IX. Defining Rules and Processes for the Evaluation of Operating Schedules

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A. Introduction and Problem Statement

Defining and verifying export controls is a critical foundation for energy storage, but it is not all that is needed to enable customers and the grid to capture arguably the greatest benefit of ESS: its schedulable and dispatchable nature. Many electric system impacts have a temporal aspect to them due to both daily and seasonal changes in the load curve and the prevalence of generating resources (*e.g.*, solar or wind) that operate during certain times of the day or have seasonal output variations. Energy storage is unique among inverter-based resources in its ability to provide or consume energy at any time.

ESS may be designed to operate on a schedule or to respond to dynamic signals for a variety of reasons (*e.g.*, customer needs, rate schedules, market participation, or to avoid distribution system constraints). However, today the default method for conducting an interconnection analysis is to study projects in a manner that assumes the project may export or import its full capacity at any time. In some cases, utilities are able to take into account that solar systems only operate during daylight hours, but there is very little nuance beyond that in terms of hourly, daily, or seasonal variations, or variations in output quantity. Unfortunately, the existing rules and methods often complicate or prevent the interconnection of storage on constrained infrastructure where ESS could be most beneficial.

The following two terms will be used to describe the scheduled operation in this chapter:

> ***Operating Profile*** *means the manner in which the distributed energy resource is designed to be operated, based on the generating prime mover, Operating Schedule, and the managed variation in output power or charging behavior. The Operating Profile includes any limitations set on power imported or exported at the Point of Interconnection and the resource characteristics, e.g., solar output profile or ESS operation.*
>
> ***Operating Schedule*** *means the time of year, time of month, and hours of the day designated in the Interconnection Application for the import or export of power.*

Analysis of a resource operating continually at full capacity—an impossible scenario for energy storage which must charge at some point—may lead to unnecessary and time-consuming studies or costly upgrades, and can impair the ability of applicants to propose projects that are targeted at resolving specific system needs or providing necessary services. To realize the full value of ESS, it will be necessary to create or modify interconnection rules and processes such that time-specific operations are enabled. This includes the ability to interconnect on the basis of scheduled operation in locations where nonconformance to an operating schedule would have adverse impacts. Unfortunately, unlike the other barriers discussed in this Toolkit, there is a considerable amount of additional research, evaluation, and analysis needed before concrete solutions can be recommended.

The BATRIES team has identified three areas where critical work and resources need to be developed to facilitate the safe and reliable evaluation of DERs operating with fixed schedules:

1. Identify methods of providing utilities with assurance that ESS can safely and reliably conform to a fixed schedule. Just as utilities need to have confidence that the export control technologies discussed in Chapter III are reliable, they will also need to be able to trust the scheduling functionality.

2. Determine how utilities will screen and study projects that are utilizing reliable scheduling methods. This requires better understanding of what the current utility capabilities are, what the data needs are, and what new methods or approaches can be used to efficiently evaluate operating schedules of varying levels of complexity.

3. Define how interconnection applicants should communicate their proposed operating schedule to the utility with their application. This may include developing standardized templates for data transmission based upon the complexity of the schedule and the utility's data needs.

This chapter outlines these essential areas of development that are needed to allow for evaluation and implementation of fixed schedule operation of ESS. It provides recommended actions regulators can take to accelerate the development of both near- and long-term solutions. The chapter points to further opportunities to implement dynamic controls, but primarily focuses on fixed schedule operation.

B. Enabling Safe and Reliable Scheduling Capabilities

When storage resources are deployed on the grid to avoid distribution system impacts at particular times, or to offer services at critical times, it is essential that utilities have confidence that they will operate according to the established schedules. The project team surveyed a handful of utilities in states with active ESS markets and utilities in states such as California, New York, and Massachusetts all indicated that they would need adequate assurance that the control systems used by customers would perform as intended.[101]

[101] *See, e.g.*, NY Interconnection Technical Working Group, *Industry & JU, CESIR Analysis Methodology Review for Hybrid PV & Battery Energy Storage Systems* (Sept. 9, 2021), https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/def2bf0a236b946f85257f71006ac98e/$FILE/2021-09-09%20ITWG%20CESIR%20Analysis%20Methods%20Review%20for%20PV+BES%20Systems%20v1__JU%20Responses.docx [dps.ny.gov] ("Granting permission for projects to operate outside of operating limits determined by studying worst-case scenarios is dependent on the implementation of advanced operational technologies such as ADMS and DERMS. These systems and associated investments can enable greater utility visibility and control of DER. Ensuring that customer control systems perform as needed is an issue that will need to be addressed as standardization and

Trust in the operational performance of interconnected resources can be established in several ways. Where standards are in place, test protocols have been established, and real-world performance is well understood, acceptance of equipment covered by these standards follows. However, since scheduled operation of energy storage is not yet covered by standards, trust presently must be established in other ways. This section first discusses the need for standards and the likely steps necessary to get standards in place that enable scheduling for storage. It then examines potential alternative methods for establishing confidence in scheduled operation that could be explored while the standards development process is underway.

1. Establishing Standards and Certification for Scheduling Capabilities

One major task for incorporating scheduling into interconnection study processes is the development of standards that describe scheduling of energy storage operations, especially time-specific import and export limitations. Standards do not yet exist today that establish performance requirements for operating schedules within Power Control Systems (PCS) or other technologies. As discussed in Chapter III and Appendix B, the UL 1741 CRD establishes test standards for the export and import control capabilities of PCS. However, under the existing CRD, these limits are static and apply at all times, thus further work is needed to incorporate scheduling functions.

Optimally, the following steps would need to be taken to establish standards to support scheduled operation of ESS and other DERs.

UL 1741, the primary standard for the certification of inverter functionality, would need updating. The UL 1741 Standards Technical Panel has discussed the need for UL 1741 to address scheduled operations and plans to begin working on incorporating PCS scheduling into the standard. The proposed modification to UL 1741 would enable recurring fixed schedules by implementing time-bound values for the export and import limits or operating modes. This process could potentially be completed by mid-to-late-2022, but the development process is open-ended.

A task group has been formed to introduce scheduling into the UL CRD for PCS. The task group has developed a draft scope of scheduling requirements and will work to create test language to evaluate those concepts. This language could be incorporated into the existing proposal for inclusion of PCS tests in UL 1741. The Standards Technical Panel for UL 1741 will eventually vote on whether or how to incorporate this language directly in the UL 1741 standard. The process of testing products for scheduling functionality can be accelerated if UL first updates the CRD for scheduling prior to full incorporation into the standard.

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deployed system configurations reinforce engineering designs and produce expected outcomes, especially with respect to performance during tail events.").

In addition to incorporating scheduling into UL 1741, it may be desirable to update the testing procedures specified by IEEE 1547.1 or other standards to validate operation in compliance with scheduling requirements for non-inverter or non-PCS systems. Because IEEE 1547.1 is based upon the requirements of IEEE 1547, the latter would first need to be updated to include scheduling requirements. The most efficient pathway to testing non-PCS systems is currently unclear, so it is not certain whether IEEE 1547 would take on this task. Other standards could potentially be developed as necessary to support scheduling apart from IEEE 1547 and 1547.1. Additionally, since storage system configurations can vary and often cannot be lab tested as an integrated system, the creation of a validation procedure for field certification by a NRTL, as well as a normalized witness testing methodology for utilities, may facilitate implementation. The process for including schedule capabilities in 1547 and 1547.1 or other standards would likely take multiple years and has not yet begun.

The standards development process may consider many aspects as part of scheduling DER operations beyond import and export power limits. However, at a minimum, for the purposes of interconnections, the standards should address definitions of time-specific import and export limits and tests to verify compliance. One of the challenges to developing standards is that it may be difficult to determine exactly what the standard should be designed to cover, and in what manner, if there have been few pilot deployments or preliminary uses of schedules in the field to inform the standards development process. The following subsections describe some steps regulators can take to help facilitate greater use in the field while the standards development process is underway.

a. Recommendations for Supporting and Accelerating Standards Development

Overall, developing standards for scheduled ESS operations is of critical importance to enabling ESS to avoid interconnection upgrades and to provide critical grid services when they are needed. However, the standards development process is lengthy and it can take multiple years to complete under the best conditions. It also takes additional time once standards are complete for equipment to be tested and deployed in the field, for interconnection procedures to incorporate use of the new standards, and for utilities to gain comfort with evaluating the newly certified equipment. It is very likely that some states will need or desire ESS that can perform according to operating schedules on a much faster timeline than the traditional standards development process can support. For this reason, regulators may want to engage proactively in support of expedited standards development while also supporting the exploration of other methods of providing utilities with assurance of schedule performance.

Although regulators do not have direct control or authority over the standards development bodies or processes, regulators can create a sense of urgency and expectation. Incorporating scheduling functionality into interconnection rules, with implementation dates set based upon standard publication, can provide a powerful signal to the parties participating in the standards development process and can motivate market participants to actively engage to ensure the standards are being developed properly.

Regulators can also allow the use of equipment that conforms to proposed or draft standards such as has been done by states in the case of the UL CRD for PCS.

Finally, regulators can support the development of standards by convening working groups to discuss the use of DER schedules and the associated interconnection rules and requirements. These working group processes can be used to better define the specific schedule needs and capabilities which can help ensure that the standards development discussions are supported by information about the real market and regulatory needs. Conducting these working group proceedings concurrently with the standards development process can also enable regulators to put into place interconnection rules that can take full advantage of schedule capabilities once the standards are approved. These working groups will want to both consider the requirements for new projects being proposed with an operating schedule and also any transition issues associated with existing projects shifting toward scheduled operations. Eliminating the lag time between standards completion and the incorporation of those standards into interconnection rules is one process that regulators have direct control over.

2. Alternate Approaches for Safe and Reliable Utilization of Operating Schedules

In light of the potentially long road ahead for the development of standards that govern scheduling performance in the interconnection process, regulators will likely want to consider other methods for providing utilities with adequate assurance of ESS scheduling capabilities. The BATRIES project team has identified several different approaches that could be explored for enabling safe and reliable use of schedules absent standards. The following subsections discuss the concepts and their potential pros and cons. It is recommended that regulators evaluate these options more thoroughly to identify those that might be most practical to deploy to meet scheduling needs in particular circumstances.

a. Field Testing

Another way to expedite implementation is the parallel development of a field test program to validate performance of a deployed system to a fixed operating schedule or profile. Since storage system configurations can vary and often cannot be lab tested as an integrated system, creation of field test procedures and the establishment of entities to conduct them would enable a wider variety of systems to be validated. The regulator could either actively develop such a test procedure or simply encourage said development. This pathway could potentially be leveraged for field certification by a NRTL. However, due to the cost and complexity of field testing every deployed system, this option would likely only be potentially practical for large systems. This would also still require the development of detailed test specifications.

Additionally, harmonized commissioning testing methodologies for utilities may facilitate implementation. Depending on the level or type of testing available for a given ESS system, more or fewer commissioning steps are needed to validate the installation. These procedures are often determined by utility engineers in consultation with the developer and manufacturer documentation. As no guidance yet exists on how to perform such tests for scheduling functions, developing typical commissioning steps could save effort at the individual utility and/or interconnection level.

b. Regional Test Standard

Regulators can also help to inform the standards development process, while creating a more immediate pathway for scheduled operation of ESS in their state, by developing their own interim testing protocol that can be utilized while national standards are under development. This can be a resource-intensive process to undertake and requires expert input and preferably manufacturer engagement, but it could be valuable for one or more states with a large market to consider development of interim test protocols. Ultimately, manufacturers prefer not to develop multiple bespoke products that need to be tested to different standards, but these initial efforts can help identify scheduling needs and functionalities on a faster schedule than national efforts.

The structure of who performs the tests and who the “certifying body” is could vary. Manufacturers could submit in-house test data to either a utility or potentially a body designated by the regulator which could review the data to ensure the equipment is in compliance. Otherwise, NRTLs could be employed to provide attestations as is normally done with standard test protocols. This can be a time-intensive process both to develop the test protocol (though potentially faster than a full standards process) as well as to verify compliance for bodies that do not normally serve that function. However, since detailed test procedures can be used, the verification is more robust and the process may be seen as more trustworthy.

This type of process has been utilized by Hawaiian Electric to implement their “TrOV-2” qualification which tests for the ability of inverters to avoid damaging load rejection overvoltage. Manufacturers submit their data to the utility along with other certifications and attestations in order to be listed on the qualified equipment list.[102]

Early regional developments can inform national standards and test protocol development as parallel activities. In order to enhance this work, pilot programs to investigate and trial the verified fixed operating schedules could be conducted in regions of critical interest. Such programs can help to foster trust in these scheduled operations through demonstration of performance.

c. Monitoring and Backup Control

Either with or without any of the previously mentioned verification strategies, monitoring for compliance with a schedule can be achieved with equipment that is commonly available today. One way this can be done is through the application of a monitoring device that the utility has an interface to. This may be a site controller (or “gateway"), or it may be

[102] The test procedure is based on one developed by the Forum on Inverter Grid Integration Issues and tested by NREL before being adopted by Hawaiian Electric. It eventually served as the basis for the IEEE 1547.1-2020 tests for load rejection overvoltage.

a utility-owned node, sometimes referred to as a remote terminal unit (RTU). Depending on the monitoring capabilities of the utility, the level of other verification used, or other assurances such as contractual obligations and ramifications for non-compliance, monitoring of compliance may be deemed sufficient to ensure schedules are adhered to. Due to the typically high cost of implementing a communication system, this pathway may only be feasible for large projects. Large projects, however, may already be required to connect to a communications channel (*i.e.*, SCADA or telemetry) as a requirement of interconnection, in which case this may not add significant additional costs. In some instances, cheaper and/or slower communication may be sufficient for the particular use case of monitoring schedule compliance, making it more affordable for smaller systems. However, utilities will need the resources and capability to process all the data.

Utilities may desire more direct control due to a lack of certainty or potential for highly adverse effects due to schedule mis-operation. In this case, similar communications channels may provide for control in addition to monitoring. The RTU may be leveraged where it hierarchically sits above the site control and has the ability to override the site controller in the event that the operating schedule is not followed or if abnormal operating conditions occur. In this way, an RTU can provide assurance to a utility that ESS operations can be prevented from causing negative grid impacts.

Some larger solar and storage projects have used and continue to use customized site controls, such as Real Time Automation Controllers (RTAC) and RTUs to gain acceptance for interconnections that might otherwise have required additional upgrades. For example, the California Independent System Operator certified the SEL RTAC as a remote intelligent gateway serving this purpose in 2015.[103] These controls are typically built on utility-grade hardware and have to be validated by project-specific agreement with the utility. EPRI is conducting research and development[104] on utility reference gateways for DERs that may help to normalize the specification and lower the cost of such devices.

Protective relay arrangements are also often utilized to prevent negative grid impacts in the event ESS controls do not function correctly. Such relays are well known and trusted by utilities to prevent operations in excess of limits. Even though these additional layers of control and protections can add cost, time, and complexity to a project, they are viable ways of securing interconnections in critical locations. Protective relay schemes, RTUs, RTACs, and other forms of utility-recognized control can be leveraged presently through negotiated interconnection agreements and provide an interim pathway while development of streamlined processes continues.

d. Attestations

Vendor attestations may be an avenue to provide utilities with some performance assurance while standards are in development. This method has been used by some

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103 Schweitzer Engineering Laboratories, *California ISO Certifies SEL RTAC as a Remote Intelligent Gateway* (July 23, 2015), https://selinc.com/company/news/111520/.

104 Electric Power Research Institute, *Applications of the Local Distributed Energy Resource (DER) Gateway: Low Cost, Secure DER Network Gateways for Integration of Smart Inverters* (June 11, 2021), https://www.epri.com/research/products/000000003002018673.

states and utilities in the past to allow manufacturers to "self-certify" that their equipment meets a certain set of requirements. For instance, before certification test requirements were available for PCS, manufacturer attestations (generally signed by an officer of the company) were accepted by the Hawaiian Electric utilities as a means of verifying compliance to be added to the utility's qualified equipment list. The attestations stated that the equipment complied with Hawaiian Electric's inadvertent export requirements in Rule 22 Customer Self-Supply. A similar tack was taken by the California investor-owned utilities for certain advanced inverter features in Rule 21 while certification to IEEE 1547.1-2020 was still unavailable.

This is the simplest method of verification and manufacturers that have compliant products can likely turn around signed attestations in much less time than typical certifications through a NRTL. However, since the manufacturers' capabilities are neither checked against a standard test protocol nor verified by a third party, there are potential risks. Without a detailed test specification, there can be no guarantee that different products behave in similar ways in response to a wide range of conditions. There is no real way around this drawback, but detailed, clear performance requirements can help ensure the required capabilities are not interpreted differently between different companies or individuals. It would be important for manufacturers to take part in the development of the performance requirements to ensure they are well understood by those that will implement them.

Since the manufacturer is providing the attestation, there is no check from a third-party to ensure the equipment capability is actually in line with requirements, potentially leading to equipment mis-operating once installed in the field. Market dynamics may be enough of a deterrent to ensure manufacturers do not willfully misrepresent their equipment. Additionally, if a manufacturer were to intentionally misstate their equipment's capabilities, the utility could impose compliance penalties on the manufacturer, such as by no longer accepting its attestation.

As discussed above, if one or more states were to pursue this avenue it might provide useful information to inform the standards development process, while also enabling ESS systems to begin providing the benefits associated with operating schedules.

C. Developing Methodologies for Efficient Evaluation of Energy Storage Projects With Proposed Operating Profiles

While the development of standards and/or other means for providing utilities with assurance that ESS can reliably perform according to operating schedules is a critical step, this alone does not resolve the fundamental question of how projects with operating schedules will be evaluated in the interconnection process. To date, very little has been done to explore how utilities will evaluate the potential impacts of projects that are proposed with an operating schedule or any type of operating profile. Significant gaps exist in terms of understanding existing utility capabilities, data needs, and methods that can be used to efficiently, and cost-effectively, screen and study projects using operating profiles. The grid benefits of schedulable ESS cannot be realized if utility screening and study processes do not evolve to accurately evaluate operating schedules, thus it is critical for regulators to facilitate development in this area. Promoting pilots to allow energy storage to be interconnected on a non-traditional study basis where storage functionality is used to avoid negative grid impacts in place of upgrades is a recommended way forward.

1. Utility Data Needs for Evaluating Operating Profiles

Because scheduling capabilities are relatively new, are not yet supported by standards, and the need for scheduled services has not been acute in the past, utilities generally conduct the screening and study process assuming that projects will be operating at full capacity 24 hours a day, 365 days a year. In the case of solar-only projects, the penetration screens (see discussion in Chapter IV.C.3.a.i) and the study process can take into account that the project will only operate during daytime hours, but this is different than evaluating a true schedule. It is important to recognize that since utilities assume consistent operation, they are able to conduct studies using relatively limited grid data currently. In essence, many utilities may be evaluating projects using only the absolute recorded minimum and peak loads on a feeder. This means that the utility effectively needs to run only a single iteration of the power flow analysis to determine if a project will cause system impacts at any point during a year.

When it comes to evaluating a project using a more nuanced operating profile, utilities are likely to need access to grid data for more hours of the day and year, and may also need to develop new methods for running power flow models so that evaluations of operating profiles can be conducted efficiently.

The exact data needs and study capabilities and techniques will vary based upon how complex of an operating profile is being evaluated. For example, if a solar-plus-storage project is proposing to simply extend the hours of operation into the evening hours and can propose a fixed operating schedule that corresponds to these hours, the technical evaluation can be conducted in essentially the same manner as it would be for a solar-only project, with the minimum load only being selected from a wider range of hours. Similarly, if an ESS project is proposing to not export to the grid during periods of low demand (*i.e.*, between 12-3 pm when solar generation may be abundant in certain states), the minimum load can be selected during just the proposed hours of operation.

However, studies—and corresponding data needs—get more complex when operating schedules contain multiple different operating periods. For example, if a project proposes to utilize a seasonal operating schedule, there may be a maximum output period for each season and thus there may need to be more than one minimum load hour evaluated. The complexity can continue to increase, including variations during different days of the week, months of the year, and different export amounts (output), up to the point where there is a different operating point for each of the 8,760 hours of the year. As the schedules increase in complexity, so too will the utility's data needs in order to be able to accurately evaluate how the varying output corresponds to different grid conditions during those hours.

There is considerable variation across the country in the amount of data that utilities collect and can readily access. Some utilities do not presently collect, warehouse, or publish hourly feeder data for interconnection purposes, but others have access to considerably more data for a variety of uses, including for interconnection, hosting capacity analysis, and other grid operational needs.

To start studying complex operating profiles in the context of time-specific feeder conditions, it will be necessary for some utilities to collect granular feeder load data for comparison to the proposed operating profile. On the other hand, it may be possible for many utilities to start evaluating projects with simpler operating profiles immediately while further data is collected and study processes are refined.

This data can come from many sources. These sources may include, but are not limited to, advanced metering infrastructure (AMI), substation metering, SCADA, distribution transformer metering, billing departments, etc. This data can be further processed for better load modeling if needed.[105] Additional methods of capturing this hourly data through distributed energy resource management systems (DERMS), advanced distribution management systems (ADMS), DER communications such as IEEE 2030.5, etc. may also need to be investigated and developed by industry stakeholders where rapid and ubiquitous AMI deployments are cost prohibitive.

2. Defining Screening and Study Techniques for Operating Profiles

In addition to addressing utility data needs, the techniques for screening and studying projects with operating profiles require further development as well. Transitioning from comparing a project to a single minimum load hour to comparing it to multiple different temporally-specific periods requires consideration of the most efficient method for conducting the analysis, the computing and technical resources required, and the manner in which the results will be communicated to customers. As discussed above with respect to the data needs, the complexity of the studies will vary based upon the nature of the proposed operating profile.

a. Using Hosting Capacity Analyses to Evaluate Proposed Operating Profiles

One method for screening projects with operating profiles that regulators may want to consider is the utilization of detailed hosting capacity analyses. When hosting capacity analyses are conducted using granular hourly profiles (*e.g.*, 576 hours per year or more), they can provide a detailed "hosting capacity profile" that shows for each hour evaluated what the hosting capacity limit is for each technical criteria evaluated. If the analysis is conducted with high-quality, granular data and is updated frequently, it has the potential to dramatically simplify the process for screening projects with operating profiles. Projects could be allowed to interconnect without the need for customized power flow analyses so

[105] Xiangqi Zhu and Barry Mather, *Data-Driven Distribution System Load Modeling for Quasi-Static Time-Series Simulation* (Sept. 10, 2019), https://www.osti.gov/pages/servlets/purl/1606307.

long as their proposed profile is below the hosting capacity limit for every hour evaluated in the analysis. Chapter VI.B.2.b discusses this option further, describes the steps that California has taken in this direction, and also details the reservations that some stakeholders have about utilizing hosting capacity analyses in the screening processes.

3. Recommendations

At present, discussions regarding evaluation of operating profiles are just beginning to occur in the U.S. and there have yet to be comprehensive papers, best practices, or guides drafted to inform regulators on how to conduct these analyses. As of this writing, few jurisdictions appear to have established guidelines for interconnecting ESS with an operating profile. Identified efforts led by Massachusetts are preliminary and, based on project research, no schedule-based interconnections have been allowed to date. In order to move this capability forward and enable ESS to provide valuable time-specific grid services, it is recommended that regulators either proactively begin to convene working group discussions or encourage others to do so in order to work through these issues with utility and DER stakeholders. Some outside bodies (*e.g.*, the National Association of Regulatory Utility Commissioners, the U.S. Department of Energy, etc.) could help move the conversation forward.

Specifically, regulators should seek to have utilities identify what data they have available and what additional data they believe they may need to evaluate a range of different operating profiles. They should also outline what methods utilities intend to use to evaluate projects with proposed operating profiles. Armed with this information, a working group can determine what changes to the interconnection procedures may be necessary and also what data or capabilities may need to be acquired to facilitate an efficient evaluation of ESS with operating profiles. As discussed more below in Chapter IX.D, these discussions can also help determine what information, and in what format, applicants should provide to utilities about proposed operating schedules. If the necessary data or capabilities for a full evaluation of sophisticated operating profiles does not exist, the working group can evaluate steps to allow for evaluation of simpler profiles in the near term. This work can be conducted concurrently with the standards or other schedule assurance processes outlined in Chapter IX.B.1.a and IX.B.2.

D. Establishing Standardized Formats for Communication of Operating Schedules

The final area that requires attention in order to facilitate the interconnection of ESS with fixed operating schedules concerns how those schedules will be communicated to the utility for evaluation. For utilities to be able to evaluate the interconnection application of an ESS with a proposed operating schedule, the applicant will need to provide detail about the project's operating profile in a format that aligns with how the utility will be evaluating the project.

The project team surveyed several utilities across states typically engaged in progressive interconnection rulemaking, including California, New York, and Massachusetts. While none of the utilities surveyed are at the stage of conducting analyses that lead to binding interconnection agreements based on proposed schedules, some are at least starting to consider how information on schedules should be provided.

Where they exist, schedule submission guidelines vary. For example, the NY Standardized Interconnection Requirements (SIR) Appendix K simply states: "Indicate any specific and/or additional operational limitations that will be imposed (e.g. [*sic*] will not charge between 2-7pm on weekdays)".[106] The Massachusetts process is more refined and was developed through a series of collaborative meetings between the utilities and key stakeholders. This effort resulted in the development of a standardized worksheet, shown in Figure 11, which some of the collaborating stakeholders proposed for use as a template for the submittal of an operating schedule.[107] The Massachusetts Department of Public Utilities had previously approved the use of a more simplified worksheet and has yet to formally adopt the proposed updated worksheet, but it is a useful example nonetheless.[108]

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[106] National Grid, Upstate NY Form K, https://ngus.force.com/s/article/Upstate-NY-Form-K.

[107] MA Dept. of Pub. Util. Docket 19-55, Inquiry by the Department of Public Utilities on its own Motion into Distributed Generation Interconnection, *Collaborative Process Filing, Consensus Document B* (Oct. 13, 2020), https://fileservice.eea.comacloud.net/FileService.Api/file/FileRoom/12771446.

[108] MA Dept. of Pub. Util. Docket 19-55, *Hearing Officer Memorandum: Interim Guidance – Energy Storage Systems, ESS Questionnaire* (Dec. 3, 2019), https://fileservice.eea.comacloud.net/FileService.Api/file/FileRoom/11510272.

☐ **Seasonally Variable** ☐ **Export OR** ☐ **Import** (identify annual max & min values in question 4)

Season A: Start Date: Month:__________________ Day:____________________
End Date: Month:__________________ Day:____________________
Daily Time Periods:
1. Setting: ___________________ Start Time: _________ End Time:_________________
2. Setting: ___________________ Start Time: _________ End Time:_________________
3. Setting: ___________________ Start Time: _________ End Time:_________________
4. Setting: ___________________ Start Time: _________ End Time:_________________

Season B: Start Date: Month:__________________ Day:____________________
End Date: Month:__________________ Day:____________________
Daily Time Periods:
1. Setting: ___________________ Start Time: _________ End Time:_________________
2. Setting: ___________________ Start Time: _________ End Time:_________________
3. Setting: ___________________ Start Time: _________ End Time:_________________
4. Setting: ___________________ Start Time: _________ End Time:_________________

Season C: Start Date: Month:__________________ Day:____________________
End Date: Month:__________________ Day:____________________
Daily Time Periods:
1. Setting: ___________________ Start Time: _________ End Time:_________________
2. Setting: ___________________ Start Time: _________ End Time:_________________
3. Setting: ___________________ Start Time: _________ End Time:_________________
4. Setting: ___________________ Start Time: _________ End Time:_________________

Season D: Start Date: Month:__________________ Day:____________________
End Date: Month:__________________ Day:____________________
Daily Time Periods:
1. Setting: ___________________ Start Time: _________ End Time:_________________
2. Setting: ___________________ Start Time: _________ End Time:_________________
3. Setting: ___________________ Start Time: _________ End Time:_________________
4. Setting: ___________________ Start Time: _________ End Time:_________________

Figure 11. Proposed Operating Schedule Details, Massachusetts
Note: *Each additional season/variation provided will increase the cost and duration of the Impact Study*

In addition to the table shown above, New York and Massachusetts utilities currently request that applicants provide a free-form description of the use cases and other characteristics of the operating profile. Such methods are likely to elicit responses including undefined use cases, non-uniform times, or other features that are subject to interpretation and not conducive to uniform or automated study processes. For utilities to use such free-form responses in an automated study process, it would need to be translated into a software-compatible format. Additionally, developers and utilities would have to align on use case definitions and other factors. The gap between these free-form responses and a template that could be directly used by automated study processes has been identified as an opportunity for development.

1. Taxonomy Working Group Template

In 2021, EPRI convened the Energy Storage Functional Taxonomy Working Group.[109] The goal of this working group is to develop a common understanding of ESS terms and a template that can be used to communicate a complete operating schedule at the time of interconnection for any proposed energy storage project. The goal is to help to streamline interconnections and reduce workload as the quantity of deployed DERs continues to rise. The operating schedule under development will contain information regarding what the storage is doing, when it is intended to do it, and perhaps most importantly, what import and export limits are in place at what times. It is intended that this information can be communicated in a single spreadsheet format that can prevent the utility from needing to manually translate it to an electronic format.

As part of the taxonomy effort, the group is developing a template, shown in Figure 12, to communicate these datapoints in an hourly format that could be used directly by automated study processes. The goal of this template is to provide a normalized format that can enable streamlined future interconnections that account for the unique capabilities of storage, such as operating to a schedule, and/or in accordance with import and export limitations. Since this working group is ongoing at the time of this writing, the template is likely to evolve.

The template proposes an hourly operating schedule, and could be adapted to a shorter or longer time interval as needed. Hourly scheduling is currently recommended by the working group as most tariffs with time-of-use components or other peak times typically use whole-hour times. Use of an 8760-hour schedule is recommended as hourly load data will be stored in this format and because many tariffs include weekends, seasonal changes, holidays, and similar features that could affect system operations.

The second and third columns describe import and export limitations by percentage of either system nameplate or total facility rating. These import and export limit columns provide the critical information that describes a scheduled system's capability to respect time-specific hosting capacity issues. Subsequent columns describe the use cases and how each use case is related to the next. This is useful for understanding the likely behavior of a proposed system.

As an example, the sample template shown below depicts a purely theoretical customer storage system that would normally operate in self-consumption mode but can provide demand response during afternoon peak hours. The sample system is configured to be able to export only during demand response events. During that time, import or charge is disabled to prevent it from adding to peak demand.

The list of use cases below is provided as an example. In cases where multiple use cases are intended, such as time-of-use support with a secondary use case of backup power, a

[109] Electric Power Research Institute, Energy Storage Functions Taxonomy Working Group (June 3, 2021), https://www.epri.com/research/programs/067418/events/93B041AC-D90B-4F0E-B9D5-8EDA6439A33F.

secondary or even tertiary column may be used to express the alternate use case. The hourly import and export limits are the items of primary interest for interconnection needs today. However, the communication of what use case(s) the storage will engage in can aid future modeling and study efforts. A column between the primary and secondary use cases provides a description of the relationship between use cases. In the sample, it suggests that the secondary use case is engaged by a grid outage. Other example descriptors of relationships between use cases could include “dispatched,” “simultaneous,” “price signal,” and others.

Hour	Import Limit	Export Limit	Primary Use Case	Relation Between Uses	Secondary Use Case	Sample Use Cases
0:00	100%	0%	Self-Consumption	Outage	Backup Power	• RE Firming • Solar Smoothing • Clipping Capture • Self-Consumption • Backup Power • Black Start • Upgrade Deferral • Microgrid • Grid Forming • Energy Arbitrage • TOU Support • Demand Response • Demand Charge Management • GHG Reduction • Frequency Regulation • Voltage Regulation • Energy Balancing • Storm Preparedness
1:00	100%	0%	Self-Consumption	Outage	Backup Power	
2:00	100%	0%	Self-Consumption	Outage	Backup Power	
3:00	100%	0%	Self-Consumption	Outage	Backup Power	
4:00	100%	0%	Self-Consumption	Outage	Backup Power	
5:00	100%	0%	Self-Consumption	Outage	Backup Power	
6:00	100%	0%	Self-Consumption	Outage	Backup Power	
7:00	100%	0%	Self-Consumption	Outage	Backup Power	
8:00	100%	0%	Self-Consumption	Outage	Backup Power	
9:00	50%	0%	Self-Consumption	Outage	Backup Power	
10:00	50%	0%	Self-Consumption	Outage	Backup Power	
11:00	50%	0%	Self-Consumption	Outage	Backup Power	
12:00	50%	0%	Self-Consumption	Outage	Backup Power	
13:00	50%	0%	Self-Consumption	Outage	Backup Power	
14:00	0%	100%	Demand Response	Outage	Backup Power	
15:00	0%	100%	Demand Response	Outage	Backup Power	
16:00	0%	100%	Demand Response	Outage	Backup Power	
17:00	0%	100%	Demand Response	Outage	Backup Power	
18:00	0%	100%	Demand Response	Outage	Backup Power	
19:00	0%	100%	Demand Response	Outage	Backup Power	
20:00	100%	0%	Self-Consumption	Outage	Backup Power	
21:00	100%	0%	Self-Consumption	Outage	Backup Power	
……	……	……				
8760	……	……				

Figure 12. Sample Operating Schedule Template and Applicable Use Cases

This template is intended to communicate the import/export limits that comprise an applicant’s fixed operating schedule. Many stakeholders, however, have significant interest in the ability to dispatch energy storage. This dispatch may be for many purposes including grid support, market participation, or renewables integration, but the ability to model and study how dispatch of energy storage will impact the grid is presently lacking. The provision of hourly import/export limits can serve as guardrails to keep any potential actions dispatched by remote signals from directing the ESS outside of acceptable operating parameters for that specific time of day.

2. Recommendations

Regulators will need to convene a process to establish a standard template for the communication of operating profiles. While the final outcome of the Energy Storage Functions Taxonomy Working Group will be informative to this process, regulators will need to consider whether all of the information indicated above is actually necessary to provide based upon the manner in which utilities will actually study projects. A utility's study capabilities will inform whether all the information indicated above actually serves any functional purpose in the interconnection review process. For example, it is not clear to all of the BATRIES project team members how detailed information on use cases in the interconnection application will actually be used if the utility is only ultimately going to analyze the amount the project imports or exports during each hour. Thus, regulators and utilities should work together to consider the requirements for communicating an operating schedule at the same time that the utility's data needs and study process are evaluated as outlined above in Chapter IX.C. By considering these topics together, regulators and utilities can settle on an approach that facilitates safe and reliable interconnection of ESS while also not overburdening either the applicant or the utility with unnecessary data requirements. To this effect, regulators and utilities may want to consider whether the template and information requirements should vary based upon the level of complexity of an applicant's proposed operating schedule and also whether they should evolve along with the utility's study capabilities.