

International Energy Storage Working Group

Authors

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Pacific Northwest National Laboratory

Support from DOE Office of Electricity Delivery & Energy Reliability
Energy Storage Program

US DOE-OE Energy Storage Systems Program Review
Portland, OR
September 24, 2015



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► Energy Storage Challenge

- How do we compare performance of different storage technologies on an apples to apples basis? Huge challenge for the end user to evaluate various technologies.

► Project Objective

- Develop an approach to determine performance of energy storage to help stakeholders evaluate multiple storage technologies for various applications.
- Gain recognition nationally and internationally as the relevant procedure for assessing ESS performance.

► Accomplishments

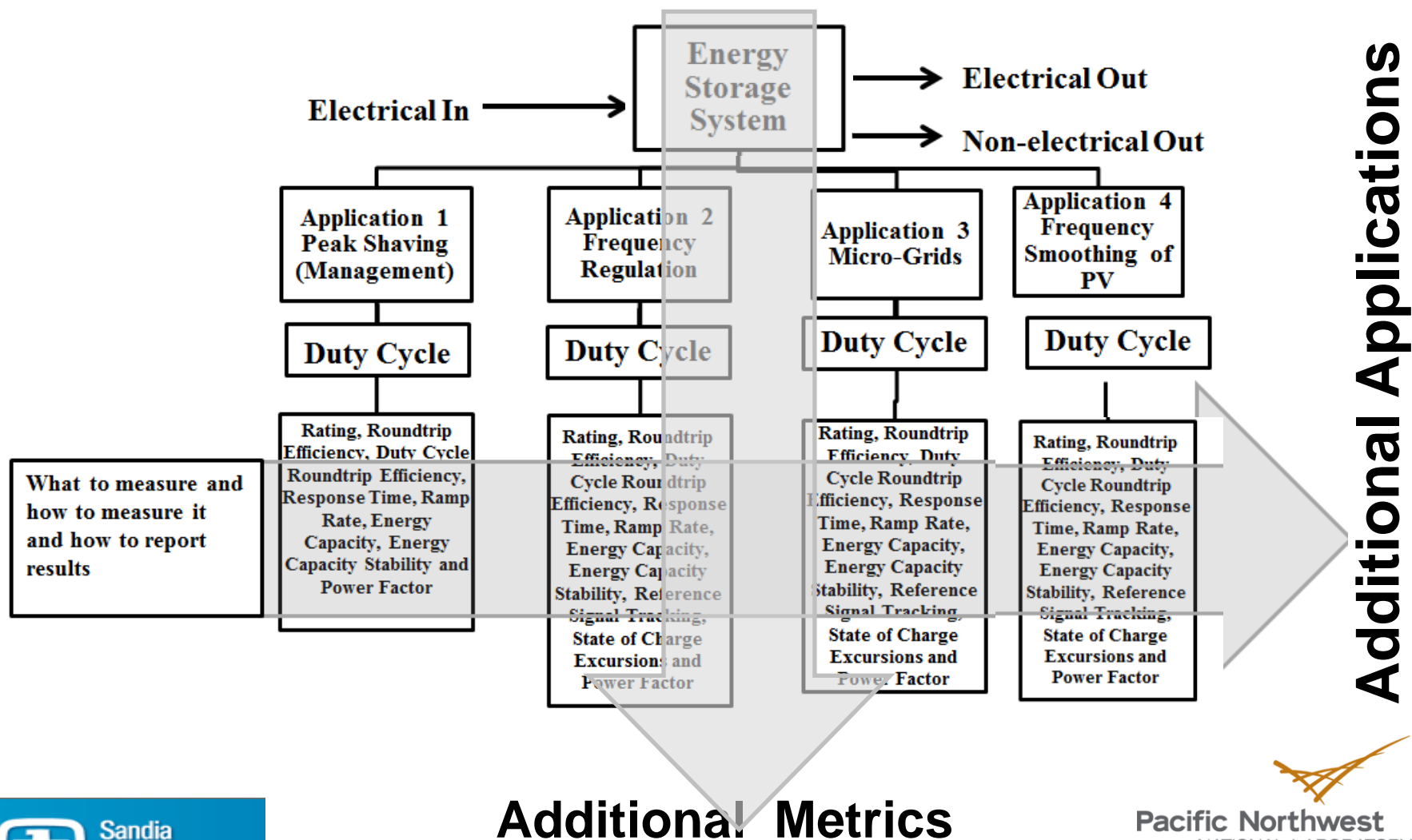
- Completed 7 applications to date, and nearing completion on the 8th
- Protocol has been adopted/adapted by IEC TC120 Metrics & Performance WG
- Protocol partially adopted/adapted by IEC TC120 Grid Integration WG
- The DOE-OE sponsored Codes and Standards Inventory (PNNL 23618) forms the bases for gap analysis to guide future work for TC120 team.
- Protocol has been adopted/adapted by EPRI ESIC Metrics & Performance WG
- Multiple users have used test driven the protocol to evaluate storage systems
- There is acceptance in the US and internationally about this work being a standard bearer for evaluation of storage performance.

- ❑ Initiated March 2012, first protocol released November 2012 and first revision released June 2014, second revision to be released September 2015
- ❑ Currently in use to report system performance
- ❑ Currently being used as a basis for US (NEMA and ASME) and International (IEC) standards covering energy storage system performance



Protocol Overview

PNNL-SA-112833



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Current Applications and Metrics

☐ Applications

- ☐ Peak shaving
- ☐ Frequency regulation
- ☐ Islanded micro-grids
- ☐ *Volt-Var*
- ☐ *Power Quality*
- ☐ *Frequency Control*
- ☐ *PV Smoothing*
- ☐ *Renewable firming / load following*



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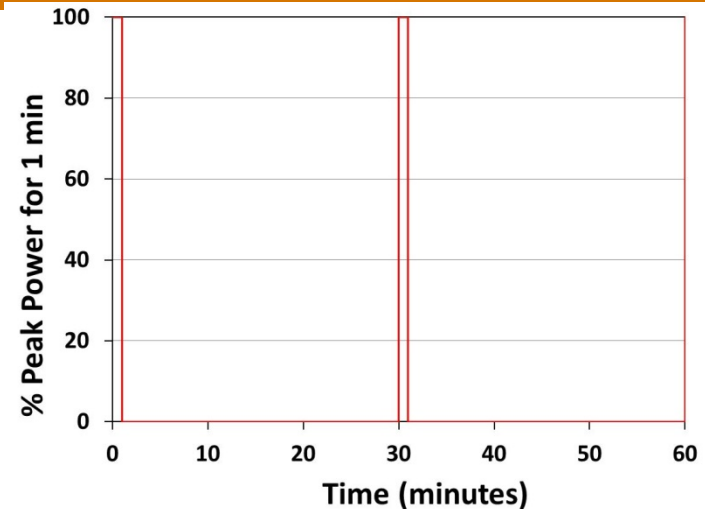
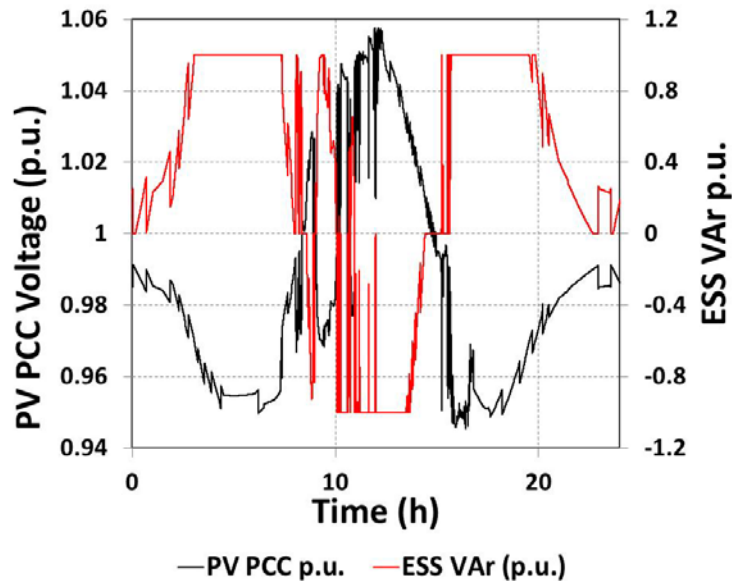
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- ❑ Volt/VAR support
- ❑ Power quality
- ❑ Frequency control
- ❑ PV Smoothing
- ❑ Renewable (wind or solar) firming & load following over 24 hours)
- ❑ Identify new metrics that are relevant and needed

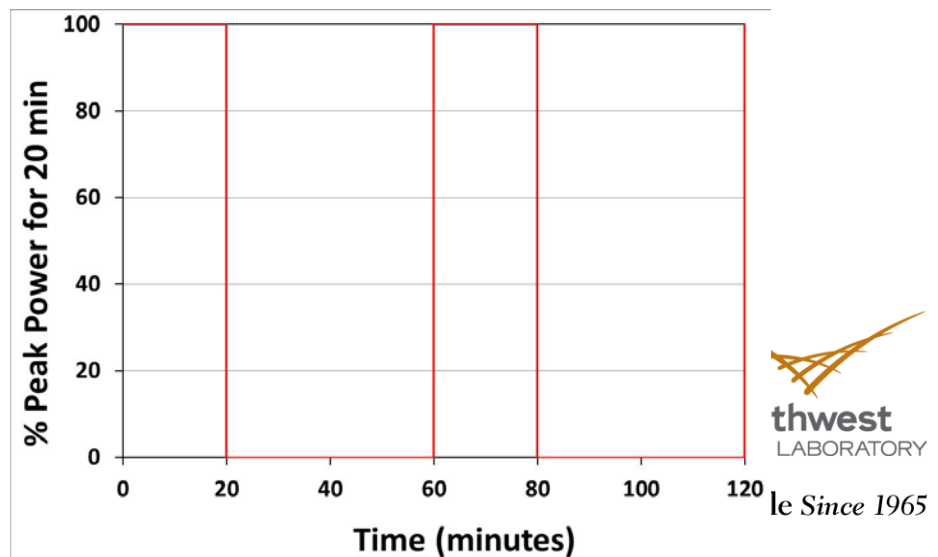
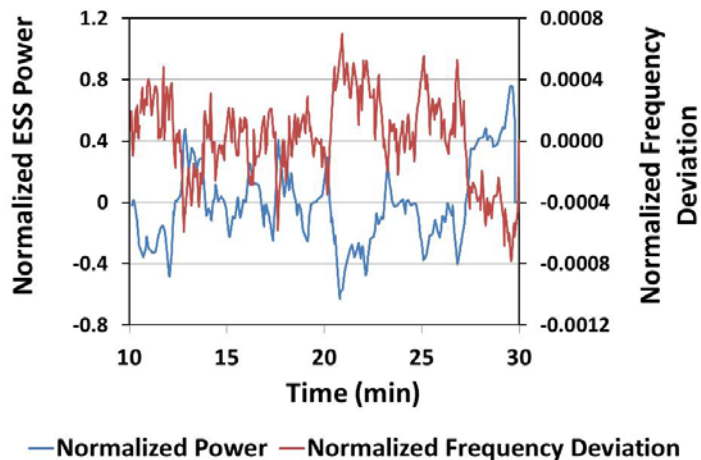


Duty cycles for Volt-VAR support, Power Quality and Frequency Control

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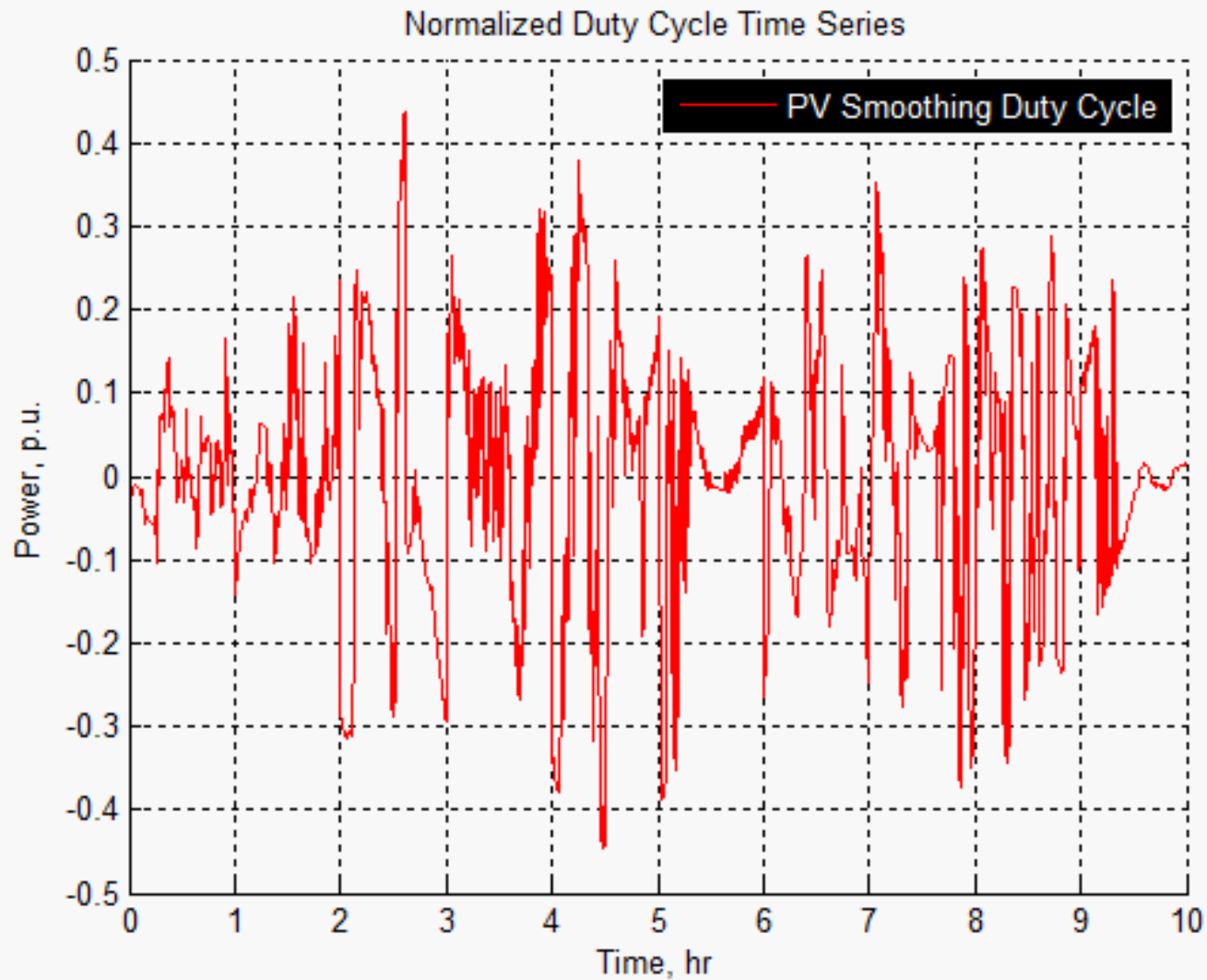


Duty cycle for ESS from top clockwise
Volt-VAR, Power Quality. Secondary Frequency
Control, dynamic frequency control



*Didier Colin et al ERDF/SAFT/Schneider
Electric and others – Venteea 2 MW 1.3 MWh
battery system. Lyon France 15-18 June 2015*

PV Smoothing Duty Cycle



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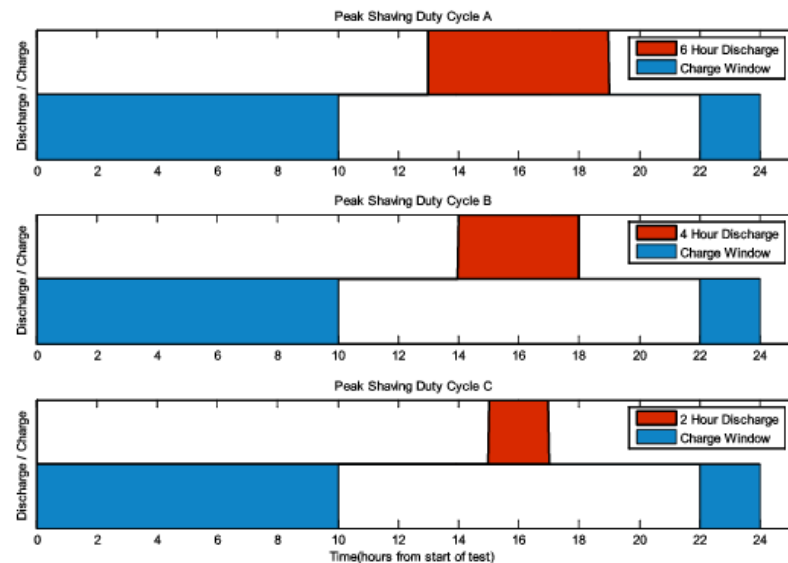
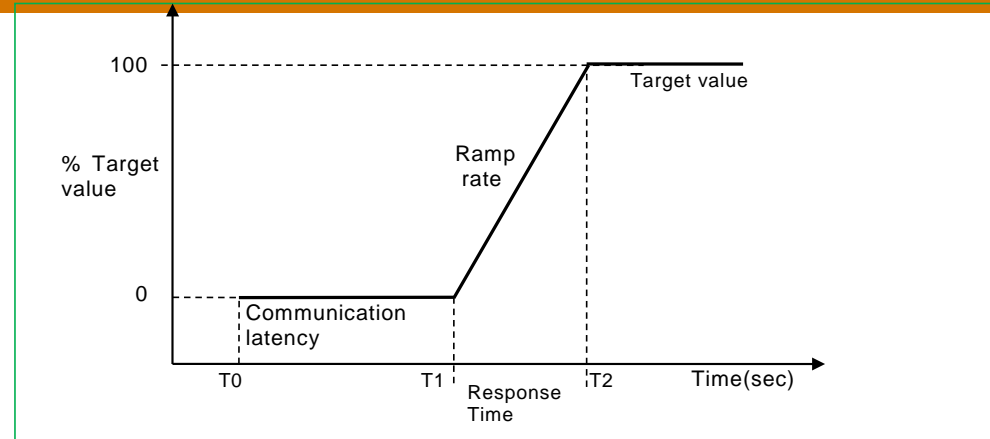
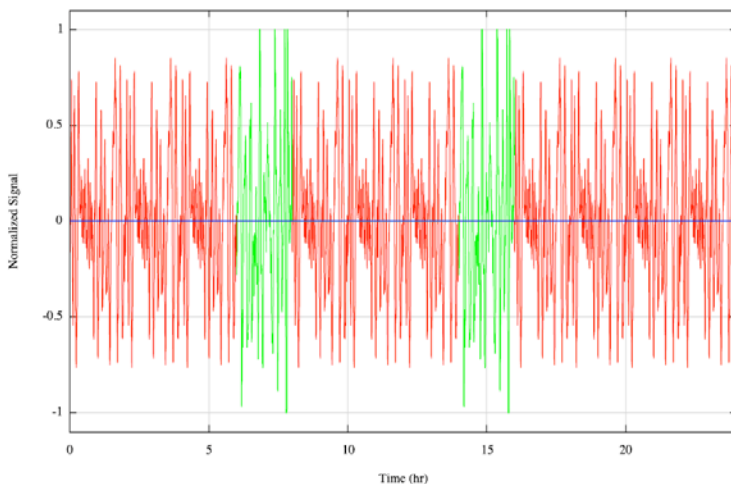
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IEC TC 120 WG2 Performance Working Group

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- ▶ Performance working group WG2 has adopted our work
- ▶ Stored energy capacity test
- ▶ Duty cycle tests (Peak Shaving and Frequency Regulation)
- ▶ All the metrics
- ▶ Will feed FY15 work to TC120 WG2
- ▶ The DOE-OE protocol gaining attention from international community

Example Frequency Regulation Duty Cycle



IEC 62934: Unit Parameters and Testing Methods, of IEC technical committee TC120.
Electrical Energy Storage System (EES) by Pacific Northwest National Laboratory
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IEC TC 120 WG3 Planning & Installation of EESS Working Group

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- ▶ IEC 62935 - PLANNING AND INSTALLATION OF ELECTRICAL ENERGY STORAGE SYSTEMS
- ▶ This International Standard establishes guidelines for the planning and installation of Electrical Energy Storage (EES) systems, to be used by power systems planners, system integrators and commissioning staff.
- ▶ Applications (most of these addressed by the DOE-OE Protocol)
 - - grid stabilization
 - - peak load management
 - - load shifting
 - - black start capabilities
 - - power reserve
 - - frequency and voltage regulation
 - - renewable integration
 - - back-up power supply

Common Performance Parameters:

- Energy Capacity
- Round trip efficiency
- Duty cycle round trip efficiency
- Response time

IEC TC 120 Gap Analysis Working Group

- ▶ The DOE-OE work on Codes & Standards (PNNL 23618) adapted by the gap analysis working group to begin screening for applicable standards

SGAM Function Layer(PNNL23618)					
TC120					
2	2	2	2	2	Market
2	2	2	2	2	Enterprise
4	4	4	4	4	Operation
4	4	4	4	4	Station
4	4	4	4	4	Field
4	4	4	4	4	Process
Generation	Transmission	Distribution	DER	Customer Premises	

Domain

Zone

ongoing TC57

TC120

- The gap analysis working group assigned the relevant codes and standards into various cells as shown
- This provides a good starting point for determining where the TC120 team's efforts should focus
- US DOE-OE's support was crucial in getting this done.

Other IEC work – TC21 New Work Items Proposal

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- ▶ Evaluated Multiple New Work Item Proposals
- ▶ TC 21 JWG7 (also called JWG 105) – IEC 6XXXXX FLOW BATTERY SYSTEMS FOR STATIONARY APPLICATIONS– Part 2-1: Performance general requirements & methods of test
- ▶ 21/819/NP. Flow batteries - General requirement and test method of vanadium flow batteries
- ▶ 21/823/NP. Flow Battery Technologies – Safety
- ▶ 21/829/NP. Secondary Cells and Batteries of the Flow Type: Flow Batteries - Guidance on the Specification, Installation and Operation
- ▶ 21/860/NP IEC 62485-5 : SAFETY REQUIREMENTS FOR SECONDARY BATTERIES AND BATTERY INSTALLATIONS – Part - 5 : Lithium-ion batteries for stationary applications
- ▶ 21/861/NP IEC 62485-6 : SAFETY REQUIREMENTS FOR SECONDARY BATTERIES AND BATTERY INSTALLATIONS – Part - 6 : Lithium-ion batteries for traction applications

TC21 Committee Draft for Voting (for future IEC standards)

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- ▶ Participated in preparation of multiple future IEC standards committee drafts
- ▶ 21/841/CDV. IEC 61427-2: Secondary cells and batteries for renewable energy storage - General requirements and methods of test - Part 2: on-grid applications
- ▶ 21/844/CD IEC 62660-3: Secondary lithium-ion cells for the propulsion of electrical road vehicles – Part 3: Safety requirements
- ▶ 21/852/CDV: IEC 61982-4: Secondary batteries (except lithium) for the propulsion of electric road vehicles – Safety requirements of nickel-metal hydride cells and modules
- ▶ 21/855/CDV/IEC 62660-3: Secondary lithium-ion cells for the propulsion of electrical road vehicles – Part 3: Safety requirements
- ▶ 21/857/DC Draft Technical Report on Candidate alternative test methods for the internal short circuit test of IEC 62660-3
- ▶ 21/821/CDV Safety requirements for secondary batteries and battery installations – Part 1: general safety information
- ▶ CENELEC CWA 05:2013 – Redox flow battery specification, installation and operation. Allows comparison of technical requirements of different types of flow batteries.
 - This work used in TC 105 to develop Flow Battery System Standards
 - PNNL is actively engaged with this effort.

Collaboration with EPRI Electricity Storage Integration Council

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- ▶ Active participation in WG1, WG2, WG3, WG4
- ▶ . Our engagement with ESIC WGs allows 2-way transfer of information
- ▶ WG1: Use case analysis – helped guide
- ▶ WG2: Performance Metrics and Measurements.
 - The DOE-OE protocol has been recognized as the “go to” work. PG&E is currently using this protocol for baseline testing as part of the ESIC effort.
 - EPRI ESIC WG2 members also joined the Volt-VAR working group to provide valuable input
- ▶ WG3: Systems development working group. ESIC WG3 provided a list of Technical specifications for ESS that the DOE protocol Version 2 will reference.
 - The ESIC WG3 is leveraging on the Smart Inverter Working Group (SIWG) work. The PNNL Volt-Var effort uses significant portions of the SIWG work.
 - Collaboration with Sunspec and MESA standards.
- ▶ WG 4: Grid Integration Working Group
 - Using The DOE-OE work on Codes & Standards (PNNL 23618) applicable to ESS
- ▶ *SGIP Distributed Renewables, Generators and Storage working Subgroup C – Microgrids and Hierarchical Distributed Control 2-way exchange of information on Microgrids work and Volt-VAR work.*
- ▶ *SUNSPEC-MESA Energy Storage Forum – provide input to the Forum on Model Parameters hierarchy.*



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Summary

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- The protocol is recognized as the “go to” resource for assessing and comparing ESS performance on an apples to apples basis
- IEC TC120, the first International ESS Standards effort, has co-opted our work for its Performance Working Group and Grid Integration Working Group
- The DOE-OE Codes and Standards effort (PNNL 23618) is driving the TC120 gap analysis to guide future direction
- Engaged with IEC TC21 on New Work Item Proposals and Committee Drafts for ESS Standards
- Engaged with IEC TC105 on Flow Battery Standards Development, building on CENELEC effort
- EPRI ESIC Performance working group has co-opted our work
- Multiple stakeholders are test driving this Protocol in the US – this model will be extended to the IEC TC120 effort
- Participating in MESA SUNSPEC Energy Storage Forum to develop Models to represent BESS Parameter hierarchy

Questions and Contact Information

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www.pnnl.gov/main/publications/external/technical_reports/PNNL-22010Rev1.pdf - 1030k - 2014-06-24

Acknowledgements

- Support from US DOE Office of Electricity Delivery & Energy Reliability - Dr. Imre Gyuk, Energy Storage Program Manager
- PNNL Contributors
 - Alasdair Crawford, Matthias Engels, Jason Fuller, Sri Gourisetti, Trevor Hardy, Landis Kannberg, Francis Tuffner
- External Contributors
- Sandia National Laboratory
 - Summer Ferreira, David Rosewater, David Schoenwald
 - Various DOE-OE ESS Protocol working groups for each application
 - DOE-OE ESS Protocol Performance metrics measurement working group
 - IEC TC 120 working groups
 - Performance working group
 - Grid Integration Working group
 - Gap Analysis Working Group
 - EPRI ESIC – Use Case Analysis, Performance, Grid Integration WGs
 - Smart Inverter Working Group (Volt-VAR)
 - PV PCC voltage data received from Sandia National Laboratory
 - SGIP DRGS SubGroup C - Microgrids
 - NEMA for collaboration on International SDOs.