Sharing Best Practices and Capacity Building on the Role of Battery Energy Storage Systems (BESS) Standards in Promoting Safety, Energy Resilience and Sustainability

APEC Sub-Committee on Standards and Conformance

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Note:
Various terms referenced in this report do not imply the political status of any APEC economy.

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1. Executive Summary

Energy is the foundation on which the world's economies are built upon. Recognizing that the world's current energy systems are the primary energy driver of climate change, the greatest existential threat faced by the world, APEC and its member economies have identified and committed ambitiously to the long-term agenda of accelerating the clean energy transition. Economies' will to invest in technologies that will enable the increased adoption of renewable energy sources is propelling the market for battery energy storage systems (BESS) globally.

Battery storage is recognized as the most viable solution to the challenges brought about by the inherently intermittent nature of renewable energy sources. The flexibility BESS provide makes BESS an increasingly critical resource for grid integration within domestic energy systems[1]. BESS will eventually be integral to applications such as optimization of energy consumption at scale, backup power in the event of outages, and peak shaving, amongst others. All these have positioned the BESS market as one with significant economic opportunities, with the global BESS capacity likely to quintuple between 2023 and 2030[2]. The BESS market will also have spillover growth impact on adjacent markets, such as that of clean energy generation, electric mobility, battery repurposing, and more.

Both standards and conformance (S&C) play big roles in supporting the implementation of BESS within APEC economies, in particular mitigating safety risks of BESS, which in turn support regulatory efficiency and enhance public acceptance of BESS to accelerate environmental protection and implementation of energy reliability policies. Other benefits include boosting the quality, performance and interoperability of BESS infrastructure. At present, a common concern associated with BESS is the fire hazards brought about by possible thermal runaway incidences, which can be severe, life-threatening, easily propagatable and difficult to put out. There have been 63 BESS failure events between 2011 to 2023[3], some of which have resulted in thermal runaway. Notable incidents are the BESS explosion in Surprise, Arizona[4] which led to four firefighters being injured in 2019, and the series of 28 consecutive battery fires in Korea between 2017 and 2019[5].

Safety research of BESS is pivotal to enabling the implementation of BESS at scale, through the conduct of objective investigation into the risks BESS pose to the public. Safety research explores the benefits and hazards of the underlying BESS technologies, and enables the pursuit of answers to mitigate identified hazards. Such discoveries serve as the scientifically-based and technologically-agnostic foundation to S&C programs. For instance, the post-incident investigation of the BESS explosion in Surprise, Arizona and subsequent research results were fed to the BESS standards developed by both UL Standards & Engagement (ULSE) and the International Electrotechnical Commission (IEC). The vibrant research scene in APEC economies also covers other aspects of BESS, such as simulation and modelling,

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[1] ADB East Asia Working Paper Series: Designing a Grid-Connected Battery Energy Storage System: https://www.adb.org/sites/default/files/publication/880116/eawp-062-battery-energy-storage-system-mongolia.pdf

[2] McKinsey Energy Storage Insight, BESS Market Model: https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/enabling-renewable-energy-with-battery-energy-storage-systems

[3] Electric Power Research Institute, BESS Failure Event Database: https://storagewiki.epri.com/index.php/BESS_Failure_Event_Database

[4] FSRI Report: Four Firefighters Injured in Lithium-Ion Battery Energy Storage System Explosion - Arizona

[5] PV Magazine: What's behind Korea's Battery Fire Accidents?

novel materials, grid storage, battery reliability, R&D commercialization, deployment and implementation, recycling and repurposing, amongst others.

Regulations and policies – in the form of standards, codes, guidelines, schemes – hence serve as crucial enablers and levers to ensure the safe and secure deployment, operation and maintenance of BESS. The International Fire Code, National Fire Protection Association (NFPA) codes, BESS-related standards (e.g. UL 9540, IEC 62933-5-2) by renowned standards development organizations ULSE and the IEC, Chinese Taipei's Voluntary Product Certification (VPC) scheme for BESS sites, Australia's Design Guidelines and Model Requirements for renewable energy facilities are all noteworthy examples of regulatory levers implemented to enhance the safety of and minimize the risks present in the global BESS landscape. Completing the regulations and policies implemented are the suite of conformity assessment programs that provide assurance to stakeholders installed BESS infrastructure are safe for operationalization as stipulated in the renowned standards. Given the wide range of standards across the battery value chain that could aid economies to scale up operationalization of BESS infrastructures, harmonization of standards and mutual recognition agreements (MRAs) between economies could be beneficial in reducing compliance costs and time-to-market. Importantly, the roles research play in uncovering risks and corresponding solutions to emergent energy storage technologies should not be understated.

End-of-life (EoL) battery is also a key topic of interest for APEC economies as disposal of batteries used within BESS infrastructures comes with negative environmental implications. The common approaches are repurposing (second-life), remanufacturing (back to the same application), and recycling. With the increased demand for BESS, the demand for second-life batteries is correspondingly expected to grow significantly in Asia, which could be hampered by safety concerns due to the battery aging process. To mitigate the risks, APEC economies are looking into implementing standards including UL 1974, IEC 62933-4-4 and IEEE P 2993, and policy levers such as Extended Producer Responsibility. In comparison, standardization for recycling is nascent where APEC economies are still focusing on research.

Recognizing the significant role private sector plays in BESS deployment, research as well as contribution to S&C program development, several economies have developed industry consortiums and associations, such as Singapore; Thailand; and the United States. Besides influencing codes and standards development, such establishments are effective in driving public-private partnerships, providing networking opportunities, and nurturing local ecosystems, among others. With firsthand BESS deployment experiences, industry players are well-positioned to drive the safety innovation and share learning points of failure events.

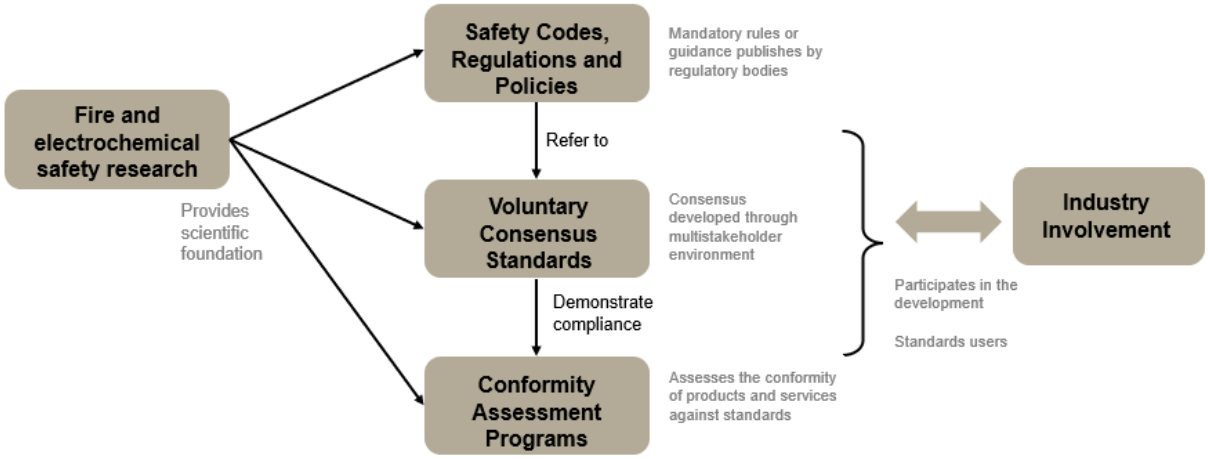

Figure 1: Interrelation of Research, Standards, Conformity Assessment and Industry Involvement supporting BESS Development in APEC region

This project has seen common challenges to implementing BESS at scale brought up by APEC economies' stakeholders, such as insufficient technical understanding of the standards and codes available to address the safety risks of BESS, lack of conformity assessment programs hindering BESS implementation, and insufficient access to research. As such, it is recommended that APEC economies continue to provide one another with the tools, resources and capacity to propagate technical knowledge of BESS and related codes and standards at scale. More collaboration and partnerships between APEC economies, across the areas of regulation and policy, standards development, research and technical assistance, would be key to bolster APEC's capabilities to implement BESS at scale.

2. Introduction

2.1 Background

The workshop on sharing best practices and capacity-building on the **role of battery energy storage systems (BESS) standards to promote safety, energy resilience and sustainability** is an APEC project held under the ambit of the Sub-Committee on Standards and Conformance (SCSC). It is overseen by the Office of the United States Trade Representative (USTR), UL Research Institutes (ULRI) and ULSE. This project was supported by co-sponsoring economies which include Australia; Indonesia; Japan; New Zealand; The Philippines; Singapore; Chinese Taipei; and Thailand.

Access to renewable and clean energy sources is gaining prominence as an economic priority, as the APEC region and economies globally implement their net-zero transition plans in efforts to combat climate change. A common concern associated with the increased use of renewable energy technologies for energy production is the intermittent availability of energy, particularly for sources which are weather-dependent such as solar and wind. BESS, a type of battery system which receives and stores electrical energy for later use on-demand, has become a broadly-accepted solution to overcome issues of energy intermittency and support the stability of energy supplies.

There are, however, hazards involved in the usage of BESS such as thermal runaway, stranded energy, lack of standardized testing environments, and electrical abuse, amongst others; with the increased interest and projected increased installation[6] of BESS by industry and governments across global economies, it would be imperative that stakeholders understand the safety risks associated with the usage of BESS. This project will facilitate stakeholders' understanding of how standardization and conformity assessment can help mitigate the safety risks, thereby supporting the implementation of BESS against the backdrop of economies making the transition towards adopting renewable and clean energy at scale.

Thailand's APEC 2022 priority of "Balance in all Aspects" calls for the exchange of perspectives on the most pressing issues facing Asia-Pacific, particularly on climate change and sustainability. This project supports the priority through the sharing of the latest knowledge, research and trends concerning the adoption and installation of renewable energy infrastructure. Additionally, this project also supports the objectives of the APEC SCSC, *viz* (i) aligning domestic economies' standards with international standards, and (ii) encouraging participation in standards education and awareness programs to build capacity and capability to enhance the competitiveness of businesses, including micro, small and medium enterprises (MSMEs).

2.2 Project Objectives

The project aimed to (i) facilitate the sharing of the latest standardization and conformity assessment trends concerning BESS, including the knowledge exchange of best practices, initiatives, policies and case studies within APEC economies; (ii) raise awareness on the importance having enablers such as quality infrastructures could support the adoption of BESS at scale; and (iii) build capacity on clean energy-related topics, particularly for the MSMEs of APEC economies.

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[6] BloombergNEF estimates that energy storage installations globally will reach a cumulative 358 gigawatts/1,028 gigawatt-hours by the end of 2030, more than twenty times larger than the 17 gigawatts/34 gigawatt-hours reached at the end of 2020.

2.3 Project Approach

Pre-Workshop Baseline Research and Survey (March – April 2023).

In the initial phases of the project, desktop research as well as a pre-workshop survey were conducted to ascertain the BESS landscape across APEC economies. The desktop research delved into the implementation progress of international standards, codes, regulations, and policies related to BESS across APEC economies, that would support economies' net-zero transition strategies and targets. The desktop research was validated and supplemented by a pre-workshop online survey that was disseminated to target participants; the survey included questions that aimed to derive deeper insights on APEC member economies' existing policies and technical regulations relating to clean energy and BESS adoption, as well as knowledge needs regarding BESS standards, codes, and safety risks mitigation challenges.

Workshop Preparation (May – July 2023).

The workshop program was designed based on the findings of the desktop research and responses received from the pre-workshop survey. Gaps in APEC economies' BESS landscapes were identified, as well as the knowledge that stakeholders wanted to gather from the workshop. The designed program comprised of dedicated segments that delved into BESS initiatives by standards development organization (SDOs), BESS-related codes and policies implemented by APEC economies, the BESS research landscape, good practices on BESS-related conformity assessment programs and standards use, and the trends on batteries. Aside from knowledge sharing by the engaged speakers, participants would be invited to share their thoughts and views in a breakout discussion.

Speakers engaged to speak in the workshop were identified in consultation with the co-sponsoring economies of the project and other APEC economies with huge interest in the BESS field. To achieve gender balance, female speakers were prioritized.

Workshop and Post-Workshop Survey (August – September 2023).

The workshop was held over two full days over 4 and 5 August. Participants were from the APEC economies, who hailed from varied backgrounds and have stakes or a keen interest in BESS, *viz*. (i) public policy and regulatory officials; (ii) representatives from standards and conformity assessment bodies; (iii) professionals from the private sector and industry associations; and (iv) academia and representatives from research institutions. Delegates from other APEC functional groups were also invited to the workshop. Following the workshop, a post-workshop survey was disseminated to solicit feedback on the workshop's program, content and areas of improvement. Information from the different phases of the project was fed into this final report.

3. Desktop Research

The pre-workshop baseline desktop research was the first phase of the project. The research involved delving into the current BESS landscapes of APEC economies, and how BESS policies and practices relate to economies' broader clean energy strategies and ambitions. For individual APEC economies, researchers identified the implementation case studies, enabling policies as well as the regulations and standards that support the development of BESS and BESS-related industries. The researchers also laid out APEC economies' BESS landscapes within the context of the economies' net-zero transition strategies, plans and targets.

Across the APEC economies, BESS was commonly identified as a solution that could enable economies to meet domestic net-zero or clean energy transition ambitions. The government-directed initiatives enacted that represented commitment to the development of vibrant BESS domestic landscapes include the United States Department of Energy's Energy Storage Grand Challenge Roadmap, China's 14th Five-Year Plan: New Energy Storage Development Implementation Plan, Natural Resource Canada's Advanced Clean Energy Program - Battery Energy Storage pillar, Mexico's Smart Electric Grids Program, Australian Renewable Energy Agency's funding program, Singapore Energy Storage System Technology Roadmap, and Thailand's Feed-in-Tariff scheme for renewable energy. Most APEC economies have commissioned, or are in the midst of progressing pilot implementation or controlled-scale projects of BESS. High-profile, established BESS projects include (i) the United States Moss Landing Energy Storage Facility, the world's largest lithium BESS project, wherein a total capacity expansion to 750MW/3,000MWh was recently announced in August 2023; (ii) Australia's Victorian Big Battery, a 300MW/450MWh grid-scale battery storage project in Geelong, Victoria, which can store enough energy to power more than one million Victorian homes for 30 minutes; (iii) China's largest environmental desert control photovoltaic (PV) project in the Kubuqi desert, equipped with 400 MW/ 800MWh to enable sufficient collection of dew that could provide water for ecological restoration and agriculture development; and (iv) Singapore's Sembcorp Energy Storage System, a 285MWh facility which is also the largest in Southeast Asia. Several controlled-scale BESS projects have also been piloted within the past couple of years, such as (i) New Zealand's installation of a 35 MW BESS in Waikato, a joint investment effort by domestic electricity veteran WEL and renowned renewable energy infrastructure developer Infratec; (ii) Peru's successful commissioning of a 31MWh BESS for a thermoelectric power plant in Chilca; (iii) the launch of the Philippines' first and largest BESS network spanning 32 battery storage stations with a total of 1000MWh of power; and (iv) the launch of Malaysia's first locally-developed and produced BESS in April 2023 which could be scaled to meet various domestic industries' needs .

While the proliferation of BESS projects and the growth of BESS landscapes across APEC demonstrate economies' serious commitment to the clean energy transition, the use of BESS presents new fire safety challenges. In the United States, there was a deflagration incident at a 2.16MWh lithium-ion BESS facility in Surprise, Arizona, which injured four firefighters in 2019[7]. In Australia, a battery pack of Victoria Big Battery caught fire while it was being tested in July 2021, likely due to coolant leakage during the commissioning phase. The blaze triggered a warning for toxic smoke, and it took four days for the site to be declared under control by firefighters[8]. The investigation findings of both incidents underlined the important roles S&C infrastructure could play in supporting the safe development, implementation and installation of BESS and related components.

[7] https://fsri.org/research-update/report-four-firefighters-injured-lithium-ion-battery-energy-storage-system

[8] https://victorianbigbattery.com.au/2022/01/31/independent-report-released/

On leveraging standards and codes to safely implement and operationalize BESS infrastructures, in some economies such as Australia; Canada; Singapore; and the United States, requirements for the safe design and installation of ESS are contained with the economies' fire and electrical codes. Examples include the International Fire Code (IFC) developed by the International Code Council (ICC), and the NFPA 855 for the Installation of Stationary Energy Storage Systems developed by the National Fire Protection Association (NFPA). These two codes make reference to BESS system and product standards, such as UL 9540 Energy Storage Systems and Equipment, UL 9540A Evaluating Thermal Runaway Fire Propagation in BESS, and UL 1974 for repurposed batteries. Other commonly referenced international standards for BESS by standards and policy making bodies are the IEC 62933 series for Electrical energy storage (EES) systems, IEEE 2030.2.1-2019 Guide for Design, Operation, and Maintenance of Battery Energy Storage Systems, both Stationary and Mobile, and Applications Integrated with Electric Power Systems, among others.

Additionally, several APEC economies have also enacted government-sponsored initiatives or established public-private collaborations to facilitate the circular economy for batteries, such as repurposing electric vehicle batteries for BESS and recycling. Example initiatives and collaborations of such include (i) Nissan and East Japan Railway Company's collaboration (ii) the MoU between Kia Motors and SK Innovation to explore the follow-up use of end-of-life EV car batteries as stationary energy storage units, as well as the recycling of battery materials such as lithium, nickel and cobalt; (iii) Singapore's launch of an EV Battery Testing and Disassembly Line to develop key battery remanufacturing processes and systems solutions; and (iv) Canada's establishment of the Call2Recycle program, the economy's largest battery recycling program

The findings from the desktop research fed into designing next phase of the project – the pre-workshop survey.

4. Pre-Workshop Survey

The purpose of the pre-workshop survey was to seek views from stakeholders across APEC economies to understand the current landscape (i.e. policies, regulations, projects) of clean energy infrastructure, the operationalization and implementation of BESS, and views on how the harmonization and use of BESS-related standards and codes could support member economies to accelerate their transition to clean energy.

In total, five responses were received. The following supplementary information was received through the pre-workshop survey:

Chile. Chile has also adopted a binding goal of net-zero emissions by 2060, through the Climate Change Framework Law. To enable the achievement of the broader binding ambition, Chile's congress has enacted the Renewable Energy Storage and Electromobility Law in October 2022, which will compensate standalone storage projects for injecting electricity into the grid and address issues of intermittency. In the pipeline of BESS projects, the Chilean National Energy Commission has committed to releasing a USD211 million battery storage tender, which will control power flow along the 500kV lines that connect the Lo Aguirre and Parinas substations; there is also intention to launch a bill that will enable the procurement of large-scale ESS for commissioning in 2026 totaling approximately USD2 billion in investments. References to appropriate standards are being considered for future amendments to the Renewable Energy Storage and Electromobility Law.

Japan. To meet the economy's net-zero emissions goal by 2050, Japanese firms have been accelerating investments in battery storage projects, as the Government gears up efforts to expand intermittent renewable power sources. Japan has been a strong proponent of international standards as a viable solution to global demands of methods in which industries are able to assess the safety of large-scale stationary ESS due to fire accidents or system failures. Demonstrating the economy's commitment to contribute to the development of international standards, Japan submitted a draft proposal to the IEC for the safety of large scale stationary electrical ESS, which culminated in the formation of IEC Technical 120, who consequently developed the IEC 62933-5-2 standard. Broadly, Japan makes reference to IEC standards to develop corresponding safety standards for ESS and batteries. For instance, the development of the JISC 8715 standard series was revised and compiled according to IEC 62619, while JISC 8712 was revised according to IEC 62933. Japan is also looking to secure battery materials to 150GWh/year by 2030, to boost domestic lithium-ion battery production and consequently, drive a vibrant battery economy where batteries could be used across the various applications of electric vehicles, stationary storage batteries and as exports to other economies.

Malaysia. The Government has pledged for the economy to emit net-zero emissions by 2050, and to do so, it was important for Malaysia to rethink how energy could be generated, distributed, stored, supplied and consumed. BESS was identified as one of the solutions which could enable and support the energy transition, in that BESS could maximize large-scale and large capacity storage of energy. Malaysia's first BESS – developed and produced through the special purpose vehicle Citaglobal Genetec BESS – was launched in April 2023. At present, given the nascent nature of BESS in the economy, Malaysia has adopted IEC 62133 as Malaysian standard for secondary cells and batteries, and references IEC 62619 and IEC 62620 in other related policy guidelines. While binding technical regulations and codes are still in development, the Ministry of Domestic Trade and Costs of Living issued the Guidelines on Secondary Battery Safety Standard Compliance in 2018.

Thailand. To bolster the energy sector's concurrent contributions to economic growth and enabling the economy to meet its net zero emissions goal by 2065, the Ministry of Energy has prepared a 2023-2032 action plan to promote the economy's BESS industry, consisting of four multi-strand strategies with fifteen approaches. Key highlights of the strategies and approaches include promoting and intensifying investments in BESS infrastructure to drive more BESS installations, improving the enablement landscape (i.e. legal processes, regulations, standards) to enhance attractiveness of the BESS industry to foreign investors, and creating a vibrant research and development ecosystem for BESS. Thailand has already made headways in implementing this plan. The Thai Industrial Standard Institute (TISI) has developed two mandatory standards and fifteen voluntary standards relating to BESS; the mandatory standards are TIS 2217-2548 (Secondary cells and batteries containing alkaline or other non-acid electrolytes –Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications) and TIS 2879-2560 (Portable power bank – safety requirements), while the voluntary standards span batteries for other applications, electric vehicles and photovoltaic modules. At present, Thailand is investing in growing the research landscape for energy storage and electric vehicles; for instance, the Thailand Energy Storage Technology Association is actively bringing together private, academia and public players across the battery value chain to collaborate on, educate stakeholders about and nurture technological advancement in the BESS industry.

In general, APEC economies identified safety, interoperability and environmental protection, as the most important areas of concern with which BESS-related standards can address. To support further development and adoption of BESS standards, APEC economies require more research and data in ascertaining the potential of international standards to be a viable solution to BESS-related challenges, technical knowledge and training to develop relevant conformity assessment programs and schemes, and would like to encourage more stakeholder participation in international standards development work.

5. Workshop Proceedings and Discussions

The workshop was a two-day in-person event held over 4-5 August 2023; a tailored program was designed and executed to share best practices amongst stakeholders and build capacity across APEC economies, to collectively enhance stakeholders' knowledge on the role's standards could play to promote the safety, energy resilience and sustainability of BESS-related infrastructure. Broadly, the expected outcomes of the workshop were to (i) increase participants' understanding on how standardization could drive the implementation of BESS; (ii) provide policy-makers with the knowledge on how BESS implementation challenges could be overcome; (iii) drive thought leadership on the latest standardization, risks, research and conformity assessment trends to do with BESS; and (iv) promote communication and the exchange of best practices on BESS-related policies, initiatives and plans amongst APEC economies' stakeholders.

The workshop program included several content sessions with expert sessions, moderated panel discussions, open participant question and answer segments and smaller group break-out segments. The workshop was attended by approximately 61 participants from 14 APEC member economies. Participants hailed from varied backgrounds relevant to BESS and standards, *viz* government officials (i.e. policymakers, regulators), standards practitioners from standards and conformity assessment bodies, private sector and civil society influencers, technical expert representatives from research institutes and academia, as well as representatives of other APEC and APEC-related groups and committees.

The workshop comprised of 6 segments:

- Opening Remarks and Keynote Speeches
- Session 1 – BESS Initiatives by Standards Development Organizations (SDOs)
- Session 2 – APEC Economies' Approach to BESS Codes and Policies
- Session 3 – Research Supporting BESS Development
- Session 4 – Conformity Assessment for BESS
- Session 5 – Standards Supporting Circular Economy and Cascade Use of Batteries
- Session 6 – Good Practices on the Use of Standards and Conformance in Industry to Support BESS within APEC Economies

The agenda of this workshop can be found in Annex 1.

5.1 Opening Remarks and Keynote Speeches

The workshop was opened by **Mr Kent Shigetomi, Chair, APEC Subcommittee on Standards and Conformance**, and **Mr Terry Brady, President and CEO, UL Research Institutes**, while **United States Department of State Representative for APEC Ms Angeline Bickner**, **Dr Lori Moore-Merrell, United States Fire Administrator** and **Dr David Steel, Executive Director, UL Standards & Engagement** delivered keynote addresses.

The keynote speakers and the salient points of their speeches were:

United States Department of State Representative for APEC Ms Angeline Bickner shared the United States' theme and priorities for APEC 2023. The theme, "Creating a Resilient and Sustainable Future for All" centers around three priorities. They are (i) Interconnected – Building a resilient and interconnected region that advances broad-based economic prosperity; (ii) Innovative – Enabling an innovative environment for a sustainable future; and (iii) Inclusive – Affirming an equitable and inclusive future for all.

Dr Lori Moore-Merrell, United States Fire Administrator shared about the United States Fire Service's Strategy in achieving its mission of preventing and controlling fires, as well as what is next on the Service's radar. Within the upcoming priorities for government-to-government collaboration areas, technology challenges such as safety hazards associated with the use of lithium-ion batteries were identified.

Dr David Steel, Executive Director, UL Standards & Engagement shared about the roles BESS plays towards increasing economies' usage of renewable energy, notwithstanding the risks that wide-scale implementation of BESS comes with. Dr Steel emphasized standards as a solution, which could address the safety challenges of BESS.

5.2 Session 1 – BESS Initiatives by Standards Development Organizations (SDOs)

This content session saw expert presentations of existing standards development initiatives and projects relating to BESS from major SDOs across APEC economies. The follow-on discussion panel was moderated by **Ms Ebonique Barker, Government Affairs Lead, UL Research Institutes**.

The expert speakers and the salient points of their presentations and the panel discussion were:

Ms Anna Tanaka, representing the **National Institute of Technology and Evaluation (NITE) of Japan**, presented on the IEC standards relating to batteries and electrical energy storage systems (EESS). The context of the presentation was set against breaking down the drivers of BESS failure events – mainly thermal runaway– which could consequently lead to fire, explosion and generation of toxic gas, and flammable gas. On Japan's involvement in standardization activities at the IEC, Japan served as the secretariat to TC 120, which oversees standards development in the field of grid integrated EESS. Worth noting was that IEC BESS-related standards, 62933-5-2 (Safety requirements for grid-integrated EES systems - Electrochemical-based systems) which was published in 2020, and 62933-5-3 (Safety requirements for grid-integrated EES systems – Performing unplanned modification of electrochemical based system) which was expected to be published in early 2024[9]. These standards took into consideration the learning points of the past BESS incidents, especially the incident in Surprise, Arizona. Ms Tanaka shared Japan's experience in adopting IEC 62933-5-2, as well as designing the conformity assessment programs to this standard. To support the testing of BESS in Japan, NITE Japan owns a facility called the National Laboratory for Advanced Energy Storage Technologies (NLAB).

Dr George Borlase, Vice President of Standards Development, UL Standards & Engagement, provided an introduction of ULSE as a global nonprofit SDO. UL Standards are developed through technical committees with independent experts. UL standards could address challenges for the global clean energy value chain, which cuts across five key clean segments – clean energy generation, distributed energy systems and interconnection, energy storage systems and batteries, electric vehicles, and the circular economy. Dr Borlase then delved into several UL standards that address the potential energy, electrical, mechanical and chemical hazards associated with the use of lithium-ion BESS, notably:

- UL 9540, Energy Storage Systems and Equipment (Ed. 3 published in June 2023);
- UL 9540A, Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems (Ed. 4 published in November 2019); and

[9] IEC 62933 was published on 10 October 2023, earlier than expected.

- UL 1974, Evaluation for Repurposing Batteries[10].

Dr Judy Jeevarajan, Chair of the IEC Subcommittee (SC) 21A on Secondary Cells and Batteries Containing Alkaline or Other Non-acid Electrolytes, and Vice President and Executive Director of UL Electrochemical Safety Research Institute, shared her report on the status of IEC SC 21A, which is under IEC Technical Committee (TC) 21 on Secondary Cell and Batteries. The scope of this SC is to prepare standards on product and test specifications for all secondary cells and batteries of sealed and vented designs containing alkaline or other non-acid electrolytes, and to support other technical committees standardizing application-oriented systems using secondary cells and batteries. The SC is represented by 27 participating economies, including 8 from APEC region, and 13 observer economies. There are currently 7 Working Groups (WG) under the ambit of this SC, focusing on work items for new secondary batteries standards[11].

Mr Jay Illescas, Chief, Product Testing Division of the Bureau of Philippine Standards provided an overview of the Philippine National Standards (PNS) across the areas of EV batteries, secondary cells and batteries, secondary cells and batteries containing alkaline or other non-acid electrolytes, primary cells and batteries, and other related standards. Mr Illescas also spoke about the Philippines' mandatory product certification scheme for automotive batteries, which included a sharing on the scheme's product coverage, as well as the PNS referenced by the scheme. In the medium-term, the Philippines intends to boost domestic product testing capabilities in EV battery testing, photovoltaic system battery testing, as well as explore appropriate standards across the emergent industries of solar power, wind power and EVs.

5.3 Session 2 – APEC Economies' Approach to BESS Codes and Policies

This content session saw expert presentations on a selection of APEC economies' policy and regulatory approaches towards managing BESS fire risks, as well as economies' experiences adopting these approaches. The follow-on discussion panel was moderated by **Dr Steve Kerber, Vice President of UL Research Institutes and Executive Director of UL's Fire Safety Research Institute (FSRI)**.

The expert speakers and the salient points of their presentations and the panel discussion were:

In response to the need for modern solutions to be provisioned to address the emergent fire risks brought about by high-voltage lithium-ion batteries and BESS, **Dr Lori Moore-Merrell, United States Fire Administrator** shared about the Administration's partnership with UL's FSRI and the United States Department of Homeland Security Science and Technology Directorate (DHS S&T) to develop and implement the National Emergency Response Information System (NERIS) for use by fire and emergency services departments economy-wide. NERIS is the premier source of all hazard-related information with in-built analytics capabilities, and aims to provide fire and emergency services authorities with near real-time information on fire and emergency incidents across the United States. NERIS also enables stakeholders to document and introduce community fire and emergency risk reduction efforts, as well as provide insights into vulnerability gaps where resources can be directed towards

[10] UL 1974 edition 2 was published in November 2023. The new edition includes requirements for both repurposing and remanufacturing batteries:
https://www.shopulstandards.com/ProductDetail.aspx?productId=UL1974_2_S_20231110
[11] https://www.iec.ch/dyn/www/f?p=103:7:510789591680552::::FSP_ORG_ID,FSP_LANG_ID:1410,25

minimizing future emergency and disaster events. Following a demonstration of how fire and emergency authorities could leverage on NERIS' data to reduce fire and emergency risks for communities at-large, Dr Moore-Merrell emphasized the need to resource fire departments with appropriate solutions to address fires brought by emerging technologies.

Dr Steve Kerber, Vice President of UL Research Institutes and Executive Director of UL's Fire Safety Research Institute (FSRI) provided an introduction of UL FSRI and its five priorities which include battery fire safety, together with others such as firefighter health and safety, fire dynamics and materials, wildland urban interface, and fire modelling. He presented analyses of BESS-related fire incidents, including a detailed breakdown of the BESS fire incident that occurred in Surprise, Arizona. Aside from laying out the trajectory of how the Surprise BESS fire incident evolved, Dr Kerber comprehensively covered the factors that led to the incident, as well as the corresponding recommendations developed by UL FSRI for fire safety researchers and firefighters[12]. Further, the test methods and UL FSRI's experience conducting the BESS fire tests as specified by UL 9540A was expounded on. UL FSRI has published a series of useful resources about fire safety of batteries and electric vehicles, which can be found on its website[13].

As a follow-up from Dr Kerber's sharing on BESS fire incidents and UL FSRI's experience in conducting BESS fire tests specified by UL 9540A, **Mr Sean DeCrane, Director, Fire Fighter Health and Safety Operational Services for the International Association of Fire Fighters (IAFF)** detailed two recent projects related to fires in part driven by lithium-ion batteries. They are (i) an assessment of the potential impact of residential lithium-ion BESS on incident response, a collaboration between the United States Department of Energy, IAFF, UL FSRI and UL Solutions, and (ii) an investigation of lithium-ion batteries' explosion hazards, a follow-up project to (i) led by UL FSRI and UL Solutions. Mr DeCrane delved into the various test procedures undertaken as part of the projects, and the demonstrated results of the tests. Mr DeCrane also provided an introduction of the existing codes and standards for the safety of BESS, including the International Fire Code (IFC), NFPA 855, UL 9540, and UL 9540A, which are commonly adopted as regulations in the United States. These publications are regularly revised to keep up with technological advancements, and are based on research projects, industry feedback and learnings from past incidents, such as the incident in Surprise, Arizona. The sharing was topped off with calls to fire chiefs to regularly document, develop and update community risk-assessments and procedures of extreme-risk incidents.

Mr Matthew Allen, Specialist Risk and Fire Safety Manager of the CFA, provided Australia's perspective on managing BESS-related fire incidents. Mr Allen spoke to Victorian firefighters' adherence to the CFA's Design Guidelines and Model Requirements for Renewable Energy Facilities[14], as an approach of pre-emptively reducing and managing fire risks of the economy's BESS facilities. A large number of other jurisdictions within Australia have also adopted the CFA Guidelines. These guidelines play a pivotal role due to the fast-growing number of BESS installations across Australia. The sharing spanned various sectional requirements of the guidelines, *viz* fire risk management, facility location and design, facility construction and commissioning, facility operation, emergency planning, commercial and industrial BESS, and neighborhood BESS. The guidelines call out the use of codes and standards to reduce the risk of BESS fire, which includes NFPA 855, UL 9540, UL 9540A and FM Global Property Loss Prevention Data Sheet 5-33 Electrical Energy Storage Systems.

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[12] https://fsri.org/research-update/report-four-firefighters-injured-lithium-ion-battery-energy-storage-system

[13] https://fsri.org/research/fire-safety-batteries-and-electric-vehicles

[14] https://www.cfa.vic.gov.au/plan-prepare/building-planning-regulations/renewable-energy-fire-safety

5.4 Session 3 – Research Supporting BESS Development

This content session saw expert presentations on the future trends of ESS and related research, the latter often being recognized as a baseline for potential standards development and design of conformity assessment systems. The follow-on discussion panel was moderated by **Ms Ebonique Barker, Government Affairs Lead, UL Research Institutes**.

The expert speakers and the salient points of their presentations and the panel discussion were:

Dr Judy Jeevarajan, in her capacity as **Executive Director of UL's Electrochemical Safety Research Institute (ESRI)**, presented on the current industry and research advances in energy storage that could lead to a sustainable future. She shared that ESRI, based out of Houston, Texas, is part of a larger enterprise driven by a mission of working for a safer world. ESRI's programs and initiatives include convening battery safety summits, forums, symposiums, webinars and campaigns; sharing expertise in standards development initiatives; and brokering participation in research collaborations. She stressed that these programs and initiatives are of increasing importance as the risks of battery energy storage grow in tandem with available energy capacity, which could result in more fire incidents. On the research front, ESRI has a series of projects which are focused on safety research (including recycling), simulation and modeling, and novel materials and new energy forms; research projects are often executed in partnership with major research bodies within the United States and APEC region.

Dr Vince Sprenkle, **Strategic Advisor, Pacific Northwest National Laboratory**, provided an overview of the standards referenced by the Laboratory to support multiple activities, such as facilitating transfer of storage R&D to industry commercialization, development of grid storage infrastructure and technologies, and the conduct of battery reliability tests. Dr Vince also particularly highlighted the Grid Storage Launchpad being developed by the laboratory, which could accelerate development of battery technologies through enabling rigorous performance testing across scales.

Mr Biatna Dulbert Tampubolon, representing the **National Research and Innovation Agency of Indonesia**, shared about Indonesia's plans to develop ESS infrastructure, as well as Indonesia's research needs to enable the development of local standards and conformity assessment programs that could enable the ESS industry.

Prof Yossapong Laoonual, Associate Professor at King Mongkut's University of Technology Thonburi (KMUTT) representing the **Thailand Energy Storage Technology Association,** highlighted various Thai entities' and stakeholders' initiatives and capabilities to drive R&D in battery. Academic institutions such as the National Energy Technology Centre (ENTEC), Khon Kaen University, and the Mobility & Vehicle Technology Research Centre have been building up capabilities in material development, production, and testing; while private sector entities such as the Nuovo and PTTEP have been involved in projects relating to battery product and process development, and green energy technologies. Prof Laoonual also brought up the Thailand Battery Swapping Platform Project as a use case of Thai stakeholders working in partnership to enable the translation of battery R&D to commercialization.

5.5 Session 4 – Conformity Assessment for BESS

This content session saw expert presentations on how conformity assessment programs by third-party conformity assessment bodies, as well as mutual recognition arrangements, could enhance the efficiency of implementing BESS-related regulations and codes. The follow-on

discussion panel was moderated by **Mr Kolin Low, Regional Director, UL Standards & Engagement**.

The expert speakers and the salient points of their presentations and the panel discussion were:

Ms LaTanya Schwalb, Principal Engineer at UL Solutions, gave a broad overview of UL Solutions' testing and certification programs that could enhance the safety of BESS installations. Across the UL standards relevant to BESS, the standards mainly addressed the construction, performance, manufacturing, and production aspects of BESS. UL 1973, UL 9540, UL 9540A, and UL 1974 – and the scopes of these standards, as well as the NFPA 855 fire code and the chapters in the 2021 International Fire Code (IFC), were highlighted, as best installation practices for ESS.

Mr Graeme Drake, Secretary, Asia Pacific Accreditation Cooperation (APAC), provided an overview on the roles of accreditation and Mutual Recognition Arrangements (MRAs). Accreditation further supports the trust in conformity assessment results by determining a conformity assessment body's competence, impartiality and consistent operation based on the ISO/IEC 17000 series of standards. APAC, an APEC SCSC Specialist Regional Body (SBR), administers a MRA program and network where member accreditation bodies evaluate each other's accreditation activities for mutual recognition. APAC is also a recognized regional member for the Asia Pacific by the International Accreditation Forum (IAF), and International Laboratory Accreditation Cooperation (ILAC). Mr Drake said that recognition of the equivalence of conformity assessment results by domestic accreditation members under a MRA could avoid unnecessary resources expended on conformity assessment processes, facilitate market access, and provide added assurance to results of testing, inspection and certification activities for global acceptance.

Dr Yu-Ting Yen, representing the **Industrial Technology Research Institute**, **Chinese Taipei**, presented the economy's Voluntary Product Certification (VPC) scheme for BESS sites. Dr Yen walked through attendees on the end-to-end conformity assessment process for BESS sites certified under the VPC scheme, from pre-construction of BESS sites to post-installation operations and maintenance. As conformity assessment systems and programs for BESS across APEC are still in their early stages, Dr Yen cautioned that finding the appropriate conformity assessment and regulatory approach towards the management of BESS risks is likely to vary between economies.

5.6 Session 5 – Standards Supporting Circular Economy and Cascade Use of Batteries

This content session saw expert presentations by academia and research institutes on the latest trends regarding end-of-life and second-life batteries. The follow-on discussion panel was moderated by **Mr Kolin Low, Regional Director, UL Standards & Engagement**.

The expert speakers and the salient points of their presentations and the panel discussion were:

Mr Matthew Paiss, Technical Advisor, Pacific Northwest National Laboratory (PNNL), gave an overview of the economic potential of second-life battery use, particularly the repurpose of batteries from electric vehicles to BESS. The second-life battery market is estimated to be valued at USD7 billion by 2033, with an estimated CAGR of 44.7% till then; Asia is likely to lead this growth. The safety concerns with second-life batteries include potential of internal short circuit as the batteries age, loss of battery history data, lack of established validation testing protocols and ESS product safety standards for second-life use. The existing standards specifically for second-life batteries including UL 1974, IEC 62933-4-4

(Environmental requirements for battery-based energy storage systems (BESS) with reused batteries), IEEE P 2993 (Recommended Practices for Energy Storage System Design using Second-life Electric Vehicle Batteries). Mr Paiss shared about the second-life battery test pad commissioned by the PNNL to develop a test protocol that would requalify, and re-rate retired 7kWh mobile battery modules from bus fleets, for reuse in BESS.

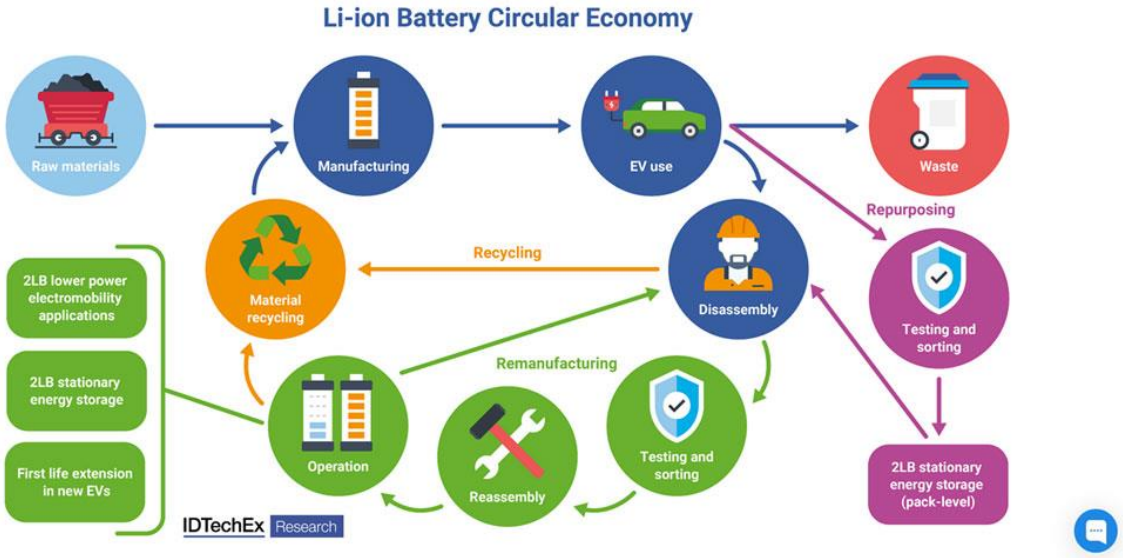

Figure 2: Li-ion Battery Circular Economy (Courtesy of: Mr Matt Paiss)

Dr Sohini Bhattacharyya, Research Fellow, Rice University, gave a detailed breakdown of the scientific recycling process of commercial grade batteries, which could be repurposed or remanufactured for various second-life uses. The recycling process most employed by researchers is based on extracting deep eutectic solvents (DESs), which enables spent commercial batteries of different chemistries to be recycled. However, more research is needed to optimize this DES-based process – particularly in terms of obtaining balanced lixiviant composition and process operating conditions – for this DES-based recycling process to be made economically viable. The battery academia community is presently working to fine-tune and optimize the DES-based recycling process, so that the correct morphology of recovered products can be obtained. On further research needed in this field, detailed technoeconomic analysis and life cycle analysis needs have been identified.

Dr Chiam Sing Yang, Director, Singapore Battery Consortium, spoke about the latest trends on battery end-of life processes, second-life battery deployment, and cascade use by academic, research institutions and industry. Following an introduction of the international standards and regulations with provisions on the reuse and repurpose of batteries, Dr Chiam shared Singapore's and EU's experiences implementing regulations to guide the proper manufacture and disposal of second-life batteries. For the former, e-waste is regulated based on the Extended Producer Responsibility approach, which is stipulated in the Resource Sustainability Act. For the latter, the newly approved EU Battery Regulation 2023/1542 (replacing the Battery Directive 2006/66/EC) was implemented to improve the environmental performance of batteries and accumulators. Further, Dr Chiam spoke about the ecosystem and stakeholder partnerships approaches Singapore has been taking in order to drive a vibrant battery repurpose value chain.

5.7 Session 6 – Good Practices on the Use of Standards and Conformance in Industry to Support BESS within APEC Economies

This content session saw expert presentations on how businesses, through S&C, have demonstrated their commitment to consumer safety, environmental protection, and sustainable development. The follow-on discussion panel was moderated by **Dr Chiam Sing Yang, Director, Singapore Battery Consortium**.

The expert speakers and the salient points of their presentations and the panel discussion were:

Dr Chiam Sing Yang, Director, Singapore Battery Consortium, shared the various S&C levers relating to BESS in Singapore. Technical Reference 77 (TR 77) was the first set of technical guidelines put in place to educate and guide consumers on the safe and reliable deployment of ESS in Singapore, and is the output of modified adoptions of IEC TS 62933-3-1: 2018 and IEC TS 62933-5-1: 2017. Singapore's Code of Practice for Fire Precautions in Buildings, Fire Safety Act and Electricity Act also include provisions specific to ESS, across the deployment, installation and inspection aspects. As a follow-up from his previous presentation on the circular economy, Dr Chiam reiterated that driving the successful growth of a vibrant BESS landscape requires an ecosystem approach – a collective effort from players across the battery value chain (i.e. cells, pack, end-of-life), end users of BESS, suppliers and manufacturers, conformity assessment and standards bodies, public agencies and institutes of higher learning.

Prof Yossapong Laoonual, representing the **Thailand Energy Storage Technology Association**, shared about developments in BESS in Thailand, including the standards and conformity assessment infrastructures to enable such developments. Thailand has a vibrant battery ecosystem, with more than 50 entities spread out across the battery value chain – mining and fining, materials and parts, cell and pack, system integration, recycle and second-life use, and testing. EV and BESS pack production facilities are owned and operated by large international and domestic players, namely Kuvolt, Nuovo, Energy Absolute, Mercedes-Benz and BMW. On conformity assessment, the Thai Industrial Standards Institute (TISI) has implemented a product certification system for batteries based on ISO / IEC 17067. At present, there are only two mandatory standards for batteries, TIS 2217-2548 and TIS 2879-2560 – which are based on IEC 62133:2002 and IEC 60950-1. There are a whole slew of voluntary standards relating to Thailand – close to 30, considering those published and those awaiting publication; Thailand hopes to convert some of these voluntary standards to mandatory status in due time, as the BESS landscape grows and there is greater impetus for safety risks to be managed.

Mr Charles Picard, Senior Engineer, Energy Product Applications, Tesla, shared Tesla's usage of design and architecture, conformance and compliance, and large-scale fire testing to design, manufacture and install industry-leading BESS. Tesla has a wide presence in codes and standard development activities globally to share their experiences in practical applications of regulatory frameworks, failure events, and support harmonization of codes and standards. Tesla is a leading proponent of large-scale fire testing and evaluation of the latest testing standards including UL 9540A, which provides critical information on the outcomes and impact of a failure and ensure the highest level of risk mitigation. Some of the safety standards Tesla adheres to include UL 1642, UL 1973, UL 9540 (Battery cell to BESS system), UL 1741 (Interconnection), IEC 62109-1 (Power Converter), IEC 62619 (Cell and Batteries) and AC 156 (Seismic Acceptance Criteria). As for certifications obtained to assure allowable emissions are limited globally, and environmental compatibility and safety, these include EN 61000 Class B, WEEE Directives on Weaste Electrical and Electronic Equipment, UN 38.3, and IEEE 693-2005, amongst others.

Mr Jonathan Stewart, Managing Director, National Electrical Manufacturers Association (NEMA), shared about the standards developed by the organization for the electro industry. These standards were highlighted, in particular, as best practices for the implementation of BESS, *viz* (i) NEMA US 80027-2023, which identifies safety issues and hazards, as well as provides best practices for testing the state of health of battery systems; (ii) NEMA BS 30000-2021, which identifies potential fire causes for lithium-ion batteries, suggests prevention and mitigation solutions, as well as raises post-fire management considerations; and (iii) NEMA ESS-1, which prescribes applications, performance metrics, test procedures and performance reporting.

5.8 Breakout Discussions

After hearing from the invited speakers, a breakout discussion was organized for the participants to reflect on the knowledge they gained from the speakers over the past six sessions, and brainstorm ideas to support BESS development within their economies. The participants were broken into five groups. Each group was assigned the same set of four questions.

Each of the breakout groups was asked to identify a chairperson who will lead the discussion, a notetaker to jot down the key discussion points, and a presenter to present the findings to the plenary.

The questions and salient points of the breakout discussion are:

5.8.1 What are the standards used in your economy? What else should be developed? What are the outstanding gaps that are required to be addressed through new standards developed or adopted? What are the challenges in adopting existing international standards?

The existing standards used and adopted within APEC economies for BESS are IEC, NFPA, UL, IEEE standards, which have been introduced by the speakers. UN standards are adhered to in the aspect of BESS transportation needs. There are also GBT standards in China.

Some of the gaps mentioned by the participants include lack of deep knowledge of standards for battery fire safety, slow End-of-Life battery (disposal, reuse, repurposing and recycling) value chain development, and lack of standards for cutting edge battery technologies such as compressed air and flow batteries.

It was noted in some developing economies, there were no standards for BESS yet, and these economies have only adopted standards at the battery cell level. There is potential to provide capacity building training for developing economies to adopt standards at the BESS level, including technical assistance on the existing international standards for BESS available, strengthening the capacity of testing facilities, raising awareness of BESS fire safety risks, among others.

5.8.2 What are the existing policies in your economy referencing Standards & Conformance (S&C) to support BESS development? What other policies should be developed?

In most APEC economies, the policies making reference to BESS S&C activities are subsumed under the broader policy framework or initiatives for renewable energy transition or battery manufacturing. Only a handful of economies had specific, standalone policies such as the Fire Codes in the United States, the Design Guidelines of CFA Australia, and the Voluntary

Product Certification scheme of Chinese Taipei; these were presented by the speakers during their earlier presentations.

In some economies, especially developing economies, such policies are only being considered new. There is an opportunity for these economies to take reference from the good practices from their APEC peers on the use of S&C to accelerate BESS development and policymaking. Some recommendations on how these economies could start were to develop BESS deployment roadmaps, commission pilot projects for BESS applications including indoor BESS, take reference from case studies on S&C implementation and related regulations, as well as open up more channels for stakeholders' exposure and access to S&C procedures.

5.8.3 What are the existing research and future needs for BESS in your economy? What are some of the challenges and opportunities for BESS research?

Currently, the research interests in APEC region are diverse. Some economies including China and the United States are driving novel material research such as Na-ion battery. There are some research initiatives on the performance of batteries for implementation within APEC economies, especially to suit specific climatic conditions or implementation within used environment such as residential. Research on end-of-life batteries, ranging from disposal, reuse, repurpose, remanufacture, recycle to decommissioning will gain more traction as the adoption of batteries increases. Cybersecurity for BESS is also raised by some participants.

Managing safety risks of BESS, including fire and chemical risks, is another significant area of interest for research. APEC economies are interested in large-scale fire testing to understand explosion and deflagration risks, fire suppression, failure management, and deployment in highly populated regions, amongst others.

Some participants raised the concern of research costs and capabilities. Hence, research collaborations across APEC economies could be effective to address the challenges and gaps. There is also a call for the developed economies to support their developing economy peers.

5.8.4 How can Standards & Conformance (S&C) support industry adoption of BESS? What are the pain points? What can we do to support industry involvement in codes & standards development and why is it important?

Standards are developed through a consensus approach, which allows for industry participation and input to produce a set of requirements acceptable to all actors including policymakers, authorities having jurisdiction, industry, academia, etc. Generally, the large industry players are involved.

S&C can build public trust in the safety of BESS, reduce failure incidents that form negative impression among citizens, to support the deployment of BESS and related infrastructure for APEC economies to move closer to meeting their clean energy transition goals. S&C can also play a part in boosting the confidence of industry in the BESS landscape, to crowd in more private sector investments. Finally, S&C enables the establishment of common definitions for performance and safety, thereby raising the bar for implementation, operationalization and maintenance of BESS for the industry.

The challenges include the burden of conformity assessment, especially given the current lack of conformity assessment infrastructures within APEC region. The industry may also encounter the issue of having too many BESS-related standards published, which makes it difficult for key stakeholders (e.g. policymakers, regulators, domestic standards bodies) to identify the appropriate ones to study and review for adoption. Besides the baseline safety or

performance standards, good performing industry players have needs for high-end performance or rating standards in order to benchmark themselves, which can incentivize industry players to invest in more cutting-edge BESS development. Harmonization of standards' requirements and MRA can be effective tools to address these concerns.

6. Post-Workshop Survey

6.1 Introduction

A post-conference survey was conducted to collect feedback on the activities and proceedings of the conference, including attendee takeaways, amongst other recommendations. Attendees across all stakeholder groups were requested to respond to the same set of questionnaires, wherein respondents were invited to share their views on the extent with which the activities met expectations, such as the relevance, reasonableness and execution of the conference objectives, agenda and topics, speakers and content discussed, organization, materials disseminated, and knowledge-sharing platforms. Several open-ended questions were included to derive deeper insights on how attendees' takeaways from the conference could be applied in related matters within their respective economies, areas for improvement, and suggestions on future activities that could be planned under the ambit of the SCSC.

6.2 Findings

Against a base total of 31 respondents, respondents had broadly positive sentiments about the workshop. On the content, strategic objectives, and delivery of the workshop, respondents were asked to provide feedback to the following statements –

- The objectives of the workshop were clearly defined;
- The workshop achieved its intended objectives;
- The agenda items and topics covered were relevant;
- The speakers were well-prepared and knowledgeable about the topic; and
- The materials distributed were useful.

90% of the responses were positive (i.e. ascertained by selection of 'Agree' or 'Strongly Agree' responses to the above statements), with just 3 respondents indicating that the usefulness of the materials distributed were 'neutral'. On the organization of the workshop, respondents were asked to provide feedback to the following statements –

- There was gender balance of speakers at the workshop; and
- The time allotted for the workshop was sufficient.

83% of the responses were positive, with 3 respondents indicating neutral sentiment towards the expectation of gender balance and 2 respondents indicating the same on the sufficiency of the duration of the workshop.

On the extent to which the workshop had enriched participants' knowledge of the topic, 83% of the responses indicated an increase in understanding. Participants' increased knowledge of the topic could be broadly categorized within the buckets of (i) the types of BESS-related standards available across various economies and how these standards have been integrated within public policy and applied domestically to encourage the growth of BESS; (ii) BESS usage risk factors and how these factors could be anticipated, mitigated and better managed; and (iii) state of BESS and BESS-related industries across economies, including the latest technological developments and research progress in the field.

When asked how participants would follow-up with the knowledge takeaways from the workshop, many shared that they were inspired to (i) begin concerted discussions with domestic stakeholders on future strategies and plans to develop domestic standards and regulations for batteries and energy storage systems; (ii) consider incorporating safety

concerns and requirements within domestic policies, programs and regulated procedures; and (iii) develop conformity assessment systems and initiatives within their economies.

Additionally, there were a handful of post-workshop feedback centered upon establishing formal mechanisms (e.g. APEC SCSC working groups, community of practitioners) to encourage longer-term, cross-economy engagements. Suggestions were raised on what these engagements could be related to include harmonizing BESS-related standards, assistance with the implementation of standards, information dissemination on the latest research, continuous sharing of scientific and standards best practices, and detailed guidance on integrating related standards within member economies' public policy frameworks.

7. Recommendations

The following recommendations were derived through the workshop presentations, panels and breakout discussions, observations and feedback solicited on the sidelines.

7.1 Continued sharing of good implementation practices of BESS-related codes and standards across APEC economies would enhance technical understanding, and hence fourth drive greater willingness by APEC stakeholders to implement BESS and related soft and hard infrastructures.

Many participants, especially those from developing economies, reflected that one of the biggest benefits of this conference was learning the good practices of research, as well as implementation of codes, standards and conformance assessment programs related to the BESS value chain, in other APEC economies. Hence, APEC and APEC economies should conduct more activities to share these good practices, exchange experiences and case studies, to support economies' clean energy transition momentum.

7.2 Safety risks of BESS are still broadly understated, hence there is a need to continue raising awareness and educate stakeholders on the appropriate standards and conformity assessment programs to adopt.

Throughout the project phases, especially after learning from the expert speakers, respondents and participants agreed that safety of BESS is one of the biggest obstacles hindering the deployment of BESS within the APEC region. Following from this workshop, APEC and APEC economies should continue raising the awareness of (i) the importance of BESS in relation to supporting net zero goals and clean energy transition; and (ii) the safety risks of BESS and how the risks can be mitigated by scientific research, standards & conformance.

7.3 More initiatives to incentivize harmonization of standards and development of Mutual Recognition Arrangements (MRA) relating to batteries and BESS are necessary.

Some APEC economies have developed codes, standards, regulations, and voluntary programs for BESS. Through an objective and science-based approach, other APEC economies could consider taking reference from these existing good practices of standards and regulatory development to support international trade, regional harmonization and economic integration. Availability of conformity assessment programs for BESS is commonly raised as a hindrance to BESS development in APEC region. APEC economies could tap on the existing MRA programs for conformity assessment administered by APAC, ILAC and IAF, while developing domestic conformance infrastructure. Harmonization of standards and scaling of MRAs could create economies of scale, reduce cost, encourage innovation of BESS and accelerate sustainable development in APEC region.

7.4 More participation by APEC economies' stakeholders is needed in international standards activities, to influence development of global standards related to BESS, identify gaps in the existing standards landscape, and derive new standards areas.

APEC economies' stakeholders agreed that participating in international standards activities is beneficial, as doing so allows APEC economies to (i) influence the development of these standards for battery and BESS, (ii) obtain first-hand information about the drivers leading to particular international standards being developed, which

could incentivize APEC stakeholders to support the adoption, harmonization and implementation of the standards. As BESS is still a relatively new area of economic and industry development that could support the global clean energy transition movement, there is opportunity for APEC economies to identify gaps in the current standards landscape relating to BESS and batteries, and take the lead in driving new standards development.

7.5 More technical guidance and assistance should be provided to APEC economies on how Standards & Conformance (S&C) could be leveraged upon to drive implementation of BESS.

While APEC economies generally agreed that S&C are effective tools for regulation and policy making to support BESS development and the clean energy transition, this is still a new area in APEC region, especially for developing economies. Developing economies are calling for their developed peers to provide more targeted assistance on sharing technical expertise on S&C related to BESS, drive policy development leveraging S&C, lead development of quality infrastructure including standardization and conformity assessment facilities that could be applied broadly, push research to identify gaps and local implementation of standards, among others.

7.6 Continue involvement of private sector in the development of BESS policy and standards.

Private sector players are often on the frontlines of pushing the boundaries of innovation with regards to BESS deployment within an economy or across borders, with experiences in mitigating the challenges and potential shortfalls of BESS facility deployments. Policymakers and standards bodies in the APEC region should rope in private sector when developing policy and standards.

7.7 Consider the end-to-end clean energy value chain especially End-of-Life (EOL), when developing policy and standards for BESS.

BESS is part of a larger clean energy value chain, which includes clean energy generation, grid connection, electric mobility, and integration with existing infrastructure. The risk profiles of different BESS infrastructures will vary based on the application and locations with which BESS have been deployed, such as underground facilities or in densely populated areas. Research and use of application-specific or context-relevant standards can help APEC economies better understand and mitigate such risks. Additionally, with the projected proliferation of batteries and BESS, there is growing concern for the EOL handling of batteries within APEC economies, such as disposal, recycling, reuse, repurpose or second life, etc. APEC economies should review the potential safety gaps and identify needs to adopt existing standards or collaborate to develop new standards that could address specific concerns across the clean energy value chain or of various BESS infrastructures.

7.8 Encourage collaboration and partnership amongst APEC economies to steer safe innovation for BESS to meet net-zero targets within APEC region.

Scaling of BESS deployment in APEC region is imminent to support net-zero targets. This is a shared goal that requires all APEC economies to move forward together. Notwithstanding the shared goal, it should be acknowledged that moving forward as one APEC can be challenging given the complexities involved to deploy BESS at scale, safety risks, lack of infrastructure and technical expertise, the high costs and different economic and industry contexts. Collaborations and partnerships among APEC economies could

help APEC accelerate the process of overcoming these challenges. APEC should consider more cross-fora collaboration among the Committee on Trade and Investment (CTI), the SCSC, the Energy Working Group (EWG), the Policy Partnership on Science, Technology and Innovation (PPSTI), and the Transportation Working Group (TPTWG), where BESS and the battery value chain can play roles in meeting the objectives of these fora.

Annex I

AGENDA

APEC Workshop on Sharing Best Practices and Capacity Building on the Role of Battery Energy Storage Systems Standards in Promoting Safety, Energy Resilience and Sustainability

Seattle, Washington, United States

4-5 August 2023

Day 1: 4 August 2023 (in US Pacific time)	
8.30 am – 9.00 am	**Registration and Arrival**
9.00 am – 9.15 am	**Welcome Remarks** Mr Kent Shigetomi, Chair, APEC Subcommittee on Standards and Conformance Mr Terry Brady, President & CEO, UL Research Institutes (recorded message)
9:15 am – 10:00 am	**Keynote Speakers** Ms Angeline Bickner United States Department of State Dr Lori Moore-Merrell, United States Fire Administrator Dr David Steel, Executive Director, UL Standards & Engagement **Photo Opportunity**
10:00 am – 10:30 am	**Break**
10:30 am – 12:00 pm	**Session 1 – BESS initiatives by standards developing organizations** *Sharing of existing standards development initiatives and projects relating to BESS from major standards developing organizations within APEC region.* **Speakers:** 1.1 Ms Anna Tanaka, National Institute of Technology and Evaluation (NITE), Japan 1.2 Dr George Borlase, UL Standards & Engagement 1.3 Dr Judy Jeevarajan, IEC SC 21A 1.4 Mr Jay Illescas, Bureau of Philippine Standards **Moderator:** Ms Ebonique Barker, UL Research Institutes

12:00 pm – 1:15 pm	**Lunch**
1:15 pm – 3:15 pm	**Session 2 - APEC economies' approach to BESS codes and policies development** *Economies in the APEC region have created or are exploring the possibilities of creating BESS policies, including codes, policies, and regulations, with a focus to ensure safety of BESS. Research and use of existing standards play key roles to support the efficiency of these policies. This panel will highlight a selection of economies' approaches and good practices.* **Speakers:** 2.1 Dr Steve Kerber, UL Fire Safety Research Institute 2.2 Dr Lori Moore-Merrell, United States Fire Administrator 2.3 Mr Sean DeCrane, International Association of Fire Fighters 2.4 Mr Matthew Allen, CFA, Victoria, Australia **Moderator:** Dr Steve Kerber, UL Fire Safety Research Institute
3:15 pm – 3:45 pm	**Break**
3:45 pm – 5:15 pm	**Session 3 – Research Supporting BESS Development** *Future trends of ESS and research. Research as baseline for standards development and conformity assessment.* **Speakers:** 3.1 Dr Judy Jeevarajan, UL Electrochemical Safety Research Institute 3.2 Dr Vince Sprenkle, Pacific Northwest National Laboratory 3.3 Mr Biatna Dulbert Tampubolon, National Research and Innovation Agency Indonesia 3.4 Prof Yossapong Laoonual, Thailand Energy Storage Technology Association **Moderator:** Ms Ebonique Barker, UL Research Institutes
5:15 pm – 5:30pm	**Wrap up and closing**
Day 2: 5 August 2023 (in US Pacific time)	
8.30 am – 9.00 am	**Registration and Arrival**
9.00 am – 10:15 am	**Session 4 – Conformity Assessment for BESS** *Conformity assessment, including testing, inspection and certification, is a critical system that helps industry players demonstrate their compliances to standards and codes. Third party conformity*

	assessment bodies and global mutual recognition arrangement could enhance efficiency of BESS regulation and code implementation. **Speakers:** 4.1 Ms LaTanya Schwalb, UL Solutions 4.2 Mr Graeme Drake, Secretary, Asia Pacific Accreditation Cooperation 4.3 Dr Yu-Ting Yen, Industrial Technology Research Institute, Chinese Taipei **Moderator:** Mr Kolin Low, UL Standards & Engagement
10:15 am – 10:45 am	**Break**
10:45 am – 12.00 pm	**Session 5 – Standards supporting Circular Economy and Cascade Use of Batteries** *Latest trends on battery end-of-life, second life batteries and cascade use by the academia, research institutions and industry* **Speakers:** 5.1 Mr Matt Paiss, Pacific Northwest National Laboratory 5.2 Dr Sohini Bhattacharyya, Rice University, USA 5.3 Dr Chiam Sing Yang, Singapore Battery Consortium **Moderator:** Mr Kolin Low, UL Standards & Engagement
12:00 pm – 1:30 pm	**Lunch**
1.30 pm – 3:00 pm	**Session 6 – Good Practices on Use of Standards and Conformance in Industry to support BESS in APEC economies** *In emerging areas such as clean energy and BESS, businesses have been using standards and conformance to demonstrate and contribute their commitment to safety, environmental protection, and sustainable development. In addition, businesses benefit from customer confidence boost, increased efficiency, improved market access, among others.* **Speakers:** 6.1 Dr Chiam Sing Yang, Singapore Battery Consortium 6.2 Prof Yossapong Laoonual, Thailand Energy Storage Technology Association 6.3 Mr Charles Picard, Tesla 6.4 Mr Jonathan Stewart, National Electrical Manufacturers Association **Moderator:**

	Dr Chiam Sing Yang, Singapore Battery Consortium
3:00 pm – 3:30 pm	**Break**
3:30 pm – 4:30 pm	Break-out discussion
4:30 pm – 5:00 pm	Reporting of break-out discussion results
5:00 pm – 5:30 pm	**Wrap up and closing**