SUSTAINABLE ENGINEERING DESIGN AND PRACTITIONERS' PROFESSIONAL OBLIGATIONS

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Practitioners have professional obligations to incorporate sustainable engineering design principles in their practice, while understanding their roles in managing environmental aspects.

WHAT IS SUSTAINABILITY AND HOW CAN IT BE INCORPORATED INTO ENGINEERING DESIGN?

Sustainability is a term that has several definitions. It can be defined as a "problem statement that integrates the environment and the economy in a way that both sides can live with it," according to international environmental consultant Albert F. Appleton; and/or "the possibility that human and other forms of life will flourish on the planet forever," according to environmental researcher John R. Ehrenfeld.

There is a global commitment to achieve sustainable development in three pillars: economic, social and environmental. The challenge is how the integration of these pillars can be achieved in a balanced manner. How do we ensure social acceptance of environmental protection? How do we protect the environment at a reasonable cost? Practitioners could face many challenges when trying to integrate these three pillars of sustainability in practice.

Practitioners should consider the following when developing sustainable engineering design projects:

- Adopt life-cycle assessments (LCAs) in their engineering practice;
- Design for targeted durability;
- Prevent waste at the design stage rather than treating it at the end-of-life cycle;
- Design for recycling and reuse;
- Minimize toxic reagents;
- Minimize energy consumption and/or consider renewable energy sources;
- Minimize material diversity;
- Reduce demand for resources;
- Reduce waste production; and
- Carry out a comprehensive risk assessment prior to commencing projects to evaluate the potential environmental, economic and societal impacts.

The *Professional Engineers Act* (PEA) defines the practice of professional engineering as "any act of planning, designing, composing, evaluating, advising, reporting, directing or supervising that requires the application of engineering principles and concerns the safeguarding of life, health, property, economic interests, the public welfare or the environment or the managing of any such act."

The above-mentioned definition covers the safeguarding of the environment. Therefore, practitioners could refer to the global Sustainability Development Goals (SDGs) (https://sdgs.un.org/goals) as a framework to aspire to. The 17 SDGs were adopted by the United Nations in 2015 to address some of the world's urgent challenges. The specific SDG goals that require engineering skills and technical knowledge include:

- Goal 6—clean water and sanitation to ensure availability and sustainable management of water and sanitation for all;
- Goal 7—affordable and clean energy to ensure access to affordable, reliable, sustainable and modern energy for all;
- Goal 9—industry, innovation and infrastructure to build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation;
- Goal 11—sustainable cities and communities to make cities and human settlements inclusive, safe, resilient and sustainable; and
- Goal 12—responsible consumption and production to ensure sustainable consumption and production patterns.

Sustainable design in infrastructure is one of the most critical areas because it affects everyone. Consequently, practitioners should consider utilizing green technologies and adopting the concept of sustainability, particularly if they work in construction design. Practitioners also need to be careful while designing any structure, paying attention to limited resources and energy and on procedures that reduce the impact on the environment. They should read the targets and indicators of each of the above-mentioned SDG goals to understand their mandate and how sustainable engineering design principles can be applied to achieve them.

DO PRACTITIONERS HAVE A PROFESSIONAL OBLIGATION TO CONSIDER SUSTAINABILITY PRINCIPLES IN THEIR WORK?

The short answer is yes. Furthermore, if a practitioner's client does not want to consider sustainability principles in their project, practitioners have an obligation to present the consequences to be expected when their judgment is overruled. In section 72(1)(2)(f) of Regulation 941 of the PEA, "professional misconduct" means "failure of a practitioner to present clearly to the practitioner's employer the consequences to be expected from a deviation proposed in work, if the professional engineering judgment of the practitioner is overruled by non-technical authority in cases where the practitioner is responsible for the technical adequacy of professional engineering work." Practitioners are responsible for incorporating sustainability considerations into the industrial design process and considering environmental implications of a product during its development and at its later stages of life.

Furthermore, in section 72(1)(2)(b) of Regulation 941 of the PEA, "professional misconduct" means "failure to make reasonable provision for the safeguarding of life, health or property of a person who may be affected by the work for which the practitioner is responsible." Because practitioners play a significant role in safeguarding life, health and welfare—and air, water and land are essential for human life—it could be reasonably argued that engineers must make reasonable provisions for air, water and land to be clean and safe. Consider that:

1. In the case of air pollution, engineers should design their projects with the consideration of fewer emissions and potentially zero waste. For more information, refer to PEO's *Guideline for Providing Engineering Services Under O. Reg. 1/17 and Part II.2 of the EPA* (www.peo.on.ca/sites/default/files/2021-06/ProvidingEngServicesGdlne2021.pdf);
2. When it comes to water, engineers should resolve water quality and quantity issues and address wastewater issues in their work. For more information, refer to the PEO guideline *Engineering Evaluation Reports For Drinking Water Systems* (www.peo.on.ca/sites/default/files/2019-07/Engineering%20Evaluation%20Reports%20For%20Drinking%20Water%20Systems.pdf); and
3. For land, engineers should efficiently promote pollution prevention in their designs and promote early detection and response to land quality issues through legislated requirements for mandatory reporting of site contamination. Refer to the PEO's *Solid Waste Management Guideline* (www.peo.on.ca/sites/default/files/2019-11/Solidwastemanagementguideline.pdf) and *Environmental Site Assessment Remediation and Management Guideline* (www.peo.on.ca/sites/default/files/2020-07/ESAGuideline2020.pdf).

Section 72(1)(2)(d) of Regulation 941 of the PEA further defines "professional misconduct" as a "failure to make responsible provision for complying with applicable statutes, regulations, standards, codes, bylaws and rules in connection with work being undertaken by or under the responsibility of the practitioner." According to the American Society of Civil Engineers, the following are essential steps to achieve a sustainable development project:

1. Perform LCAs from planning to reuse—Practitioners should use rigorous life-cycle methodologies that quantify the economic, environmental and social effects of the project;
2. Use resources wisely—Minimize use of non-renewable resources. Sustainable development should include progressive reductions in resource use for a given level of service and resiliency. The feasibility of restoration, or return of depleted resources, should be evaluated by the practitioner;
3. Plan for resiliency—Sustainability requires planning for the impact that natural and man-made disasters and changing conditions can have on economic, environmental and social resources; and
4. Validate the application of principles—Engineers must guide project development and validate the application of these principles by using metrics and rating tools such as the EnvisionTM Rating System for sustainable infrastructure.

WHY ARE LIFE-CYCLE ASSESSMENTS IMPORTANT?

An LCA is an essential tool to evaluate the environmental impact of a chemical, product, project, development or operation. LCAs consider energy production, material extraction, manufacturing, packaging and transportation and use and end-of-life stages. Each stage has raw material input and output flows such as waste, air or water emissions.

LCAs can be used by practitioners to achieve the goal of designing for the environment by considering different material options at the early design stage and selecting one action over another. For example, an LCA could be used to help determine which option is greener: an aluminum frame or a steel frame. On one hand, aluminum is more energy intensive to produce than steel. On the other hand, aluminum has a higher strength density ratio than steel. So, an aluminum frame can be lighter but still as strong as a steel frame. Consequently, the most optimal material would depend on the application; for example, if weight is a key factor, aluminum might be the best choice for a frame. For more information on an LCA of different materials in buildings, visit www.mdpi.com/2075-5309/9/1/20.

In summary, practitioners should design for sustainability, adopt LCAs in their engineering practice and propose sustainable solutions to their clients and employers and indicate any consequences expected from a deviation proposed in the work. **e**

FURTHER READING

Engineers Canada's *National Guideline on Sustainable Development and Environmental Stewardship for Professional Engineers,* engineerscanada.ca/national-guideline-on-sustainable-development-and-environmental-stewardship-for-professional-engineers

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