Energy Storage Integration Council (ESIC) Energy Storage Commissioning Guide 2016

3002009250

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Technical Update, December 2016

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THE ELECTRIC POWER RESEARCH INSTITUTE (EPRI) PREPARED THIS REPORT.

This is an EPRI Technical Update report. A Technical Update report is intended as an informal report of continuing research, a meeting, or a topical study. It is not a final EPRI technical report.

NOTE

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ACKNOWLEDGMENTS

The Electric Power Research Institute (EPRI) prepared this report.

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This report describes research sponsored by EPRI.

The author would like to thank all ESIC participants for their thought leadership, and also acknowledge individuals for their roles to date. Omissions are sole responsibility of the author.

Working group leadership and key contributors are listed below:

Grid Integration Working Group, Commissioning Subgroup: Co-Chairs Mark Siira (ComRent) and Charlie Vartanian (MEPPI). Key contributors: Md Arifujjaman (RES-Americas); Richard Bendert (ViZn Energy); Demetrio Bucaneg (HECO); Rick Cwiakala (NEC ES); Dave Conover (PNNL); Kevin Fok (LG Chem); Steve Emling (MEPPI); James Eckert (ComEd); Babak Enayati PhD (National Grid); Robert Helt (NEC ES); Thomas Hickman (Leidos); Darren Jang (National Research Council Canada); William Lowder (Duke Energy); Russ Morphis (Emerson); Emeka Okafor (AEP); Jim Prueitt (NEC ES). EPRI coordinators and contributors, Ben Kaun, Erin Minear, and Steve Willard.

Additionally, numerous others provided feedback in the conception and review of this product and underlying concepts, including Grid Integration Working Group webcasts and participants in ESIC general meetings and breakout session.

This publication is a corporate document that should be cited in the literature in the following manner:

Energy Storage Integration Council (ESIC) Energy Storage Commissioning Guide 2016, EPRI, Palo Alto, CA: 2016. 3002009250.

ABSTRACT

An energy storage commissioning reference document has been developed collaboratively with industry participants of the Energy Storage Integration Council (ESIC). It documents guidelines for energy storage commissioning, recommissioning, and decommissioning, and it is organized to support users through all phases of energy storage project development—from initial planning to end of life. The focus of this document relates particularly to the deployment of energy storage connected to utility distribution systems. The document's purpose is to support an understanding of the requirements and common practical approaches for the deployment of safe and reliable projects.

A successful commissioning process includes clearly defined roles, responsibilities, and tests. This process begins in the planning phase, during which commissioning requirements, schedules, and budgets are incorporated into a commissioning plan. In the procurement phase, the commissioning plan is refined and formalized through contractual language. The commissioning plan is continuously refined throughout the project. The commissioning and site-acceptance tests occur after the installation and connection of an energy storage system to the grid during the deployment and integration phase. These tests ensure that the system and sub-systems—such as safety, protection, and communication and control—were properly installed and are operating within specification. Tests can include a combination of factory acceptance tests and field verification and acceptance tests. Test data from initial system commissioning can be used as a baseline for trending and benchmarking for future retesting of the system. Additionally, changes in operation use or major component replacement may require recommissioning of the system to confirm proper operations. At the end of the system life, the system will need to be decommissioned. These guidelines describe the key elements of a decommissioning plan—including scope, risk assessment, safety plan, environmental assessment, recycling and/or disposal plan, and shutdown procedures—as well as many other process-related punch-list items.

These guidelines will be periodically updated and refined, incorporating best practices and key findings from industry use and experience. Users of this guide can participate in future iterations by enrolling in ESIC.

Keywords

Energy storage
Energy Storage Integration Council (ESIC)
Energy storage commissioning
Decommissioning
Energy storage testing

CONTENTS

1
INTRODUCTION

Objective

The objectives of this report, “Commissioning Guide,” are:

- To serve as a high-level, non-project-specific practical guide for utility users and their suppliers who are jointly planning energy storage system (ESS) projects that include a system commissioning stage of project execution.
- To support the development of practical, deployment-oriented industry practices where gaps exist today.
- To document work being performed in the ESIC, and incorporate and coordinate with other Working Group efforts including development of energy storage system test procedures.

Commissioning is defined as “a process that assures that a component, subsystem, or system will meet the intent of the designer and the user.”[1]

After the installation and connection of an energy storage system to the distribution system, a commissioning and site acceptance testing phase is required to ensure successful integration. These tests are intended to address the following list of typical concerns:

- Was the system installed correctly and does it remain within specification?
- Are all safety systems properly installed and operational?
- Is the utility switchgear and protection equipment operating as designed?
- Are the communication and control systems fully operational?

While some of these tests will support the characterization and validation of an energy storage system’s operational performance, additional issues to consider relate to the integration with the utility system to provide confidence that the system has been installed and integrated safely and reliably prior to transferring responsibility for the operation and maintenance of the energy storage system over to the operations personnel.

Note that while this guide is focused on commissioning of new energy storage systems and is intended to ensure their proper operation prior to system acceptance and initiating service, it can also be used as a basis for any necessary system recommissioning.

Development of this stand-alone commissioning guideline was conducted within the wider ESIC program and involved coordination between the Testing and Characterization Working Group (working on the test protocols) and the various subgroups within the Grid Integration Working Group focused on safety, communications and controls, and updating the implementation guide.

[1] http://dictionary.ieee.org/index/c-10.html

Commissioning Process General Requirements

Elements of the commissioning process take place in all phases of project execution. The Commissioning Guide is intended to reference best practices from relevant equipment (e.g. photovoltaic or wind project commissioning) or industries (e.g. ASHRAE for ventilation and temperature control). General requirements for commissioning include:

- Clear definition of roles and responsibilities, which should be set before the project starts and refined at each phase of the project.
- A clearly defined and effective set of commissioning tests, including field testing, subsystem testing and/or factory acceptance test (FAT), which is a key requirement for the overall commissioning process. The commissioning test needs to be planned for early in a project's planning phase, as well as executed successfully prior to system turn-over.
- Contingency plans for special project circumstances that could affect timing associated with the conduct of any of the processes associated with system commissioning.

The figure below is a graphical representation of the general commissioning process by project phase outlined throughout this document, as it fits within the overall project activity (note particularly the boxes shown under the Deployment and Integration column). There is a full page version of this figure in Appendix B.

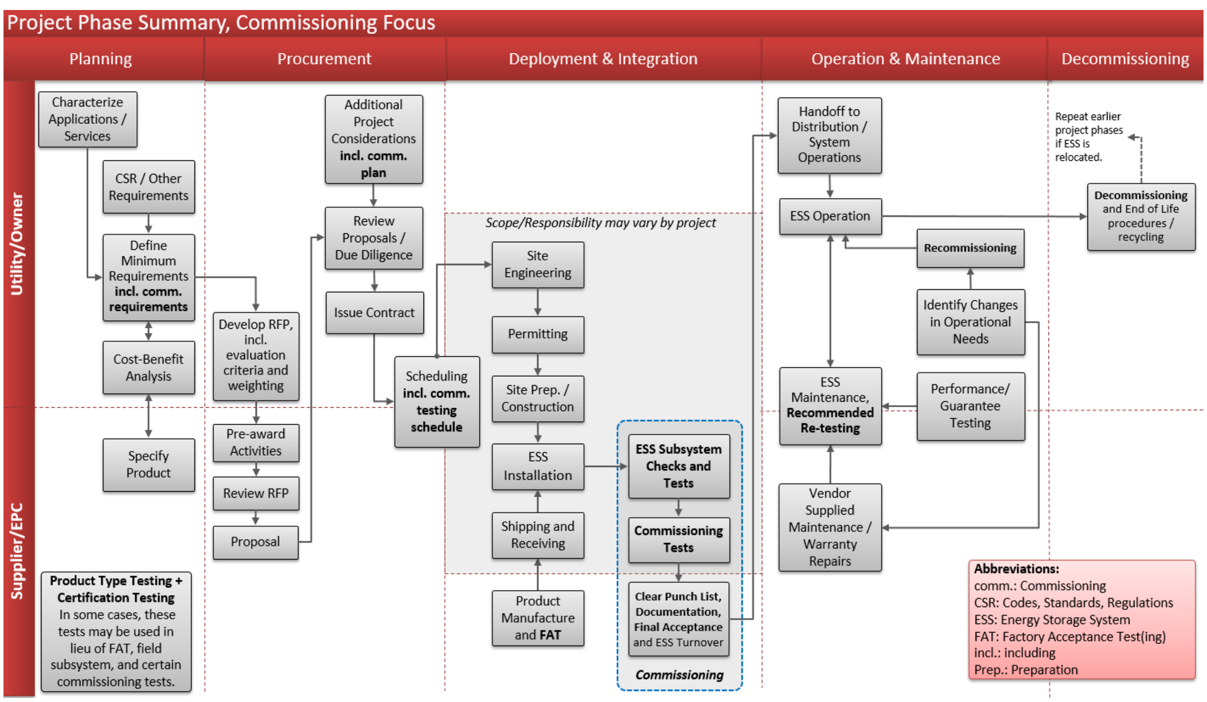

Figure 1–1
Summary of Project Phases

Organization of the Commissioning Guide

For the purposes of this guideline document, the stages of the commissioning process are discussed in the typical chronological order that overall project deployment would be executed. These are based on the ESIC Energy Storage Implementation Guide 2016 [1]. These phases are consistent with the phases used to segment project states in other industries. For each of these major project deployment stages listed below, and broken out into following sections, this Guide discusses and references relevant commissioning planning and/or actions. The numbered listing below follows the ESIC Guidelines for Distribution-Connected Energy Storage Deployments' project phases, and identifies steps throughout a project's execution that are directly related to commissioning, or are relevant to assuring successful commissioning.

1. Commissioning Considerations During Project Planning (section 2)
2. Commissioning Considerations During Project Procurement (section 3)
3. Commissioning Considerations During Project Deployment and Integration (section 4)
4. Commissioning Considerations During Project Operations and Maintenance (section 5)
5. Decommissioning Considerations (section 6)

Safety Considerations

Within the context of this commissioning guide document, during each phase of planning, procurement, installation, operation, and finally decommissioning, safety must be considered. Safety considerations are detailed in the "Energy Storage Safety: 2016, Guidelines Developed by the Energy Storage Integration Council for Distribution-Connected Systems" [2]. In a format similar to that of this commissioning guide, the importance of safety throughout the entire process is discussed.

Within the safety guidelines, the following considerations are detailed but not limited to:

- Requirements during the procurement phase that ensure that the system is safe and that its ongoing operation remains safe.
- Environmental impact and constraints.
- Science-based safety validation techniques as part of the commissioning plan.
    - Failure Modes and Effects Analysis (FMEA)
    - Systems Safety Analysis (SSA)
    - Applicable codes, standards, regulations (CSR)
- Designed safety requirements and checks during installation.
- Emergency action plan for first responders, including training materials outlining these plans.
- Verification of all safety design requirements from the SSA, the applicable CSRs, and that the utility's specifications have been met.
- Operational guidelines (e.g. manuals) must include safety protocols for service and maintenance operations, including hazards that might be encountered during these operations.
- Recommissioning to verify continued safe operation, control, and shutdown of the system.
- A decommissioning and disposal plan is needed to insure materials are safely disposed of or recycled at end of life. This plan should explain the procedure for decommissioning, including any hazards this may present.

Although safety is a major cost, it must be factored into the total cost of the commissioning project; safety considerations in each area must be addressed as part of the commissioning plan.

2
COMMISSIONING CONSIDERATIONS DURING PROJECT PLANNING

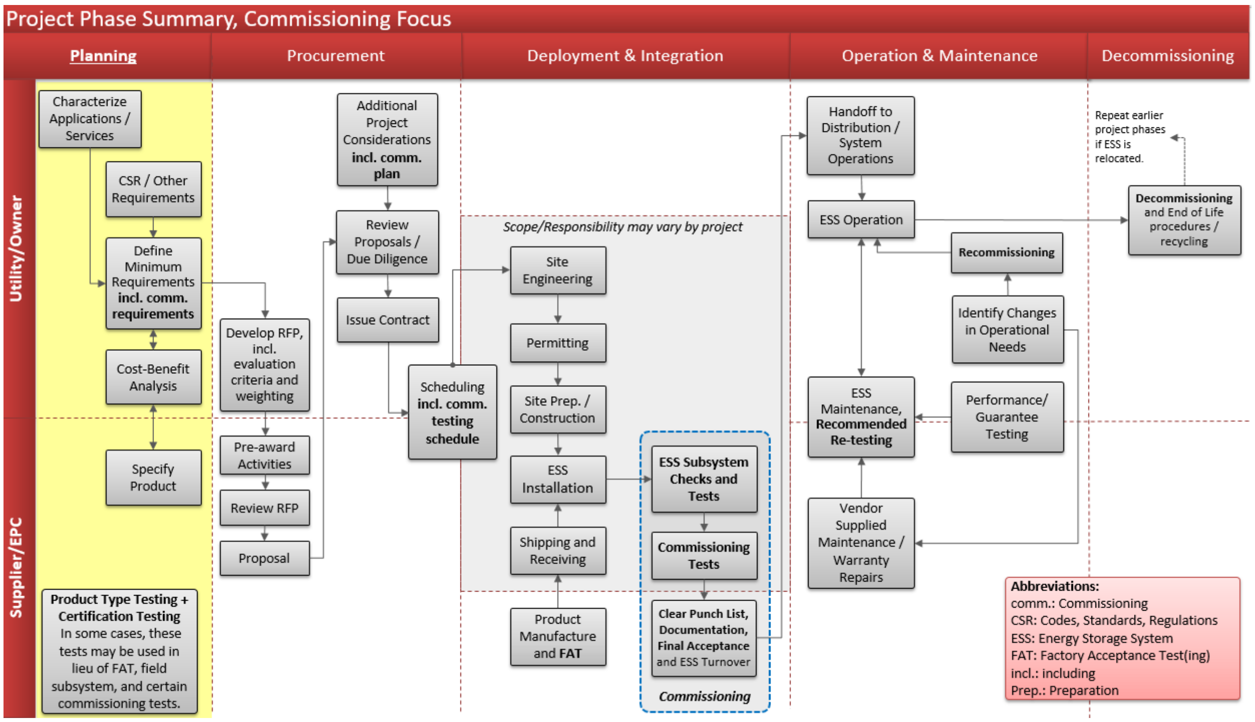

Figure 2–1
Planning Phase

The planning phase begins with the identification and definition of grid needs, and then translates these needs into requirements, and results in an analysis-based decision as to whether or not to proceed with energy storage procurement as a viable and cost-effective solution. During the project planning phase, the following elements of the commissioning plan should be included in the project:

- Develop a written commissioning plan, including utility and supplier acceptance testing methods, requirements and expected test outcomes
- Ensure the plan comprehends and includes utility commissioning requirements as well as any applicable federal, state or local regulations
- Include applicable NERC requirements
- Clarify roles and responsibilities for each phase, including those of any third parties acting on behalf of the utility, the supplier(s) or system integrators
- Develop a commissioning checklist with timeline for the project
- Determine the budgetary considerations to execute this plan by both the utility and suppliers

A primary consideration during the project planning phase is the scheduling of the commissioning acceptance tests and related final acceptance process steps. One specific example of a commissioning process is the Toronto-Hydro Commissioning Requirements and Report [3]. While it is intended for customer-owned assets, the guidance it provides in terms of schedule considerations is informative. This reference indicates some project owners/customers require supervisory access to the entire commissioning process and may need advance notice (e.g. 15 working days[2]) of when these activities are to start. Furthermore, independent professional engineers may also be required to witness the commissioning process to certify its completeness and validity.

Determining these requirements and planning for such notice and use and roles of any third-party agencies/individuals involved in the conduct of any testing and/or system performance validation is essential to avoid costly project delays. This planning should also account for the customer's review and approval time, and contingency to rectify any deficiencies, as well as any review and approval time associated with federal, state or local agencies (if applicable).

[2] Minimum advance notice required by Toronto Hydro; other customers may require more.

3
COMMISSIONING CONSIDERATIONS DURING PROJECT PROCUREMENT

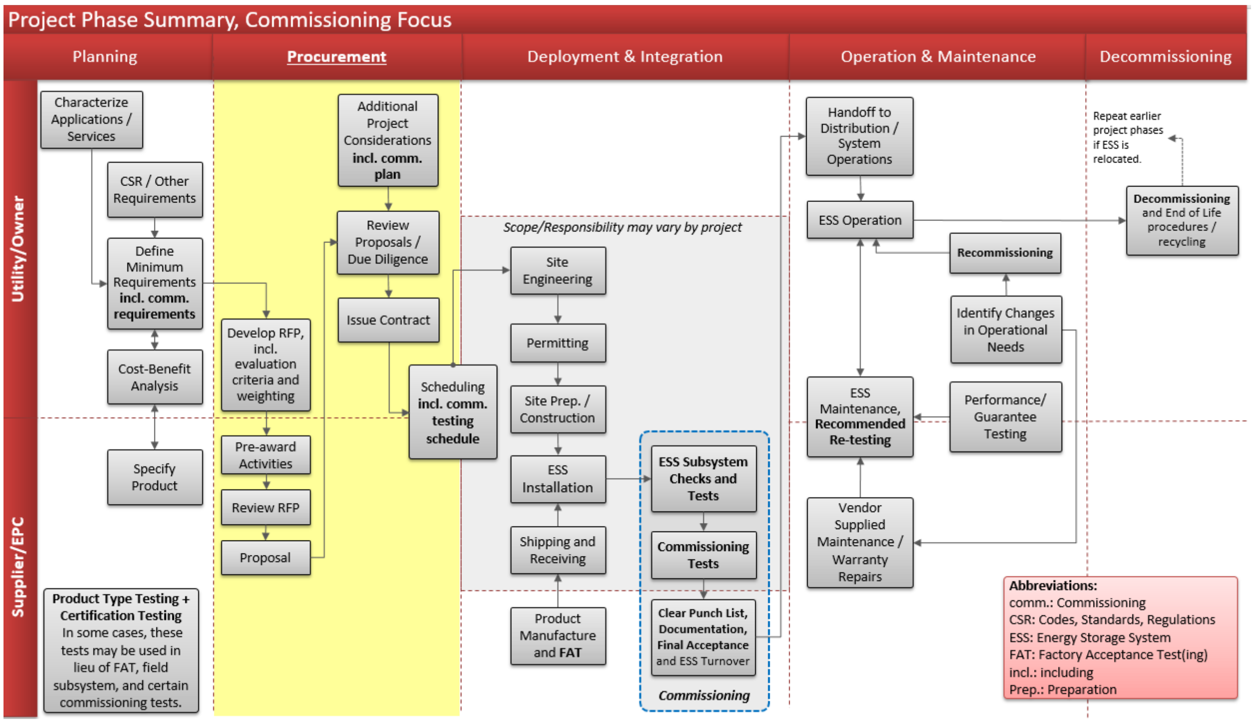

Figure 3–1
Procurement Phase

The procurement phase of energy storage implementation begins with the assumption that the planning phase has yielded a set of requirements to support the development of a specification, and that the energy storage project is worthwhile for the utility.

At this project phase, project managers should confirm the status of any site-specific commissioning requirements that will be in effect during the project construction and start-up processes. Goods or services necessary to comply with these requirements should be procured and organized to be on site when needed.

Key elements that should be added and/or updated to the commissioning plan include:

- Timeline
- Site preparation
- Environmental impact
- Identification of an authorities having jurisdiction (AHJ) and their role in review and/or approval of the project
- Permitting (review, inspection, testing and approval) as required by applicable AHJs

Consideration should be given to formalizing several aspects of commissioning through formal contract language. For example, citing specifically how compliance with any standards applicable to the project will be documented and verified, such as: through product testing and listing (e.g. certification) of the system or system components, FAT of significant equipment or representative sub-modules of the total project, or actual testing of the full integrated system as part of on-site commissioning.

4

COMMISSIONING CONSIDERATIONS DURING PROJECT DEPLOYMENT AND INTEGRATION

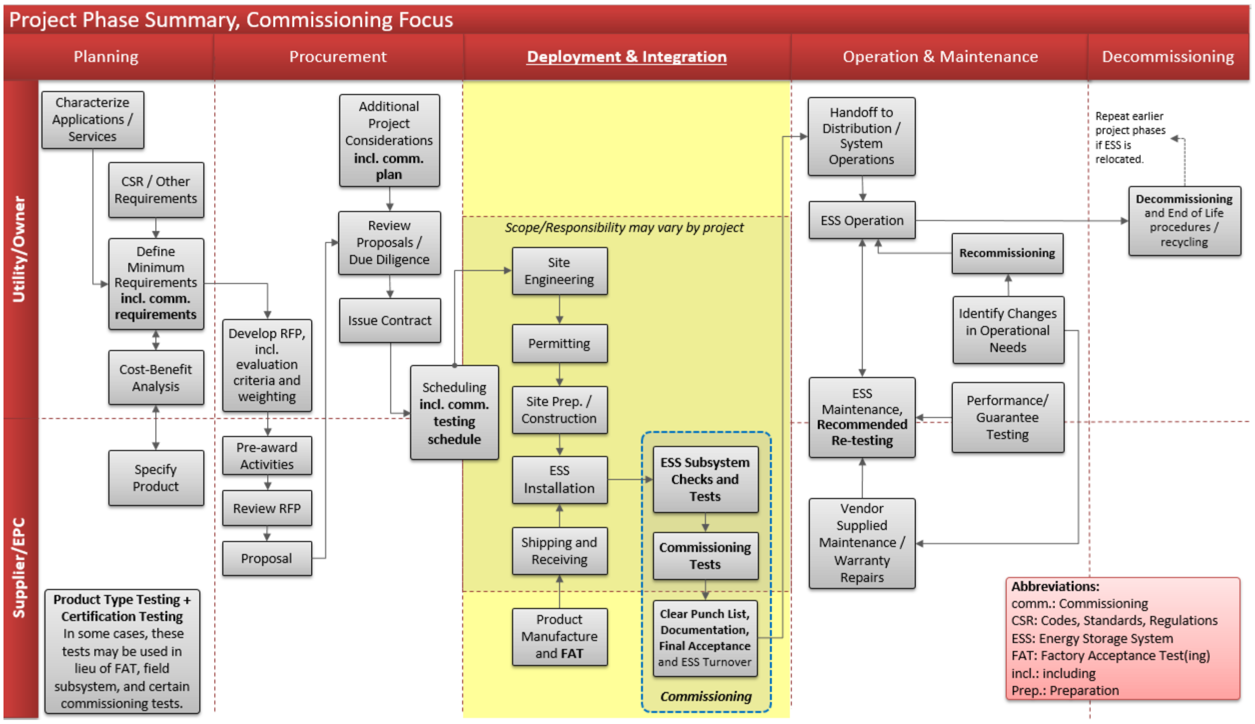

Figure 4–1
Deployment and Integration Phase

The deployment and integration phase of an energy storage project occurs after the procurement contracting of energy storage has taken place and work begins toward the integration of the project. It is during this phase that equipment is actually installed and most of the verification and validation tests are performed. The tests to be conducted should be verified in addition to the acceptability of the results, and the project schedule should coordinate the planned tests during the deployment and integration phase of the project. It is expected that some tests will be performed prior to shipment, some tests are part of installation, some tests occur upon initial power up, and some tests are done to verify system performance to metrics to create a defined release from supplier to owner. It is very important to clearly delineate in the project commissioning specifications and plan what tests are to be conducted, by whom, when in the process, the methods for conducting the tests, and the minimum acceptable test results.

Project Deployment Verification

These tests and design verification activities are intended to ensure that the following list of typical concerns during deployment are resolved and are acceptable to all:

- The system and/or components were built to initial specifications.
  - Verification that factory acceptance testing, product type testing, or other pre-shipment tests have been satisfactorily performed on critical subsystems such as disconnect device, inverter, HVAC, transformer, communications interfaces, control equipment, etc.
  - Making factory acceptance testing of major subsystems (inverters, transformers) a witnessed test may simplify planning and executing commissioning.
- The system was installed correctly (e.g. per the manufacturer's installation instructions, adopted rule and regulations, project specifications, and terms of system or component listing(s).
  - Equipment damaged during shipment is recorded and repaired.
  - Safety systems are installed.
  - Grounding is installed.
  - Required access to the system, clearances, foundational supports, signage, ventilation and thermal management, fire detection and suppression, and other aspects of the plans and specifications are satisfied.
  - Acceptance testing of subsystems, e.g. relay settings, transducer wiring, SCADA/EMS interfaces, can be completed under special circumstances that can affect timing. For example, tests may be conducted when a substation is not energized or the utility wants to verify system protection behavior before connecting.
  - If available, verify that remote access by suppliers is functioning properly.
  - Satisfactory performance of systems in disconnect tests is documented.
- Verify that the system operates within the limits as outlined in the project specifications.
  - The utility switchgear and protection equipment is operating as designed.
  - The communication and control systems are fully operational.
  - Safety systems such as but not limited to fire and smoke detection and suppression, ventilation and thermal management, electrical protection, etc. are operational.

Project Integration Activities

These acceptance tests and activities associated with verifying the system design and construction as well as its installation are intended to ensure that the following list of typical concerns during integration are resolved and are acceptable to all:

- The system remains within the established specifications during its full range of operation as per the specified sequence of operation.
  - Final validation testing is performed once all equipment is installed and interconnected to the power system, with permission to exchange power (often occurs as a temporary permission and later an operational permission) to confirm correct and intended operation.

  - Compliance with standards related to interconnection, including but not limited to IEEE 1547.1a (IEEE Standard Conformance Test Procedures) and IEEE 1547.1 Revision (expected 2018) [4,5].
  - Avoid duplication of tests, for example supplier-performed design verification tests or other testing that can be used in lieu of field tests of the installed system for commissioning and acceptance. Some testing is difficult to perform in the field and easier at the factory, thus planning needs to define and perform these tests at the appropriate level and time.
- While some of the tests performed during the integration phase will support the characterization and validation of an energy storage system's operational performance, additional issues to consider relate to the integration with the utility system to confirm that the system has been installed and integrated safely and reliably prior to transferring responsibility over to the operations personnel.
  - Integrated systems tests (sometimes referred to as in-service tests) provide a final check and approval from the organizations involved. In-service testing demonstrates and documents the performance of protection, communication, human-machine interface (HMI) equipment (if applicable) and major electrical components. For energy storage systems, this can include measuring and confirming that the voltages and currents are correct for the magnitude, phase angle, and polarity being measured. Contingency plans should be in place to compensate in the event these values exceed allowable ranges.
  - There should be a project execution mechanism devised to identify and resolve post-commissioning issues, for example a "punch list" that identifies items to be rectified before final acceptance and complete turn-over of the system to the utility as the receiving owner/operator.
  - When applicable, tests should be performed at the subsystem level during the commissioning process.
- The requirements included in the commissioning tests should flow into the operation and maintenance plans that are established for the energy storage system. The test data from the commissioning process can be used as a baseline for trending and benchmarking for future re-testing of the system. Examples of test procedures and protocols can be referenced in the following documents:
  - Appendix C provides an outline of the test manual currently being generated by ESIC Working Group 2 (WG2) [6]. A protocol for measuring and expressing energy storage system performance published by Pacific North National Labs (PNNL) and Sandia National Laboratories (Sandia) [7] is the basis for some of the content in Appendix C.
  - Tehachapi Wind Energy Storage Project, Technology Performance Report #1 [8]. This document includes detailed test plans for site acceptance tests (SAT) and characterization test for the Southern California Edison (SCE) Tehachapi Wind Energy Storage Project. The SATs evaluate and verify the system performance, capabilities and control algorithms.
  - Toronto Hydro – Electric System FIT Commissioning Requirements and Reports [3]. This document contains a commissioning summary form for project details and checklists for verifying and commissioning equipment, electrical specifications, and cease to energize functions. Although these commissioning process documents are developed for

Feed-In Tariff (FIT) Distributed Generation, they are good indicator of the types of tests that can be considered and how the results of the test can be documented and recorded.

While executing the project deployment and integration phase, fully document the entire commissioning process against the prepared commissioning plan defined earlier (section 2). The outcome at the end of this phase should be formal documentation indicating the system is acceptable and is transferred from the vender to the utility/owner/operator.

5

COMMISSIONING CONSIDERATIONS DURING PROJECT OPERATIONS AND MAINTENANCE

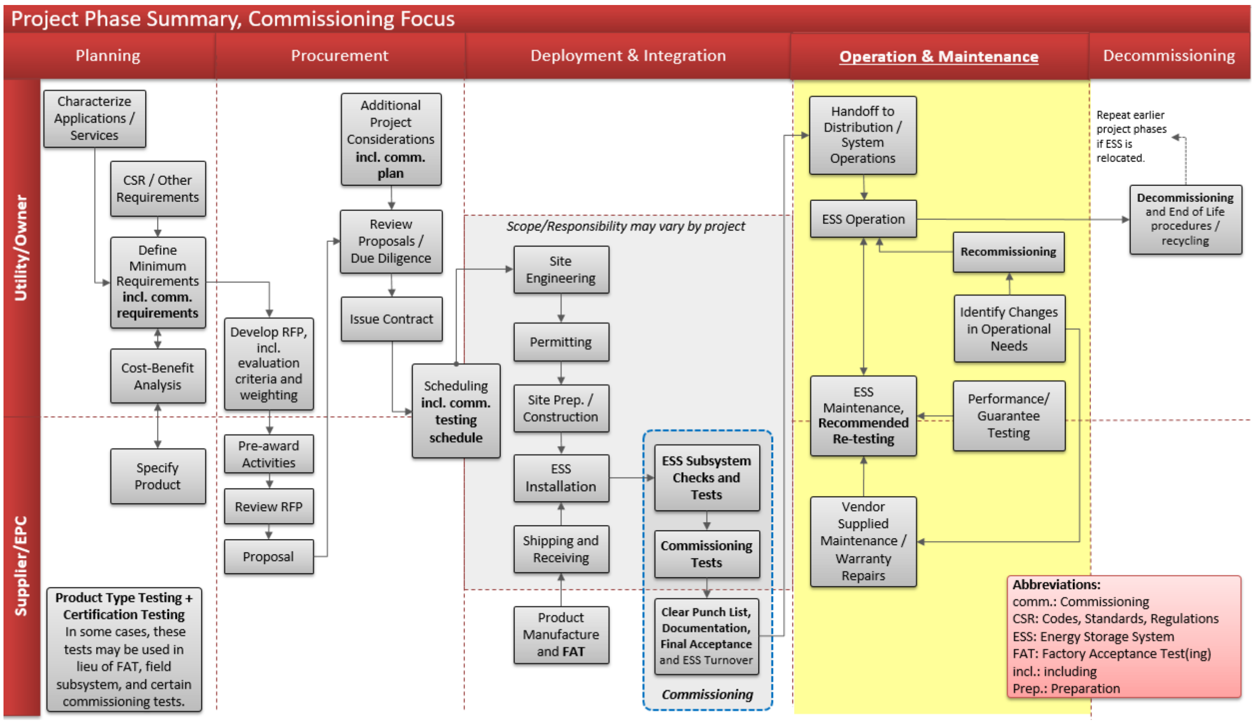

Figure 5–1
Operations and Maintenance Phase

The operations and maintenance phase of an energy storage project begins when the system has been commissioned and approved for use in the operations of the electric utility. This phase continues until the end of the project's operational life and also coincides with any planned or unplanned repair, renovation, renewal, or reconstruction of the system between initial commissioning and its final decommissioning.

Specific considerations for operations and maintenance plans include:

- Safety information, including those outlined in Energy Storage Safety: 2016 Guidelines Developed by the Energy Storage Integration Council for Distribution-Connected Systems referenced earlier. These should include:
  - Safety equipment maintenance
  - Operator training
  - Safety protocols during operation, shutdown, maintenance, and restart
  - Incident preparedness

- It is expected that an operating and/or service manual for the ESS be provided that may include:
  - Operations guidelines
  - Maintenance schedules
  - Alarm and fault codes
  - Troubleshooting guidelines
- One potential requirement is to perform periodic interconnection tests or integrated system tests based on the requirements of the IEEE 1547 Standard. These may be required based on time duration, regular shutdown frequency, or system criteria such as software upgrades to major subsystems and subsystem repairs or replacements.
  - All interconnection-related protective functions and associated batteries shall be periodically tested at intervals specified by the manufacturer, system integrator, or the authority that has jurisdiction over the distributed energy resources (DER) interconnection or the area electric power system (EPS) operator. Periodic test reports or a log for inspection shall be maintained.
  - The area EPS operator may require an interconnection test be performed outside of the normal periodic testing to verify adherence to IEEE 1547 at any time.
  - Communication of system (software, firmware, hardware) should be communicated to the area EPS operator.
  - Frequency of retesting can be determined by area EPS operator policies for protection system testing or industry practices.
- Service contract or warranty-related protocols between a manufacturer or service provider and the customer to insure the system remains functional throughout its operational life.
  - The test data from the project deployment and integration phase of the commissioning process may be used as a baseline for future ESS evaluations to indicate any performance degradation that may prompt service, warranty, or end-of-life action.
- Recommissioning: Changes in operational uses or major component replacement may trigger a need to recommission a system. Depending on the extent of the system changes, various levels of acceptance and verification tests outlined in the deployment and integration section may need to be performed again to confirm proper system operation.

The end of an ESS's operating life can be triggered by several events. Regardless of the cause, the termination of operation should include a deliberate and planned decommissioning process. Section 6 provides guidance for ESS decommissioning.

6
DECOMMISSIONING CONSIDERATIONS

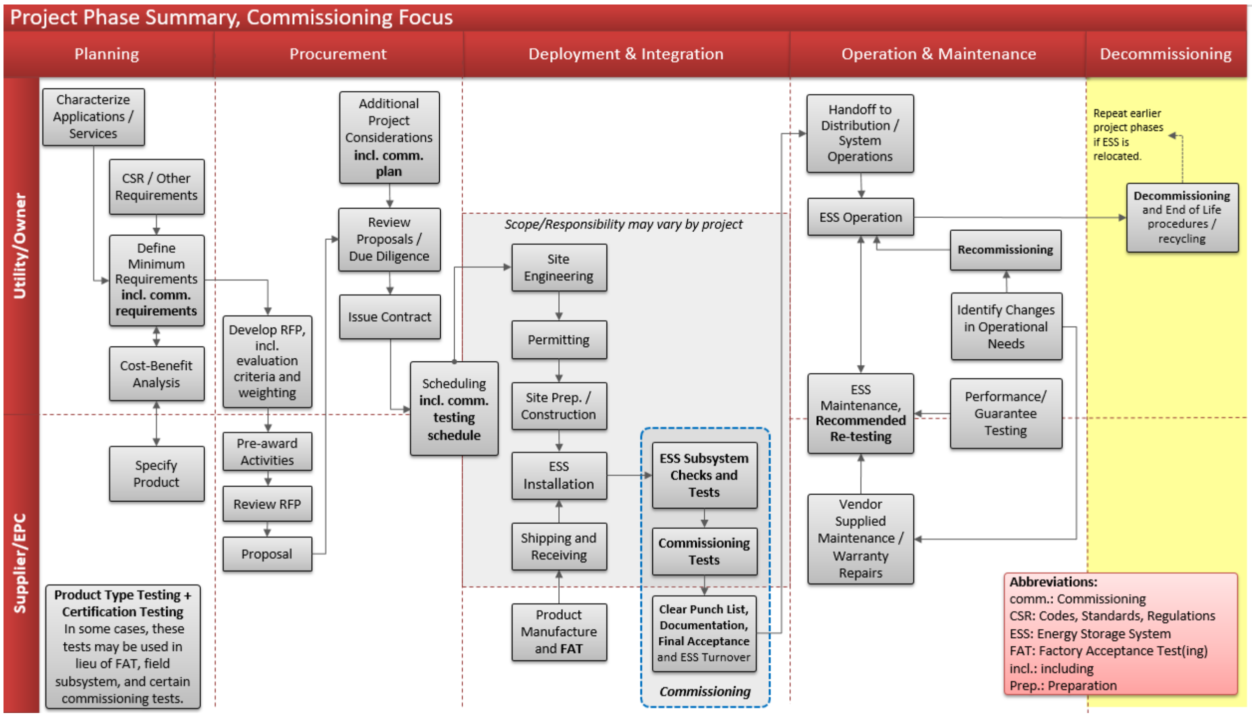

Figure 6–1
Decommissioning Phase

This section addresses considerations related to the decommissioning of an energy storage system to minimize risks to the owner and/or customer, the environment, and those involved in the decommissioning process. System decommissioning occurs at the termination of a system's operations, and at some point all energy storage systems will need to be permanently decommissioned. One potential trigger for decommissioning is when one or more components have reached the end of life. For battery technologies this may be defined as an energy capacity threshold. At this point it may make sense to decommission from a financial or safety perspective, but there may be an opportunity to replace components, recommission, and extend the life of the system. Additionally, there may be an opportunity to re-purpose the system to a less demanding application. Another major trigger for decommissioning is when the ESS is no longer needed to serve the grid at its given location. If there is still useful life remaining in the system, after decommissioning the system can be relocated and recommissioned at a new location.

A successful decommissioning process depends on an experienced and qualified team. The team should be augmented with appropriate subject matter experts selected to complement the specific technical concerns of the project being decommissioned. The specific types of expertise needed will be dependent on the type of facility being reviewed and decommissioned, as well as other factors such as complexity and hazards or risks.

It is preferred that personnel selected to participate in a decommissioning, planning, and review have decommissioning experience. It is strongly recommended that the team leader should either be a project or systems engineer experienced in the energy storage system installation, design, operation, and or management. A multi-disciplined review and decommissioning team (e.g. mechanical, electrical, chemical, industrial) should match, to the extent practicable, the contractor's decommissioning team. The review team should be augmented with subject matter experts as appropriate to review specialty matters such as criticality safety aspects.

Decommissioning Plan

A decommissioning plan describes the process for decommissioning an energy storage facility and associated utility services and subsurface facilities. The information in this section is not intended to provide a detailed plan for the eventual decommissioning of an energy storage facility, but to demonstrate that decommissioning can be completed with existing technology in a manner that ensures the protection and safety of workers, members of the general public, and the environment, as well as the security of possible hazardous waste.

A decommissioning plan should be prepared prior to the commencement of any decommissioning activities. Appropriate methods and technologies available at that time will be reviewed, adopted, and described in a detailed plan. Planning for decommissioning is an ongoing process, and planning assumptions are expected to change with evolving technologies, international and operational experience, regulations, and cost estimates. A detailed decommissioning document should be reviewed and revised periodically in order to incorporate any changes in the planning that arise during the decommissioning process.

Decommissioning Plan Steps

- Decommissioning scope, objective, end-state and strategy, including:
  - A description of the site and the structures, systems, and components to be decommissioned
  - Schedule for decommissioning activities
  - Estimate of the decommissioning cost
- Regulatory process
- License application and receipt
- Risk management assessment:
  - Ensure the project risks associated with the alternatives, including the preferred alternative, are systematically identified and managed using a documented and adequate process.
  - Risk identification and management is essential to the overall success of the project, and the risks associated with all of the considered alternatives need to be considered as part of the determination of the preferred alternative.
  - Risk management is also integrally tied to the identification of "adequate" characterization with the analysis leading to decisions regarding the balance between known and unknown characterization information and the acceptance and/or integration of the identified risks.

- Safety plan:
  - The safety plan integrates safety in the selection of decommissioning alternatives and processes.
  - It considers safety for the workers and surrounding area.
  - It addresses the requirement for the completion of a preliminary hazards analysis (for chemical and construction hazards) for the preferred alternative and the associated identification of safety class and safety significant and important to safety systems, structures, and components for decommissioning activities.
  - It provides the basis for development of the documented safety analysis and is key in defining the safety responsibilities and planning.
  - It includes emergency responses and communication plans.
- Environment assessment:
  - Decommissioning activities, particularly the removal of project components and grading, could cause negative environmental effects similar to those of the construction phase. For example, there is the potential for disturbance (erosion/ sedimentation/ fuel spills) to adjacent watercourses or significant natural features.
  - Mitigation measures similar to those employed during the construction phase of the project will be implemented during the decommissioning process.
  - Mitigation measures will remain in place until the site is stabilized in order to mitigate erosion and silt/sediment runoff and any impacts on the significant natural features or water bodies located adjacent to the project location.
  - Road traffic may temporarily increase due to the movement of decommissioning crews and equipment.
  - There may be an increase in particulate matter (dust) in adjacent areas.
  - Emissions from the diesel engines of construction machinery and equipment may cause localized impacts to air quality.
  - Noise levels from heavy machinery and traffic to the project location may increase. Work should be undertaken during daylight hours and should conform to all local noise ordinances.
  - Additional considerations: Existing land use adjacent to the ESS site; vegetation; wildlife habitats near the site; aquatic environment, if any.
- Recycling and/or disposal considerations:
  - An estimated inventory of the hazardous wastes will be generated during decommissioning.
  - Most of the materials used in an ESS facility are reusable or recyclable, and some equipment may have manufacturer take-back and recycling requirements.
  - Any remaining materials should be removed and disposed of at an appropriate facility.
  - Battery suppliers for ESS systems should provide policies and procedures to maximize recycling and reuse, and should work with recyclers, local subcontractors, and waste firms to segregate material to be disposed of, recycled, and/or reused.
  - Processing required for removal, storage, handling and transportation.
  - Processing and characterization for packaging

- Packaging by waste type
- Processing required for waste removal
- Transportation mode and permits by waste type
- Disposal destinations
- Organization of waste materials
- Verifications or inspections required
- Demolition waste disposal

- Additional pre-shutdown considerations:
  - Site security
  - Geology
  - Seismicity
  - Topography
  - Quality assurance
  - Documentation (records)
  - Community relationships
- Site and facility preparation
- Safe removal of power and de-energization of ESS
- Disconnection of the equipment
- Equipment removal
- Site restoration
- Post decommissioning:
  - Final surveys
  - End state report

7
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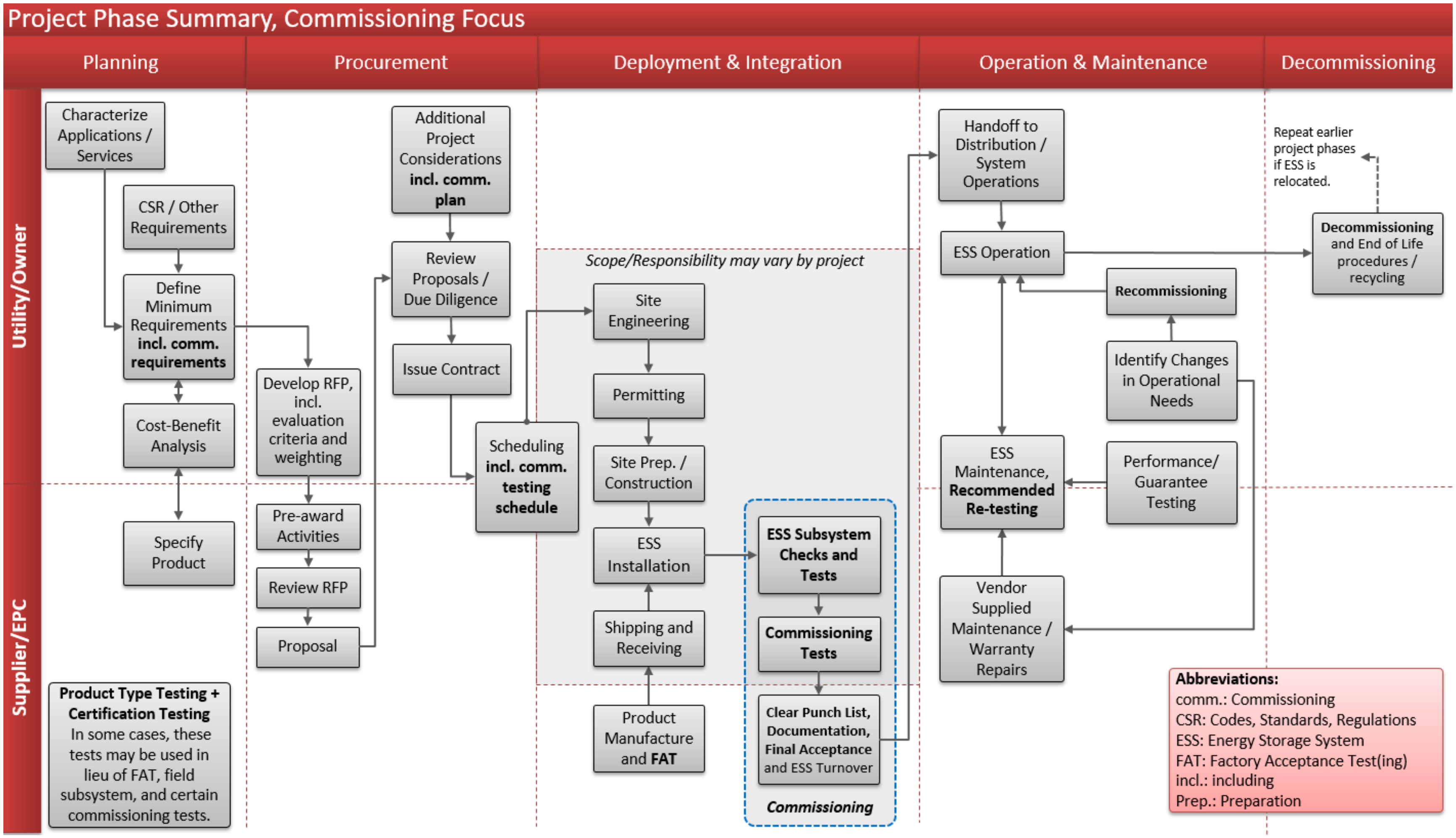
A
ACRONYMS AND ABBREVIATIONS

AHJ	authority having jurisdiction
BESS	battery energy storage system
CSR	codes, standards, and regulations
DER	distributed energy resources
DOE	U.S. Department of Energy
EMS	energy management system
EPRI	Electric Power Research Institute
EPS	electric power system
ESIC	Energy Storage Integration Council
ESS	energy storage system
FAT	factory acceptance test
FIT	feed-in tariff
FMEA	failure modes and effects analysis
HMI	human-machine interface
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
NERC	North American Electric Reliability Corporation
PCS	power conditioning system
SAT	site acceptance test
SCADA	supervisory control and data acquisition
SCE	Southern California Edison
SOC	state of charge
SSA	systems safety analysis
WG2	Working Group 2

B

PROECT PHASE SUMMARY, COMMISSIONING FOCUS



C
TEST PROCEDURES FOR USE OR IN SUPPORT OF ESS COMMISSIONING

The ESIC Energy Storage Test Manual, published by ESIC, provides guidance on testing and characterizing energy storage systems [6]. The manual includes a complete outline with high level scope and descriptions for tests that may be used in energy storage system evaluations. There are also detailed procedures for key performance and functional tests listed below. Additional detailed procedures will be developed in future revisions of the manual. A commissioning plan for any particular project may include some or all of the tests in the manual. The test manual can be downloaded from www.epri.com/esic.

Detailed procedures in the manual include:

- Auxiliary Load Determination
- Roundtrip Efficiency
- Available Capacity
- Charge Duration
- Rated Continuous Power
- Response, Rise and Settling Time
- Harmonic Distortion
- Frequency Regulation
- Volt-VAR Regulation

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