Update on and Overview of Model Codes and Standards for Energy Storage System Safety

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Purpose and Expected Outcome Today

Purpose

- Reinforce the relevance and importance of voluntary sector standards and model codes (CS) to timely deployment of safe EES
- Provide information on the revision of current CS and development of new CS applicable to ESS
- Stress the importance of collaboration on the development, adoption and implementation of CS to ensuring acceptance of ESS

Expected Outcomes

- Recognition that CS are critical to successful ESS development and deployment
- Knowledge of current and future CS development activities and who is sponsoring them
- How to most effectively participate in those activities
- Understanding various means of adopting those CS

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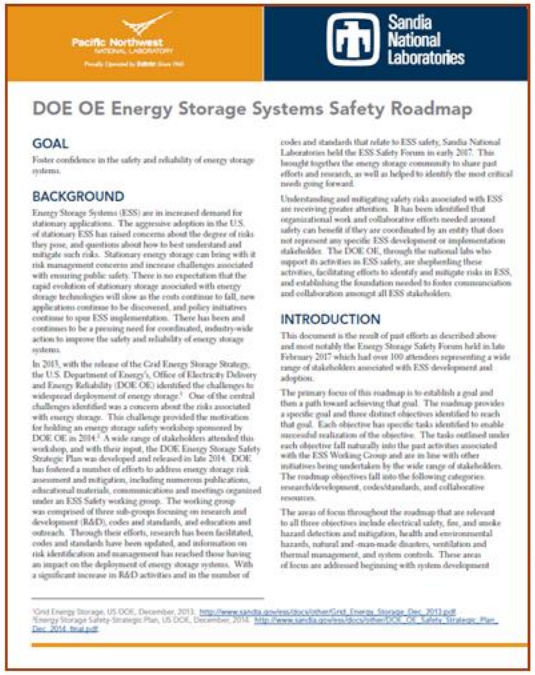
Connection to the DOE OE ESS Safety Roadmap

- Codes and standards are one of three areas of focus in the DOE OE ESS Safety Roadmap
- PNNL and Sandia National Laboratories partner to support efforts to achieve the stated goal by facilitating and coordinating activities under three key objectives (R&D, C/S and Collaborative Resources)

Roadmap to ESS Safety and Reliability



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DOE OE Energy Storage Systems Safety Roadmap

GOAL

Foster confidence in the safety and reliability of energy storage systems.

BACKGROUND

Energy Storage Systems (ESS) are in increased demand for stationary applications. The aggressive adoption in the U.S. of stationary ESS has raised concerns about the degree of risks they pose, and questions about how to best understand and mitigate such risks. Stationary energy storage can bring with it risk management concerns and increase challenges associated with ensuring public safety. There is no expectation that the rapid evolution of stationary storage associated with energy storage technologies will slow as the costs continue to fall, new applications continue to be discovered, and policy initiatives continue to spur ESS implementation. There has been and continues to be a pressing need for coordinated, industry-wide action to improve the safety and reliability of energy storage systems.

In 2013, with the release of the Grid Energy Storage Strategy, the U.S. Department of Energy's, Office of Electricity Delivery and Energy Reliability (DOE OE) identified the challenges to widespread deployment of energy storage.[1] One of the central challenges identified was a concern about the risks associated with energy storage. This challenge provided the motivation for holding an energy storage safety workshop sponsored by DOE OE in 2014.[2] A wide range of stakeholders attended this workshop, and with their input, the DOE Energy Storage Safety Strategic Plan was developed and released in late 2014. DOE has fostered a number of efforts to address energy storage risk assessment and mitigation, including numerous publications, educational materials, communications and meetings organized under an ESS Safety working group. The working group was comprised of three sub-groups focusing on research and development (R&D); codes and standards; and education and outreach. Through their efforts, research has been facilitated, codes and standards have been updated, and information on risk identification and management has reached those having an impact on the deployment of energy storage systems. With a significant increase in R&D activities and in the number of codes and standards that relate to ESS safety, Sandia National Laboratories held the ESS Safety Forum in early 2017. This brought together the energy storage community to share past efforts and research, as well as helped to identify the most critical needs going forward.

Understanding and mitigating safety risks associated with ESS are receiving greater attention. It has been identified that organizational work and collaborative efforts needed around safety can benefit if they are coordinated by an entity that does not represent any specific ESS development or implementation stakeholder. The DOE OE, through the national labs who support its activities in ESS safety, are shepherding these activities, facilitating efforts to identify and mitigate risks in ESS, and establishing the foundation needed to foster communication and collaboration amongst all ESS stakeholders.

INTRODUCTION

This document is the result of past efforts as described above and most notably the Energy Storage Safety Forum held in late February 2017 which had over 100 attendees representing a wide range of stakeholders associated with ESS development and adoption.

The primary focus of this roadmap is to establish a goal and then a path toward achieving that goal. The roadmap provides a specific goal and three distinct objectives identified to reach that goal. Each objective has specific tasks identified to enable successful realization of the objective. The tasks outlined under each objective fall naturally into the past activities associated with the ESS Working Group and are in line with other initiatives being undertaken by the wide range of stakeholders. The roadmap objectives fall into the following categories: research/development, codes/standards, and collaborative resources.

The areas of focus throughout the roadmap that are relevant to all three objectives include electrical safety, fire, and smoke hazard detection and mitigation, health and environmental hazards, natural and -man-made disasters, ventilation and thermal management, and system controls. These areas of focus are addressed beginning with system development

[1]Grid Energy Storage, US DOE, December, 2013; http://www.sandia.gov/ess/docs/other/Grid_Energy_Storage_Dec_2013.pdf

[2]Energy Storage Safety Strategic Plan, US DOE, December, 2014; http://www.sandia.gov/ess/docs/other/DOE_OE_Safety_Strategic_Plan_Dec_2014_final.pdf

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Challenges Associated with ESS Development and Deployment

- The ever increasing number of ESS technologies and applications and ability of relevant stakeholders to ‘keep up’
- Codes and standards provide a vehicle to uniformly document and validate ESS safety
- Research and data to define what is and is not safe are needed to develop appropriate codes and standards
- All interested and affected parties may not recognize the importance of codes and standards or if they do may be reluctant to participate and collaborate with others
- When codes and standards are available they may not be adopted and applied in a timely manner
- Ensuring all stakeholders have the necessary training and resources to document, validate and ensure compliance

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Challenge Summary

Maintaining desired growth of energy storage in the built environment that is minimally impacted by safety-related incidents and is fostered by the availability of updated codes and standards that support the technology, are founded on robust research and field data and are known to and supported and understood by all relevant stakeholders

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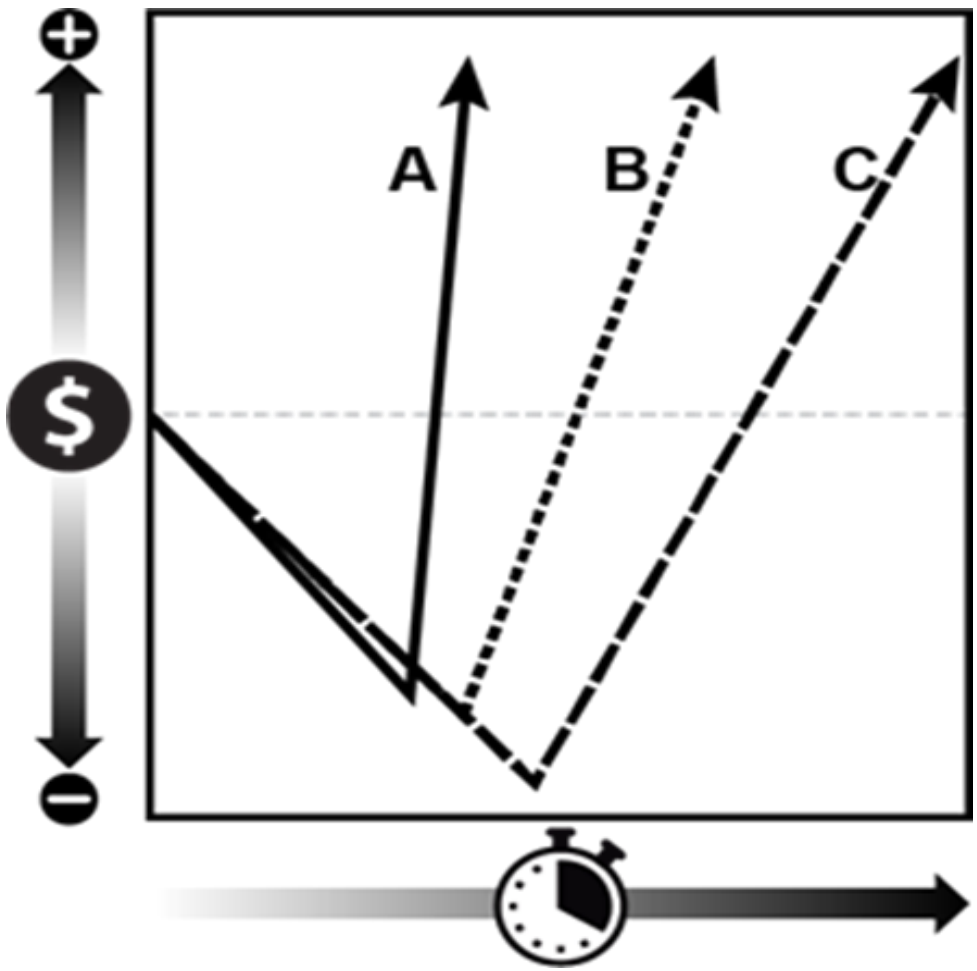
The Value Proposition

- The investment in ESS development and deployment over time
- C/S provide a vehicle to uniformly document and validate ESS safety
- ESS proponents can choose to make an investment in C/S or not
  - A – active participation
  - B – track efforts of others
  - C – no activity
- The timing and scope of the investment will affect long term success



Short C/S History on ESS

- Energy storage has been in use for centuries through mechanical and thermal means
- Ben Franklin coined the word ‘battery’ and their types and uses have not seen significant change until just recently
- Codes and standards have addressed battery safety through criteria for vented lead acid batteries for a few decades (UL 1973, NFPA 1 and 70 and the ICC Fire Code and ICC legacy organization BOCA, SBCCI, and ICBO model fire codes)
- More recently other battery types have been included in C/S
- Current efforts are focused beyond batteries to include criteria for ESS and the myriad of ES technologies and applications

Ensuring Codes and Standards are Current

New ESS technologies and applications coupled with the need to address safety increase the challenges in updating C/S and the amount of research needed as a basis for C/S provisions

- ESS location in relation to the grid (e.g., customer meter) and whether it is grid-connected
- ESS location in relation to buildings and facilities (e.g., indoors, outdoors, rooftop, below grade, sidewalk vault, etc.)
- The type of building or facility in which an ESS may be located or installed on or adjacent to (e.g., single family dwelling, hotel, parking structure, business, industrial, etc.)
- Nature of the installation (e.g., rural/remote, urban, etc.)
- Whether the ESS is associated with a new building or an existing building
- Whether the ESS is stationary, mobile but “stationary,” or truly movable (e.g., on wheels) or portable.

Ensuring Codes and Standards are Current

New ESS technologies and applications coupled with the need to address safety increase the challenges in updating C/S and the amount of research needed as a basis for C/S provisions

- clearances and working space
- shocks and arc flash
- structural loading
- protection against natural and manmade disasters
- spill control
- impact protection
- access to and egress from the ESS area
- smoke and fire detection and fire suppression
- separation of ESSs from each other and from other spaces/areas
- Ventilation, exhaust and thermal management

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U.S. Codes and Standards Overview

- Voluntary sector standards and model code developers (SDOs)
- Federal, state, local, tribal and territorial government
  - adoption of voluntary sector standards and model codes
  - implementation and enforcement of adopted CS
- Utility, insurance underwriter, etc. adoption, implementation, and enforcement of CS
- The need to document and verify compliance with those adopted CS directly and through the efforts of accredited third party agencies

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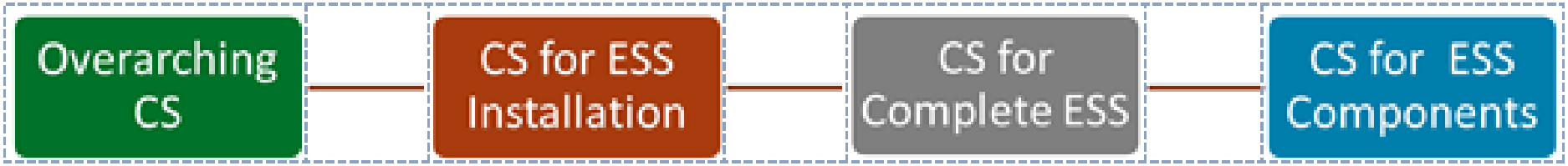
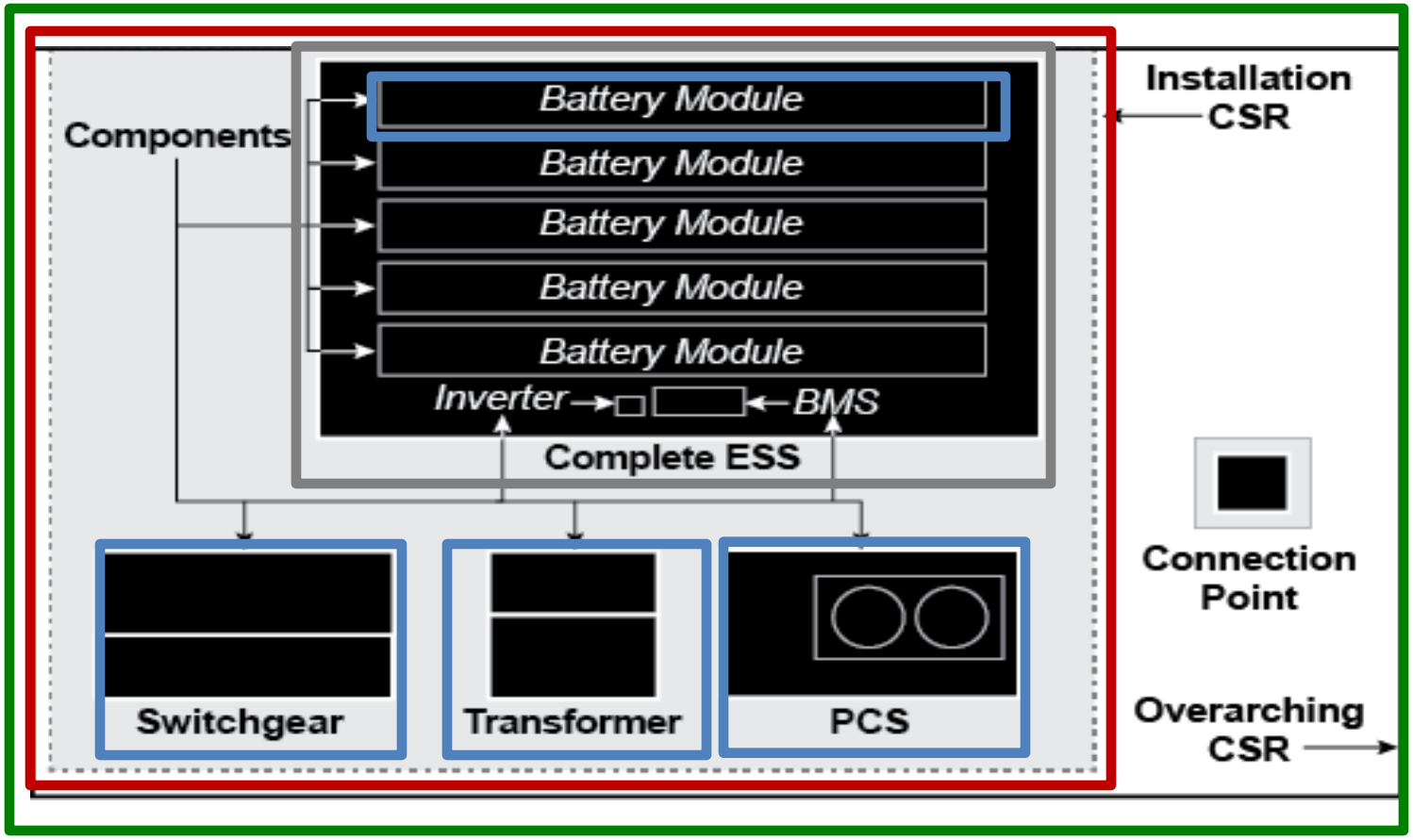
Scope of Codes and Standards in Relation to ESS





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Overarching Codes and Standards

Overarching CS

- **NFPA 1-2015** (Fire Code) Chapter 52 and new 2018 edition with public inputs for the 2021 edition due in mid-2018
- **NFPA 70-2017** (National Electrical Code) Article 706 for ESS and Article 480 for batteries with public inputs due September 7, 2017 that initiate a revision process leading to the 2020 edition
- **2018 IFC** (ICC International Fire Code) Section 1206 covers electrical ESSs with proposed changes due January 8, 2018 that will initiate the development of the 2021 edition
- **2018 IRC** (ICC International Residential Code) a section of the IRC covers ESSs and proposed changes are due January 8, 2018
- **IEEE C2-2017** (National Electric Safety Code) with a final date to receive change proposals of July 15, 2018 that will lead to the 2022 edition
- **DNVGL-RP-0043**, September 2017 (Safety, Operation and Performance of Grid-connected Energy Storage Systems)

Codes and Standards for ESS Installation

CS for ESS Installation

- **NFPA 855-20XX** (Standard for the Installation of Stationary Energy Storage Systems) with first public input on the first draft due October 4, 2017 and final approval targeted for June 2018

- **NECA 416-2016** (Recommended Practice for Installing Stored Energy Systems) that describes installation practices for ESSs such as battery systems, flywheels, ultra-capacitors, and smart chargers used for electric vehicle (EV) and vehicle-to-grid applications

- **FM Global Property Loss Prevention Data Sheet # 5-33 January 2017** (Electrical Energy Storage Systems) describes loss prevention recommendations for the design, operation, protection, inspection, maintenance, and testing of electrical ESSs and is focused primarily on lithium-ion battery technology with development of an interim revision planned for 2018 and publication in 2019

Codes and Standards for Complete ESS 'Product'

CS for Complete ESS

- **UL 9540** (Energy Storage Systems and Equipment) first published November 21, 2016 and now under revision based on proposal requests (proposed changes and rationale) received by UL in July 2017

- **ASME TES-1** (Safety Standard for Thermal Energy Storage Systems) a first draft has been developed providing safety-related criteria for molten salt ESSs and the drafting committee balloted to submit the document for public review

Codes and Standards for ESS Components

CS for ESS Components

- **IEEE P1679.1** (Guide for the Characterization and Evaluation of Lithium-Based Batteries in Stationary Applications) is a proposed new standard providing appropriate information about safety attributes and operating conditions related to stationary applications of lithium-based batteries slated for publication in late 2017
- **IEEE P1679.2** (Guide for the Characterization and Evaluation of Sodium-Beta Batteries in Stationary Applications) is a proposed new standard providing appropriate information about safety attributes and operating conditions related to stationary applications of sodium-beta batteries that had a public review earlier in 2017 and the committee is now working on resolution of comments received
- **UL 1973** (Batteries for Use in Light Electric Rail and Stationary Applications) the proposal review work area in the UL standards development process closed in late August 2017
- **UL 1974** (Evaluation for Repurposing Batteries) a new standard that will cover use of repurposed EV batteries for stationary applications, including ESSs and the preliminary review work area in the UL standards development process for the proposed first edition of the standard closed in July 2017
- **UL 810A** (Electrochemical Capacitors) the standard covers the safety of electrochemical capacitors and was reaffirmed on March 28, 2017

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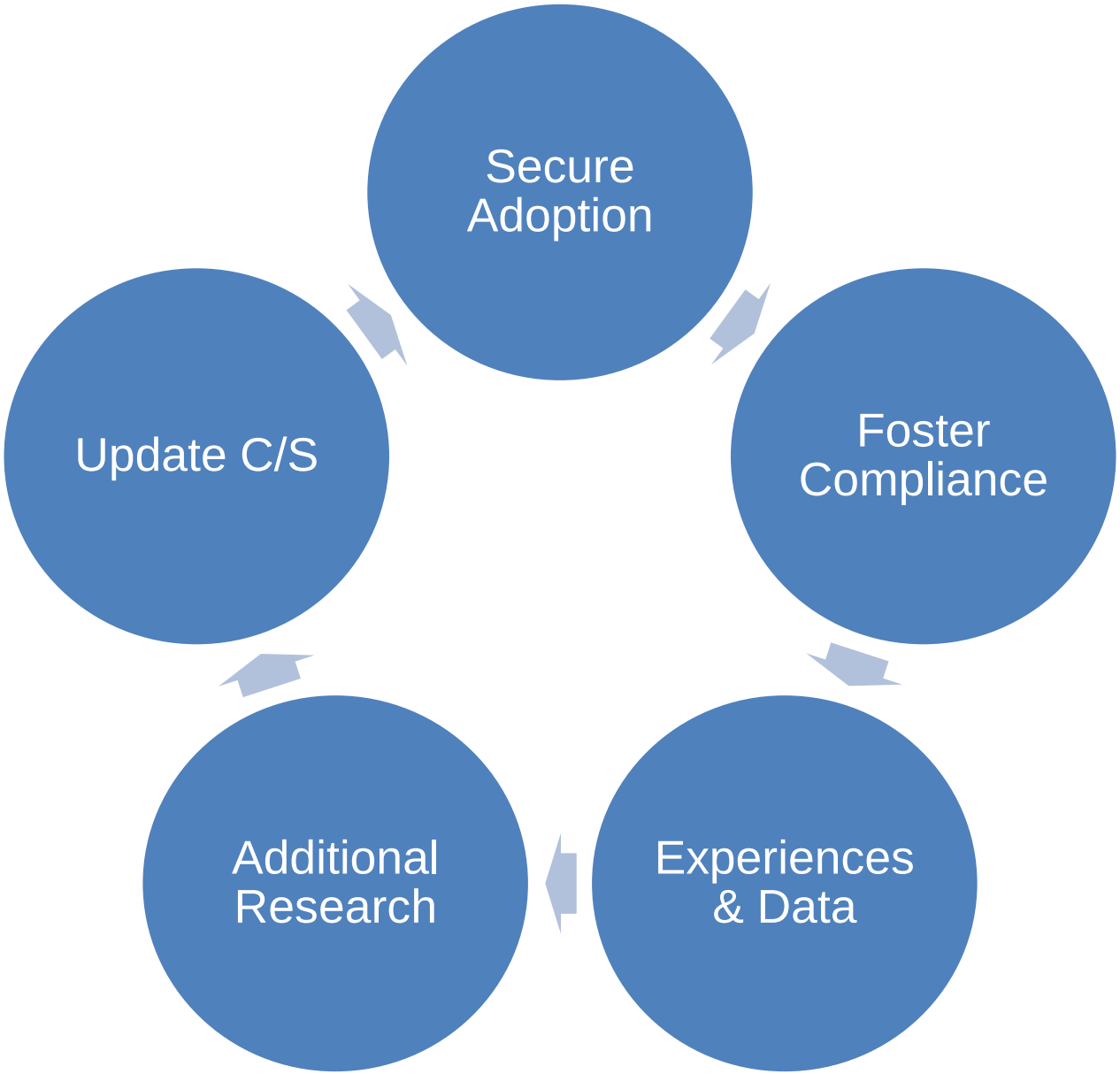
What Should Happen After C/S are Updated



All stakeholders need to coordinate and collaborate to achieve success

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Acknowledgment

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DOE-Office of Electricity Delivery and Energy Reliability

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Q/A and Further Information

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