Emerging technology, standards and sustainability

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Abstract

Technical standards play a critical role at the intersection of emerging technology and sustainability by providing a foundation for the development and deployment of new technologies that promote sustainability and protect the environment. By establishing guidelines for the safe, reliable, and efficient use of new technologies, and by promoting sustainability through resource efficiency and environmental protection, they shape the future of technology and sustainability.

Technical standards are published documents that establish specifications and procedures designed to maximize the reliability of the materials, products, methods, and services people use every day. They are strategic tools for raising safety and environmental performance and ensuring interoperability. They drive innovation, competitiveness, sustainability, and consumer protection, while helping to aggregate markets, facilitate technology diffusion, and promote production efficiency.

They result from collective work by experts in a field and provide a consensus of those experts at the time when the standards are developed and help to make life simpler and increase the reliability and the effectiveness of many of the goods and services we use.[1] Standards in technical domains provide people and organizations with a basis for mutual understanding and are instruments to facilitate communication, measurement, commerce, and manufacturing.

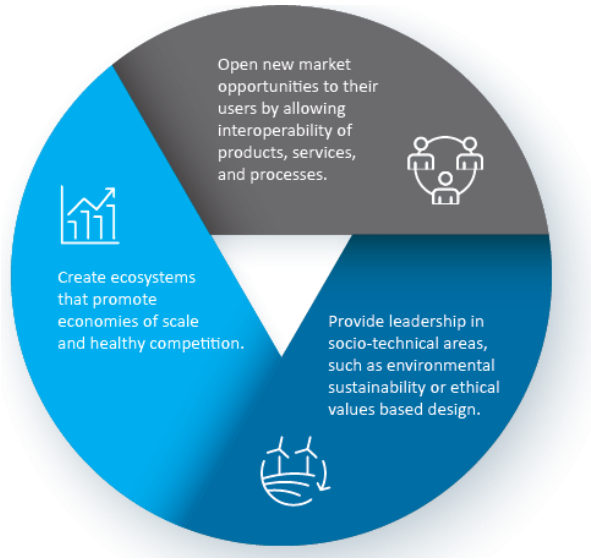

Figure 1. Value of standards.

These attributes are essential to help ensure that markets remain open, allowing consumers to have choice and new entrants to successfully enter markets, and they are instrumental to addressing local and global challenges we face today, including sustainability.

Standards are developed by several types of standards bodies from around the globe. Those with a geographic designation are usually categorized as inter-national, regional, and national standards bodies that typically function under a nation-centric standardization approach where governments, or bodies closely coupled to government, set or mandate standards. Those with a global technical or industry designation include state-independent standards developing bodies with a globally open participation mode. Several professional and technical organizations function in such a decentralized, pluralistic, and industry-led manner, and typically do not involve national representation, being thus exempt from state intervention.[2]

Value of Standards

The United Nations Economic Commission for Europe recognized the value and impact of standards in the 2018 publication *Standards for Sustainable Development Goals*, which addresses how international standards are used by policymakers to support sustainability and the achievement of the goals. The report notes that standards support the achievement of the 2030 Agenda in different ways. Some standards are cross cutting and provide guidance to all types of organizations, regardless of their size or location. They support the integration of socially and environmentally responsible behaviour in the management of plants and workplaces. Examples include standards that reduce and monitor emissions or energy use, and

[1] https://www.iso.org/benefits-of-standards.html

[2] https://standards.ieee.org/wp-content/uploads/import/documents/other/Market-driven-communications.pdf

standards that help close the gender pay gap and curb discrimination against female workers. A number of standards have target-specific and goal-specific relevance. For example, standards on electrotechnical materials are indispensable for the attainment of Goal 7, as they ensure: (i) the safety and dependability of core infrastructure projects (e.g., wind farms and smart grids), and (ii) promote energy efficiency and the transition to modern energy services. Standards support companies and communities in conceiving and bringing to the market cleaner and more energy-efficient products, helping protect and conserve environmental resources. Standards enable all three dimensions of sustainability and play a key role in supporting a distributed governance model. This model empowers people to take action in their respective fields of influence and promotes the social, economic and political inclusion of all.[3]

Standards for Sustainability

Technical standards play a vital role at the intersection of emerging technology and sustainability by providing a common framework for the development and deployment of new technologies. Therefore, they should be used in an effective way to empower innovation across borders for an ecologically and socially sustainable prosperity.[4]

As the pace of technological advancement continues to accelerate, it is critical that new technologies are designed, developed, and deployed in ways that promote sustainability and protect the environment. Technical standards help to ensure that can happen by providing guidelines for the safe, reliable, and efficient use of new technologies, while also promoting sustainability through guidelines for resource efficiency and environmental protection.

For example, technical standards for energy efficiency in consumer electronics help to reduce the energy consumption of devices and promote sustainability by reducing greenhouse gas emissions. Standards for the use of renewable energy sources such as solar and wind power help to ensure the development of a clean and sustainable energy system. Technical standards for environmental protection, such as those for e-waste management, help to minimize the negative impact of new technologies on the environment.

In addition to these specific areas, such standards play a broader role in shaping the development of new technologies and promoting sustainability by establishing a common understanding of what is possible and what is desirable. This helps to ensure that new technologies are developed and used in ways that promote long-term sustainability, rather than simply pursuing short-term goals that may have negative environmental or societal consequences.

It is important to note that technical standards evolve and change over time as new technologies emerge and new challenges arise. As such, the development of new technical standards is an ongoing process that requires close collaboration between stakeholders from academia, industry, government, and civil society.

The current state of emerging technology standards and sustainability is evolving, with a growing recognition of the need for standards to support the transition to more sustainable practices, technologies, and innovation. Emerging technologies have the potential to drive significant advances in sustainability, but they also present new challenges and risks that need to be managed. One challenge is the speed at which emerging technologies are being developed and the need for standards to keep up with the latest developments. There is an increasing recognition of the need for standards to support responsible development and deployment of emerging technologies for sustainability.

The development and implementation of standards for emerging technologies with a focus on sustainability can face additional challenges.

Measurement	Limited metrics are used in current standards relevant to sustainability
Transparency	Data and methods to calculate emissions are not transparent creating challenges to understanding or duplicating results
Compromise	Need for better balance when applying "tradeoffs" between environmental, social, and economic outcomes
Interdisciplinary	Sustainability requires expertise from many fields, lack of collaboration creates challenges for standards development
Coordination	Without synchronization among standards bodies, challenges arise as to what sustainability approach to take
Pace	Standards development and the rate of adoption limit effectiveness in addressing climate change

Figure 2. Challenges.

[3] https://unece.org/DAM/trade/Publications/ECE_TRADE_444.pdf

[4] Such examples include open programs of the IEEE Sustainable Development Platform, Sustainability for Connectivity and Telecom Systems and Sustainable Maritime.

Response

These factors, among others, have contributed to the complexity of the interplay of emerging technology, standardization, and sustainability. Subsequently, it has also brought to the forefront the growing recognition of the importance of sustainability in the development of standards for emerging technologies and the impetus for bodies to drive efforts to incorporate such considerations into initiatives and work programs.

As noted, standards can play a crucial role in addressing sustainability and contributing to advancing the climate agenda. For example, standards can support the accomplishment of SDG 13 (Climate Action) by establishing consensus-based specifications and procedures designed for the monitoring of climate change, the measuring of greenhouse gasses, and the fostering of good practice related to environmental management.

Such standards, inter alia, provide businesses and institutions with practical tools to reduce the impact of their operations on the environment, implement effective environmental management systems, communicate on environmental performances, as well deliver climate change mitigation and adaptation strategies, and open the markets to clean energy.

Organizations like IEEE, through decentralized direct-participation mode, are leading the development of standards for emerging technologies, including standards for autonomous and intelligent systems, next generation networking, mobility, etc., and have established programs for the standards lifecycle grounded in collaborative and consensus-based processes.[5]

In addition, through such a model, a robust collection of IEEE standards that cover a range of topics related to sustainability are available, including:

- IEEE 1547(™) series of standards for interconnecting distributed energy resources with electric power systems
- IEEE 1680(™) series on environmental assessments
- IEEE P7010.1™ on Environmental Social Governance (ESG) and Social Development Goal (SDG) Action Implementation and Advancing Corporate Social Responsibility
- IEEE P7800™ for Addressing Sustainability, Environmental Stewardship and Climate Change Challenges in Professional Practice

Considerations and conclusion

Standardization is one factor in the emergence of new technologies and systems. The journey from promising emerging technology to full industrialization or use is a complex process involving a range of innovation activities, including research, systems engineering, manufacturing, marketing, business models, regulation, value chain development, etc., as well as standards development. Standards can have different functions throughout this journey and, consequently, can involve different innovation systems actors performing different roles at different stages in the technology's development lifecycle. Because of the complex, dynamic, multi-actor nature of the process of technological emergence, there can be significant value in endeavours that create ongoing awareness and alignment among all innovation system actors - industrial, technical, regulatory, and governmental.

A new integrated framework that takes into account the various factors at play, the diverse ecosystem of actors, the anticipated future of advancement at the interplay of emerging technology, standardization and sustainable development in the context of the urgent state of the planet is needed. Such a framework is yet to emerge. However, it is useful in the formation of such a framework to take the following into account to inform research agenda and discussion, and to ensure diverse needs and conditions are reflected and lasting and reasonable solutions are explored and proposed.

- A new era of standardization which needs to be global and inclusive, as well as nimble and innovative– with sufficient clear rules.
- The forms of standardization which serve purpose. The need for stability (provided by formal standards bodies), coping with rapid change (provided by ephemeral consortia or alliances), specific intellectual property and marketing environments and the need for robust community involvement (provided by Open Source).[6]

[5]Such examples include open programs of the IEEE Sustainable Development Platform, Sustainability for Connectivity and Telecom Systems and Sustainable Maritime.

[6] Mega Regionalism 2.0 Trade and Innovation within Global Networks

- Programs to help policymakers better understand the use of standards to support public policy initiatives, inclusive of referencing standards in legislation or regulation, as well as leveraging standards to support public decisions and actions.

- Acknowledging challenges with not recognizing the broader set of Standard Development Organizations (SDO's) involved in the global standardization system, particularly around digital and green transformation, and how this could potentially hinder advancements in achieving climate goals. Failure of standards development work to keep up with the rapid pace of technical innovation could result in standards needed to be unavailable.

- Opening up the standardization system horizontally to leverage achievements of the broader standardization ecosystem for global needs.

- Working to extend the coverage of standards to new sectors and industries thereby helping to ensure that all areas of economic activity are included in sustainability efforts.

- Identifying gaps in the portfolio of international standards which will be needed to support and enable the transition and sustainability of a sustainable future.

- Fostering innovation by providing platforms for the exploration, development and testing of new technologies and approaches to sustainability.

- Promoting the use of standards by policymakers and businesses as a tool for them to help reduce technical barriers to trade, promote increased resilience to disasters, foster innovation and good governance.

- Accelerating the development and implementation of new standards, helping to ensure they are able to respond rapidly to challenges of climate change.

- Advancing the use of standards in the implementation of UN-wide goals, including the implementation of the Agenda 2030.

Many organizations are leading the development of standards for emerging technologies to align with the growing recognition of the importance of sustainability in the development of standards for emerging technologies and as such are driving efforts to incorporate sustainability considerations into their work.

References

Sarewitz, D. and Nelson R., 2008, Three rules for technology fixes, Nature, 456

International Organization for Standardization. (2029) ISO and innovation https://www.iso.org/files/live/sites/isoorg/files/store/en/PUB100444.pdf

International Organization for Standardization. (2021) A blueprint for sustainable innovation . https://www.iso.org/news/ref2688.html

International Organization for Standardization. (2020) The innovation game, Knut Blind. https://www.iso.org/news/isofocus_142-4.html

European Committee for Standardization. (2020) Webinar 'Exploring standardization's contribution to the achievement of the United Nations Sustainable Development Goals (SDGs)' https://www.cencenelec.eu/news-and-events/events/2020/2020-06-08-standardization-s-contribution-sdgs/

European Committee for Standardization. (2022) New CWA 17935 'Sustainable Nanomanufacturing Framework' https://www.cencenelec.eu/news-and-events/news/2022/brief-news/2022-10-19-new-cwa-17935-sustainable-nanomanufacturing-framework/

European Committee for Standardization. (2022) https://www.cencenelec.eu/media/CEN-CENELEC/CWAs/RI/cwa17935_2022.pdf

European Committee for Standardization. CEN and CENELEC Journey towards the UN Sustainable Development Goals (SDGs) https://www.cencenelec.eu/european-standardization/sustainable-development-goals-sdgs/

World Intellectual Property Organization.(2020) How trademarks can promote **sustainability** https://www.wipo.int/ip-outreach/en/ipday/2020/articles/sustainable_trademark.html

World Intellectual Property Organization. (2020) Sustainability Assessment of Technologies (SAT) https://www.wipo.int/edocs/mdocs/mdocs/en/wipo_ip_mnl_15/wipo_ip_mnl_15_t16a.pdf

World Intellectual Property Organization. (2020) **Sustainability** in the circular economy https://www.wipo.int/wipo_magazine/en/2020/01/article_0002.html

International Electrotechnical Commission. (2017) Standards Council of Canada: How International Electrotechnical Standards promote sustainability. Standards Council of Canada https://etech.iec.ch/issue/2017-07/how-international-electrotechnical-standards-promote-sustainability

International Electrotechnical Commission. (2017) How standards can promote future sustainable transport. https://etech.iec.ch/issue/2022-04/how-standards-can-promote-future-sustainable-transport

International Electrotechnical Commission. (2022) How standards drive the sustainable development goals https://etech.iec.ch/issue/2022-02/how-standards-drive-the-sustainable-development-goals

International Electrotechnical Commission. (2022) IEC to host strategic dialogue on standards for UN Sustainable Development Goals https://www.iec.ch/blog/iec-host-strategic-dialogue-standards-un-sustainable-development-goals

United Nations Environment Programme (2019). *Towards an Inter-Agency Joint Plan of Action (JPoA) for Achieving the Trade related Targets of Sustainable Development Goal 14: Agenda - Room VIII, Palais de Nations, Geneva, 10 a.m.–1 p.m., 13 June 2019*. https://wedocs.unep.org/20.500.11822/28385.

American National Standards Institute (ASTM) E2876-13 (2023) – Standard Guide for Integrating Sustainable Objectives into Cleanup https://webstore.ansi.org/standards/astm/astme2876132020?_ga=2.182205742.841793670.1678400692-114045385.1662940443

European Commission. (2019). Scaling up Voluntary Sustainability Standards through Sustainability Public Procurement and Trade Policy | UNCTAD https://knowledge4policy.ec.europa.eu/publication/scalin...

World Trade Organization. (2021) Standards and Trade Development Facility (STDF) Annual Report https://standardsfacility.org/stdf-2021-annual-report

Tsalis, Thomas A., et al. "New challenges for corporate sustainability reporting: United Nations' 2030 Agenda for sustainable development and the sustainable development goals." Corporate Social Responsibility and Environmental Management 27.4 (2020): 1617-1629. https://onlinelibrary.wiley.com/doi/abs/10.1002/csr.1910

Montiel, Ivan, et al. "Implementing the United Nations' sustainable development goals in international business." *Journal of International Business Studies* 52.5 (2021): 999-1030. https://link.springer.com/article/10.1057/s41267-021-00445-y

de Cordoba, Santiago Fernandez, et al. *Voluntary Sustainability Standards, Trade and Sustainable Development: 3rd Flagship Report of the United Nations Forum on Sustainability Standards (UNFSS)*. UNFSS, 2018. https://library.wur.nl/WebQuery/wurpubs/fulltext/469894

Rotolo, Daniele, Diana Hicks, and Ben R. Martin. "What is an emerging technology?." *Research policy* 44.10 (2015): 1827-1843. https://www.sciencedirect.com/science/article/pii/S0048733315001031

Kim, Dong-hyu, Heejin Lee, and Jooyoung Kwak. "Standards as a driving force that influences emerging technological trajectories in the converging world of the Internet and things: An investigation of the M2M/IoT patent network." *Research Policy* 46.7 (2017): 1234-1254. https://www.sciencedirect.com/science/article/pii/S0048733317300835

Zhao, Langqiu. "Policy Requirements for Infrastructure Planning and Construction of Large Cities in the Development of New Energy Vehicles—A Case Study of the Sustainable Transport Policy of Large Cities in China." *Law and Economy* 2.3 (2023): 42-50. https://www.paradigmpress.org/le/article/view/483

AlMashaqbeh, Sahar, and Jose Eduardo Munive-Hernandez. "Risk Analysis under a Circular Economy Context Using a Systems Thinking Approach." *Sustainability* 15.5 (2023): 4141. https://www.mdpi.com/2071-1050/15/5/4141

Allen, Robert H., and Ram D. Sriram. "The role of standards in innovation." *Technological Forecasting and Social Change* 64.2-3 (2000): 171-181. https://www.sciencedirect.com/science/article/pii/S0040162599001043

Borraz, Olivier. "Governing standards: the rise of standardization processes in France and in the EU." *Governance* 20.1 (2007): 57-84. https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1468-0491.2007.00344.x

Palan, Nicole, Nuno Crespo, and Nadia Simoes. "Inequalities in Trade." *REDUCED INEQUALITIES* (2023): 83. https://www.mdpi.com/books/edition/6778/article/6804/pdf#page=100

United Nations Economic Commission for Europe (UNECE) (2018) Standards for Sustainable Development Goals. https://unstats.un.org/sdgs/files/report/2018/thesustainabledevelopmentgoalsreport2018-en.pdf

Measurement: The United Nations Economic Commission for Europe (UNECE) notes in their 2018 publication "Standards for Sustainable Development Goals" that "measuring progress towards sustainable development requires indicators that capture the multi-dimensional and interrelated aspects of sustainable development" (p. 12). They highlight the need for collaboration and data-sharing among stakeholders to develop comprehensive and effective indicators for sustainability.

Transparency: The International Organization for Standardization (ISO) has developed several standards related to environmental management, such as ISO 14001, which includes requirements for transparent reporting and communication of environmental performance (ISO, n.d.). The Greenhouse Gas Protocol, developed by the World Resources Institute and the World Business Council for Sustainable Development, provides guidelines for transparent and consistent reporting of greenhouse gas emissions (Greenhouse Gas Protocol, n.d.).

Compromise: The UNECE publication mentioned earlier notes that "sustainable development standards are more complex and challenging to develop than traditional technical standards because they involve a broader set of stakeholders with varying and sometimes conflicting interests" (p. 14). The publication highlights the need for inclusive and transparent stakeholder engagement to address trade-offs and ensure equitable outcomes.

Interdisciplinary: The UNECE publication also emphasizes the need for interdisciplinary collaboration in the development of sustainable development standards. They note that "sustainability standards require the involvement of experts in many fields, including engineering, natural and social sciences, economics, law and policy" (p. 15).

Coordination: The UNECE publication highlights the need for coordination among different bodies developing sustainability standards, noting that "it is important to identify and address overlaps and gaps in standards development activities to avoid duplication of efforts and promote coordination among different standardization bodies" (p. 16).

Pace: The UNECE publication notes that "the pace of standardization can be too slow to address the rapidly evolving needs of sustainability" (p. 17). They highlight the need for agile and flexible standardization processes to keep pace with technological and societal changes.

IEEE Sustainable Infrastructures and Community Development program
https://standards.ieee.org/industry-connections/sustainable-infrastructures-development/

IEEE Publications on Sustainability
IEEE Transactions on Sustainable Energy
IEEE Transactions on Sustainable Computing
IEEE Transaction on Green Communications and Networks
IEEE Electrification Magazine
IEEE Transactions on Transportation Electrification

IEEE Standards for Sustainability
IEEE P1922.1™ – Standard for a method for calculating anticipated emissions caused by virtual machine migration and placement
IEEE 1922.2™-2019 – IEEE Standard for a Method to Calculate Near Real-Time Emissions of Information and Communication Technology Infrastructure
IEEE P1923.1™ – IEEE Standard for computation of energy efficiency upper bound for apparatus processing communication signal waveform
IEEE P1924.1™ – Recommended practice for developing energy efficient power-proportional digital architectures
IEEE P1925.1™ – Standard for Energy Efficient Dynamic Line Rate Transmission System
IEEE P1926.1™ – Standard for a Functional Architecture of Distributed Energy Efficient Big Data Processing
IEEE P1927.1™ – Standard for Services Provided by the Energy-efficient Orchestration and Management of Virtualized Distributed Data Centers Interconnected by a Virtualized Network
IEEE P1928.1™ – Standard for a Mechanism for Energy Efficient Virtual Machine Placement
IEEE P1929.1™ – An Architectural Framework for Energy Efficient Content Distribution
IEEE 1547(™) series of standards for interconnecting distributed energy resources with electric power systems
IEEE 1680(™) series on environmental assessments
IEEE P7010.1™ on Environmental Social Governance (ESG) and Social Development Goal (SDG) Action Implementation and Advancing Corporate Social Responsibility
IEEE P7800™ for Addressing Sustainability, Environmental Stewardship and Climate Change Challenges in Professional Practice

World Economic Forum (2020) Six Qualities of Sustainable Infrastructure in Action
https://www.weforum.org/reports/six-qualities-of-sustainable-infrastructure-in-action/

International Organization for Standardization. (ISO) Benefits of standards
https://www.iso.org/benefits-of-standards.html