

National guideline on sustainable development and environmental stewardship for professional engineers

Notice

Disclaimer

Engineers Canada's national guidelines and Engineers Canada papers were developed by engineers in collaboration with the provincial and territorial engineering regulators. They are intended to promote consistent practices across the country. They are not regulations or rules; they seek to define or explain discrete topics related to the practice and regulation of engineering in Canada.

The national guidelines and Engineers Canada papers do not establish a legal standard of care or conduct, and they do not include or constitute legal or professional advice

In Canada, engineering is regulated under provincial and territorial law by the engineering regulators. The recommendations contained in the national guidelines and Engineers Canada papers may be adopted by the engineering regulators in whole, in part, or not at all. The ultimate authority regarding the propriety of any specific practice or course of conduct lies with the engineering regulator in the province or territory where the engineer works, or intends to work.

About this Engineers Canada paper

This national Engineers Canada paper was prepared by the Canadian Engineering Qualifications Board (CEQB) and provides guidance to regulators in consultation with them. Readers are encouraged to consult their regulators' related engineering acts, regulations, and bylaws in conjunction with this Engineers Canada paper.

About Engineers Canada

Engineers Canada is the national organization of the provincial and territorial associations that regulate the practice of engineering in Canada and license the country's 295,000 members of the engineering profession.

About the Canadian Engineering Qualifications Board

CEQB is a committee of the Engineers Canada Board and is a volunteer-based organization that provides national leadership and recommendations to regulators on the practice of engineering in Canada. CEQB develops guidelines and Engineers Canada papers for regulators and the public that enable the assessment of engineering qualifications, facilitate the mobility of engineers, and foster excellence in engineering practice and regulation.

About Equity, Diversity, and Inclusion

By its nature, engineering is a collaborative profession. Engineers collaborate with individuals from diverse backgrounds to fulfil their duties, tasks, and professional responsibilities. Although we collectively hold the responsibility of culture change, engineers are not expected to tackle these issues independently. Engineers can, and are encouraged to, seek out the expertise of Equity, Diversity, and Inclusion (EDI) professionals, as well as individuals who have expertise in culture change and justice.

1.0 Introduction

This National guideline consists of ten guidelines that have been prepared to complement the existing codes of ethics of the 12 engineering regulators of Engineers Canada. It supplements environmental and sustainability guidelines and codes of practice developed for local use by some regulators. It serves as a national benchmark that has been mutually agreed.

The purpose of this document is to describe engineering practices that are anticipatory of sustainable development and preventative in degrading the environment. For example, instigating monitoring systems so that any environmental and social impacts of engineering projects are identified at an early stage contributes to their sustainability and provides information on the environment that can be used to implement remedial actions.

Each of the guidelines, along with additional amplification and commentary, are intended for engineers and Certificate of Authorization/Permit to Practice holders to practice in an environmentally responsible and sustainable manner. In particular they are intended to be pro-active in the protection and stewardship of the environment by following principles of sustainability.

Appendix A provides a glossary of the terms used in this document as well as others that are commonly used in describing sustainable development, sustainability, environment and stewardship.

2.0 Background

Sustainable development is an emerging aspect of engineering practice which is more comprehensive and anticipatory and in many areas is overtaking the more narrow discipline-specific activity of 'protection of the environment'. This practice of sustainable development can be expected to evolve and engineering

education and continuing professional development will need to include an understanding of sustainable development.

There are pressing challenges due to the adverse effects of, and damage from depletion of resources, environmental pollution, rapid population growth and damage to ecosystems. The future availability of energy, water and non-renewable materials are at risk in spite of environmental protection efforts. The earth's environmental carrying capacity is being overloaded in a number of ways. The International Federation of Consulting Engineers, known as FIDIC (2013) notes that:

“These changes are beginning to fundamentally shift the way engineering project performance is judged, and they add invisible design criteria that will ultimately affect every engineering project, whether for products, processes, facilities or infrastructure. The effect of sustainable development will be to bring broad resources, ecological and social issues into the mainstream of engineering design and it has become critically important that engineers understand these issues and look for ways to incorporate these considerations in all that they do.”

Responsible environmental management is an inherent part of duties undertaken by all engineers, regardless of discipline or role; whether as employees, employers, researchers, academics, consultants, regulators or managers. As noted in the Engineers Canada code of ethics, the primary duty of engineers is to hold paramount the protection of public safety and welfare with due regard for the environment and societal values.

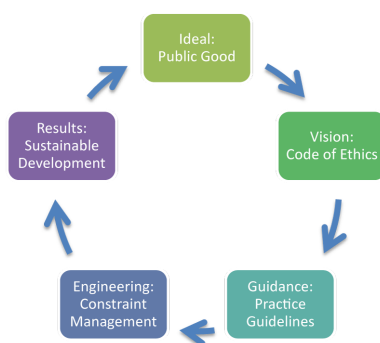
Sustainable development is an aspect of engineering practice which is more comprehensive and anticipatory and in many areas is overtaking the more narrow discipline-specific activity of ‘protection of the environment’. A purely environmental approach is insufficient, and increasingly engineers are required to take a wider perspective including goals such as poverty alleviation, social justice and local and global connections. This practice of sustainable development can be expected to evolve and engineering education and continuing professional development will need to include an understanding of sustainable development.

The practice of engineering continues to evolve over time through a process of continuous improvement as illustrated in Figure 1. This includes not only the technology but also the human aspects. Pursuit of the idea of “public good” through sustainable development contributes to the long-term benefit of society, the economy and the environment. Government provides some guidance under various pieces of legislation that helps with continuous improvement and the pursuit of “public good”. As subject matter experts, engineers can have considerable influence on how an issue is dealt with on behalf of their clients. There are few unambiguous standards to guide them and it is here where the role of engineering judgement comes into play.

Engineering and related disciplines also need to utilize expertise from other professions such as planning, economics, the social sciences, finance and law. Collectively these professions will be instrumental in realizing sustainable development and environmental stewardship.

A substantial body of legislation setting out environmental requirements has existed for some time, and much of this can be found in the Canadian Environmental Protection Act [1], the Canadian Environmental Assessment Act [2] and various provincial or territorial environmental acts, regulations and standards. Environmental regulations and standards are evolving. In some aspects, legislation and regulations from federal, provincial and municipal and First Nations jurisdictions overlap in a complex manner.

Figure 1 - Engineering and the Public Good



Implicit in the concept of “public” is society, its resources, economy and the environment. It is desirable to include concepts of sustainable development and environmental stewardship within the Code of Ethics, the various guidelines used to support professional practice and learnings that constitute Continuing Professional Development. Some engineering acts some Acts explicitly include the “environment” in their definition of the practice of engineering, for example the Professional Engineers Act in Ontario:

“practice of engineering” means 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”.

3.0 Engineers and Sustainable Development

There is an imperative for engineers to think sustainability and incorporate sustainable development principles into their professional practice. It is incumbent on the engineering profession to provide guidance:

“The implications of sustainability for engineers are major. Long-term thinking on resources and paradigm shifts in economics and technology design are necessary. Improving the quality of life without merely increasing the quantity of goods is required. Engineers must become more effective at identifying real needs rather than wants. This will require them to become problem framers so they can help decide on the most effective directions for technology to take. In addition there is an educational function; some clients may not be aware of sustainable alternatives when scoping a new project. The engineering profession must lead the way and be seen to lead the way towards a more sustainable future.” [3]

The long-term objectives of sustainable development practice that incorporate environmental stewardship are to maintain the viability of our ecosystems as well as assure that the well-being of future generations is not compromised by our activities today. Engineers recognize that stewardship of the environment is a responsibility of all citizens who have a rightful role in setting goals for environmental management, even though public expectations are evolving and vary widely. Over time, a balanced approach will create development that meets the needs of society by integrating environmental sustainability with social and economic considerations.

Environmental work is often best accomplished by a multi-disciplinary team. Due diligence requires that all reasonable steps be taken to ensure that the team comprises the necessary expertise and that this expertise is appropriately applied.

3.1 Sustainable Development and Environmental Stewardship

The level of awareness, understanding and value of sustainability, sustainable development and environmental stewardship is still low across much of society and their application is still evolving. Since the world is not unanimous on defining the needs of human beings (often confusing between needs and wants), it is hard to correctly differentiate between sustainability and sustainable development. Sustainability is the ability to endure or hold on while sustainable development is a strategy to achieve development without compromising with the ability of our future generations to fulfill their needs. Sustainability looks at saving the environment as the primary objective while sustainable development focuses on development of infrastructure, keeping the environment clean, to achieve growth.

These concepts are not well integrated into engineering practice. For the purpose of this guideline, sustainable development and environmental stewardship (SD&ES) are discussed as two complementary themes, and then integrated into a single comprehensive framework.

3.2 What is Sustainable Development?

In 1987, the Brundtland Commission published what is perhaps the broadest, best known and most widely accepted definition of sustainable development:

“Sustainable development is development that meets the social, economic, and environmental needs of the present without compromising the ability of future generations to meet their needs.” [4]

This and any other definition of sustainable development share the view that long-term economic and social change can only be sustainable and beneficial when safeguarding the natural resources upon which development depends. Implicit in all definitions is the concept of “intra-generational and intergenerational equity” (i.e. the fair distribution of, and access to resources within the same generation, and between succeeding generations).

The principles of the Brundtland definition are used throughout this Guideline.

3.3 What is Environmental Stewardship?

Stewardship means to take care of something even if it does not belong to you. For the purposes of this guideline, Environmental Stewardship is defined as:

"The prudent use of the finite resources in nature to produce the greatest benefit while maintaining a healthy environment for the foreseeable future".

Environmental Stewardship exists even without development and is not always triggered by a proposal for developing resources or projects.

3.4 Relationship between Sustainable Development and Environmental Stewardship

Environmental stewardship is about keeping what we have while sustainable development is about getting what we need. We cannot fully satisfy one without satisfying the other.

Sustainable development rarely comes without impacts to the environment and environmental stewardship rarely occurs without costs to the economy. Project-focused assessment that ignores impacts beyond the project boundaries is one of the major problems in sustainable development.

In order for a society to protect and preserve the environment it must be able to afford to do so. For this to happen sustainable development and environmental stewardship must jointly inform our decision making. Ideally sustainable development should achieve a balance between environmental stewardship, society and economies. However, the economic benefits of environmental stewardship are not always apparent or easily quantifiable.

3.5 Role of the Engineer in the Delivery of a Sustainable Future

Engineers work as employees, employers, researchers, academics, consultants, and in regulatory and managerial roles. They frequently work as a team where they are involved with other specialists and this means that they may or may not have control of, or be solely responsible for, a particular project. To the greatest extent possible however, engineers should understand and manage the environmental aspects of projects that they are involved with. In all projects, engineers should be engaged for preparing and presenting clear justifications to implement more sustainable solutions that serve the public interest.

Engineers perform engineering work in various types of projects that include, for example:

1. Design and build projects to meet basic human needs (potable water, food, housing, sanitation, energy, transportation, communication, resource development, and industrial processing).
2. Design, build, operate and manage facilities and systems that mitigate environmental problems (e.g. create waste treatment facilities, recycle resources, clean up and restore polluted sites site clean-ups, environmental restoration and protect or restore natural ecosystems).[5]

Short-term environmental impacts are often considered a design constraint. Broader long-term environmental outcomes are much more difficult to predict, may lead to unintended consequences and therefore present a significant challenge for the engineer. For instance, engineers are often pressured to consider short-term cost cutting measures which may compromise sustainable development or that may have long-term consequences that are beyond the scope of their mandate. Defined scopes of work for a project consider immediate requirements and not downstream ancillary or relocated burdens on technology, economies, social structures or the environment. Many of these are very hard to foresee, and less likely to have financial resources available to address them.

All engineers however need to consider the impact that their undertakings (i.e. systems and structures) will have on the environment and what effect the environment may have on those undertakings.

It is an engineer's responsibility to understand the consequences of actions on projects in respect of their environmental and societal implications. As noted by the Association of Consulting Engineering Companies - Canada,

"These responsibilities are held jointly with clients, with regulators and with policy makers (government) at all levels. The Code of Ethics gives engineers the responsibility to inform, not the ultimate authority to decide. This distinction argues for close ties with government and clients in regard to the consequences of project development, and suggests that engineers should be partners in the evolution of sustainable projects and in the evolution of the appropriate regulatory environment"
[6]

Engineers are sometimes faced with a dilemma. They are usually neither the ultimate decision maker for a

project nor do they necessarily reflect the perspective of the local community. Both these factors, namely the decision making constraint and the need for sensitivity, must be recognized and respected if the engineer is to influence the development and management process. In some cases the engineer will have significant support (i.e. financial resources and mandate) from the project sponsor in pursuing SD&ES. With knowledge and understanding of SD&ES principles, the engineer has the potential to contribute positively to the future and can do so by providing leadership within their area of practice.

4.0 The Ten Guidelines

The following ten guidelines encompass the principles of SD&ES as applied to the practice of engineering in projects that are executed by, and the responsibility of engineers.

It is highly recommended that engineering regulators compile these into a single page and to be placed alongside the Code of Ethics as official posted documents to remind engineers of their professional practice and responsibilities to serve the public interest.

Engineering regulators may strengthen these guidelines by replacing the word “should” with “shall” or “must”.

Engineers:

1. Should maintain and continuously improve awareness and understanding of environmental stewardship, sustainability principles and issues related to their field of practice.
2. Should use expertise of others to adequately address environmental and sustainability issues and enhance understanding and improve practices.
3. Should incorporate global, regional and local societal values applicable to their work.
4. Should establish mutually agreed sustainability indicators and criteria for environmental stewardship at the earliest possible stage in projects, and evaluate these periodically against performance targets.
5. Should assess the costs and benefits of environmental protection, eco-system components, and sustainability in evaluating the economic viability of the work.
6. Should integrate environmental stewardship and sustainability planning into the life-cycle planning and management of activities that impact the environment, and should implement efficient, sustainable solutions.
7. Should seek and disseminate innovations that achieve a balance between environmental, social and economic factors while contributing to healthy surroundings in the built and natural environment.
8. Should become engaged in a leadership role in the ongoing discussion of sustainability and environmental stewardship and solicit input from stakeholders and accredited experts in an open and transparent manner.
9. Should assure that projects comply with regulatory and legal requirements by the application of best available, economically viable technologies and procedures.
10. Should implement risk mitigation measures in time to minimize environmental degradation where there are threats of serious or irreversible damage but a lack of scientific certainty.

5.0 Amplification and Commentary on the Ten Guidelines

The following sections provide further explanation to practice the ten guidelines that comprise the whole of the national guideline. Examples are provided for illustrative purposes only.

5.1 Guideline #1 - Maintaining and Improving Knowledge and Competency

Engineers should maintain and continuously improve awareness and understanding of environmental stewardship, sustainability principles and issues related to their field of practice.

Amplification

- »Recognize the general extent to which an engineer’s activities can affect the environment and sustainability. Develop a working knowledge of environmental stewardship, sustainability considerations and environmental impacts in order to broadly judge the potential interaction of professional activities with those issues.
- »Recognize the importance of Environmental Management Systems (EMS) to identify, control, and reduce these effects.
- »Maintain expertise and keep up with advancements in technology and increased specialization as a part of due diligence and the application of reasonable care.

Commentary

Society has developed an increased awareness of the degree to which development projects can affect the environment and expect projects to be environmentally sustainable. Engineers involved in designing and implementing projects must maintain a reasonable level of understanding of environmental concerns, and the possible significant effects of their professional activities on the environment. Practices that improve project sustainability over the life cycle are increasingly recognized and demanded.

The foregoing responsibility does not imply that every individual engineer can or should be an environmental specialist. As with any other specialization, there will be degrees of environmental expertise that will be required for specific circumstances. The general obligation is to possess sufficient knowledge of relevant environmental impacts to be able to competently judge the degree of need for specialist assistance. Given the normal technical responsibilities of engineers, society may expect them to anticipate and understand environmental problems.

Engineers should maintain a current understanding of the principles of sustainable development and apply them to projects to the extent that resources allow. Engineers should monitor environmental and sustainability issues relative to their field of practice, similar to maintaining knowledge of current local codes and standards.

Maintaining expertise is part of due diligence and the application of reasonable care. There are many challenges to rapidly evolving knowledge and practices in these fields including increased specialization, devolution of routine work to technologists and technicians, increased use of information technology and automation, and the expansion of skills and areas of practice beyond traditional engineering science.

5.2 Guideline #2 - Working with Multi-Disciplinary Teams

Engineers should use expertise of others to adequately address environmental and sustainability issues and enhance understanding and improve practices.

Amplification

- »Exercise care and clearly communicate the limits of their expertise in accepting or interpreting assignments and setting expected outcomes
- »Make appropriate recommendations on obtaining further advice if a project's environment and sustainability issues require qualifications and expertise outside their field of experience
- »Recognize that environmental issues and sustainability are multi-disciplinary in nature, requiring expertise beyond their competence.
- »Encourage integrated decision-making involving disciplines outside of engineering. Consult with social sciences such as sociology, impacts on humans, planning, law and finance to determine social and external economic impacts that are generally outside of most engineering training and practice.
- »Consult with natural scientists e.g. climate professionals, hydrologists, biologists, geoscientists or other scientific disciplines to provide their expertise where the situation demands.

Commentary

The codes of ethics of engineering regulators state that engineers must undertake only that work that they are competent to perform by virtue of education, training and experience. Engineers should understand the limits of their understanding of complex environmental and social issues. They should engage specialists in these fields for their expertise and perspectives in planning and development, construction, operation and the close-out of engineering projects.

Increasing complexity and innovation are driving the need for multi-disciplinary teams. Involvement with other experts and peers should occur at the earliest stages and continue as necessary throughout the project life cycle. Engineers acting as prime consultants will need to seek out these individuals. Engineers acting as sub-consultants will need to know to ask the questions.

For example, issues where engineers should normally consult include climate change, waste management, social factors, macro-economics, risk assessment and others.

Central to sustainability is recognition that continuous attention by the engineer related to evolving environmental practices enables integrated decision-making to achieve sustainability and environmental stewardship. For example, using the expertise of qualified professionals outside an engineers' competence is critically important when dealing with hazardous substances that may be released into the environment on purpose or by accident, over the life of a project, including during its construction and at end-of-life decommissioning.

5.3 Guideline #3 - Considering Social Impacts

Engineers should incorporate global, regional and local societal values applicable to their work.

Amplification

- »Values to be considered include regional, local and community concerns, quality of life and other social concerns related to environmental impact along with traditional and cultural values including First Nations where applicable.
- »Define and assess all societal needs, issues and concerns at the local and community level first to serve the public interest.
- »Seek information and input on societal values.
- »Consider the local societal acceptance of the project over its life cycle, and potential effects due to other displaced technology and techniques.
- »Determine and articulate the positive and negative effects of proposed actions considering local societal needs in the short-term as well as over the long-term.

Commentary

Engineers should engage and solicit input from local and community stakeholders in an open manner, and shall respond to their environmental concerns in a timely manner. A broader perspective beyond one's own locality and the immediate future is healthy for the profession and for society. Ensuring local and community-based societal values are considered in engineering maintains and enhances these values and the quality of life. But local conditions and social impacts may influence the options available and the subsequent engineering actions.

Engineers are often given specific instruction as to the problem to be addressed and the expected outcome. From that engineers develop the best solution. However, solving the problem as given may have unintended social consequences. Engineers should look beyond the initial solutions to better understand the social consequences to the public and account for them in the implementation.

Incorporating sustainable development into projects is a logical extension of the traditional broad, but local, view of the public good. Engineers need to consider the wider implications of their proposed solutions. Engineers should 'Think Global and Act Local', taking a big-picture long-term perspective.

Traditional and cultural values of First Nations may be of vital importance in the assessment of impacts of certain projects. Consultation processes need to be planned and executed to ensure that these values are defined and understood by local and community stakeholders. These can be accounted for in the development of engineering solutions to minimize negative social impacts on tradition and culture.

Most engineering outcomes affect the environment, the economy that functions within the environment, and the people who work in the economy and live in the environment. When engineers implement solutions they are trying to satisfy their clients' requirements while protecting the public. Engineering projects however are usually not neutral and can have unintended social consequences that need to be considered.

Instead of relying solely on traditional practices and existing permitting processes to protect the interests of the environment, engineers should always be vigilant of the intent of sustainable development from a social perspective. What may be considered safe or harmless to the environment or society in the short-term may not be so over the long-term. There is also the danger of externalizing or exporting risk to others outside of the local environment. The health and welfare of the local public may be safeguarded but that of broader community may be at risk.

5.4 Guideline #4 - Designing and Evaluating Sustainability Outcomes and Environmental Stewardship Indicators

Engineers should establish mutually agreed sustainability indicators and criteria for environmental stewardship at the earliest possible stage in projects, and evaluate these periodically against performance targets.

Amplification

- »Performance targets should be project-specific and involve key stakeholders to define key sustainability and environmental issues.
- »Employ appropriate standards, systems, tools, and data that provide objective evidence.
- »Consider an appropriate Environmental Management system based on the ISO 14000 standards that

include performance indicators and methods to collect and analyse data. Including this element should be part of the project implementation. This includes a commitment to conduct periodic reviews and identify opportunities for improvement.

- »The indicators should be objective, measurable and comparable as well as comply with any statutory requirements. Collect and record baseline data and derive outcomes using accepted methods at the time of collection and analysis. Methods to derive indicators will evolve but data should continue to be collected over the life cycle of the project.
- »Examine indicators from previous projects and determine which ones, if any may be appropriate for the current project, based on local and regional needs, issues and concerns as well as statutory requirements.
- »The nature and scope of indicators should be reasonable and based on need. Financial resources should be included in the project budget to collect and process data and prepare periodic progress reports.
- »Become aware of existing systems for measuring and rating sustainability indicators and outcomes for projects. Monitor new ones under development to maintain competence relative to best practices.
- »Contribute perspective and experience from past projects to develop publicly accepted criteria to evaluate the environmental stewardship of a project. Explore, develop and document criteria which reflect known standards that may apply.

Commentary

Sustainability indicators and measures of environmental stewardship should be developed at the earliest possible stage rather than after the project is underway or completed when adjustments or retrofits to address deficiencies become impossible or cost-prohibitive.

Measuring social and economic effects of developments contribute to sustainable outcomes. Local and neighbourhood concerns, quality of life, specific effect concerns (e.g. visual, sound, odour), along with traditional and cultural values are particularly important. These have all gained acceptance as pertinent and definable criteria that many jurisdictions are now interpreting and applying to report on sustainable outcomes.

At present, there is no known system unique to Canada for measuring the sustainability of projects. Engineers are encouraged to investigate systems in other countries and, where appropriate and cost effective, utilize such systems from elsewhere. The outputs serve as inputs to professional judgment.

Sustainability rating systems have been developed in the United States, Great Britain and EU, Australia and France that have possible application in Canada with limitations and modifications. Typically these system-level tools suggest major themes related to the environment such as: Quality of Life, Leadership, Resource Allocation, Climate and several others. Sub-categories within each major theme include topics such as: Communities, Well-being, Innovation, Biodiversity, Energy, Emissions among many others. Typical metrics covered include energy, water, materials, sites, indoor / outdoor environments, social, existing environment among other parameters.

These systems provide for assigning a point score for each sub category which yields an overall rating such as "Good", "Excellent", "Leading". These systems indicate how sustainable was the engineering design and construction once completed. Four systems and links for more information are as follows:

- »Envision™ (USA) provides a holistic framework for evaluating and rating the community, environmental and economic benefits of all types and sizes of infrastructure projects to assess the sustainability indicators over the course of the project's life cycle. <http://sustainableinfrastructure.org/envision/>
- »CEEQUAL© (Great Britain & EU) takes a very broad view of 'civil engineering' in covering all infrastructure that supports modern life as well as landscaping and the public realm. <http://www.ceequal.com/>
- »The IS (Australia) rating scheme for evaluating sustainability across design, construction and operation of infrastructure is developed and administered by the Australian Green Infrastructure Council (AGIC). <http://www.agic.net.au/ISratingscheme1.htm>
- »CBDD System (France): Carnet de Bord Développement Durable is a methodological support, consisting of a set of tables to define and monitor the objectives and challenges in terms of sustainable development, specific items / equipment. <http://www.syntec-ingenierie.fr/actualites/2013/06/10/le-carnet-de-bord-developpement-durable-2013/>

For other types of projects and especially for comparing the merits of one concept to another, a Life-Cycle Analysis (LCA) system should be considered. LCA tools are still evolving but several are available.

These systems will evolve and new ones may be developed so monitoring and evaluating their application in

future projects is recommended. As with any system or process, the results should be used to inform professional judgment, not replace it.

Another specialized system available in Canada is the Leadership in Energy and Environmental Design (LEED), managed by the Canada Green Building Council (www.cagbc.org). It is an interactive process for the design, construction, operation, and maintenance of green buildings, homes and neighborhoods. It offers a comprehensive system of interrelated standards covering all aspects of the development and construction process. It is a well-recognized system to encourage design and construction of sustainable buildings with a lower environmental footprint. Most of the concepts in LEED are transferable to other non-building projects.

Another alternative for buildings is the Integrated Design Process (IDP). It involves a holistic approach to high performance building design and construction. It relies upon every member of the project team sharing a vision of sustainability, and working collaboratively to implement sustainability goals [7]. Green Buildings Canada offer a number of tools to plan and implement sustainable solutions that also address environmental concerns. [8]

Engineers should assure that SD&ES indicators are reported periodically in an open and transparent manner in accordance with the public interest.

5.5 Guideline #5 - Costing and Economic Evaluation

Engineers should assess the costs and benefits of environmental protection, eco-system components, and sustainability in evaluating the economic viability of the work.

Amplification

- » Conduct an economic analysis of the project in comparison to the benefits. The analysis should normally include capital, operating, maintenance, and commissioning, decommissioning, social, and environmental costs.
- » Environmental protection and sustainability over the project life cycle should be included for comprehensive project costing.
- » Those involved in manufacturing should include the full costs of the product which include use of the raw resource, manufacturing, by-products, packaging and end-of-life disposal.
- » Include environmental protection and associated costs as an integral part of project development.
- » Assessing the costs and benefits of mitigating climate change through GHG reductions should also be considered where appropriate.
- » Consider the costs of adapting the work to improve resilience to the impacts of changing climate and extreme weather.

Commentary

The engineering objective is to secure the most sustainable solution that can be cost-effectively obtained. In practice the profession is competitive and subject to many competing interests that constrain system wide and life-cycle thinking. When engineers undertake work, a balance between doing a thorough job against pressures to control costs and meet deadlines must be achieved.

Engineers are responsible for the technical detail that will form the basis for costing developments, even if the overall decisions about proceeding with a development are the responsibility of others. Consideration of the full scope of environmental costs at the earliest possible stage of project development can often provide considerable cost savings, compared to retrofitting or remedial actions. It is becoming more common in project costing to consider the full, life-cycle costs, from project conception to final decommissioning. If the technical detail for the project life cycle fails to consider the full scope of environmental costs, then project decision makers may reach an invalid decision about the true economic viability of a project.

These environmental costs may include: prevention, mitigation or compensation for adverse effects, operational and long term monitoring, inspection and maintenance and decommissioning and reclamation costs. Increasing awareness and resulting legislation are requiring that environmental costs be assigned to project proponents. Consequently, engineers need to advise the responsible parties of these obligations.

Examples of environment cost accounting and sustainability performance indicators that may be suitable for analysis include:

- » System of Environmental-Economic Accounting (SEEA) is a framework to compile statistics linking environmental statistics to economic statistics <http://unstats.un.org/unsd/envaccounting/seea.asp>
- » Environmental full-cost accounting (EFCA) is a method of “triple bottom line” cost accounting that traces direct costs and allocates indirect costs by collecting and presenting information about the possible environmental, social and economic costs and benefits or advantages for each proposed

alternative.

»Life Cycle assessment tools are available for application to buildings (<http://calculatelca.com/>)

Engineers should ensure that they have reasonably considered the impact of changing weather and climate conditions over the entire service life of their project. Projects that do not include consideration of climate in their scope may seem to be less costly for initial procurement. However, projects with no scope for incorporating climate risk are likely to incur much higher costs associated with renewing non-resilient designs over the life of the system. It is a question of allocating more resources now along with good operations and maintenance practices to reduce or avoid substantially higher costs of repair and replacement at some unexpected time later in the service life.

Engineers involved in operations, maintenance and planning functions should ensure that they allocate (or are allocated) appropriate resources to allow other professionals the scope to incorporate appropriate adaptive measures into their project. Where the engineer does not have direct authority to allocate resources, they should advocate decision-makers to delegate them sufficient authority to do so [9].

5.6 Guideline #6 - Planning and Management

Engineers should integrate environmental stewardship and sustainability planning into the life-cycle planning and management of activities that impact the environment, and implement efficient, sustainable solutions.

Amplification

- »Recognize the effects of environmental factors such as air, land and water pollution, dust, noise and visual pollution that may impact on human beings as well as the natural environment.
- »Identify the possible environmental effects and sustainability at all project stages (e.g. design, construction, operation and decommissioning), using life-cycle assessment tools.
- »Prevention of adverse effects is the preferred option, followed by mitigation. This is best done under a risk assessment / risk management approach.
- »Consider the role of compensation for impacts that cannot be avoided or mitigated sufficiently.
- »Seek alternative solutions that not only protect, but also enhance the environment and its sustainability.
- »Work within an Environmental Management System that requires the identification and prioritization of environmental aspects and the organization of cost-effective programs to control and reduce the related effects for the ongoing operation.
- »Know how to design and understand the operation of infrastructure to minimize the effects of long term changes in the environment including the impacts of the changing climate.
- »Find innovative ways to minimize the need for resources, especially resources with scarcity issues.
- »The scope of planning should include reasonable investigations into the individual and cumulative effects on other micro ecosystems in the vicinity of the work being completed.
- »Specify and implement appropriate operation and maintenance policies and procedures that assure service and performance over the intended life cycle and avoid premature repair or replacement.

Commentary

Extending the life cycle of a resource is a means to increase sustainability.

If prevention and mitigation of environmental effects is not inherent in the initial project development, it will most likely be required subsequently, probably at much higher cost and after public debate.

The engineer, as well as the project proponent, has a responsibility to consider environmental effect prevention and mitigation as a part of doing business. The engineer should endeavour to resolve all issues surrounding a project or product before proceeding.

“Green Engineering” involves the use of green solutions or natural solutions, rather than traditional "built" engineering solutions for projects. An example for smaller systems where local conditions and zoning permit is to use the ground to filter and clean water, rather than using pipes to send water kilometers away to a treatment plant.

For product development, the appropriate choice of materials, packaging requirements, storage, transportation and end of life considerations are key factors. Alternatives to disposal in landfill, such as reducing, reusing and recycling of products should be considered. The use of the extended producer responsibility approach, where products that have reached their end-of-life are managed by the manufacturer, can help minimize resource requirements and environmental impacts over the product's life

cycle.

Sustainability has, in the past, often focused on the development and use of natural resources. A change in this focus is required. Engineers must understand the effect of all projects on resources, both natural and man-made and should look for alternatives. Although waste minimization is a key part of sustainability so is the effect of a project on its surroundings. As well, many projects also present an opportunity to consider planning and design alternatives that may actually enhance the environment by having a positive effect.

Further guidance is available through national and international standards like ISO series of environmental management standards [10] .

An EPD® (Environmental Product Declaration) is a verified and registered document that communicates transparent and comparable information about the life-cycle environmental impact of a product (<http://www.environdec.com/>). The International EPD® System is a global programme for environmental declarations based on ISO 14025 and EN 15804. The database currently contains more than 500 EPDs registered by 150 companies in 27 countries. This approach has the potential to revolutionize the materials side of projects, if adopted in Canada.

Further guidance on the science of climate change as well as approaches to mitigation through GHG reduction and adapting to climate change to increase resilience can be found in the Fifth Assessment Report of the International Panel on Climate Change (IPCC) [11] . Natural Resources Canada has recently updated its science assessment of climate change impacts for Canada. [12]

Engineering regulators may provide more detailed guidance for particular types of projects through technical bulletins and practice guidelines.

5.7 Guideline #7 - Seeking and Disseminating Innovation

Engineers should seek and disseminate innovations that achieve a balance between environmental, social and economic factors while contributing to healthy surroundings in the built and natural environment.

Amplification

- »Engage in innovation as a key aspect in the development and application of sustainable solutions.
- »Apply innovative products and processes that reduce environmental impacts.
- »In planning for facilities, implement a comprehensive and innovative design strategy to reduce or prevent generation of solid waste.
- »Use advanced and innovative manufacturing processes to produce products that require less energy
- »Identify and further the reapplication of good innovative solutions through knowledge transfer, capacity building and measurement of outcomes.

Commentary

Engineers are structured problem solvers. If a problem is not defined then they will seek to define it and if the scope for acceptable solutions is not given then they will try to identify the constraints. A problem well-defined enables the pursuit of innovative solutions.

Engineers play a key role in transforming science into technology for application in the real world. Innovation, in the form of both hard technologies (i.e. devices) and soft technologies (i.e. methodologies, processes and procedures) is often fostered by the profession. This will include harnessing and maximizing the potential of technological innovation. Examples include carbon capture and storage systems, more efficient irrigation methods, essential medicines, household water purification devices, and manufacturing processes that minimize waste and pollution.

Sustainable technologies use less energy, fewer limited resources, do not deplete natural resources, do not directly or indirectly pollute the environment, and can be reused or recycled at the end of their useful life. However, the most appropriate technology may not be the most sustainable one; and a sustainable technology may have high cost or maintenance requirements that make it unsuitable

The engineering profession is generally risk averse. Established methodologies are often applied because they are easy and generally accepted. Precedence does not necessarily mean that they are the best approach. Advancements in technology and improved approaches to planning and management mean that innovation can often enable a better solution. In some cases innovative “green engineering” [13] solutions can enhance the environment at little or no cost.

Engineers are uniquely placed to facilitate innovative approaches and to assess the improvements in cost reduction and/or minimizing negative outcomes for both the built and local environments. However, it may be difficult for the engineer to implement innovative solutions as existing governmental regulations or

opinions of clients may limit their ability to implement.

Engineers should strive to advance the state of the art in their professional area and pursue innovations that can help advance the application and effectiveness of sustainable development.

5.8 Guideline #8 - Leading, Communicating and Consulting

Engineers should become engaged in a leadership role in the ongoing discussion of sustainability and environmental stewardship and solicit input from stakeholders and accredited experts in an open and transparent manner.

Amplification

- »Actively champion and participate (consistent with the scope of the assignment and expertise) in the development of a strategy to address environmental concerns in an ongoing manner. The principles for guiding action should include accountability, inclusiveness, transparency, commitment and responsiveness.
- »Consult and engage with stakeholders to determine local, neighbourhood, traditional and cultural values and priorities. Public meetings, focus groups and other means of open dialogue foster community engagement. These processes can further document any environmental, social or economic impacts that justify and necessitate mitigative actions or adjustments to design assumptions
- »Immediately advise the employer and/or client of any potentially adverse effects discovered in the course of any assignment in which they are involved. Particularly important is communicating and documenting the possible consequences if the engineers' recommendations on environmental remediation or sustainable development are overruled or ignored.
- »Actively share expertise and educate other professions, government and the public to improve societal support for environmental stewardship and sustainability practices.

Commentary

Engineers are uniquely positioned in three ways to address the two extremes of absolute preservation and unfettered development. First, engineers consult with stakeholders to obtain feedback and ensure input is considered to the maximum extent possible. This includes advising how the feedback was considered and not considered in the decisions that were made. Second, engineers contribute to bodies constituted to formulate environmental laws and their enforcement. Finally, engineers are in a position to act as true environmental stewards who have viable, knowledge-based solutions.

Engineers have duties and obligations to their clients or as employees to their employers. In cases of environmental degradation or a project that is unsustainable, there may be a conflict between legal duties and ethical obligations. If an engineer has reason to believe that there is a threat to the environment that negatively impacts public health or safety in the short or long-term, there is an obligation to bring this to the attention of the relevant authority in written form rather than verbal communication. Documentation in writing fulfills the engineer's duty of care and due diligence.

Engineers are encouraged to be actively involved with environmental issues. Through proactive involvement, they can offer analytical skills to bring a balanced, knowledge-based perspective to the discussion. This could apply even though the individual professional activities of some members may primarily involve expertise that is apparently unrelated to environmental matters.

When engineers become aware of public concerns relative to an assignment they are involved in, the nature of the concern should be investigated in a timely manner to determine the validity of the concern.

The validated information should be promptly communicated through the normal lines of responsibility. Where the withholding of confidential information poses a potential threat to the environment, the engineer should make a reasonable effort to contact responsible stakeholders before disclosure of the information to the proper regulatory authority.

Engineers are encouraged to seek a second professional or specialist opinion as necessary to validate their conclusions, especially when a difference of opinion is apparent with other responsible parties regarding environmental effects.

Engineers must recognize their individual responsibilities for reporting releases and for environmental protection in accordance with legislated reporting requirements and the Code of Ethics.

Sustaining the viability of our environment is a broad responsibility of all citizens. Likewise, our society must seek to reconcile these environmental needs with our need for responsible development.

Engineers should take a pro-active and cooperative role to assist society to meet these challenges and be the champion to preserve the environment.

5.9 Guideline #9 - Complying with Regulatory and Legal Requirements

Engineers should assure that projects comply with regulatory and legal requirements by the application of best available, economically viable technologies and procedures.

Amplification

- »Engineers must comply with regulatory and legal requirements.
- »Hold due regard of the reality and trend of environmental legislation to assign personal responsibility for both action and omission. Reflect this reality in professional duties as it relates to the engineer, employer, colleagues and clients.
- »Look-ahead for likely legislation changed during the project lifecycle.
- »Ensure that appropriate action or notification of proper authorities occurs in any instance where public safety or the environment is endangered, or where required by relevant legislation, approvals or orders.
- »Maintain client and/or employer confidentiality unless otherwise required by relevant laws, regulations, approvals or orders. When any confidential information is disclosed to public authorities, ensure that their employers and clients are advised of such disclosure.
- »For jurisdictions where limited regulatory standards exist, advise on, and use other national or international regulations, codes or standards that are judged to be locally appropriate.

Commentary

Engineers are responsible to know and be aware of environmental laws and regulations, either directly or through the retention of qualified specialists. Due diligence is required in the conduct of professional duties to ensure that reasonable analysis is done to comply with environmental requirements. This implies an understanding of environmental policy.

Environmental audits and the implementation of an Environmental Management System are effective means for accomplishing these objectives.

Legal responsibilities such as environmental legislation can place responsibility for environmental impairment on any individual. The greater the likelihood and/or consequences of a negative occurrence, the greater the care that is expected.

In such cases, a defence for the engineer may have to rely upon demonstrating due diligence; the premise that the individual took all reasonable measures to mitigate the problem or adapt to the situation. An important element of due diligence is being able to document that reasonable care has been exercised. Reasonable care may be assessed by comparing what was done to what could have been done, and determining if there were any practical alternatives that could have been used to avoid or to minimize problems.

The engineer can ensure a high level of due diligence by ensuring that, where appropriate, activities take place within an adequate Environmental Management System, which is either consistent with or formally certified to a recognized standard.

Due diligence is a moving standard which will be progressively defined by the courts with the passage of time. However, engineers should use their knowledge and problem solving skills to help adapt and move the regulatory requirements to allow more innovation.

5.10 Guideline #10 - Managing Risk

Engineers should implement risk mitigation measures in time to minimize environmental degradation where there are threats of serious or irreversible damage but a lack of scientific certainty.,

Amplification

- »Assess risks in advance to enable a precautionary approach to recommend actions that protect, restore or improve the environment and the sustainability of a project.
- »Ensure “no” or “low regret” actions that are precautionary are not excessive and lead to unnecessary expense for limited benefit or risk reduction. Assess through risk assessment the potential impacts and liabilities of specific actions, or not taking specific actions.

- »Provide the decision-maker with a clear statement of the potential actions required to reduce risks by protecting, restoring and, if possible, improving the environment that may be impacted by their projects respecting local needs and concerns.

Commentary

Assessing risks due to uncertainties or incomplete scientific information informs decisions on actions is a precaution to potential impacts' Uncertainties in scientific data or incomplete evidence of adverse impacts can be addressed through the proven process of risk management. This includes assessing risks, developing mitigation strategies, communicating the risks and strategies to stakeholders and implementing accepted mitigative actions.

Risk assessment may include defining engineering, environmental and financial risks and social impacts. This process should engage experts in the fields of expertise required as well as stakeholders.

Engineering risk management means the process of analyzing exposure to loss or damage and taking appropriate steps to eliminate the risk or reduce it to acceptable levels. Key to this definition is the concept of an integrated approach to reducing loss exposure; i.e. the recognition that loss or damage can occur in a number of areas (people, environment, assets and production).

With this approach to risk management, engineers focus on hazards relevant to their work (e.g. chemicals, thermal radiation, mechanical forces, electricity, etc.), and analyze the risk from these hazards with regard to injuries, environmental damage, destruction of property, and business interruption (all of which would typically involve financial loss).

A degree of knowledge with respect to financial risk management would be expected of engineers. Often the issues of concern are liability with respect to professional practice and the performance of major undertakings from a business perspective.

The precautionary principle provides a basic no-regret approach to help determine if an action should or should not be undertaken when the associated risks are not known with full certainty. This can be difficult to interpret however and can be used to suggest that the precautionary principle either does not apply, applies but demands certainty that cannot be had, or that measures that do not benefit the client should not be taken.

Engineers are often employed for their ability to deal with uncertainty. Problem definition and constraint identification allow costs and benefits to be evaluated and projects to move forward. The use of the precautionary principle can help this process. Engineers should be wary however that the precautionary principle can be misused or even abused.

For instance, one possible interpretation of the precautionary principle is that the burden of proof falls on those wishing to take an action. Although this approach may limit liability it does not support advocacy for the environment. A more useful interpretation of the precautionary principle that goes beyond the no-regrets approach by including costs is that of Principle #15 of the United Nations Rio Declaration:

"In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation." [14]

The Rio Declaration definition of the precautionary principle may be scaled to the ability of practitioners to apply it. Its application is recommended so as to avoid other self-serving definitions that might be used to circumvent accountability and responsibility.

Engineers can employ the precautionary principle to recommend actions that have little or no costs, and that can help protect, restore or even improve the environment. A risk assessment / risk management methodology can be employed to identify potential concerns and appropriate measures to deal with them. For instance, an inventory of infrastructure that might be vulnerable to the impacts of climate change would help identify potential risks and possible mitigation measures. Such an inventory would also be useful whether or not climate change proves to have a significant negative effect on any particular piece of infrastructure.

The Public Infrastructure Engineering Vulnerability Committee Engineering Protocol developed by Engineers Canada (<https://pievc.ca/>) is a risk assessment methodology that identifies and ranks current and future climate risks to public infrastructure. The climate risk profile enables engineers and other infrastructure practitioners to recommend cost-effective, adaptation actions to reduce risks and improve the resilience of infrastructures to climate impacts. Application of the Protocol is an excellent example of applying the precautionary principle to mitigate future climate risks to infrastructure over its life cycle.

6.0 Concluding Remarks

Applying these guidelines will present challenges for many engineers – some may perceive them as not relevant to their area of practice, or beyond their control, or beyond their skill set to implement at a significant level. Constraints on financial resources are often another significant constraint that may limit any effort. Certainly thought should be given as to how multi-disciplinary teams could be assembled by engineers at the earliest stages of any significant project and to determine methods for allocating appropriate resourcing.

Despite these challenges, all engineers should work towards sustainable and environmentally responsible solutions in their practice and contribute to the advancement of the profession’s capabilities to do so.

Engineers Canada and its engineering regulators have pledged to support sustainable development and environmental stewardship in the practice of engineering. Adoption of these guidelines demonstrates this commitment and benefits all registered engineers in Canada.

Definitions

List of Definitions

There are numerous terms used to refer to the concepts of sustainability, development, environment, stewardship and other combinations thereof. There are variations of terms among engineering regulators for local use and in specific areas of engineering practice. Engineers are advised to be wary of intentionally weak or vague definitions that may circumvent professional practice and accountability. International, national, provincial and territorial definitions in legislation and regulation can help engineers adapt their practice.

It is at the local or community level where sustainable development and environmental stewardship is implemented with measurable goals and outcomes. Recognized definitions assist in this process.

The following are standardized terms and definitions used in the guideline or for reference by engineers.

Acquiescence

To accept or comply passively, without question or objection.

Adverse Effect

Impairment of, or damage to: 1) the environment, 2) societal health and safety, and/or 3) property and functioning of the economy.

Association/ordre

An organization authorized by provincial or territorial legislation to regulate the qualification and registration of engineers and the practice of engineering in the authorizing jurisdiction.

Climate Change

A change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods. [15]

Climate Change Adaptation

The process of engineering decision-making for adjustments in human or natural systems in response to vulnerabilities to climatic changes, that moderates harm or exploits beneficial opportunities.

Climate Change Mitigation

The reduction of anthropogenic Greenhouse Gas (GHG) emissions by reducing the releases from sources and increasing the uptake by sinks to reduce overall radiative forcing in the atmosphere.

Conservation

The planning, implementation and ongoing management of an activity to protect the set of physical, chemical and biological characteristics of the environment necessary to maintain the health of the natural world.

Continuing Professional Development

The training and/or engineering practice, which enhances an engineer’s skills, knowledge and ability to practice engineering. These activities typically include the application of theory, management of engineering, communication or understanding the social implications of engineering. [16]

Cost-Benefit Analysis

An economic analysis method that expresses the costs of an activity, in comparison to the benefits, using common units, to aid decision-making. The analysis would normally include capital, operating, maintenance, commissioning and decommissioning, social, and environmental costs.

Cradle to Cradle

An approach that looks beyond efficiency to systems that are essentially waste free. All material inputs and outputs are seen either as “technical” nutrients that are indefinitely reusable by society or as “biological” nutrients that are recyclable by nature.

Cumulative Effects

Cumulative effects are changes to the environment that are caused by an activity in combination with other past, present and future human activities. Individual effects that are incremental, additive and synergistic can lead to cumulative effects and must be considered collectively and over time, in order for a true measure of the total effect and associated environmental costs of an activity to be assessed.

Due Diligence

The care that a reasonable person exercises under the circumstances to avoid harm to other persons, property and the environment.

Ecosystem

The interactive system involving all of the organisms in a specified area, their interactions with each other, energy and material flows and the components of air, land and water.

End-of-Life

For goods and services, the period after which a product is expected to have reached the end of its useful or serviceable life, or when a service would no longer be expected to be available from the service provided.

Engineering regulator

An organization authorized by provincial or territorial legislation to regulate the qualification and registration of engineers and the practice of engineering in the authorizing jurisdiction.

Environment

The natural and built components of the earth and includes:

- »air, land and water;
- »all layers of the atmosphere and oceans;
- »all organic and inorganic matter, and all living organisms; and,
- »the interacting natural systems that include components referred in sub-clauses (i), (ii) and (iii) above.

The human built environment exists within the natural environment.

Environmental Assessment

The identification and evaluation of the effects of an undertaking and its alternatives on the environment.

Environmental Audit

A systematic, documented, objective review of the manner in which environmental aspects of a program, project, facility or corporation are being managed.

Environmental Impacts and Effects

An impact on the environment can lead to various effects. Impacts are primary events; they have magnitude and can lead to subsequent effects. Effects are secondary events; they have significance and may be good or bad, singular or multiple, immediate or distributed across time and space, and could be isolated or cumulative.

Environmental Impairment

Damage, harm or loss to the environment.

Environmental Management System (EMS)

A continual cycle of planning, implementing, reviewing and improving the processes and actions that an organization undertakes to meet its business and environmental goals. Most EMS's (i.e. ISO 14001) are built on the "Plan, Do, Check, Act" model. This model leads to continual improvement based upon:

- »establishing policy or strategic direction;
- »planning, including identifying environmental aspects and establishing goals [Plan];
- »implementing, including training and operational controls [Do];
- »checking, including monitoring and corrective action [Check]; and,
- »reviewing progress and acting to make needed changes to the EMS [Act].

Environmental Protection

Measures and controls to prevent damage and degradation to the environment, including the sustainability of its living resources.

Environmental Specialist

An individual not limited to engineers, who is qualified with training, knowledge and experience in a field or discipline of science dealing with the environment.

Environmental Stewardship

The wisest use of the finite resources in nature to produce the greatest benefit while maintaining a healthy environment for the foreseeable future.

Extended Producer Responsibility

A scheme under which producers assume responsibility for disposal costs that can reasonably be expected to arise when their products reach End-of-Life. This usually involves some up-front securitization mechanism.

Hazardous Substance

A substance or mixture of substances, other than a biocide, that exhibits characteristics of flammability, corrosivity, reactivity, toxicity or other harmful effects when released into the environment.

Hazardous Waste

A category of waste requiring special handling, treatment or disposal as specified in currently applicable regulations.

Innovation

An innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations. [17]

Liability

Legal responsibility to another or to society, which is enforceable by civil remedy or criminal penalty.

Life-Cycle Assessment

Assessing the environmental effects of a chemical, product, project, development or activity from its inception, implementation and operation through to termination or decommissioning.

Mitigation

In respect to a project, the elimination, reduction or control of the adverse environmental effects of the project, and includes restitution for any damage to the environment caused by such effects through replacement, restoration, compensation or any other means.

Persistent Effect

A compound or substance that is resistant to degradation processes, and has the potential to accumulate in the environment and exert long-term environmental effects.

Precautionary Principle

Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation. [18]

Professional engineer/Engineer

The title given to a person in Canada who is allowed to engage in engineering under local law. The protected title given to a person licensed to practice as a “Professional Engineer” or “Engineer” is authorized under the applicable provincial or territorial engineering act.

Quality of Life

The factors related to the state of health and well-being of an individual or a community.

Engineer Standard of Reasonable Care

Performing in a manner consistent with that degree of care and skill ordinarily exercised by members of the engineering profession currently practicing under similar circumstances.

Reclamation

The removal of equipment, buildings or other structures or appurtenances; and the stabilization, contouring, maintenance, conditioning or reconstruction of the surface of land resulting in a biologically productive landscape that is equivalent to pre-disturbed state.

Recycle

To do anything that results in providing a use for a thing that otherwise would be disposed of or dealt with as waste, including collecting, transporting, handling, storing, sorting, separating and processing the thing, but does not include the application of waste to land or the use of a thermal destruction process.

Remediation

The process of correcting or counteracting the contamination of structures, land or water to meet or exceed specified requirements. Requirements may be regulatory or set by stakeholders but must be specific.

Societal Values

The attitudes, beliefs, perceptions and expectations generally held in common in a society at a particular time.

Stakeholder

A person or organization that is directly involved with, or affected by, a development, product, or activity and therefore has an interest in it.

Sustainability

Ability to meet the needs of the present without compromising the ability of future generations to meet their own needs, through the balanced application of integrated planning and the combination of environmental, social, and economic decision-making processes.

Sustainable Development

Sustainable development is development that meets the social, economic, and environmental needs of the present without compromising the ability of future generations to meet their needs [19].

Sustainable Economic Development

One of numerous variants of the term Sustainable Development. [There is little consistency among definitions for this and other related terms in the literature. This term is not defined in this document and its use is avoided in the guideline.]

Valued World Component

Any part of the social, economic and environmental system that is considered important based upon cultural values, resource impacts and environmental concerns.

Vulnerability

The degree to which a system is susceptible to, or unable to cope with, the adverse effects of climate, including climate variability and extremes or any other natural events or man-made activity.

Waste

Any material or substance that is unwanted by its generator.

World

The world is the entire earth. It consists of both of the natural environment and the human built environment; plus the people, their society and their global economy.

Acknowledgement

This guideline has been developed from the following publications, which served as source documents:

- »The Association of Professional Engineers and Geoscientists of British Columbia (APEGBC) - Sustainability Guidelines, May 2013.
- »The Association of Professional Engineers and Geoscientists of Alberta (APEGA) - Guideline on Environmental Practice, February 2004.
- »Canadian Council of Professional Engineers - National Guideline on Environment and Sustainability, 2006.
- »Canadian Engineering Qualifications Board – Model Guide for Constituent Associations: Risk Management, August 2012.
- »World Federation Of Engineering Organizations - Model Code of Practice for Sustainable Development and Environmental Stewardship, October 2013.
- »Association of Consulting Engineering Companies Canada - Sustainable Development for Canadian Consulting Engineers, 2014.
- »International Federation of Consulting Engineers (FIDIC) - Project Sustainability Management – Applications Manual, 2nd Edition – 2013.

Permission to use the referenced material is gratefully acknowledged.

Endnotes

[1] Canadian Environmental Protection Act (CEPA) 1999; www.ec.gc.ca/lcpe-cepa

[2] Canadian Environmental Assessment Act 2012 (S.C. 2012, c.19, s.2) <http://laws-lois.justice.gc.ca/eng/acts/C-15.21/index.html>

[3] Engineers New Zealand, (May 2005). Practice Note 05, Sustainability and Engineers. ISSN 1176-0907. Retrieved on December 2010 from <https://ipenzproduction.blob.core.windows.net/cms-library/docs/default-source/news-publication/engineering-practice/practice-notes/pn05-sustainability.pdf?sfvrsn=4>

[4] The Brundtland Commission, included 23 members from 22 countries, was formed by the United Nations in 1984, and for three years studied the conflicts between growing global environmental problems and the needs of less-developed nations. See http://en.wikipedia.org/wiki/Brundtland_Commission)

[5] Adapted from World Federation of Engineering Organisations, (2002). Engineers and Sustainable Development, Prepared by the World Federation of Engineering Organisations' Committee on Technology, August 2002.

[6] Association of Consulting Engineering Companies - Canada –“Sustainable Development for Canadian Consulting Engineers”, Section 3.2 p. 13-14

[7] <http://www.nrcan.gc.ca/energy/efficiency/buildings/eenb/integrated-design-process/4047>

[8] <http://www.greenbuildingcanada.ca/infobase/>

[9] Principles of Climate Change Adaptation for Engineers, Engineers Canada, 2014 https://www.engineerscanada.ca/srv/drupal-engineerscanada-website/src/sites/default/files/01_national_guideline_climate_change_adaptation.pdf

[10] http://www.iso.org/iso/theiso14000family_2009.pdf

[11] <http://ipcc.ch/report/ar5/wg2/>

[12] CANADA IN A CHANGING CLIMATE:Sector Perspectives on Impacts and Adaptation- Synthesis, Natural Resources Canada, 2014(http://publications.gc.ca/collections/collection_2015/rncan-nrcan/M174-2-1-2014-eng.pdf)

[13] <http://www.epa.gov/green-engineering>

[14] REPORT OF THE UNITED NATIONS CONFERENCE ON ENVIRONMENT AND DEVELOPMENT, (Rio de Janeiro, 3-14 June 1992). Annex I, RIO DECLARATION ON ENVIRONMENT AND DEVELOPMENT. Retrieved on August 8, 2011 from <http://www.un.org/documents/ga/conf151/aconf15126-1annex1.htm>

[15] United Nations Framework Convention on Climate Change, (March 21, 1994). ARTICLE 1 Definitions. Retrieved on April 2011 from http://unfccc.int/paris_agreement/items/9485.php

[16] Engineers Canada, (2004). Guideline on Continuing Professional Development and Continuing Competence for Professional Engineers. Retrieved on July 12, 2011 from <https://www.engineerscanada.ca/srv/drupal-engineerscanada-website/src/sites/default/files/guidelinecompetency2004.pdf>

[17] Definition from: Organisation for Economic Co-Operation and Development, Statistical Office of The European Communities, (08 Nov 2005). Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data, 3rd Edition. Page 46. ISBN 92-64-46 01308-3. Retrieved on (July 21, 2011) from http://epp.eurostat.ec.europa.eu/cache/ITY_PUBLIC/OSLO/EN/OSLO-EN.PDF

[18] Definition from: Principle #15 of the Rio Declaration

[19] Definition from: Brundtland Commission report