data

Parameter	Required/ Recommended	Location	Units	Instantaneous / Average	Minimum Resolution/ Accuracy	Minimum Update Frequency	Requirement Reference(s)
Facility Power Generation	Required	Facility-wide total	MW	Instantaneous	As required by OP-18	As required by OP-18	OP-18 Section V.C OP-18 App.F
Facility Reactive Power Production	Required	Facility-wide total	MVAr	Instantaneous	As required by OP-18	As required by OP-184 or 10 s	OP-18 Section V.C OP-18 App.F
Voltage	Required	Facility	kV	Instantaneous	As required by OP-18	As required by OP-18	OP-18 Section V.C OP-18 App.F
Facility main breaker status	Required	Facility	binary	Instantaneous	N/A	As required by OP-18	OP-18 Section V.C OP-18 App.F
Facility voltage regulation mode	Required	Facility	binary	Instantaneous	N/A	As required by OP-18	OP-18 Section V.C OP-18 App.F
15-Minute Available Energy	Required	Facility-wide total	MWh	Instantaneous	0.01 MWh with accuracy of +/- 1%	Every 10 s	OP-14 App. I Section 5.1
1-Hour Available Energy	Required	Facility-wide total	MWh	Instantaneous	0.01 MWh with accuracy of +/- 1%	Every 10 s	OP-14 App. I Section 5.1
4-Hour Available Energy	Required	Facility-wide total	MWh	Instantaneous	0.01 MWh with accuracy of +/- 1%	Every 10 s	OP-14 App. I Section 5.1
15-Minute Available Storage	Required	Facility-wide total	MWh	Instantaneous	0.01 MWh with accuracy of +/- 1%	Every 10 s	OP-14 App. I Section 5.1
1-Hour Available Storage	Required	Facility-wide total	MWh	Instantaneous	0.01 MWh with accuracy of +/- 1%	Every 10 s	OP-14 App. I Section 5.1

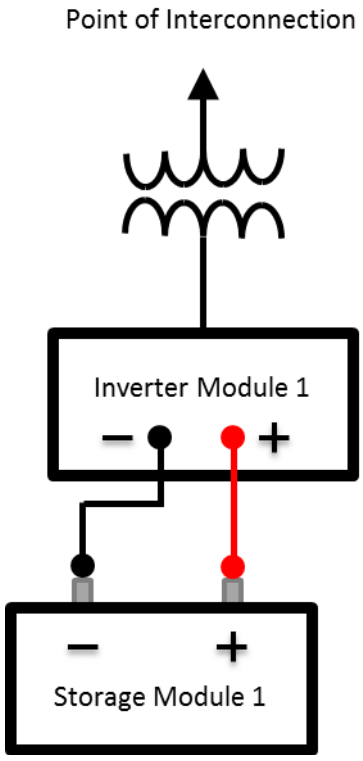
Parameter	Required/ Recommended	Location	Units	Instantaneous / Average	Minimum Resolution/ Accuracy	Minimum Update Frequency	Requirement Reference(s)
4-Hour Available Storage	Required	Facility-wide total	MWh	Instantaneous	0.01 MWh with accuracy of +/- 1%	Every 10 s	OP-14 App. I Section 5.1
Facility Max Reactive Leading Capability	Recommended	Facility-wide total	MVAr	Instantaneous	0.01 MWh with accuracy of +/- 1%	Every 10 s	OP-14 App. I Section 2
Facility Max Reactive Lagging Capability	Recommended	Facility-wide total	MVAr	Instantaneous	0.01 MWh with accuracy of +/- 1%	Every 10 s	OP-14 App. I Section 2

7. Revision History

Rev No.	Date	Reason
Rev 0	04/01/19	Initial version
Rev 0.1	11/05/20	Periodic review performed by document owner with no changes required;
Rev 1	03/19/21	Cleanup of Section 2 to remove duplicate information given in Tariff and OP-14; Addition of Requirement References column to Table 6.1 Added Attachment C - Available Energy and Available Storage Calculation Examples
Rev 1.1	11/01/22	Periodic review performed by document owner with no intent changes required.
Rev 2	07/18/23	Periodic review completed by the procedure owner; Updated Table 6.1 Real-Time Data: Removed at point of interconnection from Voltage Parameter and updated references in Minimum Resolution/Accuracy, Minimum Update Frequency, and Requirement Reference(s) columns.

Attachment A - CSF Configuration Diagrams

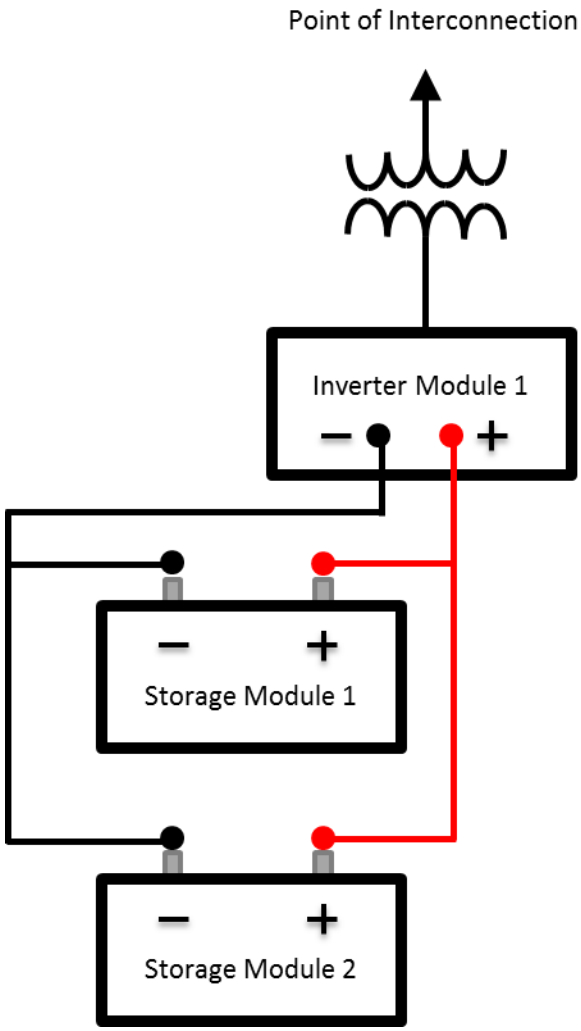
A total of four different example CSF configurations are shown in order to aid in completing the inverter-by-inverter MWh mapping required in Attachment B - CSF Static Data Information Form.



One inverter module with one storage module

Figure A-1

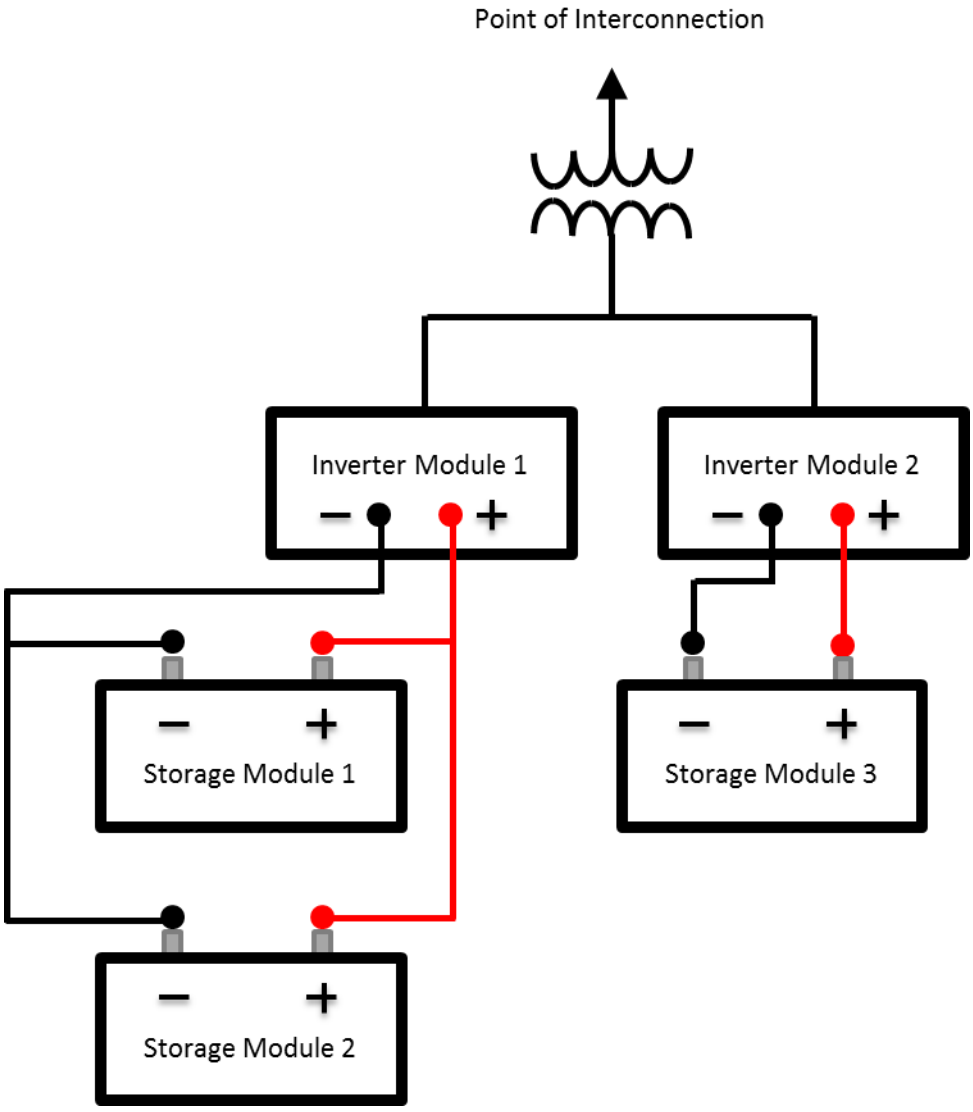
This would be one inverter group as all storage modules can be used by all inverter modules.



One inverter module with multiple storage modules

Figure A-2

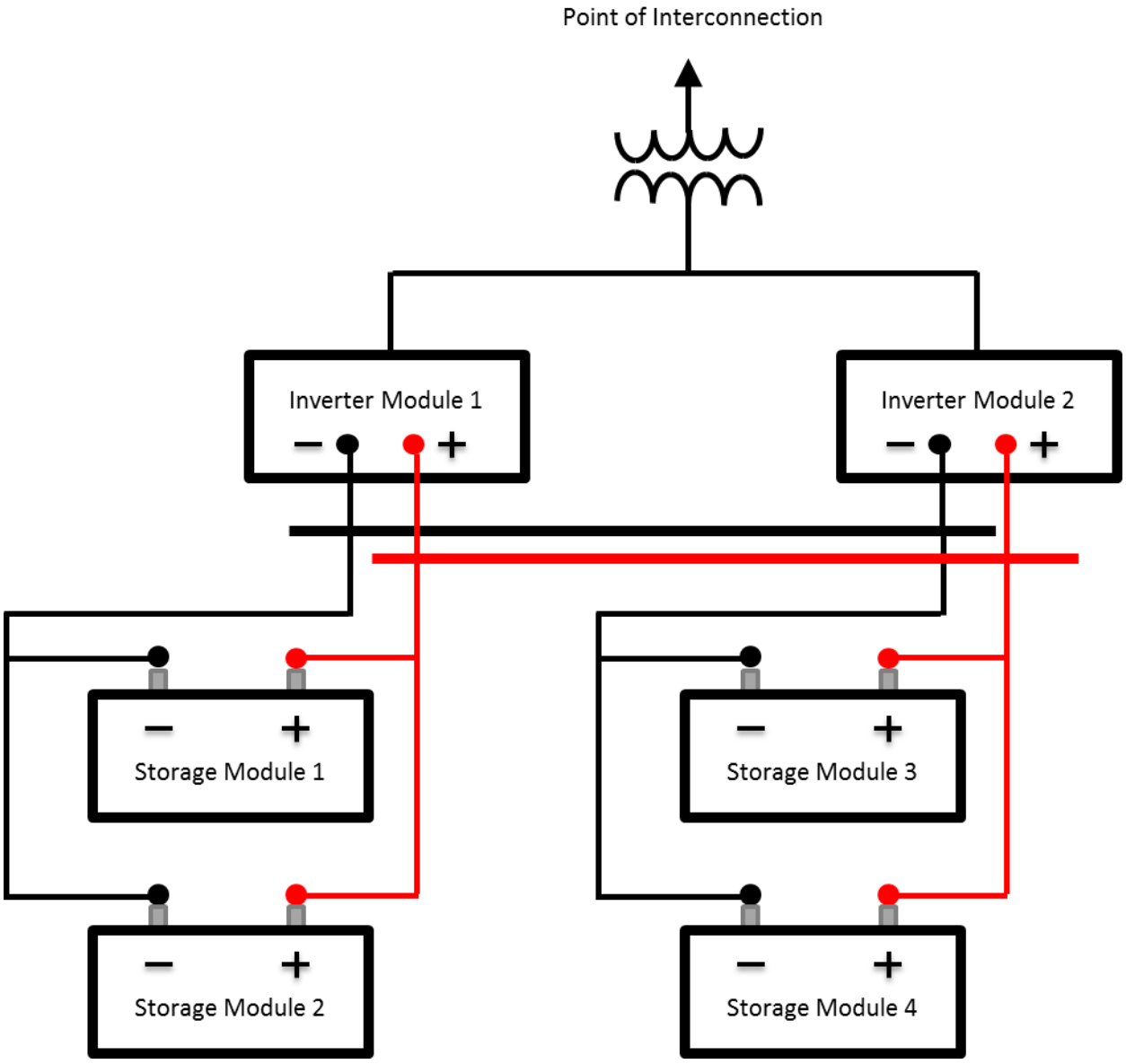
This would be one inverter group as all storage modules can be used by all inverter modules.



Multiple inverter modules with multiple unshared storage modules

Figure A-3

This would be two inverter groups as all storage modules **cannot** be used by all inverter modules.



Multiple inverter modules with multiple shared storage modules

Figure A-4

This would be one inverter group as all storage modules can be used by all inverter modules due to the common bus.

Attachment B - CSF Static Data Information Form

Sample only – For a functioning version of this Excel workbook file contact the ISO at RenewableResourceInt@iso-ne.com.

OP-14 Appendix I Attachment B

Instructions for filling out this form. Version 1.0

1) This form is an editable Excel Workbook and shall be requested by sending an e-mail with the subject line "Continuous Storage Facility Static Data Form Request" to the ISO's renewable resource integration department at the following address: renewableresourceint@iso-ne.com. Once the form is completed, it shall be returned via e-mail using the subject line "Continuous Storage Facility Static Data Form Submission" also to the ISO's renewable resource integration department.

2) The CSF Operator shall complete this form (i.e. this Excel workbook and all tabs within it except this "Instructions" tab), certify it to be true and correct by completing and executing the attestation on the "Main Page" tab of this form, and submiting it to ISO prior to commercial operation. Within two weeks of any changes to any of the parameters listed on this form, the CSF Operator shall update this form, and certify it to be true and correct by completing the attestation on the "Main Page" tab of this form. The tabs have sufficient space for all plant statistics to be listed and the characteristics to be filled out. Some "dummy" values have been inserted in the user editable fields (e.g. the "Overall CSF Data" tab) in order to help the user enter in the correct values with the correct formatting. These "dummy" values should be overwritten by the user. The user shall only edit the text that is in the Calibri, italicized, non-bold, 11 pt font.

3) In order to certify that the data contained in this form is true and correct, the Lead Market Participant shall complete the "Main Page" tab. A Senior Officer of the Lead Market Participant shall attest that the data is true and correct, shall print the form, date it, and execute it by hand. An Adobe Acrobat (.pdf) version of the complete, printed and executed certificate shall be electronically submitted with this form.

4) On the "Main Page" tab of this form, describe any and all permitting and/or administrative restrictions (such as requirements to reduce or to cease power production during certain hours or during certain events or weather conditions) that will potentially affect the power output of the Continuous Storage Facility. Include in the description the expected frequency of occurrence, expected duration, and expected impact of the restrictions. The effect of any restrictions on the potential power output of the plant must be fully described.

Attachment B - CSF Static Data Information Form (cont.)

OP-14 Appendix I Attachment B

Continuous Storage Facility Static Data Information Form Main Page

Lead Market Participant	Local Control Center	Generator Name	Unit #	Gen/Asset ID

Designated Entity	DE Location	DE Contact Name	DE Phone #	DE E-Mail

1. Data Preparation Documentation

Data Revision No. _____ **Date Prepared** _____

Prepared By _____ **Requested Effective Date** _____
(e-mail)

Attestation that data is true and accurate
The enclosed data has been reviewed and is accuarate as of the date of submission.

Signed: _____

Name: _____ **Title:** _____

Date: _____

Continuous Storage Facility Operational Restrictions

Describe any and all permitting and/or administrative restrictions (such as requirements to reduce or to cease power production during certain hours or during certain events) that may affect the power output of the facility. Include in the description the expected frequency of occurrence, expected duration, and expected impact of the restrictions. The effect of any restrictions on the potential power output of the facility shall be fully described.

Attachment B - CSF Static Data Information Form (cont.)

OP-14 Appendix I Attachment B **Overall CSF Data**

Total MWh Energy Storage Nameplate
xxx.xx
Total AC MW Power Nameplate
xxx.xx

Inverter #	Inverter Rating [MVA]	Inverter Model	Inverter Group #
1	xxx.xx		1
2	xxx.xx		1
3	xxx.xx		
additional entries as required			

Storage Module #	Storage Module Size [MWh]	Storage Module Model	Inverter Group #
1	xxx.xx		1
2	xxx.xx		1
3	xxx.xx		1
additional entries as required			

Attachment C - Available Energy and Available Storage Calculation Examples

The following examples are presented to illustrate how Available Energy and Available Storage could be calculated under various conditions. These are only meant to illustrate potential use cases that may occur and are not meant to capture all situations.

Example 1:

The CSF in this example is configured the same as shown in Figure A-1, with one inverter module rated at 5 MW and one storage module rated at 20 MWh, but where the last 1 MWh of energy will not be used for generation to avoid equipment degradation. There are no more restrictive Interconnection Agreement power limitations and no on-site generation from other equipment. Inverter efficiency is 90%, meaning that for each 1 MWh of consumption, only 0.9 MWh is able to be stored.

The storage module currently contains 12 MWh of energy.

Time Horizon	Available Energy (MWh)	Available Storage (MWh)
15 Minute	1.25	1.25
1-Hour	5.00	5.00
4-Hour	11.00	8.89

Explanation:

In 15 minutes and 1 hour, the CSF could generate or consume at full power without running into the 1 MWh lower limit or completely filling the storage module at 20 MWh. Therefore, the 15 minute Available Energy and Available Storage are both 1.25 MWh (5 MW * 15 minutes / 60 minutes per hour) and the 1 hour Available Energy and Available Storage are both 5 MWh (5 MW * 1 hour). These are both examples of being power limited; there is more energy stored (or remaining storage capability) at the facility than could be utilized within these time horizons due to the size of the inverter module.

In 4 hours, the CSF could not generate or consume at full power without running into the 1 MWh lower limit or completely filling the storage module at 20 MWh. Therefore, the 4 hour Available Energy is 11 MWh (12 MWh currently available – 1 MWh reserved to avoid equipment degradation) and the 4 hour Available Storage is 8.89 MWh (20 MWh total facility capability – 12 MWh currently stored) / 90% efficiency. In this case, the 4 hour values are not power limited but rather, both are storage limited.

Example 2:

The CSF in this example is configured the same as shown in Figure A-3, with two inverter modules and three storage modules but where storage modules 1 and 2 can only be used by inverter module 1 and storage module 3 can only be used by inverter module 2. Equipment capabilities and current storage levels are summarized in the

table below. In addition, there is a 10 MW Interconnection Agreement limitation for both generation and consumption and no additional on-site generation.

Inverter Group	Inverter Rating (MW)	Inverter Efficiency (%)	Storage Module	Storage Rating (MWh)	Current State of Charge (MWh)
Inverter module 1	6	90%	Storage module 1	7	4
			Storage module 2	5	1
Inverter module 2	9	95%	Storage module 3	12	10

Time Horizon	Available Energy (MWh)	Available Storage (MWh)
15 Minute	2.50	2.50
1- Hour	10.00	9.89
4- Hour	15.00	9.89

Explanation:

Inverter module 1 has a total of 5 MWh available for generation and 7 MWh that could be stored, which would require 7.78 MWh of consumption based on inverter efficiency.

Inverter module 2 has a total of 10 MWh available for generation and 2 MWh that could be stored, which would require 2.11 MWh of consumption based on inverter efficiency.

In 15 minutes, inverter module 1 could generate at full power without running out of storage (6 MW * 0.25 hours for 1.5 MWh). Inverter module 2 could also generate at full power without running out of storage (9 MW * 0.25 hours for 2.25 MWh), however, doing so would violate the Interconnection Agreement limitation of 10 MW maximum power. Because there is enough energy to supply the inverters for 15 minutes, this becomes power limited. At most, the facility could generate at 10 MW for the entire 15 minutes for a 15 minute Available Energy of 2.5 MWh (10 MW * 0.25 hours). There is also enough capability to store more energy such that the facility could generate at the full 10 MW allowed for the entire 15 minutes for a 15 Minute Available Storage of 2.5 MWh.

In 1 hour, the facility is able to generate at the Interconnection Agreement limit without running out of energy, however it cannot consume at the full Interconnection Agreement limit without running out of storage capability. 10 MWh could be generated and 9.89 MWh could be consumed within 1 hour.

In 4 hours, the facility is not able to generate or consume at full output without running out of energy in all the storage modules or run out of storage capability. All 15 MWh of energy could be used for generation within that time and the 9 MWh of storage capability could be filled by consuming 9.89 MWh (7.78 in inverter module 1 and 2.11 in inverter module 2)

Example 3:

The CSF in this example is configured the same as shown in Figure A-1, with one inverter module rated at 5 MW and one storage module rated at 10 MWh, but additionally with 3 MW nameplate of Solar PV-capability connected to the same inverter module as the storage. There are no more restrictive Interconnection Agreement power limitations and the inverter efficiency is 92%

The CSF Operator determines that the Solar PV output over the next 15 minutes, 1 hour, and 4 hour time horizons is expected to be 0.5, 1.2, and 4.6 MWh respectively based on their solar PV forecast. The storage module currently contains 2 MWh.

Time Horizon	Available Energy (MWh)	Available Storage (MWh)
15 Minute	1.25	1.25
1-Hour	3.20	5.00
4-Hour	6.60	8.70

Explanation:
In the next 15 minutes, 0.5 MWh of energy is expected to be generated by the on-site PV. If put directly into storage (assuming 100% efficiency since the energy will not flow through the inverter), there would be 2.5 MWh available for generation. Given the 5 MW inverter rating, only 1.25 MWh of energy could be supplied during that time. During that same time, if necessary the PV energy could be foregone to maximize the amount consumed from the Interconnection, which, at full power, would be 1.25 MWh of energy.

In the next 1 hour, 1.2 MWh of energy is expected to be generated by the on-site PV. In addition to the already 2 MWh in storage, this would result in 3.2 MWh of energy available for generation. During that time, the facility could alternatively consume at full power without filling up the storage for a 1 hour Available Storage of 5 MWh (5 MW * 1 hour).

In the next 4 hour, 4.6 MWh of energy is expected to be generated by the on-site PV. In addition to the already 2 MWh in storage, this would result in 6.6 MWh of energy available for generation. During that time, the facility could alternatively consume at full power and fill up the storage at 10 MWh for a 4 hour Available Storage of 8.70 MWh (10 MWh storage capability – 2 MWh currently stored) / 92% inverter efficiency.

Example 4:

The CSF in this example is configured the same as Example 3 (5 MW inverter with 10 MWh of storage and 3 MW PV) above with the following difference – the solar PV generation is participating as a separate market Resource and wants to operate the CSF such that the storage can only be charged from the co-located generation and no energy can be consumed from the Interconnection. There are no more restrictive Interconnection Agreement power limitations and the inverter efficiency is 92%

The CSF Operator determines that the Solar PV output over the next 15 minutes, 1 hour, and 4 hour is expected to be 0.5, 1.2, and 4.6 MWh respectively based on their solar PV forecast. The storage module currently contains 7 MWh.

Time Horizon	Available Energy (MWh)	Available Storage (MWh)
15 Minute	0.75	0.50
1- Hour	3.80	1.20
4- Hour	7.00	3.00

Explanation:
Because the solar PV is now a separate market Resource, its expected generation should not factor into the CSFs' energy available for generation except to the point that it might violate a combined equipment rating or Interconnection Agreement limit; it will however impact the amount of energy available for the CSF to consume since it only desired to do so from the solar PV.

In the next 15 minutes, even though there are 7 MWh available for generation, given the 5 MW inverter rating, only 1.25 MWh of energy could be supplied during that time. Because the PV is expected to generate 0.5 MW during that time, the CSF cannot generate more than 0.75 MWh without exceeding the inverter rating. During that same time, since only 0.5 MWh of energy will be produced by the PV, that is all that would be available to be put into storage without consuming from the Interconnection.

In the next 1 hour, even though there are 7 MWh available for generation, given the 5 MW inverter rating, only 5 MWh of energy could be supplied during that time. Given that the PV is expected to produce 1.2 MWh during that time, only 3.8 MWh could be generated from the CSF without exceeding the inverter rating. Based on the expected amount of PV generation available, the facility could alternatively consume 1.2 MWh.

In the next 4 hour, 4.6 MWh of energy is expected to be generated by the on-site PV. In addition to the already 7 MWh in storage, this would result in 11.6 MWh of energy flowing through the inverter, which does not exceed its rating. Therefore, all 7 MWh of the stored energy could be used for generation. During that time, the CSF could alternatively store some of the PV generation. Because there are 4.6 MWh of PV energy available but only 3 MW of storage capability remaining, the 4 hour Available

Storage would be 3 MWh. Inverter efficiency wouldn’t apply since the PV energy would be going directly into the battery rather than from the Interconnection.