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CIRCULAR ECONOMY

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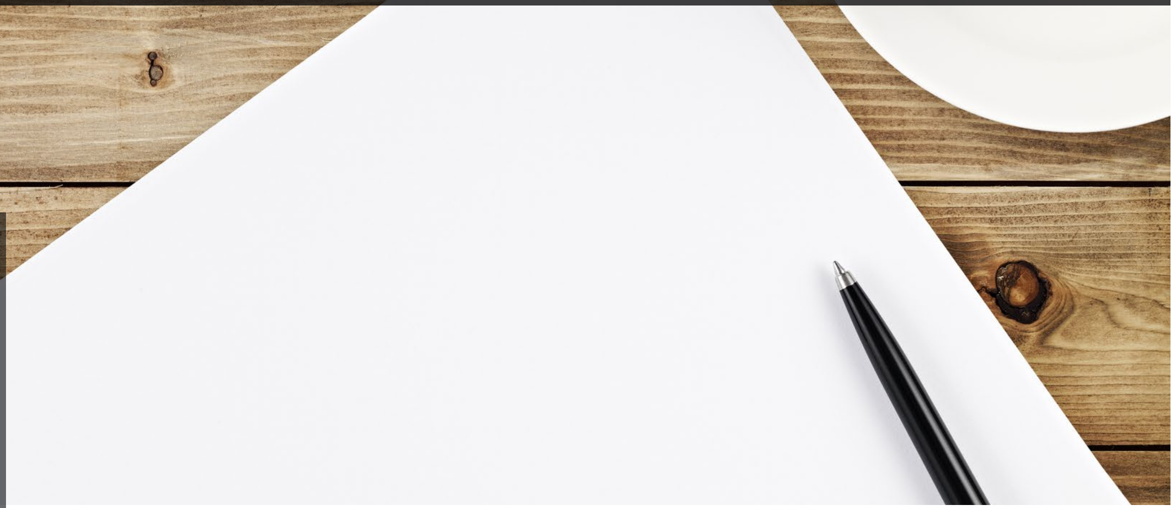
CIRCULAR ECONOMY

FEATURED STORIES

IN THIS ISSUE

LETTER FROM THE USNC PRESIDENT

Veronica Lancaster – USNC President; Vice President, Standards Programs at Consumer Technology Association



As we begin 2025, a new year usually results in resolutions. It's a great time to consider how important the circular economy will be in our future. Considering changes now could result in better bottom lines to avoid unnecessary waste but can also result in a better future for next generations. The circular economy is rapidly transforming industries worldwide, driven by technological advancements that enable sustainable resource management, waste reduction, and material reuse. Unlike the traditional linear economy, which follows a "take-make-dispose" model, the circular economy focuses on keeping materials and products in continuous use, minimizing waste, and maximizing efficiency. Emerging technologies are playing a pivotal role in accelerating this transition.

One of the key areas of progress is in sustainable materials and manufacturing processes. Companies are increasingly adopting technologies that enable the recycling and repurposing of materials, reducing waste and minimizing the environmental footprint of production. For example, artificial intelligence (AI) and machine learning are revolutionizing waste management by improving sorting and recycling processes. AI-powered robots equipped with computer vision can accurately identify and separate different types of waste materials, increasing recycling rates and reducing contamination. These advancements make material recovery more efficient, ensuring that more resources are reintegrated into the economy rather than ending up in landfills.[1] From advanced sorting and recycling technologies to novel biodegradable materials, these innovations are paving the way for a more sustainable future.

Beyond traditional waste management, advancements in recycling will support the circular economy. New recycling technologies are making it possible to process complex and traditionally non-recyclable materials. Chemical recycling, for instance, breaks down plastics into their basic molecular components, enabling them to be reused in the production of new plastic

1 Kesari, G. May 31, 2024. Turning Trash Into Treasure: How AI Is Revolutionizing Waste Sorting. Forbes. https://www.forbes.com/sites/ganeskesari/2024/05/31/turning-trash-into-treasure-how-ai-is-revolutionizing-waste-sorting/

products. Additionally, bio-based recycling techniques use enzymes and microbes to break down organic waste into reusable materials.[2]

Interestingly, 3D printing is contributing to the circular economy by providing manufacturing "as-needed." Additive manufacturing, a.k.a. 3D printing, is contributing to circularity by reducing material waste and enabling localized production. By using recycled materials as feedstock, companies can produce components and products with minimal environmental impact.[3] This technology also extends product lifespans by enabling on-demand production of spare parts, reducing the need for excessive manufacturing.[4]

Additionally, digital technologies such as blockchain and IoT are playing a crucial role in enhancing transparency and traceability within supply chains in circular supply chains. By providing a permanent record of a product's lifecycle, blockchain ensures transparency in sourcing, production, and recycling processes.[5] The Internet of Things (IoT) is playing a crucial role in optimizing resource usage and minimizing waste. IoT-enabled sensors can track product usage, monitor equipment efficiency, and provide real-time data on material flows.[6] Smart waste bins, for example, use IoT to optimize collection schedules, reducing unnecessary emissions and improving overall waste management efficiency.[7] These technologies allow businesses and consumers to verify the sustainability credentials of products and promote efficient waste management, fostering trust and encouraging responsible consumption.

Furthermore, the concept of product-as-a-service (PaaS) is gaining traction, where products are leased or rented rather than sold outright, redefining ownership and consumption patterns. Instead of purchasing products outright, consumers and businesses can subscribe to services where products are maintained, repaired, and eventually recycled by the provider.[8] This shift incentivizes manufacturers to design products that are durable, modular, repairable, easily upgradeable, and recyclable, thereby extending their lifecycle and reducing overall resource consumption.

Some of the latest breakthroughs in material science will be critical to the circular economy. Innovations in material science are leading to the development of biodegradable and regenerative materials that reduce dependency on finite resources. Researchers are creating alternatives to conventional plastics, such as bioplastics derived from algae or agricultural waste, which decompose naturally without harming the environment. These materials offer sustainable solutions for packaging, textiles, and other industries.

In conclusion, advancements in technology within the circular economy are both promising and necessary. By continuing to invest in innovation and collaboration, we can create a future where economic growth is decoupled from resource consumption, and where sustainability is at the forefront of every industry.

—Veronica A. Lancaster

2 U.S. Government Accountability Office. November 21, 2022. Science & Tech Spotlight: Biorecycling of Plastics. *U.S. Government Accountability Office.* https://www.gao.gov/products/gao-23-106261

3 Toor, R. August 29, 2024. How Sustainable 3D Printing Operators Embrace Circularity. LinkedIn Sustainable 3D Printing Guide. https://www.linkedin.com/pulse/how-sustainable-3d-printing-operators-embrace-circularity-ravi-toor-tthee/

4 Raise 3D Technologies, Inc. December 27, 2024. 3D Printing Sustainability. *Raise3D.* https://www.raise3d.com/blog/3d-printing-sustainability

5 Yontar, E. 2023. The role of blockchain technology in the sustainability of supply chain management: Grey based dematel implementation. *Cleaner Logistics and Supply Chain, Volume 8.* https://doi.org/10.1016/j.clscn.2023.100113.

6 Zuckerman, J. March 19, 2024. What is IoT Remote Monitoring? How Does It Work and Use Cases. *Xyte.* https://www.xyte.io/blog/iot-remote-monitoring

7 Bajaj, C. 2025. Industry Stories, Bins With Brains: IoT for Smarter Waste Management. Insights. *Infosys.* https://www.infosys.com/insights/industry-stories/smarter-waste-management.html

8 BambuUP. January 12, 2025. Product-as-a-Service: How businesses are adapting to meet new consumer trends? *LinkedIn InnovationUP.* https://www.linkedin.com/pulse/product-as-a-service-how-businesses-adapting-meet-new-consumer-ed05c/

NEW TECHNOLOGY FOR COMPONENT RECOVERY FROM CIRCUIT BOARDS ADVANCES THE CIRCULAR ECONOMY FOR ELECTRONICS

Dale R. Johnson – President, IC Recovery (a division of Greene Lyon Group, Inc.)

Donald F. Tyler – Senior Consultant/Principal, Ten Eyck Group LLC

The mantra for the circular economy is "Reduce, Reuse, and Recycle." Advancing the transition to a circular economy for electronics, IC Recovery (ICR), a Boston area based company, has developed a multi-patented process that removes all components from end-of-life and surplus populated printed circuit boards (PCBs), either to be reused or recycled. Components with high reuse value (typically, logic chips such as CPUs and GPUs) are safely recovered and refurbished for use, even in high reliability applications. The remaining components are harvested to concentrate their precious metal content for subsequent recycling with new technologies that are more efficient and sustainable than traditional smelting.

CHIP REUSE

Although chips can have useful lives of 10–20 years or longer,[1] rapid technological advancements lead to original electronic equipment typically being replaced—and its chips destroyed—within 3–7 years. Many of those chips, particularly logic chips, have a functional value higher than the value of their precious metal content and can be reused if properly recovered and refurbished. Reusing such chips reduces the need to source critical materials required to fabricate new chips. Most of those critical materials are extracted via ecologically and socially damaging processes, the vast majority of which are in countries with potential political obstacles to U.S. access, e.g., China and Russia. Continued high demand for new chips increases the need for such critical materials and results in even more avoidable environmental damage.

Chip reuse is also dramatically less energy intensive than new chip fabrication. A study published by Harvard concluded: "Chip manufacturing, as opposed to hardware use and energy consumption, accounts for most of the carbon output [of information and computing

1 P. Ramachandran et al., "Metrics for Lifetime Reliability", Department of Computer Science, University of Illinois at Urbana Champaign, IBM T.J. Watson Research Center (August 2006)

systems]."[2] In contrast, an independent environmental assessment firm has determined that a chip recovered for reuse by ICR has a GHG footprint 97% less than the GHG footprint of a new chip.[3]

Recovering reusable chips from PCBs already in the U.S. also enhances national security and supply chain resilience. ICR's turnaround time to produce a Certified Renewed™ chip is less than six weeks while new chip lead times are often 26 weeks or more. In the chip industry, time is money, so in some cases available renewed chips can be even more valuable than new chips on order.

2 Gupta et al., "Chasing Carbon: The Elusive Environmental Footprint of Computing" (October 2020)

3 "IC Recovery Environmental Impact Report", Boundless Impact Research & Analytics (August 2022)

ICR's process applies a thermofluid to the complete surface of the PCB and all the solder points attaching its components. The thermofluid is constantly maintained at a temperature no more than 2 degrees Celsius above the applicable solder's temperature liquidus, i.e., the temperature at which the solder points are completely liquid. This enables chips designated for reuse to be individually removed and then refurbished with well-known and proven technologies. ICR's unique ability to maintain such precise control of the thermofluid's temperature virtually eliminates any risk of thermal damage to those chips. In fact, this process exceeds the requirements of IPC 7711/21 and ramp rate limits of J-STD-020 and exposes chips to less stress than when they were originally attached to the board. This makes ICR's technology superior to other processes that use heat to remove chips from PCBs, such as infrared rays and hot gas.

FIGURE 1: EXAMPLES OF CERTIFIED RENEWED CHIPS

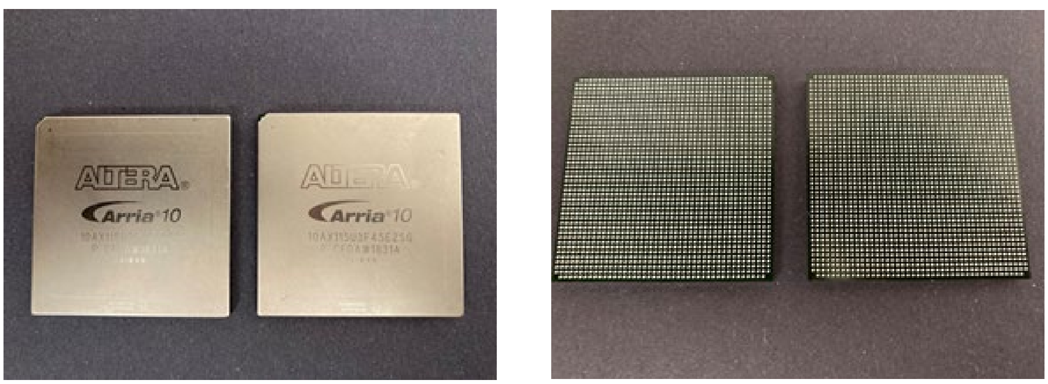
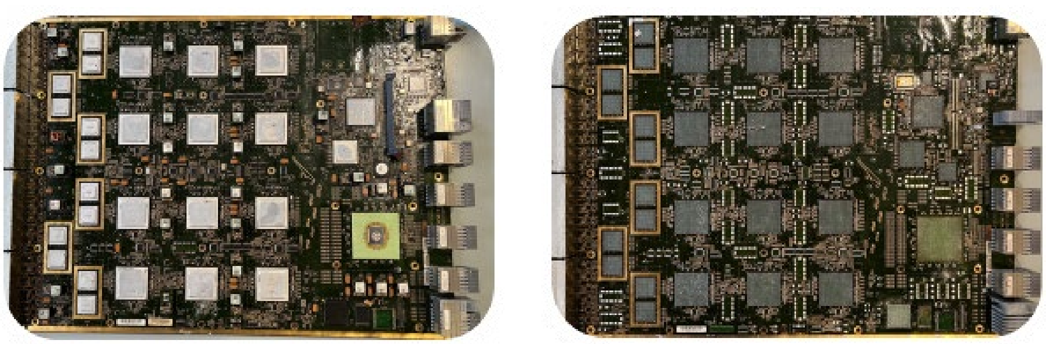


FIGURE 2: EXAMPLE OF PCB BEFORE PROCESSING AND AFTER CHIPS ARE HARVESTED



HARVESTING COMPONENTS FOR IMPROVED RECYCLING

In addition to reusable chips, PCBs contain strategic and critical materials, including precious metals (PM)—gold, silver, and palladium—virtually all of which are in the chips, tantalum and aluminum in other components, and copper in the board substrates. The current practice is to send whole PCBs to copper smelters, most of which are in Europe or Asia, where PM and copper are recovered in a pyrometallurgical process that destroys all the chips, recovers no tantalum or aluminum, and is environmentally problematic, using high energy and generating toxic discharges.

Multiple technologies have been developed to replace legacy smelting for PM recovery from PCBs, including biorefining[4] and hydrometallurgy.[5] These are designed to yield higher PM recovery and to be more sustainable than smelting—but like smelting, they focus on processing whole PCBs. Preliminary testing indicates these new recycling processes can be optimized by using ICR's technology as a pre-processing step to separate chips from PCBs so those processes can focus separately on the PM in the chips. This is a significant advantage because chips generally constitute only about 20%-25% of a typical PCB's weight but contain 98+% of the PM.[6] Consequently, harvesting chips for separate processing concentrates the PM content of PCBs, on average, by a factor of four-five.

Because ICR's thermofluid covers the entire surface of a PCB, all soldered chips can be removed in one pass for separate PM refining. At the same time, materials deleterious to the refining process can be excluded. Also, unlike smelting, components containing tantalum and aluminum can be also recycled, while solder is recovered as a saleable byproduct. The result is an expected dramatic improvement in overall yield and sustainability.

4 Mint Innovation. https://www.mint.bio/

5 The Royal Mint. https://www.royalmint.com/gold-recovery/

6 Data derived from processing experience, multiple industry sources, and OpenAI (2025) ChatGPT (January 31 version) [Large language model]. Retrieved from https://chat.openai.com.

CONCLUSION

Chip reuse is the very essence of a circular economy, and ICR's ability to safely recover and refurbish reusable chips from PCBs advances circularity for electronics. At the same time, the indicated improvements from ICR's technology as applied to recycling chips and other PCB components for their metal value will incentivize more e-scrap recycling.

ABOUT THE AUTHORS

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Mr. Johnson is President of IC Recovery, a division of Greene Lyon Group, Inc., which he founded to develop and commercialize sustainable technologies for the reuse/recycling of strategic and critical materials. Formerly a member of the startup team and EVP of MSL, an electronics contract manufacturer that grew to an annual revenue rate of $1 billion and executed a successful IPO in less than six years.

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ADVANCING RENEWABLES CIRCULARITY: A PATH TO TRULY SUSTAINABLE ENERGY

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Robert Nicholson – Senior Manager Sustainability, Solar Energy Industry Association

As the global demand for solar photovoltaic (PV) and battery energy storage (BESS) systems continues to surge, the need for sustainable end-of-life management has become increasingly critical. The concept of a circular economy for materials used in renewable technologies is becoming part of the popular discourse, aiming to minimize waste and maximize resource efficiency. This article explores current progress and prospects of recycling in these applications, drawing insights from recent studies and industry developments.

THE IMPERATIVE FOR SOLAR PANEL RECYCLING

Over the last ten years PV deployments in the U.S. have seen an average annual growth rate of 26%.[1] In total, this equates to roughly 37 million homes' worth of solar power capacity. With this rapid expansion of solar energy installations, the volume of decommissioned solar panels is expected to rise significantly in the coming decades. According to the National Renewable Energy Laboratory (NREL), the cumulative waste from retired PV modules could reach 10 million metric tons by 2050.[2] This presents both a challenge and an opportunity for the solar industry to continue in its effort to develop robust recycling infrastructures.

Aside from the economics of recapturing and sequestering materials from the waste stream, scaling up this infrastructure also goes a long way in the general public's perception of renewable energy technologies. I won't debate the merits of the counterarguments presented by the anti-renewables crowd here; suffice to say that a common talking point is that PV modules are resource intensive to manufacture and are ultimately destined for the landfill. The Electric Power Research Institute (EPRI) has estimated that module recycling capacity currently exceeds the volume of decommissioned modules entering the waste stream. This research goes further in predicting that recycling

1 Solar Industry Research date, SEIA: https://seia.org/research-resources/solar-industry-research-data/

2 Solar Photovoltaic Module Recycling: A Survey of U.S. Policies and Initiatives: https://www.nrel.gov/docs/fy21osti/74124.pdf

capacity is adequate to process the expected volume of crystalline-silicon modules reaching end-of-life through 2030.

CURRENT PROGRESS IN SOLAR MODULE RECYCLING

Recent advancements in solar module recycling technologies have shown promising results. Once again pointing to EPRI research efforts, recycling processes are evolving to recover valuable materials such as silicon, silver, and aluminum from end-of-life panels.[3] Some materials can be reintroduced into the manufacturing cycle, reducing the need for virgin resources and lowering the environmental impact of solar panel production. The challenge is developing processes that separate and reclaim materials of sufficient purity to close the loop on circularity. At the time of this writing, silicon has yet to be recycled into the semiconductor grade needed for new PV modules, for example.

We already know that recycling materials like glass and aluminum can be economically viable and environmentally beneficial, even in the complex and messy world of material goods and their associated packaging. Glass, which constitutes a sizable portion of a solar module, can be recycled efficiently. Aluminum recycling is particularly profitable due to its high market value and the energy savings achieved compared to producing new aluminum. The U.S. Environmental Protection Agency (EPA) reports that recycling aluminum saves 95% of the energy required to produce it from raw materials.

NEW AND EMERGING RECYCLING MARKETS

The recycling of rare metals and materials used in photovoltaic panels is an emerging market with significant potential. Thin-film solar cells, which use materials like indium, gallium, and selenium, present new opportunities for metal recyclers. Recent advancements in recycling methods, such as leaching-based processes, have shown high recovery rates for these valuable metals. This not only supports a circular economy but also reduces the environmental impact of mining and processing new materials.

Also worth a mention here is lithium-ion battery recycling—an area experiencing rapid growth, driven by the proliferation of electric vehicles, electronics, and renewable energy storage applications. The global lithium-ion battery recycling market is projected to reach $85.69 billion by 2033, with a robust 26.6% compound annual growth rate (CAGR). Key recycling methods include pyrometallurgy, hydrometallurgy, and direct recycling, each with its strengths and challenges. Hydrometallurgy, in particular, is favored for its efficiency and lower environmental impact, recovering up to 99% of lithium. This trend highlights the importance of sustainable practices in managing the lifecycle of energy storage systems.

The International Electrotechnical Commission (IEC) Technical Committee (TC) 120 is actively working on evaluating the environmental impacts of battery energy storage systems (BESS). This includes developing standards and guidelines to assess and mitigate environmental issues throughout the lifecycle of BESS, from design to disassembly. These efforts are crucial in ensuring that the deployment of energy storage technologies aligns with global sustainability goals.

KEY INITIATIVES AND RESEARCH EFFORTS

Several key initiatives are driving the progress towards a circular economy for solar PV systems. NREL's comprehensive studies, including the *Circular Economy for Solar Photovoltaic System Materials* report, provide a roadmap for achieving sustainable solar panel management.[4] The report emphasizes the importance of designing panels for recyclability, improving collection and processing systems, and fostering collaboration across the supply chain.

3 Solar Module Recycling Progress Follows the Global Growth of PV. EPRI Journal: https://eprijournal.com/solar-module-recycling-progress-follows-the-global-growth-of-pv/

4 A Circular Economy for Solar Photovoltaic Systems Materials: Drivers, Barriers, Enablers, and U.S. Policy Considerations. https://www.nrel.gov/docs/fy21osti/74550.pdf

Additionally, the U.S. International Trade Commission (USITC) has published an executive briefing on solar panel circularity, underscoring the economic and environmental benefits of recycling. The briefing outlines policy recommendations to support the development of a circular economy, including incentives for recycling and the establishment of industry standards.[5]

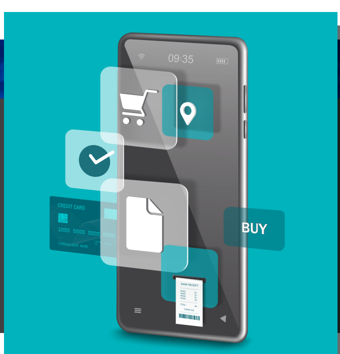
The Solar Energy Industries Association (SEIA) is contributing to these efforts through two important initiatives, among others, to educate and activate industry towards more sustainable and circular activities. First SEIA is authorized to write three national standards on decommissioning, requirements for recyclers, and end-of life, management for solar and energy storage equipment that will enable industry to learn and implement the best practices from their peers. Next, SEIA established and maintains the only national program for recyclers capable and effective at recycling solar panels in the U.S., as vetted by SEIA's sustainable principles. Additional initiatives will come this year on sustainability education and collaboration, and the continued expansion of SEIA's recycling network.

5 Photovoltaic Circularity: Solar Panel Recycling and End-of-Life Considerations

FUTURE PROSPECTS AND CHALLENGES

While considerable progress has been made, several challenges remain in realizing a fully circular economy for solar PV and BESS materials. The variability in panel designs and the presence of hazardous materials pose technical and regulatory hurdles. Similarly, overall advancements in material purification will require research collaboration beyond solar that needs further exploration. Managing decommissioned BESS in the waste stream, including those based on lithium-ion chemistries, presents additional obstacles to overcome. The mishandling of end-of-life batteries has resulted in documented fires and an aggressive educational campaign needs to accompany developments in processing capabilities.

However, ongoing research and innovation are paving the way for more efficient and cost-effective recycling solutions. This research is then driving policy and regulatory updates that address the bottlenecks and mitigate the risks identified. The journey towards a circular economy for solar PV and BESS systems is underway, driven by technological advancements and collaborative efforts across the industry. As we continue to innovate and refine recycling processes, the vision of a sustainable, circular solar economy will become incrementally attainable. The solar and energy storage industry's commitment to sustainability will play a pivotal role in shaping the future of renewable energy.



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NEW AGE OF SPACE ENTERPRISE ANTICIPATES DRIVING CIRCULAR ECONOMY WITH QUANTUM COMPUTING INNOVATIONS

Kevin B. Clark, Ph.D. – Faculty, Frontier Development Lab, NASA Ames Research Center and SETI Institute; Domain Champion in Biomedicine, NSF ACCESS; Founding Member, Peace Innovation Institute, Stanford University and The Hague; Member, IEEE Biometrics and Nanotechnology Councils and Quantum Initiative; USNC TAG Member to ISO/IEC JTC 3

Progress in traditional government-industry space partnerships and new lone commercial space ventures, as popularized by Earth telecommunications and navigation, planetary protection, private civilian space tourism, and remote automated asteroid mineral mining, now escalates at unprecedented rates of interest and want. Trends favor the exciting promises of democratized deep space exploration and habitation, responsible science and technology innovation and regulation, and a prosperous space–Earth circular economy that aligns with national to international goals for sustainable ecosocial development through sound, ethical government and corporate policies and practices, such as those listed in the 2030 Sustainable Development Agenda[1] ratified by the United Nations (UN) General Assembly and complied with by the UN Office of Outer Space Affairs (UNOOSA) and partners. Few, if any, general purpose second-generation devices and tools are believed to be more foundational for attaining such ambitions than quantum computing. Recent establishment and convening of the USNC Technical Advisory Group (TAG) for the International Electrotechnical Commission (IEC)/International Organization for Standardization (ISO) Joint Technical Committee (JTC) 3 on Quantum Technologies[2] confirm the need for approving standardization guidelines and regulations relevant to advancing this intense and still evolving intersection of research, development, and commerce.

Since being independently conceived by Richard Feynman and Yuri Manin over 40 years ago, predictable performance benefits of quantum architectures and algorithms over classical ones and the strong

1 Transforming Our World: The 2030 Agenda for Sustainable Development (A/RES/70/1). Department of Economic and Social Affairs, Sustainable Development, United Nations, 2015: 1-41. https://sdgs.un.org/publications/transforming-our-world-2030-agenda-sustainable-development-17981

2 IEC and ISO New Joint Technical Committee on Quantum Technologies. USNC Current, 2024; Summer: 17-18. https://share.ansi.org/Shared Documents/Standards Activities/International Standardization/IEC/USNC Current/News and Notes/Vol. 19 No. 2 Summer 2024.pdf

Church-Turing limit suggest quantum computing will radically improve data compute and storage capabilities. The presumed quantum advantage exploits processing speed-up and elevated storage capacity for orders-of-magnitude greater computational scaling, efficiency, accuracy, and precision. These attributes, as sought by developers at prominent multinational corporate tech giants to smaller agile boutique tech firms, benchmark hypothetical large transformations in the productivity and profitability of wide-ranging global Earth business sectors, including, among others, finance, trade, energy, medicine, education, transportation, logistics, insurance, media, science, and information technology. Practical space industry interests in quantum computing arguably began in 2012, with the opening of the United States congressionally mandated Quantum Artificial Intelligence Laboratory (QuAIL).[3, 4] QuAIL operations, located at the National Aeronautics and Space Administration (NASA) Ames Research Center, take an experimental testbed approach to proof of concept, reduction to practice, and technology transfer of hardware and software design and implementation. The lab is NASA's core facility for appraising and innovating the principles and potential of quantum computers to solve variable-sized and tunable hard computational problems that may confront the agency well into the future. Major mission-strategic concerns addressed by the lab historically involve aeronautics, Earth and space sciences, and space exploration, where open quantum system modeling and classical circuit simulation has furthered co-design of multiple architectures and tools with enhanced fault tolerance and error correction for machine learning and artificial intelligence (ML/AI) applications in, for example, optimization, condensed-matter physics, high-energy physics, quantum chemistry, materials sciences, and fluid dynamics.

Quantum computing mostly remains at an early stage of state of art, with authoritative estimates often placing devices and tools at a Technology Readiness Level of three to five associated with on-premise laboratory or cloud workspace proof of concept and validation, regardless of the readiness measurement scale adopted by NASA, the European Space Agency (ESA), ISO, or other organizations. But, quantum technology readiness may double before the end of the decade and assessments from the U.S. National Institute of Standards and Technology, National Security Agency, and Cybersecurity and Infrastructure Security Agency agree that new standards must be employed to protect against quantum cryptographic threats to critical cyberinfrastructure, offering forward-thinking recommendations for drafting organizational quantum-readiness roadmaps, conducting inventories, leveraging adversarial risk assessments and analysis, and engaging vendors over supply chain status for safer, securer, and more trustworthy emerging technology resources and services, such as utilities, transportation, banking, and healthcare.[5] Likewise, extensive QuAIL interagency, academia, and industry collaborations aim to significantly raise technology readiness and threat preparedness in quantum ML/AI-powered sensing, communications, networking, and additional disruptive technologies important for both Earth and space use cases. Some of these collaborations include the U.S. Defense Advanced Research Projects Agency's Quantum Benchmarking and Quantum-Inspired Classical Computing programs; the U.S. Department of Energy's National Quantum Information Science Research Centers; the U.S. National Science Foundation's National AI Research Resource; FermiLab and Brookhaven National Laboratory; the

3 Rieffel, E.G. et al., Assessing and Advancing the Potential of Quantum Computing: A NASA Case Study. Future Generation Computer Systems, 2024; 160(2024): 598-618. https://www.sciencedirect.com/science/article/pii/S0167739X24003121

4 Kim, S. & Bowman, A., NASA Quantum Artificial Intelligence Laboratory (QuAIL), National Aeronautics and Space Administration, 2024; October 7. https://www.nasa.gov/intelligent-systems-division/discovery-and-systems-health/nasa-quail/

5 Quantum-Readiness: Migration to Post-Quantum Cryptography. Cybersecurity and Infrastructure Security, 2023; August 17: 1-3. https://www.cisa.gov/resources-tools/resources/quantum-readiness-migration-post-quantum-cryptography

German Aerospace Agency; the Australian Center of Excellence for Quantum Computation and Communication Technology; and Google.

Besides the National Quantum Initiative and the CHIPS and Science Act that back Earth and space quantum computing research, development, and commercialization in the U.S., the United Kingdom also pursues objectives to become the first quantum-ready economy, as summarized in the recently published National Quantum Strategy.[6] The National Quantum Technologies Programme, launched in 2015, has made substantial investment into initiatives that unite academia and industry experts to explore technology and use-case portfolios within and across sectors for the promotion of quantum readiness. Similar to NASA QuAIL, the UK National Quantum Computing Centre plays a leading role in that effort, assisting technology exchange between the space sector and other market segments and creating opportunities for accelerating global quantum computing innovation by enabling mutually constructive international sustainability plans and prudent knowledge sharing with neighboring countries and beyond.[7,8,9] The European Union (EU) initiative for continental quantum communications infrastructure, funded by the Digital Europe Programme, joins the intentions of U.S. federal agencies to seek enhancements to encryption protections for sensitive data, industrial competitiveness, and critical cyberinfrastructure supporting government institutions, power grids, healthcare systems, financial networks, emergency response systems, and other key EU sectors. Member States and the European Commission work with the ESA and strategic industry partners, including Airbus, to execute schemes for terrestrial networks and off-Earth satellite systems.

Some financial market analysts project the valuation of the quantum computing sector will rise to several trillion dollars within the next ten or so years. Global expenditures from over thirty countries, including the U.S., UK, China, Germany, and France, have already reached nearly $50 billion to innovate an assortment of quantum technologies and their synergies useful for public and private Earth and space interests. Major advancements in quantum key distribution, quantum atomic clocks and accelerometers, quantum magnetometers and interferometers, and quantum optical networks will complement the harnessing of quantum computing, strengthening possibilities for securer, more sensitive and reliable, and cheaper systems for global positioning and navigation, in-process and at-line design and production manufacturing, Earth observation and orbital debris detection and tracking, communications and data trafficking, and additional outcomes. These instances figure into the UNOOSA Space2030 Agenda[10] and Space Solutions Compendium[11] for utilizing space technologies to surmount many of Humanity's grand

6 National Quantum Strategy. Department for Science, Innovation & Technology, Government of the United Kingdom, 2023; March 15: 1-61. http://www.gov.uk/dsit

7 Towards Regenerative Quantum Computing with Proven Positive Sustainability Impact. Pasqal, 2023; 1-72. https://www.pasqal.com/news/pasqal-sets-new-standards-in-sustainable-quantum-computing-at-cop28/&ved=2ahUKEwjDndj2u4qLAxWPDTQIHVr4HFMQFnoECBUQAQ&usg=AOvVaw179LMjJv1O-U71x_Cmdr29

8 Final Report: Quantum for Climate and Sustainability (NSF 22-1). National Science Foundation. United States of America, 2023; October: 1-63. https://nsf-gov-resources.nsf.gov/files/CS22047-01%2520Quantum-Workshop-Report-Current%2520-DP%2520_R3_interactive.508(2).pdf&ved=2ahUKEwjZqIDNtoqLAxXXGjQIHRIwNxYQFnoECCoQAQ&usg=AOvVaw027-IxtsQHiGx_ttMEHyET

9 Quantum for Society: Meeting the Ambition of the SDGs. Insight Report, World Economic Forum, 2024; September: 1-48. https://www3.weforum.org/docs/WEF_Quantum_for_Society_2024.pdf&ved=2ahUKEwiSxNXeuYqLAxXkIzQIHXvXElIQFnoECBYQAQ&usg=AOvVaw2YAuT-KJxdIBZWX7fzQdLp

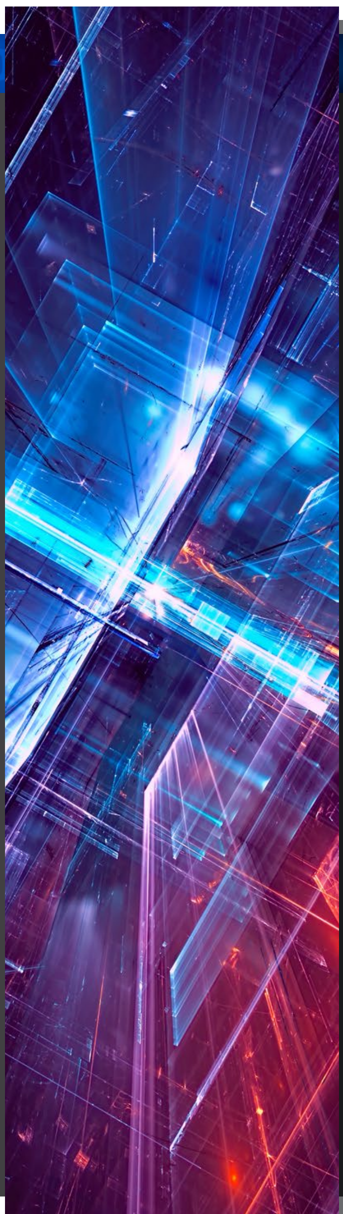
10 Contribution to the Space2030 Agenda: Eu Space – Supporting a World of 8 Billion People (ST/SPACE/85). United Nations Office of Outer Space Affairs, United Nations, 2023; July: 1-102. https://www.unoosa.org/res/oosadoc/data/documents/2023/stspace/stspace85_0_html/st_space_085E.pdf

11 Space Solutions Compendium. United Nations Office of Outer Space Affairs, United Nations, 2023. https://www.unoosa.org/oosa/en/ourwork/space4sdgs/SSC_pilot.html

challenges by fostering greater resilience and sustainability in a densely populated world of complex societies. They will likely help provide indispensable instruments for improved situational awareness, planning, and action against environmental and social injustices. Convergence of quantum computing innovation and UN Space for Sustainable Development Goals[12] may shape a space-Earth circular economy that delivers tenable optimal forecasting and solutions for poverty and hunger, quality education, health and wellbeing, clean water and sanitation, affordable and clean energy, decent work and economic growth, reduced inequalities, sustainable cities and communities, responsible consumption and production, climate action and net-zero carbon footprinting, and peace.

For inquiries, please email Dr. Clark at kbclarkphd@yahoo.com, kclark@setiap.org, or kbclark@access-ci.org

12 Space for Sustainable Goals (Space4SDGs). United Nations Office of Outer Space Affairs, United Nations, 2023; 1-2. https://www.unoosa.org/documents/pdf/Space4SDGs/UNOOSA_SDGs_2023.pdf



JUST PUBLISHED

Check out the latest and greatest recently published standards by the IEC. A complete list of recently published documents can be found here. Here's just one (of many!) we think you'll find interesting:

IEC 60194-2:2025 – ELECTRONIC ASSEMBLY, DESIGN AND CIRCUIT BOARDS - VOCABULARY - PART 2: COMMON USAGE IN ELECTRONIC TECHNOLOGIES AS WELL AS ELECTRONIC ASSEMBLY TECHNOLOGIES

IEC 60194-2:2025 covers terms and definitions related to circuit board and electronic assembly technologies as well as other electronic technologies.

The terms have been classified according to the decimal classification code (DCC) and this DCC number appears just below the defined term. The DCC numbering is fully explained in Annex A.

A list of terms in alphabetical order with code number is provided in Annex B.

This edition includes the following significant technical changes with respect to the previous edition:

- exclusion of 116 terms transferred to IEV;
- inclusion of 9 new terms related to printed electronics and packaging technology;
- revision of definitions of 23 terms reflecting current technology;
- three "printed wiring" terms were removed;
- reintroduction of identification codes for terms.

Developed by IEC TC 91 Electronics assembly technology

IEC 2024 YOUNG PROFESSIONALS WORKSHOP—AN EYE-OPENING EXPERIENCE ON GLOBAL COLLABORATION

Ashleigh McNaboe – Senior Systems Design Quality Assurance Engineer, Boston Scientific

In 2024, I was selected by the United States National Committee (USNC) to the IEC to participate in the IEC Young Professionals (YP) Workshop. This five-day intensive workshop was held in conjunction with the 88th IEC General Meeting in Edinburgh, UK. As a young professional focused on developing standards and applying conformity assessment in the medical device industry, this was a particularly exciting opportunity for me to collaborate with peers across industries, disciplines, and national committees on best practices and innovative approaches to developing and applying standards.

As one of the 85 Young Professionals (YPs) representing 45 IEC National Committees, I gained a stronger appreciation for the benefits of global collaboration and diverse perspectives. During the workshop, we heard from leaders across the Standards Management Board (SMB) and Conformity Assessment Board (CAB) on current state-of-the-art practices and their goals for the future. Additionally, we observed technical committees of personal interest, networked with our National Committee members, and formed breakout groups to work on a problem statement, with the opportunity to present a solution to the General Assembly at the end of the week.

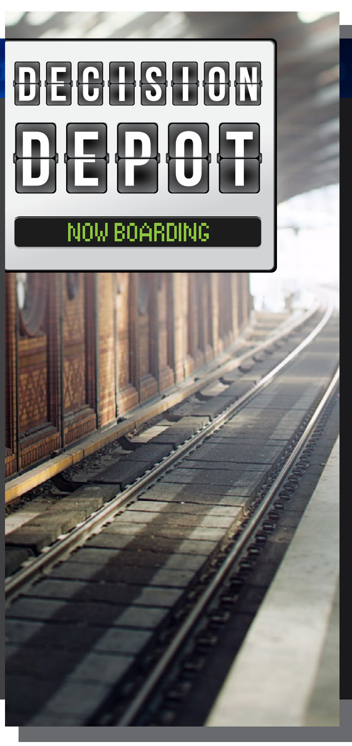
During the week, the YPs also toured The National Robotarium and Heriot-Watt University. We explored the grounds and had the chance to learn about cutting-edge research that will shape the next decade of technology, including a functional humanoid and robot prototypes that may be used in the future to assist people with disabilities. It was energizing to see how cutting-edge technology will continue to improve the human condition around the world.

One of the biggest takeaways from this workshop was the National Committees' and the IEC's commitment to their Young Professionals and their dedication to shaping future leaders. We enjoyed multiple presentations from IEC leadership, including President of the IEC, Jo Cops. IEC leaders were eager to hear our feedback, welcomed questions, and allowed us to shadow multiple board meetings, technical committees, and even the General Assembly. When observing the General Assembly, YPs had the amazing opportunity to hear Her Royal Highness, the Princess Royal address the importance of standardization in the ever-growing and connected world.

The workshop's success and its personal impact to my career development can be attributed to many individuals, but particularly the other 84 YPs who participated in the workshop from across the world. It was refreshing to collaborate with my peers not only across industries, but also across a diverse range of backgrounds, on meeting similar day-to-day goals as myself. We bonded tremendously during our week together and I have the utmost respect for their career journeys, all of which brought us to the same conference and workshop. I have gained 84 talented colleagues and have even already met with some in their home countries to visit and continue to collaborate together.

The IEC epitomizes the coming together of people across diverse backgrounds, different countries, and different disciplines with the common goal of providing a safe world for us all in the form of electrotechnical standardization. The farewell reception was held at The National Museum of Scotland, which had the profound effect of celebrating togetherness, collaboration, and future innovation in the heart of the cultural center of Scotland's capital.

I plan to stay engaged with my fellow 2024 YPs and collaborate with them in the upcoming year, particularly on the engagement of women engineers in the space of standards and conformity assessment. For a young professional like me, it was energizing to be in the same room as people in similar roles and to hear from experts and leaders from all around the world on the importance of standards, the creation of new technologies, and conformity assessment. I would say that this workshop was a once-in-a-lifetime opportunity, but I intend to continue to pursue best practices in the standards and conformity assessment space and hope to have many more opportunities to make personal and professional connections with experts and peers from across the world throughout my career.



DECISION DEPOT

This column provides easy access to recent decisions that have been made regarding IEC and USNC policies and procedures that directly affect our members. Click the link below to access the recent decisions.

See the Decision Lists below for decisions made at the following meetings: General Assembly meetings held in 2024; IEC Board meeting held on 25 November 2024; IEC Board meetings or by correspondence in 2024; and IEC Board meeting held in February 2025.

GA/247/DL

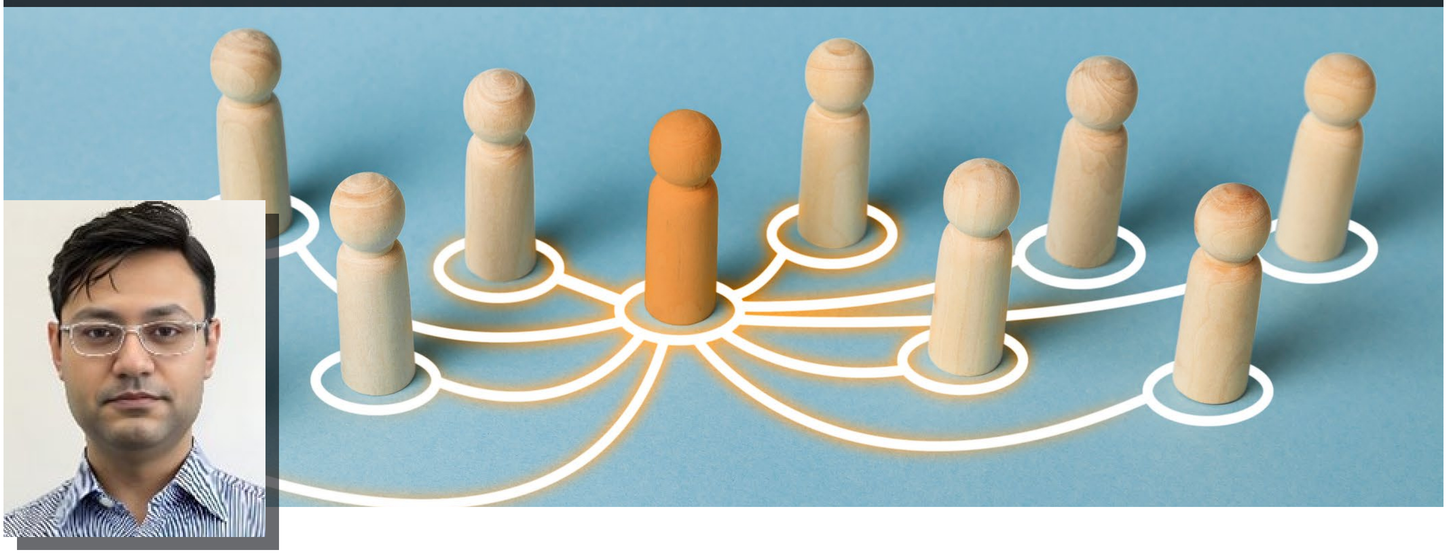
IB/382/DL

IB/394/DL

IB/419/DL

ENHANCING U.S. INFLUENCE WITHIN THE IEC

Muhammad Ali, CSP – Senior Standards Strategy and Policy Leader, HP, Inc.



Standards are effective and helpful when they facilitate trade, expand market access, boost productivity and efficiency, support innovation, increase customer confidence, and are market relevant. Standardization is a bridge between markets and technologies and whoever is on this bridge can influence the future. The International Electrotechnical Commission (IEC) is a global standards development organization that plays a critical role in preparing and publishing voluntary consensus-based international standards for all electrical, electronic, and related technologies. The U.S. National Committee (USNC) to the IEC under ANSI serves as the primary interface between the IEC and the U.S. The United States, as a leader in technological innovation, has a vested interest in enhancing the influence within the IEC to ensure that international standards reflect American technical expertise, knowledge, regulatory requirements, and market needs. The U.S. already plays a key role in IEC with numerous technical experts participating in various technical committees and leadership roles (secretariats, convenorships, chair), but there is still room for improvement for greater impact.

This article explores how to participate effectively in standards development process by leveraging the design thinking methodology Collaborate and Influence via SCARF, a brain-based model for collaboration, and setting robust standards education programs for training and development of U.S. experts.

EFFECTIVE PARTICIPATION IN STANDARDS DEVELOPMENT

The U.S. can increase its influence in IEC by ensuring that we have effective participation of stakeholders in IEC standards development process, and one of the methods to accomplish this is via Design Thinking methodology. This methodology is a well-known approach used in product development, but it is not just for product development. It can be applied in many different contexts, such as standards development. Design thinking is a non-linear, iterative, and dynamic five-stage process (See Figure 1) for creative problem-finding, problem-framing, and innovative problem-solving.

The five-stage process involves:

1. EMPATHIZE

This involves understanding the needs (drivers) and challenges of all stakeholders involved or potentially be involved in the standards development process such as end-users, industry experts, and regulatory bodies. Additionally, this also includes focusing on the needs and experiences of the end-users to ensure the standards are market relevant and beneficial. For a USNC-initiated standards proposal, this may include researching which IEC TC/SC/WG would be most appropriate, researching the current landscape of the technology/topic being standardized, and list of potential experts in U.S.

2. DEFINE

This involves clearly articulating the problems and needs identified during the empathize phase, creating a problem statement that focuses on user needs and the gaps in current standards. For a USNC-initiated standards proposal, this may include deciding on if U.S. would like to provide a Secretariat and if so, identifying who would be the chair and secretary. This is also the time to decide on what type of deliverable (standard, technical report, technical specification, etc.) is desirable, along with the scope of the document.

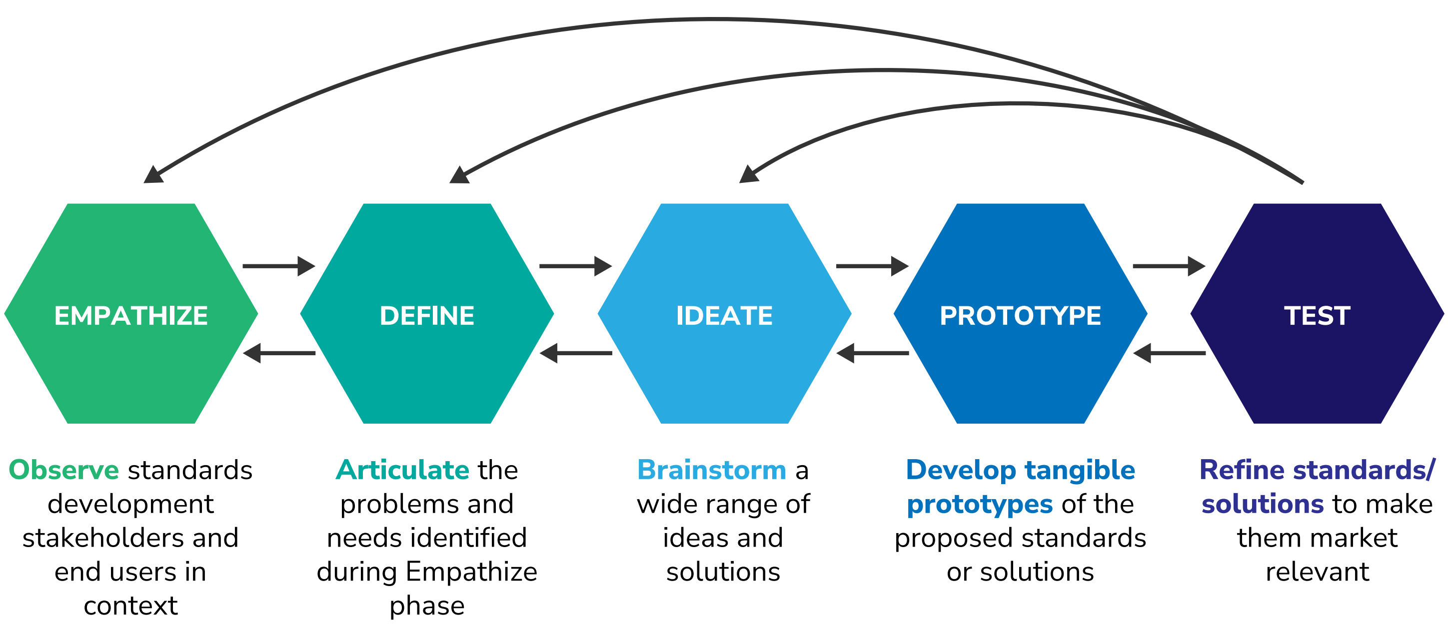
3. IDEATE

This involves brainstorming a wide range of ideas and solutions by encouraging creative thinking and challenging existing assumptions. For a USNC-initiated standards proposal, this may include engaging a diverse group of stakeholders early in the process to gather a wide range of perspectives and expertise, including government bodies, industry groups, non-governmental organizations, academia, and consumer representatives. This ensures that the standards are comprehensive and widely accepted.

4. PROTOTYPE

This involves developing tangible prototypes of the proposed standards or solutions. These can be in the form of draft documents, conformity assessment framework, or simulations. For a USNC-initiated standards proposal, U.S. also need to ensure that there is

FIGURE 1



transparency in the process being followed ensuring that the process is transparent to all stakeholders, with open access to draft standards, voting procedures, and decision-making steps. This builds trust and allows stakeholders to follow progress and understand the reasoning behind decisions.

5. TEST

This involves getting feedback and making necessary adjustments. This iterative process ensures that the standards are practical, user-friendly, and meet the needs of all stakeholders. Providing regular updates on the project progress and key milestones keep stakeholders informed and engaged throughout the standard's lifecycle. This can be done through accessible online portals or periodic meetings.

This entire five-stage process then needs to be iterated, which ensures mechanisms for accountability and continuous improvement so the standard can be revised based on feedback from users during the implementation phase, based on technology maturity and other relevant factors, or reviewed to stay the same, or be withdrawn. By integrating Design Thinking into the standards development process, the U.S. can create more effective, and market-relevant standards that servesthe needs of all stakeholders. By incorporating these principles, we can also improve the standards development process by ensuring that it is inclusive, transparent, and effective, ultimately leading to standards that are widely accepted and implemented.

COLLABORATE AND INFLUENCE

Standards development is a collaborative activity and requires consensus to create novel solutions. International standards development committees are diverse, composed of members from different countries with various cultures, perspectives, languages, areas of expertise, and ways of working. The standards development community is the heart of standardization. Without a robust community, standards activities would not be successful. They are only possible through collaboration and cooperation from all diverse stakeholders involved in the standardization process, from industry to academia to societal stakeholders to government and others.

The U.S. should also be making intentional efforts to foster collaboration and partnerships at IEC meetings such as collaboration with other national committees and regional organizations that can amplify U.S. influence within the IEC. Building strong partnerships with key allies can also helps in coordinating positions and strategies on important issues. USNC experts serving in leadership committees should be collaborating and coordinating among themselves to share best practices and resources to present a united front on USNC standards development initiatives and efforts. All this needs to be accompanied by effective communication with clear messaging to right stakeholders at the right time.

A brain-based model for collaboration and influence known as SCARF (See Figure 2) developed by David Rock in 2008 can be implemented in standards development by minimizing threats and maximizing rewards. It suggests that there are five social domains that activate the same threat and reward responses that are relied on for physical survival. These five domains are as follows:

» **Status,** which refers to the perception of one's own position relative to others. This includes respecting committee members and their viewpoints, promoting inclusion in membership, using inclusive language, providing feedback on proposals on time, respecting the work of Secretariats and Secretaries, and celebrating the successes and wins.

» **Certainty,** the need to predict outcomes of events. This includes avoiding complex jargon and keeping it simple, using project plans and business plans, circulating out meeting agendas and minutes on time, being clear on meeting goals, and staying on track to the terms of reference of the group and scope of standard.

» **Autonomy,** the need for control and the ability to make choices for oneself. This includes avoiding

FIGURE 2

S	tatus	Less than or better than others
C	ertainty	Ability to predict outcomes
A	utonomy	Sense of control
R	elatedness	In-group or out-group
F	airness	Perception of fair exchange

Threat Avoidance

...is a stronger impulse

Reward Seeking

...is a better impulse

micromanagement, using delegation effectively, checking in with team leads/committee members often but trust them to do their work, being flexible in approach, and trying out new ideas.

» **Relatedness,** the need for a sense of safety or connection with others. This includes engaging with committee members outside of meetings during coffee breaks and social events to bring a sense of community, providing help to new members, keeping members informed, and hosting meetings in a safe, inclusive, and accessible locations.

» **Fairness,** the need to be treated with equity. This includes being ethical in your work, treating everyone with respect and fairness, avoiding excluding people, having a robust set of policies and procedures, and being transparent in decision making.

CASE STUDY: STANDARDS DEVELOPMENT VIA SCARF MODEL

The merits of the SCARF model can be seen in the following case study regarding a USNC expert named Najma, also a convener of an IEC working group. The working group has been tasked to create a new standard, with a standards development track of 36 months. The working group is small, and most of the members are new to standards. She is seeing very little engagement from the group and encountering difficulty in filling key positions such as editor and secretary. Najma is overwhelmed.

Here are the steps taken by Najma using the components of SCARF, specifically focusing on certainty, autonomy, and fairness:

» Realizing that most members were new to standards, Najma began allocating 15 minutes in her working group meetings for microlearning opportunities on topics such as the role of editor and secretary, the standards development process, and so on.

» She communicated directly with committee members in between meetings on a one-on-one basis.

» She kept meetings enjoyable through good organization, distributing agendas and minutes on time, and remaining on topic.

As a result, after the first six working group meetings, the committee members became much more engaged. The roles of editor and secretary were filled. The working group was able to complete and publish the standard in 30 months. Najma shared the win at the plenary meeting by sharing the process and approach she used to achieve success.

USNC STANDARDS READY WORKFORCE

Standards education must be a top priority for a sustainable standards system. To be effective in standards engagement efforts, U.S. experts and delegates must be well-prepared and equipped with the right skillsets. We must also recognize the different education and training needs for different stakeholders within the international standards ecosystem according to the range of roles USNC TAG members play within the IEC TCs/SCs/WGs/PCs, such as convenor, chair, secretary, expert, editor etc.

Experts new to standards development can greatly benefit from understanding the IEC standards development process via its directives and the Operating Procedures for its USNC TAG, utilizing digital tools to manage their work such, as project management platforms and networking with other professionals in relevant organizations during meetings or other related social events. Just like any other profession, continuous education and training are essential to stay current with developments in the standards world. Therefore, new and emerging professionals in standardization should take advantage of opportunities such as IEC and USNC Young and Emerging Professionals Program; IEC General meeting; standards-focused conferences organized by TCs or other stakeholders; workshops; webinars such as IEC Academy or USNC webinars; training sessions by the U.S. TAG administrator and/or IEC; and mentorship programs such as the USNC Mentorship Program.

Soft skills are crucial in standards development as they create a collaborative environment, enhance communication, and facilitate problem-solving. Key skills such as self-awareness, emotional intelligence, effective communication, negotiation, conflict resolution, and networking are indispensable. Cultural awareness enables individuals to respect and appreciate diverse perspectives, fostering inclusion and effective collaboration. Emotional intelligence, on the other hand, aids in understanding and managing one's emotions and those of others, leading to improved teamwork and conflict resolution. These skills collectively ensure that all voices are heard and considered, resulting in more comprehensive and effective standards. Developing an open and global mindset in standards development requires cultural intelligence, building trust, consensus, and adaptability. For additional information, check out the article on a Global Mindset for Standards Development in the Spring 2021 edition of the USNC Current.

By enhancing U.S. influence within the IEC and adopting a proactive and strategic approach, we promote the competitiveness of U.S. industries in the global market and can play a leading role in shaping the future of global technology standards that drive innovation, safety, and quality worldwide. By strengthening our participation in standards development committees, fostering collaboration, and educating our experts on standardization, the U.S. can ensure that its voice is heard, and its interests are represented within the IEC.

USNC/IEC TRAINING & EDUCATION

New to USNC? The USNC provides education and training resources for electrotechnical standardization and conformity assessment.

We encourage you to take advantage of our training opportunities available now on the USNC webpage!

- USNC Constituent Training Modules
- USNC Effective IEC Participation Webinar
- USNC & IEC Conformity Assessment 101
- Why IEC Standards Work Is Important to My Company
- Benefits of Standards Work for Emerging Professionals

Upcoming Webinar:

IEC's Online Standards Development (OSD) – Latest Release (4.2).

Join us on Tuesday, April 1 from 10 AM – 11 AM ET to learn about the most recent version of the Online Standards Development (OSD) tool. Register here to attend or to receive the webinar recording.

ICYMI: The USNC hosted a webinar on **Effective Participation in the IEC.** View the webinar recording here.

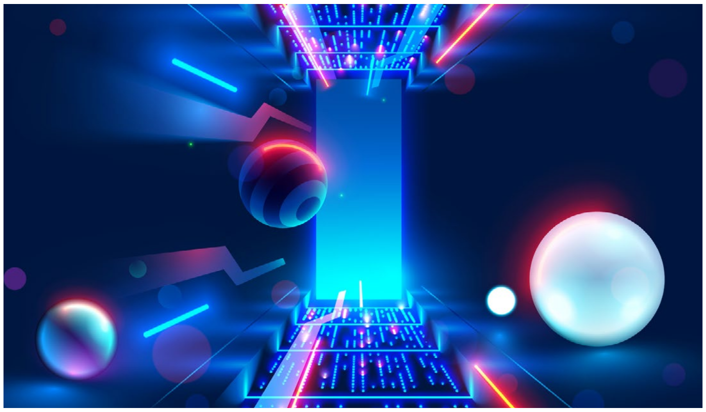
Looking for more? IEC Academy & Capacity Building hosts frequent webinars. You can access past webinar recordings and register for upcoming webinars.

THANK YOU TO OUR JANUARY 2025 USNC MANAGEMENT MEETING HOST, AMERICAN WELDING SOCITY!

AWS American Welding Society

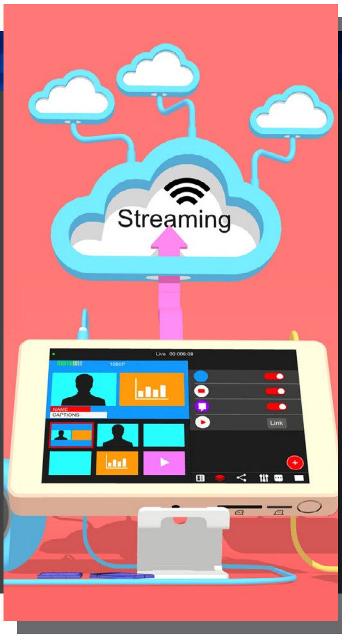
On January 28–30, the three USNC policy committees (USNC Council, Technical Management Committee (TMC), and the Conformity Assessment Policy Coordinating Committee (CAPCC) met in Doral, FL at the American Welding Society for three days of fruitful meetings. Thank you to AWS for hosting us!

USNC ONLINE PORTAL FOR TAG PARTICIPATION MANAGEMENT



In April 2024, the USNC was thrilled to launch the new online portal for TAG participation management. Features of the new portal include: roster management for TAG officers and more user-friendly way to view and pay TAG invoices.

ANSI IT and USNC staff held a demo of the new program in April; TAG officers that missed the session are encouraged to review the user guide and review the demo recording. Questions can be directed to usncbilling@ansi.org.



ANSI MEMBERSHIP WEBINARS

Membership in ANSI is the key to unlocking the benefits and opportunities that standardization can provide. Standardization and conformity assessment activities lead to lower costs by reducing redundancy, minimizing errors, and reducing time to market, resulting in enhanced profitability.

These interactive 30-minute webinars—held on the first Friday of each month and free of charge—are hosted live and provide an overview of ANSI's activities, as well as information on how to take full advantage of ANSI membership. A Q&A session encourages active dialogue between all participants.

For more details, visit our website!

JOIN THE USNC LINKEDIN GROUP

Would you like to stay updated with the news and events of the USNC? Join our LinkedIn Group to learn about and provide input on all issues electro-technical that can affect your life, from your own home to the other side of the globe! If you have any information to share on LinkedIn, please contact Catherine Pilishvili (cpilishvili@ansi.org).

ABOUT THIS PUBLICATION

The USNC *Current* newsletter is distributed to the constituency of the U.S. National Committee (USNC) of the International Electrotechnical Commission (IEC). It provides updates on technical activities and other information of interest to members of the electrotechnical community. Some articles are reprinted with permission from the IEC News log.

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HOW TO CONTRIBUTE

Contributions are gladly accepted for review and possible publication, subject to revision by the editors. Submit proposed news items to: Catherine Pilishvili (cpilishvili@ansi.org).