Energy Management and Product Sustainability Standards – A Key Link to Sustainable Supply Chains

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ABSTRACT

Reducing supplier energy consumption can be critical to creating more sustainable and resilient supply chains, and can be achieved by embedding criteria for energy management systems into product sustainability standards.

Manufacturers across the globe are taking steps to reduce their greenhouse gas emissions and become more sustainable. Large industrial corporations rightly tout their efforts and successes. However, their upstream emissions, that is, the emissions from companies supplying components, are more difficult to address. These supplier companies are often smaller manufacturers with limited awareness or incentives to reduce emissions. Within the electronics industry, a diverse group of stakeholders is seeking to make the electronics sector more sustainable and resilient through product sustainability standards. The U.S. Department of Energy is engaged in these endeavors, including efforts to reduce supplier energy consumption by incorporating criteria into these sustainability standards that encourage the adoption of energy management systems and practices.

Such activity within the electronics sector can be a significant component of a broader resilience roadmap for the sector's supply chain. This paper highlights the efforts to embed energy management practices into electronics products supply chains to build resilience, and presents a business case using examples from U.S. manufacturers that can be replicable to other manufacturing sectors.

Introduction

Concern over climate change, greenhouse gas (GHG) emissions, and natural resource depletion has led to diverse groups of stakeholders within and across many industries organizing to address the sustainability of products. A number of industries have developed, or are developing, product sustainability standards as a tool for incentivizing the manufacture of more sustainable products. Manufacturers can benefit from product sustainability standards by having harmonized and consistent criteria, and gain a market advantage. Consumers benefit by being able to identify and select, based on ecolabels or other means, products meeting the criteria within the standards.

Manufacturers and other stakeholders in the electronics sector have developed a number of sustainability standards, covering products from servers to mobile phones. These product sustainability standards address the full life cycle of a product, from raw material extraction to product end of life (see Figure 1). The Global Electronics Council (GEC) has teamed with Criteria Development Organizations (CDOs) to organize the stakeholders for many of these efforts, assembling manufacturers, purchasers, government representatives, recyclers, and environmental organizations. Electronics products meeting or exceeding standards are recognized through GEC's EPEAT registry. Between 2006-2018, according to GEC, EPEAT-

registered products have reduced GHG emissions by over 184 million metric tons, reduced hazardous wastes by over 830,000 metric tons, and conserved over 208 million metric tons of primary materials (GEC 2021a, EPA 2021a).

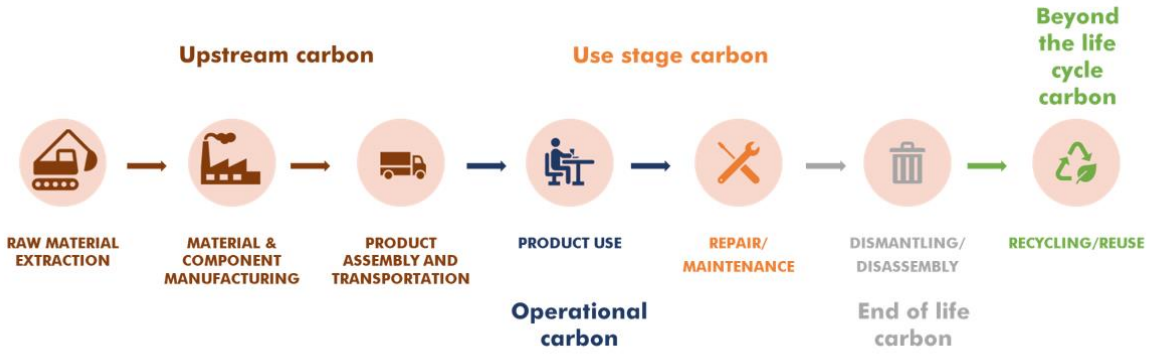

Figure 1. Typical electronic product life cycle. *Source:* GEC 2021b.

While the electronics product sustainability standards have for a number of years included criteria related to the energy consumption of products during their useful lives, only more recently have criteria been added that address the energy consumed during the component manufacturing and product assembly phases. Building upon the Department of Energy's (DOE) experience working with the U.S. manufacturing sector to achieve continual energy performance improvement and persistent energy savings within manufacturing facilities and organizations, DOE seeks to include criteria that incentivizes the implementation of energy management systems by electronics manufacturers and their suppliers.

Importance of Addressing Electronics Industry's Supply Chain Energy Use

Energy efficiency is fundamental to decarbonization. Efficiency measures can potentially cut 15% of industrial emissions through modifications to industrial buildings, equipment, and operating practices (Nadel and Ungar 2019). By extension, effective energy management is foundational to effective management of GHG emissions, and requires implementing a structured approach to energy management rather than an ad hoc approach (CEC 2019).

Making implementation of an energy management system a component of a corporate sustainability standard helps an CDO achieve the strategic objectives of ensuring reducing future energy consumption, reducing environmental impacts, and demonstrating leadership in sustainability. Implementation of a certified energy management system has been proven to be the global best practice through dozens of case studies (DOE 2021a). Facilities with robust energy management systems in place have shown above average savings, while also sustaining those savings longer. With a management system in place, facilities identify more opportunities to save energy, implement more projects, and track savings more closely (Therkelsen et al. 2021).

The inclusion of incentives for original equipment manufacturers (OEMs) and their suppliers to adopt energy management practices demonstrates an OEM's leadership in energy efficiency and energy management, and serves a critical role in catalyzing the adoption of the

global best practice by other electronic manufacturers and their suppliers. It potentially influences all organizations within an OEM's supply chain and conceivably the entire sector.

A relatively small population of OEM facilities exists within the electronics sector and since they are often assembly plants, they generally do not account for significant energy savings and greenhouse gas emission reduction potential. However, as early adopters of a global best practice, they have the capacity to motivate the more energy-intensive global electronics supply chain to adopt energy management systems.

Eighty-three percent of the life cycle greenhouse gas (GHG) emissions of an Apple iPhone 12 are produced during the manufacture of the phone (see Figure 2) (Apple 2020). The iPhone is not an outlier – the World Economic Forum (WEF) has found that 77% of greenhouse gas (GHG) emissions from the electronics industry are attributable to the electronics supply chain. It sees resource and manufacturing process efficiency improvements as the most affordable opportunities for addressing electronics manufacturing emissions, with the potential to reduce sector emissions by around 20%. WEF includes the electronics sector as one of eight industries responsible for 50% of global emissions, along with food, construction, fashion, consumer goods, automotive, professional services, and freight (GEC 2021.p.5, WEF 2021).

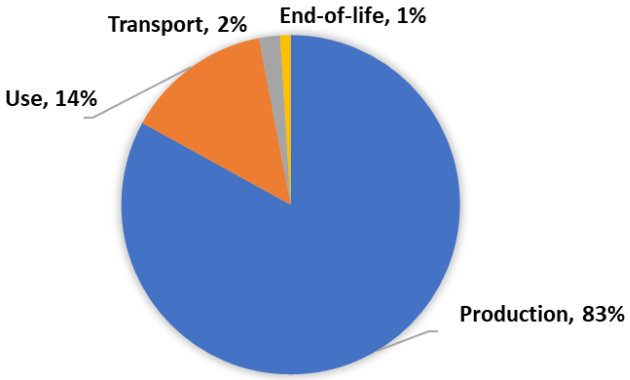

Figure 2. Life cycle GHG emissions of Apple iPhone 12. *Source*: data from Apple 2020.

Energy is consumed and GHGs emitted at each link of the supply chain as goods are manufactured, distributed, used, and discarded. OEMs' choices affect everything from which raw materials suppliers select to how products are transported. Corporate policies can drive demand for low-carbon goods and materials as well as promote efficient practices (Whitlock, Elliott, and Rightor 2020).

OEMs can use their influence with suppliers to encourage them to implement energy management business practices. They can also assist suppliers with implementation through guidance and technical assistance. Just a few OEMs engaging their suppliers to implement energy management systems can create the momentum to bring scale to the adoption of energy management best practices across supply chains and entire sectors.

Embedding Energy Management into Sustainability Standards

Energy management systems provide organizations with a systematic method for addressing energy use, costs, and waste. An energy management system establishes the policies

and procedures to systematically track, analyze, and improve energy efficiency. It enables organizations to manage their energy use, sustain savings from projects, and improve productivity on a per unit of energy basis. Management systems often incorporate continual improvement practices such as systematically and routinely engaging workers throughout an organization in group activities that identify ways to reduce waste and increase the quality and or quantity of outputs. It is often accomplished through standard operating procedures, management practices, setting of goals, and rigorous monitoring of progress.

The ISO 50001 Energy Management System standard is a set of requirements for energy management systems that enables organizations to identify top opportunities to save energy and money, ensure that savings persist and grow, establish data-driven processes and procedures to build energy efficiency, and cost-efficiently scale up energy savings across one or multiple facilities. It is a globally recognized, voluntary standard that requires third-party verification that a facility has in place the required infrastructure and practices. Facilities must go through an assessment and be recertified every three years.

DOE has created two programs, 50001 Ready and Superior Energy Performance 50001™ (SEP 50001™), to help organizations implement ISO-compliant energy management systems and then measure and verify their performance. While the ISO standard sets the requirements for an energy management system, the 50001 Ready program provides information, tools, and examples on how an organization can setup and maintain the management system. It includes an online software platform to help organizations track their progress through 25 steps culminating in a self-attestation that DOE will recognize as "50001 Ready" (DOE 2021c). The SEP 50001™ program requires use of the rigorous measurement and verification (M&V) SEP protocol, third party verification of performance and certification, and elevated DOE recognition (DOE 2021b).

Through its participation in GEC standards development working groups, DOE has advocated for inclusion of self-attestation and third-party performance verified credentials as proof that electronics manufacturers and their suppliers are committed to energy management and long-term accomplishments in energy efficiency.

The Value of Sustainability Standards

A sustainability standard for any product can create a basis for consumers to compare the sustainability aspects of similar products from different manufacturers. In addition, manufacturers can benefit from a harmonized, consistent, and relatively comprehensive set of actions to make their products more sustainable. Consumers and the environment benefit from the development of best practices for reducing emissions and embodied energy in products, and the voluntary adoption of these standards by manufacturers can more quickly result in positive impacts relative to enacting government regulations. (EPA 2021b)

Sustainability standards exist for a number of electronics products, including computers, mobile phones, imaging equipment, and others. These standards cover the key environmental impacts of these products over their full life cycles, from materials extraction to end-of-life management. The impetus for such standards is driven in part by the growing amount of electronic and electrical waste (e-waste) produced globally – about 55 million tons per year, with only about 20% of this waste being formally recycled (WEF 2019). In addition to e-waste, issues contributing to the rise of sustainability standards include material toxicity, the growing use of critical elements, including rare earths, that are increasingly difficult to obtain. Energy

consumption in the manufacturing processes, particularly the manufacturing supply chains, is another substantial area of focus for sustainability standards.

DOE representatives are part of a broad group of stakeholders that includes manufacturers, end users, government agencies, and others. These stakeholders are typically organized by accredited standards development organizations, such as Underwriter Laboratories, NSF International, and the Institute of Electrical and Electronics Engineers. The standards development process includes defining a scope for a standard, creating subgroups of stakeholders to draft specific criteria, refine each criterion through consensus, and voting on a final standard. Once approved and published, each standard is updated as needed to reflect market changes, relevant new data, or other pertinent developments.

How the Standards are Used

Product sustainability standards are sometimes used to create ecolabels, such as the GEC's EPEAT label. GEC currently has EPEAT ecolabels for computers & displays, imaging equipment, mobile phones, photovoltaic modules & inverters, computer servers, and televisions; and network equipment is scheduled to be added in the summer of 2021. Ecolabels help purchasers know that a product meets certain sustainability requirements. As a result, manufacturers often adopt the standards to gain market advantage for their products. Consumers can use the standards (especially if an ecolabel is associated with a standard) to assist in selecting a more sustainable product, and large institutional buyers, such as the U.S. government, can use the standards in procurement policies and specifications to foster broad market adoption of more sustainable products.

The embodied energy and GHG emissions in many electronics products far exceeds the energy consumed in operating them over their lifetimes, particularly for battery-operated products such as mobile phones. For a sense of the significance of the electronics sector, two-thirds of the global population now has mobile phones, with 75% being smart phones. As stated earlier, for the life cycle of an iPhone 12, 83% of emissions occur during the manufacturing of the phone. Only 14% are associated with operating the phone. For other electronics devices such as tablets, desktop computers, laptops, and displays all have embodied emissions ranging from 30 to 86 percent of life cycle emissions (Goldstein and Delforge 2015). The embodied emissions from the manufacture of devices that plug in typically are lower – for example, around 30% for televisions and 8% for servers (Malmodin and Lunden 2018, 18).

Current Activities

In the past few years, GEC has launched several initiatives to develop product and corporate sustainability standards. GEC manages the EPEAT registry and ecolabel, which is a requirement in many federal purchasing specifications (GEC 2021a).

GEC has worked with Criteria Development Organizations NSF International and TUV Rheinland on these initiatives. Table 1 provides an overview of the standards resulting from these initiatives. The standards typically include a blend of required and optional criteria, with points or credits awarded for meeting the optional criteria. For the energy management systems criteria, the more rigorous the energy management system implemented, the more points or credits the manufacturer or supplier will receive. For example, third-party certification to the ISO 50001 standard will result in more points or credits than self-declaration (e.g., DOE's 50001

Ready recognition), and third-party recognition to DOE's Superior Energy Performance 50001™ program will result in more points than ISO 50001 certification.

Table 1. Electronics industry sustainability standards and energy management criteria

EPEAT product category	Standard name	Standard publication date	Energy management criteria
Mobile Phones	UL/ANSI 110-2017 2nd edition Standard for Sustainability for Mobile Phones Revision	September 2018	none
Imaging Equipment	IEEE 1680.2a™ - 2017 Standard for Environmental Assessment of Imaging Equipment — Amendment 1	October 2012; Amended December 2017	none
Televisions	IEEE 1680.3a™ - 2017 Standard for Environmental Assessment of Televisions — Amendment 1	October 2012; Amended December 2017	none
Servers	NSF/ANSI 426-2019 Environmental Leadership and Corporate Social Responsibility Assessment of Servers	August 2017; Revised November 2018 and December 2019	For supply chains • ISO 50001 (or national equivalent) self-declaration, or • ISO 50001 (or national equivalent) 3rd-party certification, or • Superior Energy Performance (or national equivalent)
Computers and Displays	IEEE 1680.1a™ - 2020 Standard for Environmental and Social Responsibility Assessment of Computers and Displays	February 2018; Amended January 2020	For manufacturers and supply chains • ≥5% energy performance improvement over 3 years or ≥1.67% for most recent year, • After 6 years of conformity, ≥3% energy performance improvement over 3 years or ≥1% for most recent year, or • ISO 50001 (or national equivalent) 3rd-party certification • Superior Energy Performance (or national equivalent) (for suppliers only)
Network Equipment (enterprise switches, routers)	Criteria for the Sustainability Assessment of Network Equipment for the Global Electronics Council EPEAT® Ecolabel and the TUV Rheinland Green Product Mark	April 2021	For supply chains • ISO 50001 (or national equivalent) self-declaration, or • ISO 50001 (or national equivalent) 3rd-party certification, or • Superior Energy Performance (or national equivalent)
PV Modules & Inverters	NSF 457 – 2019 Sustainability Leadership Standard for Photovoltaic Modules and Inverters	July 2019	For manufacturers • ISO 50001 (or national equivalent) self-declaration, or • ISO 50001 (or national equivalent) 3rd-party certification, or • ENERGY STAR Guidelines for Energy Management and ENERGY STAR Challenge for Industry certificate of achievement

EPEAT product category	Standard name	Standard publication date	Energy management criteria
Climate Change Mitigation Module	GEC criteria applicable across ICT product categories	Anticipated 2022	Demonstrated manufacturing energy performance management, e.g. via ISO 50001 or national equivalent proposed.

DOE has participated in working groups addressing updates to the following sustainability standards:

- UL/ANSI 110-2017 2nd Edition Standard for Sustainability for Mobile Phones: This standard includes a recognition scheme with minimum criteria and elevated recognition for demonstrating leadership and implementing sustainability best practices in the manufacturing of cell phones. In 2020, GEC paused the work on energy management criterion in order to preemptively eliminate the potential for conflicting standards with similar work on NSF 487.
- NSF/ANSI 426-2019 – Environmental Leadership and Corporate Social Responsibility Assessment of Servers: This standard includes a recognition for demonstrating leadership and implementing sustainability best practices in the manufacturing of computer servers. Energy management criteria apply to supply chains.
- IEEE 1680.1a™-2020 – Standard for Environmental and Social Responsibility Assessment of Computers and Displays: This standard applies to desktop and laptop computers, tablets, small-scale servers, and other types of computers, as well as monitors and signage displays. Criteria cover substance management, materials selection, end-of-life, product longevity, energy use, life cycle assessment, corporate environmental performance, and corporate social responsibility. The energy management criteria cover both manufacturing facilities and supply chains.
- GEC-TUV – Sustainability Assessment of Network Equipment for Large Network Equipment (LNE) and Small Network Equipment (SNE): This standard includes recognition for avoiding the use of harmful chemicals in products and their manufacture, energy efficiency, and corporate sustainability, as well as energy management criteria for supply chains. This standard was published in April 2021.
- NSF 457-2019 Sustainability Leadership Standard for Photovoltaic Modules and Inverters: This standard was published in July 2019, and includes energy management criteria for manufacturing facilities. The European Commission has stated it will adopt NSF 457 now that the scope has increased to include inverters, and plans to make it the basis for its expected Ecolabel for PV electricity.
- NSF 487 Electronic Products Sustainability Standard Corporate Common Criteria: A joint committee convened to develop an international electronic products sustainability standard containing a single set of corporate criteria that are applicable to all electronic products. The objective of creating a single set of common corporate criteria applicable to all electronic products was to provide consistency and efficiency across product categories, with criteria available for reference in product specific standards for inclusion in the EPEAT registry. Areas addressed included end-of-life management, environmental performance, manufacturing chemicals, life cycle assessment, energy management, and other areas. However, work on NSF 487 paused in 2020 amid debate on the development process. After reevaluating the scope of the effort and the stakeholder engagement

process, GEC is launching a new effort in 2021 to create common criteria for electronics manufacturers. The new effort aims to develop four criteria modules, one being a Climate Change Mitigation Module that will focus on four areas:

- Conducting life-cycle GHG emission assessments to identify hot spots and inform mitigation strategy
- Implementing energy efficiency measures in product and component manufacturing to reduce embodied carbon
- Sourcing electricity from renewable energy sources for manufacture of product and components to reduce embodied carbon
- Reducing use of high global warming potential chemicals in component manufacturing

Opportunities Beyond the Electronics Industry

Across all of manufacturing, over 85% of the energy use occurs before the components and supplies are received at the final assembly plant (Smith and Hutson 2013). The electronics industry is not the only portion of the manufacturing sector working to become more sustainable. Established and new initiatives within the chemical, aluminum, steel, aerospace, forest products, and pharmaceutical industries seek to make supply chains more sustainable.

The chemical industry has many sustainably initiatives, labeling schemes, and standards. The American Chemistry Council created the Responsible Care® sustainable chemistry initiative thirty years ago to help its members focus on reducing environmental impacts (ACC 2021). The European Chemical Industry Council (CEFIC) Sustainable Development program builds on the Responsible Care® program to create a charter and roadmap to foster innovation, imagine what the chemical industry will look like in the year 2050, and meet United Nationals Sustainable Development Goals (UN SDGs) (CEFIC 2019). Together for Sustainability (TfS) is an initiative supported by 30 major chemical companies that has created a de facto global standard for environmental, social, and governance performance of chemical supply chains. The TfS initiative is based on the UN Global Compact, Responsible Care® principles, and each member company's supplier code of conduct. The initiative uses a third-party assessment scorecard, along with supplier audits and corrective action plans as needed. Currently, the management of energy use is not a focus of TfS (TFS 2021). However, incorporating energy management system practices into supplier codes of contact, the assessment scorecard, and audits is feasible, as an extension to the existing sustainability aspects within these components of the initiative. For example, both member companies Eastman Chemical and DSM mention supplier energy reduction in their supplier codes of conduct (Eastman Chemical Company 2021, DSM 2021). Offering guidance or criteria encouraging suppliers to implement energy management systems is a logical progression.

The Aluminium Stewardship Initiative (ASI) is a global non-profit standards development and certification organization. As a standards development organization, it brings users and stakeholders in the aluminum value chain together to develop standards that foster responsible production, processing, and sourcing of aluminum. Its standards define sustainability for the entire value chain and promote measurable and continual improvements in the key environmental, social, and governance of aluminum production, use, and recycling, and require third-party certification. Currently, energy use reduction is not a significant component of the initiative. However, participating suppliers must report energy use as part of a life cycle

assessment and life cycle inventory, and must implement an environmental management system (ASI 2021). With that understanding of and experience with management systems, suppliers can efficiently adopt an energy management system, should ASI incorporate energy management system criteria into their standards.

Many of the Steel Industry trade organizations have member initiatives to reduce environmental impacts. ResponsibleSteel™ used a multi-stakeholder process to create a standard for sustainable steel making and processing. The standard consists of twelve principles: Corporate Leadership; Social Environmental and Governance Management Systems; Occupational Health and Safety; Labor Rights; Human Rights; Stakeholder Engagement and Communication; Local Communities; Climate Change and Greenhouse Gas Emissions; Noise, Emissions, Effluent and Waste; Water Stewardship; Biodiversity; and Decommissioning and Closure. The standard includes language requiring suppliers to document their commitments, and includes a significant emphasis on management systems (ResponsibleSteel 2019). Supplier energy use and their management of energy currently is not a criterion in the standard.

The Forest Products industry has focused on sustainability for many years. The Forest Stewardship Council (FSC) and Sustainable Forestry Initiative (SFI) help the procurement professionals of consumer product manufacturers know whether the timber and fiber products they purchase were sustainably harvested and processed (FSC 2021b, SFI 2021c).

FSC does not issue certificates, but certifies independent certification bodies to carry out assessments of forest management practices and chain of custody (FSC 2021a). These certifications enable manufacturers of consumer products to support claims that they source sustainably harvested raw materials (FSC 2021c). SFI serves as a platform for forest owners, timber industries, social groups, and environmental organizations to develop solutions to improve forest management practices. It also has standards for tracking products through supply chains, for end-use products, and for procuring products (SFI 2021a, SFI 2021c).

The manufacture of pharmaceuticals is energy-intensive and the sector is starting to focus on the benefits of energy management as a component of its larger focus on sustainability. The industry-led Pharmaceutical Supply Chain Initiative includes environmental sustainability and efficiency of resources as one of its pillars, and a component of that pillar is energy use. The 49-member initiative embraces the use of management systems (PSCI 2019). Providing guidance and encouraging member companies and suppliers to adopt energy management systems could accelerate uptake further. This industry-led initiative is not developing the rigorous standards that the electronics industry is creating, but its emphasis on both auditing and management systems is a positive step forward.

Leading aerospace companies have formed the International Aerospace Environmental Group (IAEG) to address environmental sustainability issues within the industry, including supply chains. While energy reduction is not a primary focus of the organization, greenhouse gas reporting and environmental management are. Suppliers are rated in part on the environmental management system they have in place. IAEG has developed a “maturity framework” tailored to small and medium sized businesses and based on ISO 14001:2015 Environmental Management Systems (IAED 2019). Member companies work with suppliers as necessary to introduce or add rigor to existing environmental management systems.

In addition to industry-specific initiatives to encourage sustainable manufacturing practices, initiatives such as:

- the CDP Supply Chain Program

- U.S. General Services Administration's Sustainable Supply Chain Community of Practice
- Global Compact Advisory Group on Supply Chain Sustainability
- Sustainable Supply Chain Foundation
- 1.5°C Supply Chain Leaders pledge
- Business Ambition for 1.5°C, which is a part of the Science Based Targets initiative

are providing awareness, creating sustainability tools, and developing labeling schemes and supporting standards development to encourage sustainable practices by all participants in a value chain.

The standards, best practices, and guidance resulting from each of these initiatives can benefit from the addition of criteria for energy management systems, and is a logical evolution that can help these initiatives achieve their objectives. Including criteria for energy management will positively affect many of the other criteria because the consumption of energy is fundamental to all aspects of making a product and managing an organization. Systematically managing energy will also affect the management of raw materials, water, waste and emissions.

Summary and Conclusions

In the past decade, stakeholder groups have assembled to develop sustainability standards for several electronics products, including computers, mobile phones, televisions, and solar panels. The standards cover the key environmental impacts of these products over their life cycles, starting with materials extraction to end-of-life management. Reducing energy consumption throughout a supply chain can have a significant impact on product environmental impacts and sustainability. Embedding criteria for energy management systems into corporate sustainability standards is an effective way to do so. It is also one method CDOs have for achieving their strategic objectives of ensuring reducing future energy consumption, reducing environmental impacts, and demonstrating leadership in sustainability.

Manufacturers have found value in the ecolabels associated with product sustainability standards. This is evident in the fact that so many of them are participating in the working groups developing the standards. Industry representation and involvement requires commitments from personnel with extensive technical expertise, so participation is not an insignificant obligation. Furthermore, company representatives are agreeing to requests that are more demanding than those that they would select themselves. The active participation in and support of these standards by large, global OEMs make them a viable mechanism to impact the use of energy throughout an industry and to realize associated benefits to the environment and the economy.

The relatively small population of OEM facilities within the electronics and other sectors reduces the amount of effort needed to engage the whole of an industry. Many OEMs have captive, or semi-captive supply chains and as a result they have the capacity to motivate their suppliers to embrace desirable behaviors, such as adopting energy management systems.

The best opportunities for new corporate sustainability standards appear to be in sectors that are global in nature, have significant environmental footprints, and are in the process of transitioning from the development of product-specific standards to broader initiatives affecting business practices, manufacturing processes, and corporate governance. Supply chain initiatives are most likely to be effective when OEMs control the supply chain and can dictate terms to their suppliers.

Many of these standards are too new to have been widely adopted and therefore it is likely too early for them to show measurable impacts on the economy or the environment. However, many organizations, including the U.S. government, are already using eco-labels like EPEAT in their purchasing specification and that is driving companies to pursue them. That, by extension, is driving corporations to manufacture products with lower environmental impacts and to pursue sustainable business practices. As these product and corporate standards gain popularity with OEMs and the purchasing offices of all types of organizations, their impacts will grow. As a result, including a focus on the management of energy in these standards is likely to have a significant and long-lasting impact on energy use in the electronics sector and also produce associated environmental and economic benefits.

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