SUSTAINABLE DEVELOPMENT FOR CANADIAN CONSULTING ENGINEERS

WITH NEW 2016 PREFACE

ASSOCIATION OF CONSULTING ENGINEERING COMPANIES | CANADA

ASSOCIATION DES FIRMES D'INGÉNIEURS-CONSEILS | CANADA

"The greatest threat to our planet is the belief that someone else will save it."

Robert Swan, OBE

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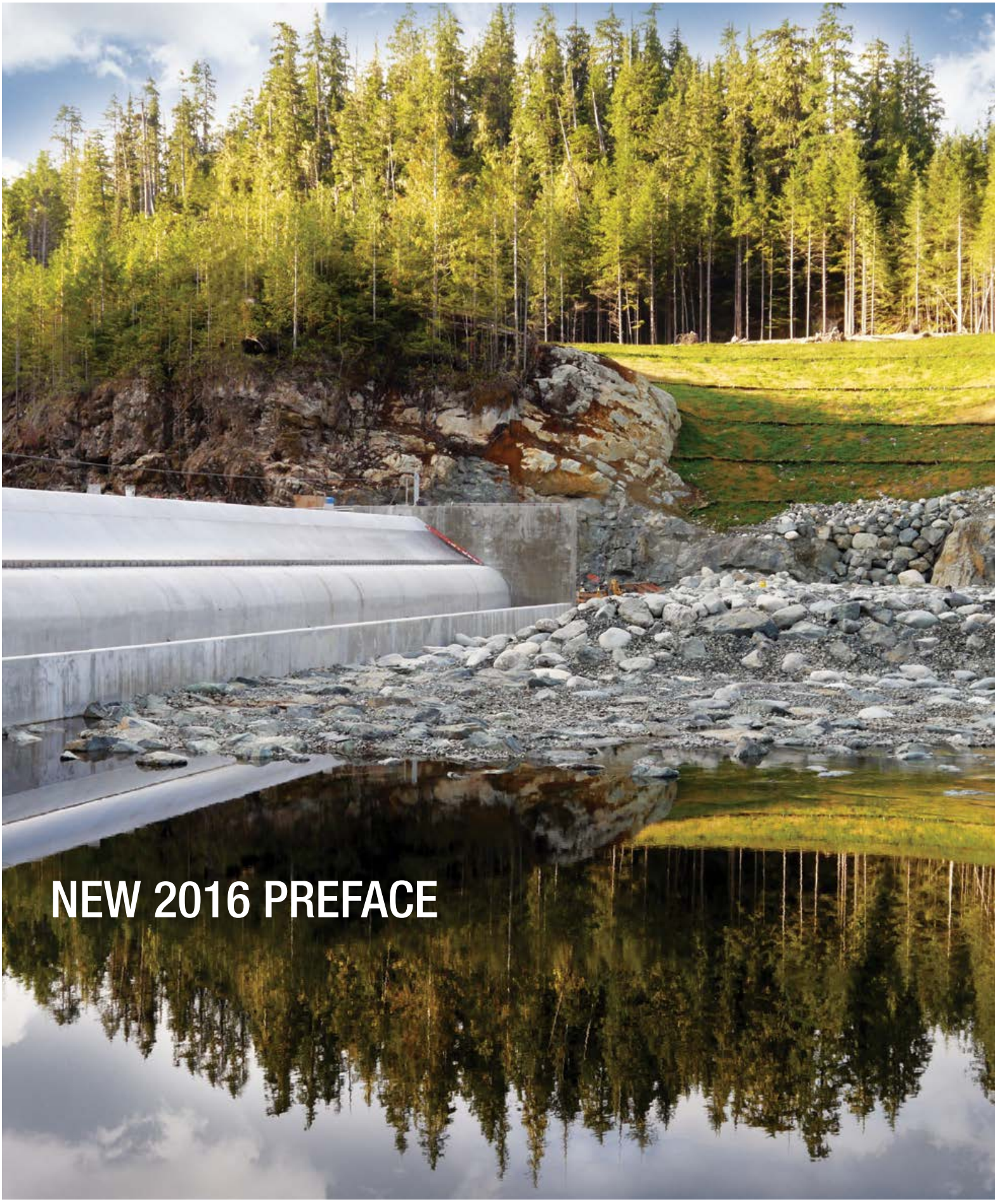

NEW 2016 PREFACE

EDITOR'S PREFACE

Sustainability in 2016

The concept of sustainable projects is one that has captured the attention of public and private sector clients in recent years. However, the idea of sustainability is not a new one to the consulting engineering sector or ACEC who released the original report in 2012. Since its release, the report has been promoted to all levels of government as part of ACEC's advocacy efforts. Now with the government's commitment of $124 billion over 10 years to infrastructure, and with a need to develop natural resources in a responsible and sustainable manner, ACEC has updated the report to reflect the latest tools and methodologies along with a new preface by author Dr. John Boyd.

AUTHOR'S PREFACE

Sustainability, Climate Change, and the Role of Consulting Engineers in Delivering a Sustainable Society

How Delivering a Sustainable Society is Changing Consulting Engineering

In the thirty years since the definition of a sustainable society was first propounded by the Brundtland Commission as "meeting the needs of the present without preventing future generations from meeting their needs," there has been an extensive debate on the nature of those needs. Consulting engineers around the world have paid careful attention to this debate because to meet the majority of these needs, project design goals will have to change significantly. In fact, without major changes in engineering design, society will not achieve its sustainability objectives. This puts the consulting engineering industry in a key role to deliver a sustainable future.

Members of the consulting engineering industry design approximately half of the world's delivered infrastructure. This percentage is much higher in Canada, and the Association of Consulting Engineering Companies - Canada's (ACEC) interest in the subject of sustainable infrastructure resulted in the publication of a status report on the issue in 2012 entitled "Sustainable Development for Canadian Consulting Engineers". Internationally, the industry's focus has been led by the International Federation of Consulting Engineers (FIDIC, of which ACEC is a member), which has produced recommendations for the delivery of sustainable projects, real property sustainability management, and the development of sustainable cities. FIDIC also published a state of the world report on sustainable infrastructure (2012) and maintains a list of available tools for sustainability on its website.

Historically, projects delivered by consulting engineers were judged on the achievement of three objectives – delivery of the client's purpose according to the safety standards of the day, delivery on schedule, and delivery on budget. About forty years ago, a fourth requirement was added – delivery adjusted to minimize negative impacts on the environment. Today, there are additional requirements – delivery that meets the needs of society in a context that often goes well beyond the direct and immediate interests of the client. Not only should the project not harm society, but it should also interact positively with affected stakeholders.

In the early 1970's, these requirements started to shift

the delivery of engineering projects to accommodate environmental considerations. Today, the shift continues by accommodating societal requirements, which places the consulting engineer in a critical position– responsible directly to the client for agreed cost, schedule, and ultimate performance, to the regulators for adherence to written standards and codes, and in a broader sense to society for project performance to unwritten sustainability objectives based largely on social values.

Many of these requirements would be considered part of the normal engineering design process, if from a somewhat different perspective. As an example, engineers would normally consider project energy requirements, energy reticulation on site, and health and safety to operators. Conversely, sustainable energy considerations include an increased focus on ways to minimize energy, substitution of renewable energy sources, and impacts outside the project on availability, and cost to others.

Other requirements affect the design but come from stakeholder issues outside the realm of engineering. As an example, opposition to transmission lines across the community or the presence of culturally sensitive areas might make it necessary to change energy access points or even to move the project site. Project success today rests upon the ability of the consulting engineer to know about, understand, and integrate these issues into the design in a sensible and sensitive manner.

Aspects of Sustainability that Directly Govern Engineering Design

Sustainability requirements directly affect engineering project design in four fundamental ways.

The first is an obligation to **conserve** or minimize the use of materials, water, and energy. This includes substituting renewable or recyclable options wherever possible and maximizing the durability of the project, including planning for simplified maintenance. Eventual decommissioning should become an integral part of design planning, which includes the handling, reuse, and/or safe disposal of wastes and restoration of the site. Finally, the project plan should consider impacts on the availability and affordability of these three project components.

The second way is an obligation to **preserve** or improve the environment, health and safety, and human rights that might be affected by the project. Environmental preservation is included in Canada's laws and regulations, which require the prevention of change due to contamination and the protection of species at risk. Sustainability considerations go further by imposing a need to design for environmental resilience, which includes the impacts of climate change. They also suggest the use of defensive engineering design, such as the substitution of lower risk process materials, to minimize operating risk.

From a sustainability perspective, health and safety considerations incorporate not only the protection during construction and operation for those working on the project but also to those affected by the project and those using the completed project or its products. This means monitoring, reporting and remediation systems should be included in the design.

While human rights are not normally a consideration of engineering design, sustainable projects should specifically consider impacts on the availability and cost of food and shelter, and avoid forced relocation of people, businesses and communities. Legal human rights that might be affected by a project include equality, security, criminality, exploitation and freedom of association. Some of these issues affect the treatment of staff by organizations involved in designing, constructing, and operating the facility – particularly in the developing world where local laws and regulations may not be as robust as those in Canada. In addition, there are other societal issues that are relevant everywhere, in particular, processes used for project procurement should be protected from bribery and corruption. Cultural considerations include protection of the natural and built environment. Development considerations include maximizing community benefits, preventing impacts on convenience, and freedom from irritants such as odor, dust, noise, and traffic congestion.

Sustainability is all about resilience and the third issue is a requirement to **predict** impacts that might affect the long-term or ultimate viability of the project. In recent years, engineering concern for the impact of the project on the environment has been broadened to now consider the impact of a shifting environment brought about by climate change on project viability.

The final issue affecting sustainability is an extended obligation to **consult** more widely with affected communities of stakeholders. To be sustainable the project must fit into the community and reflect community values and these should be consciously determined through consultation and reporting.

The Sustainable Project – Accommodating the Interests of Stakeholders

While the sustainable development issues that affect engineering design are essential to the delivery of sustainable projects, they are not the only issues that affect the overall design. Clients (whether private sector or government) bring priorities beyond those listed above, and other groups within society also bring their own specific interests based on their values. Successful project management requires the consultant listen to and understands the perspectives brought by all of the stakeholder groups and make them part of the project objectives.

Visual 1 – Typical list of stakeholders

There are a large number of possible stakeholders – indeed anyone who has an interest in the project is a legitimate stakeholder (see Visual 1). Many of the issues that the stakeholders bring are legitimate yet cannot be accommodated because of financial and technical limitations or because of project timing. Some stakeholders are simply opposed to the implementation of the project. A successful engineering consultant will listen to and understand the rationale of these diverse views and work with the stakeholder groups to define the possibilities, prioritize the issues, set performance indicators, and report progress to the group.

Measuring Success – the Sustainability Assessment

In the end, the objectives of a sustainable project will be as diverse as the society in which it is built and the priorities for its performance (and hence, its sustainability score) will reflect the values of that society. As an example, a project carried out in a desert environment might have as its highest priority the conservation of water. The same project carried out in a rainforest would not be focused on water conservation but might prioritize the preservation of old growth forest. This diversity of issues and objectives makes it very difficult to assess project success and to compare even similar projects carried out in different regions. In many respects, sustainability is more useful as a relative concept rather than an absolute one.

There are numerous assessment protocols for civil infrastructure that have been developed by groups in the UK (CEEQUAL), the USA (Envision), Australia (Infrastructure Sustainability), and elsewhere. Protocols are also available for buildings (BREEAM - UK, LEED – USA/Canada, CASBEE – Japan, Green Star – Australia, etc.). Other tools are available for water, transportation, and energy projects - details are provided on the FIDIC website. All of these national systems are relatively complex and their scoring systems are focused on the perceived needs and corresponding values of the society of origin. The suitability of the use of several of these protocols in Canada was assessed in the 2012 ACEC report "Sustainable Development for Canadian Consulting Engineers".

It is much more straightforward and less society-dependent to argue that performance should be based on how well the six engineering issues have been handled, namely: **water, energy, and material preservation; environment; health and safety; human rights protection**. FIDIC proposed to measure performance against an extreme and probably unachievable standard. In this performance protocol, sustainable projects achieved zero use of non-recoverable energy, water and materials and zero net impact on environment, health and safety, and human rights. Conventional project performance would simply be standard treatment typical of current projects. Improved performance would require a minimum of 10% improvement on conventional practice. Metastable performance would be indefinitely resilient by current practice but short of absolute sustainability. Restorative performance would achieve sustainability and remove the negative impacts of other nearby projects.

All of this makes it clear that the concept of sustainability lends itself to a treatment that is similar to environmental assessment, except that in sustainability assessment the environmental considerations would be only one piece of the process. Indeed, it is reasonable to anticipate a future regulatory environment in which sustainability assessments would be carried out in the same manner environmental assessments are conducted today. In this new environment, the consulting engineering industry will need to document and explain project decisions, including consideration of all the issues presented above and any that are raised by stakeholders in the course of the work.

Climate Change and Sustainability

Climate change is a sustainability issue that is currently receiving a considerable amount of attention. Scientific research collated since 1988 by the Intergovernmental Panel on Climate Change (IPCC) of the United Nations has been published in a series of reports that document progressive changes in world climate brought about by increases in atmospheric "greenhouse gasses" (carbon dioxide, methane, nitrous oxide, and fluorinated gasses). The scientific research on which the documents are based is carried out worldwide and is not sponsored or paid for by IPCC, which serves only as a collection and summarizing agency. The research is carefully peer-reviewed and the documents themselves are reviewed in draft and approved by the 195 member countries of the IPCC (including Canada).

The multiple documents forming the Fifth in the series of Assessment Reports were released between September 2013 and November 2014; they continue the process of improving comprehensive measurement and prediction that has characterized their predecessors. It is clear that the world's climate is changing, that anthropogenic greenhouse gasses are the major contributor to that change, and that climate impacts will grow even if attempts to reduce greenhouse gas release are successful.

These facts put the consulting engineering industry in the same kind of key role on climate change as it is in with all of the other aspects of sustainability. Society looks to our industry to deliver two types of answers to this challenge – mitigation (reduction in greenhouse gas release), and adaptation (reduction in impact of more extreme climate conditions on human ecology).

The mitigation aspects can be tied to sustainability issues by regarding greenhouse gasses as a chemical environmental pollutant. Indirectly, reduction in the CO_2 absorption capacity of the biosphere should be treated as ecological damage, and burning of fossil fuels for energy should be regarded as a more significant issue than the overall objective of generally reducing energy use. There has been some movement in this direction through the progressive substitution of cleaner versions of fossil fuels in the sequence coal -> oil -> gas. Ultimately, nuclear energy is a better option in this regard but of course it has other offsetting societal issues. Carbon capture remains a potential technology that might shift the acceptability of fossil fuels, however, it would be at the expense of overall process efficiency.

There are a number of available approaches to improve mitigation performance on all types of new engineering projects, including energy, transportation, buildings, industry, and waste management. The biggest obstacle to overall mitigation improvement is the large stock of past projects that are major greenhouse gas emitters, with a more restricted range of possibilities in the retrofitting of older projects.

Adaptation to the realities of climate change brings a different kind of engineering problem. Traditionally, design is based on historical environmental records for the site, yet with the climate changes that are taking place, new designs must now rely on climate prediction rather than history, which to date is a much less certain and specific basis for design. As a result, new projects will require greater factors of safety to achieve the same security and the projects will be more expensive than those in the past. Recent experiences with the costs of repairing and cleaning up after extreme weather events are a persuasive argument for spending the additional up-front money to provide better surety.

Preface Conclusions at a Glance

1. Without major changes in engineering design, society will not achieve sustainability. This puts the consulting engineering industry in a key role to deliver a sustainable future.

2. Significant changes in the approach to engineering design will be required to deliver sustainable projects including:

    a. Setting different design objectives

    b. Formally including stakeholder input and review in the design process

    c. Advocating sustainability assessment as a more comprehensive approach than environmental assessment

3. The industry has a similarly key role in delivering mitigation and adaptation to climate change – a role that brings its own challenges.

See summary table on next page.

Summary Table:

NAME	PROJECT SUSTAINABLITY MANAGEMENT (PSM)	ENVISION™	CEEQUAL©	CBSS: PROJECT SUSTAINABILITY LOGBOOK (PSL)	INFRASTRUCTURE SUSTAINABILITY (IS)
Country of Origin	International	USA	UK, international through adjustment of score weighting	France, Pan-European	Australia
Organization	FIDIC	Institute for Sustainable Infrastructure	CEEQUAL	European Federation of Engineering Consultancy Associations (EFCA), FIDIC	Infrastructure Sustainability Council of Australia
Type	Guideline	Rating and Certification	Rating and Certification	Guideline	Rating and Certification
Objective	Selection of target sustainability issues and performance objectives	Assessment of project sustainability performance against specific issues with defined targets	Assessment of project sustainability performance against specific issues with defined targets	Integration of sustainability into infrastructure decisions across asset lifetime from planning to operation, monitoring of performance	Assessment of project sustainability performance against specific issues with defined targets
Performance Indicators	Qualitative, relative importance of issues left open	Numerical, integrative, prescriptive	Numerical, integrative, prescriptive	Comparison between planning objectives and operational performance	Numerical, integrative, prescriptive
Sector	Infrastructure	Civil infrastructure, excluding buildings	Civil infrastructure, landscaping and the public realm	Management reporting	Civil infrastructure
Intended Users	Designer, but useable by all industry stakeholders	All industry stakeholders	Client, designer and principal contractor	Asset owner or representative	All industry Stakeholders
Complexity	Open, selectable, uncomplicated	Specific, prescribed, comprehensive	Specific, prescribed, comprehensive	Specific themes with self-defined planning objectives	Specific, prescribed, comprehensive
Training	Sporadic training, manual-based, intended for self-assessment	Regular, includes certification of trained professionals	Regular, includes certification of trained professionals	None, manual- based	Intended for self-assessment based on Excel tool and other calculators, some organizational support
Applicability	International	USA	UK, Hong Kong	International	Australia
Recognition of Compliance	No	Yes	Yes	No	Yes

FULL REPORT

FOREWORD

The Sustainability Issue and its Canadian Context

The concept of sustainable development – the idea that humanity has to greatly improve the resource efficiency and environmental protection of its development processes to provide for its growing population – has been around for more than twenty years. Over that time significant improvements have been made in the way infrastructure projects are executed, but the formal issues of sustainability have not been explicitly embedded in the consulting engineering industry's activities in Canada. Yet many of the issues of sustainability that are at the core of infrastructure design and construction, operations and closeout, in turn form the basis of most consulting engineering practice.

As the population of the planet continues to grow, the rate of progress in implementing sustainable development has not matched the need. The environment continues to be degraded by a growing population and by disastrous accidents, the level of climate altering greenhouse gases continues to rise, species face new threats of extinction, megacities continue to grow at an uncontrollable rate providing inadequate services and creating huge social problems, large parts of the world's population still have inadequate access to energy, clean water, and waste treatment – the list of deficiencies goes on. Sustainable development in its various aspects may in fact be the critical challenge of the 21st century.

Canada is not exempt from sustainability challenges. A cold climate, a population thinly spread over great distances, cities shaped with the assumption of automobile transportation, and the energy requirements of oil sands production make energy use and greenhouse gas emissions issues for this country. An economy based on the production of raw materials, plentifully supplied with water resources, does not lend itself naturally to water conservation and material use reduction. There remains plenty of opportunity for improvement in the sustainability of Canadian practices.

In this country the consulting engineering industry has an almost unique opportunity to be a leader in the effort to develop a more sustainable Canada because it is involved in almost all infrastructure development with clients who are increasingly asking for more sustainable solutions. Leadership in delivering these solutions requires innovative engineering at all scales, from the biggest projects down to the smallest ones – innovation that will only come if the industry and its clients set difficult design objectives that focus on sustainable solutions.

The Origins and Purpose of This Report

The Association of Consulting Engineering Companies (ACEC) is a not-for-profit organization representing companies across Canada that provide professional engineering services to both public and private sector clients. This report was commissioned by ACEC with three overall objectives in mind:

- To put together a summary of the background to sustainable development and its implications for consulting engineers and their clients,
- To look at existing systems to measure the sustainability of infrastructure[1] projects and consider their possible use in Canada, and
- To suggest an approach that would support the membership in their efforts to execute projects more sustainably.

The concept of sustainable projects is a rapidly evolving one that will take on new directions and mature in ways that are not currently contemplated. This report considers the way the concepts of sustainable development interact with consulting engineering practice at present, and may affect it in the future, in part by presenting a snapshot in time of a few of the many current infrastructure sustainability measurement systems – that will themselves evolve with time. It is not an endorsement of any of them but seeks to illustrate their strengths and weaknesses by considering their possible use in this country.

[1] Consulting engineers are involved in a very wide range of project types for their clients. In the context of this report the systems that are considered are those that can be used broadly for any type of development, not those that are specific to a particular project type (i.e. to building construction such as LEED©).

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1.0 EXECUTIVE SUMMARY

From its beginnings in the mid 1970's, the modern concept of sustainable development has evolved to become an increasingly important driver in the delivery of consulting engineering services.

Defined by the Brundtland commission as "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*", the concept was inserted into the world's political agenda by the 1992 United Nations Conference on the Environment and Development (a.k.a. the Rio Conference). Despite its broad appeal, after the initial burst of enthusiasm and effort at local and national levels to define a pathway towards sustainability in the 21st century, the rate of progress dropped off.

There were some notable tools developed in the early years. The efforts by international financial authorities to bring all project finance to a common developed world standard via the Equator Principles was a resounding success. Virtually all projects involving loans in excess of US $10 million are covered by this protocol and some 77 banks and financial institutions worldwide make use if it. Similarly the evolution of sustainability reporting for organizations through the Global Reporting Initiative has gradually been adopted by more than 5500 worldwide organizations, mostly businesses, as a way of demonstrating their efforts to operate in a more ecologically and socially efficient manner. The concept of sustainability also boosted international efforts in environmental protection.

Nevertheless, widespread efforts to achieve sustainable performance were not matched by corresponding successes for many years. The problem – which still exists – was the definition itself. While it was both attractive and easily understood, it did not provide a clear direction for concrete action, nor did it help to define what a sustainable world would look like at the end of that effort. In the absence of this clarity, every organization under the sun developed its own recipe for success, often based on the particular political, economic, and social circumstances of its members and often contradicting the concepts that other organizations had developed for their own use.

With this background of divergent opinion, the safest approach to defining the issues of sustainability for the consulting engineering industry is the UNCSD (United Nations Commission on Sustainable Development) list of indicators, and to treat this list as a comprehensive definition of the scope of the subject.

The situation in Canada was not different from that of the rest of the world. Initial efforts to develop plans for achieving community sustainability in the 21st century (called local Agenda 21 plans – an outcome from the 1992 Rio Conference) proved to be difficult and were gradually forgotten. Efforts to improve environmental protection that were underway in this country before sustainability became a buzzword continued, and have delivered significant progress. Many of the social issues never really seemed to apply in Canada because they were already being addressed by reforms in law and social practice.

Canada's size, its diverse geography and the even wider ethnicity of its population, meant that the importance of sustainability issues varied widely depending on location. Canada deals with diversity by subdividing political authority into federal, provincial, and municipal levels – and the nature of sustainability ensures that relevant issues can be found at all of these levels – and that their interpretation varies significantly.

Climate change is also a sustainability issue and in many respects one that has reflected the difficulty of achieving international progress. Governments and businesses (clients) have been hesitant to embrace the sort of fundamental changes that seem to be necessary to deal with climate change out of concern that the consequences might severely reduce their competitive position and their economic stability – particularly in an environment in which the reliability and accuracy of early climate change projections were widely challenged. Now, however, it has become obvious that the worldwide climate is indeed shifting. Mitigation by reducing the release of greenhouse gases and adaptation of infrastructure to the changes that are inevitable are primarily engineering problems that will require significant innovation – and a rebalancing of responsibilities between consultant and client.

It is now 20 years after the launch of the sustainability concept and the world has met again in Rio to look at progress and to rededicate its efforts to resolve the ongoing issues. Progress has been made. There have been significant improvements in agricultural productivity, and improvements in economic growth with less energy and raw material use per unit output and less pollution. The problems of acid rain and ozone attack through the release of chlorofluorocarbons have been significantly reduced. Waste disposal has been improved, and the overall standard for environmental protection is much better over a significant portion of the world.

At the same time, world population has increased and recently passed a total of seven billion. The spread of contagious disease through an extensive world transportation system has become more of a concern, and a consequence of widespread medical use of drugs has been the development of more drug resistant strains of bacteria. Economic development and increasing population have overcome the positive effects of increased material use efficiency and recycling. Water shortages have become more widespread and climate change has resulted in lengthy droughts, more severe storm events, and coastal flooding. The release of greenhouse gas continues and significant increases in average world temperatures seem to be inevitable. Overfishing has resulted in peak worldwide catches in the 1980's and a steady decline since, in spite of significant improvements in equipment and harvesting methods.

Both in the world at large and in Canada, governments and companies now understand the improved resilience that comes from reduced energy, materials, and water use. These reduced demands coupled with the protection of the environment, the health and safety of the public, and human rights are all part of the ethics of sustainable behavior. Interest in sustainability in business and in government has been stoked by the internet and by other media and the result is a public that can and will make purchasing and electoral decisions on the basis of what they perceive to be happening in this regard. There are real and obvious consequences to those who would continue to ignore the issues.

In Canada, the federal and provincial governments have enacted sustainability legislation, either dealing with the entire spectrum of interest or with specific issues that are of importance in a particular region. The concept and the promise of sustainable cities have caught the interest of municipalities and a growing number of them are declaring their specific areas of focus. The result of all of this increased interest and activity is an increase in the demand for more sustainable projects from the consulting engineering industry.

To meet this demand, numerous systems for measuring the sustainability of the huge gamut of infrastructure engineering projects have been proposed, and four of them, Envision™ from the United States, CEEQUAL© international from the UK, AGIC IS from Australia, and CBDD from France are reviewed in this document for possible application in Canada. The four systems were picked because they are typical and because they originated in countries that have close ties to Canada and many similarities with the Canadian consulting engineering industry. All have strengths and weaknesses.

Three of the systems are intended for direct use by consulting engineers, and the fourth, CBDD, is a project logbook of sustainability initiatives for the use of the owner with input from engineers. It is the only one that does not actually rate the project but rather focuses on the intended sustainable benefit of activities and then recounts what actually happened. All of the others query project performance over a large number of factors and then compare the responses with a range of possible outcomes to define a score. The scores are then aggregated and weighted to provide a single number that is intended to characterize the sustainability of the project.

All of these systems provide their scores by mixing project performance on (numerous) issues that are not related to one another and are not measured on the same scales. The final score therefore has no real meaning outside of the details of the system that gave rise to it. More importantly the original scoring and weighting reflect the interests and priorities of the originators of the system (although the CEEQUAL© approach allows for customization of these parameters) and would not necessarily be expected to match the interests and concerns of Canadian users and clients.

In addition, all of the systems give points for processes used to run sustainable projects and these processes may or may not result in tangible improvements to the actual sustainability of the projects. Because the systems try to incorporate the perspectives of the many parties who are involved (clients, contractors, engineers, and owners), many of the issues are not directly related to project aspects that are traditionally under the control of the consulting engineer, and indeed would normally be defined by the client in the terms of reference. Since the perspectives of all of the parties are factors in the ultimate sustainability of the project, it is logical to try to include them. There are distinct benefits to the involvement of all of the parties in creating a more sustainable outcome, but the result is to make the systems very complicated and detailed and to run the risk that the final system is incomplete and does not reflect the interests of all clients. While Canadian consulting engineers could (and probably will) use these systems as they are, and through their use would undoubtedly improve their focus on project sustainability, they are not entirely suited to many of the clients in Canada.

The CBDD system might be applicable with suitable adjustment for Canadian issues if a sufficient group of clients decided that such records were valuable and were prepared to rework the CBDD concept to suit their specific needs. All of the other systems would require adjustment in their scoring and weighting systems and probably adjustment in content to suit the wide range of client interests to be found in this country.

At this stage in the development of such systems it would be a better strategy for Canadian consultants to focus on those aspects of sustainability that are under their direct control on projects and adopt the FIDIC PSM II approach that identifies design issues and targets that are specific to the consulting engineering industry. With this base, discussions with clients about their specific sustainability interests and needs would be used to supplement the PSM II issues for the specific project under study.

It is clear that sustainable development will increasingly drive the project requirements of clients of the consulting engineering industry in Canada. The industry needs to take sustainability issues seriously and develop practices that produce more sustainable project solutions. The four systems that are presented in this report represent the current thinking on infrastructure sustainability and provide an excellent and comprehensive perspective on the subject.

2.0 ORIGINS AND IMPLICATIONS OF SUSTAINABLE DEVELOPMENT

2.1 International Origins of Sustainable Development

The roots of the sustainability concept were established by events in the early 1970's (see Appendix A for additional details). One was the publication of a report entitled "Limits to Growth" by the influential *Club of Rome*[2]. It examined a model of a future world of unchecked economic and population growth in an environment of finite resources. The other was the United Nations Conference on the Human Environment, held in Stockholm, which brought industrialized and developing nations together to debate and delineate the rights of humanity to a healthy and productive environment. These two aspects of humanity's future – conservation and development – were interdependent. Unless the fertility and productivity of the planet were safeguarded, humanity's future would be at risk.

In response to these concerns, in 1983 a special commission of the United Nations (the World Commission on Environment and Development) was created to critically re-examine environmental and development problems around the world and formulate realistic proposals to address them. Under the direction of its chair, Gro Harlem Brundtland the Prime Minister of Norway, it produced its report in 1987 in which sustainable development was defined as "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*."

In 1992, the UN Conference on Environment and Development (UNCED), (also known as the "Rio Conference" or the "World Summit") was held in Rio de Janeiro to discuss these issues. Agenda 21, a program of action to achieve sustainable development in the 21st century, was one of its key outcomes and in its 40 chapters it defined the issues that were considered to be important for the achievement of a sustainable future.

[2] See www.clubofrome.org

In support of this agenda, the UN Commission on Sustainable Development (UNCSD) produced a series of indicators intended to measure the sustainability of human behavior. The set of issues embodied in this list of indicators constitute an international agreement on the components of sustainability.

2.2 Progress in Sustainability

In the early years after the Rio Conference there was a burst of international effort to incorporate sustainability into everyday activities. Many communities produced local Agenda 21 plans that are now largely forgotten. Other organizations around the world developed prescriptions for sustainable behavior – many of which were mutually contradictory. But some of the initiatives and concepts had more lasting consequences.

In 1997, CERES (an NGO) together with UNEP (the United Nations Environmental Program) published a guideline for the voluntary disclosure of sustainable performance by corporations called the Global Reporting Initiative, or GRI[3]. Today version 3.1 of this protocol is used by nearly fifty-five hundred corporations around the world, and many of them are clients of the Canadian consulting industry.

In 2002, nine international banks and the International Finance Corporation (an arm of the World Bank) agreed to voluntarily develop a banking industry framework to address environmental and social risk in project financing that could be applied globally across all industry sectors. It was called the Equator Principles[4], and the current version applies to all project investment in excess of US $10 million from the 77 member financial institutions. In the developing world almost all international project finance is affected by these rules which impose developed country standards wherever in the world the project is located.

One of the influential concepts was that of the Triple Bottom Line[5] – the idea that decision making on projects should include not only the direct financial costs of implementation but also the social and environmental costs. Other conceptual models along the same lines included the Five Capitals concept[6] (defined as natural, social, human, manufactured and financial capital) and the four system conditions of the Natural Step Framework[7]. All of these concepts underlined the requirement for a balance between social, environmental, and economic interests in project decision-making. The essential difficulty lay in the details of how these aspects were to be measured, balanced and valued, and then how decisions were to be made.

2.2.1 Early Impacts in Canada

In the late 1970's and early 1980's, Canada and the United States were preoccupied with environmental protection – a problem area that had been recognized before sustainability became a buzzword. This focus brought about a revolution in the way projects were delivered by the consulting engineering industry. New regulations and environmental review processes were being developed at both the provincial and federal levels levels of government. Project teams were expanded to include new expertise in human health risk, biology, groundwater contamination and other fields relevant to the new environmental design requirements. Interaction with society on project planning became a standard part of the regulatory approval process.

In this, North America was a leader and this leadership brought major benefits to the industry. Those firms that were positioned to take advantage of their newly won knowledge developed a very successful business in transferring what they had learned to other parts of the world as those areas in turn implemented change. Competitive advantage went to those who could offer unique services on the basis of their experience at home.

[3] See www.globalreporting.org

[4] See www.equator-principles.com

[5] Slaper, T.F., Hall, T.J. The Triple Bottom Line: What Is It and How Does It Work?, Indiana Business Review, Spring 2011.

[6] See www.forumforthefuture.org

[7] See www.naturalstep.org/the-system-conditions

The social impact of sustainable development encountered a more resistant audience. Many of the issues presented by the United Nations were particular to the developing countries and there was a feeling throughout North America that they had already recognized and resolved them[8]. The response to the Agenda 21 concept of producing local plans to make communities more sustainable received a certain amount of attention at the municipal level. The Federation of Canadian Municipalities (FCM) was probably the most active group in Canada in responding to this call. Pilot projects were carried out and those involved began to understand that implementing sustainable development would not be easy.

2.2.2 Problems in Creating Sustainable Practices

Notwithstanding the agreed importance of sustainable development, the items that Brundtland was concerned about are, for the most part, still of concern today.

The idea of *satisfying the needs of the present without limiting the ability of future generations to satisfy their own needs* was easy to understand but difficult to translate into action. From the late 1980's to the mid 2000's, government and business organizations alike declared their commitment to sustainability on web sites but failed to translate the concept into operational plans at the project level. The idea of melding social, economic, and financial perspectives to make better decisions seemed to be too complicated, multidimensional, and somewhat idealistic. The issues were widely discussed but the implications in terms of individual and organizational behavior were not clear, and there was wide disagreement on steps to improve performance.

The situation was not helped by the proliferation of recipes for sustainability created by every group under the sun – often in a mutually exclusive way. There was a lack of factual information that would help decision makers distinguish between actions that might be more or less sustainable. Is concrete or steel a more sustainable choice for construction? Are paper towels or cloth ones a better choice for drying your hands? Is the power saving aspect of compact fluorescent light bulbs enough to offset the environmental danger of the mercury included in their manufacture? The answer depends on the details of each set of circumstances and the right answer in one place might be the wrong one elsewhere.

On the climate change issue there was uncertainty about the reliability and accuracy of the early predictions. Governments, businesses, and other organizations were hesitant to embrace the sort of fundamental changes that seemed to be necessary for sustainability out of concern that the consequences might severely reduce their competitive position and their ability to function in the future.

Gradually however, circumstances have changed. The world population recently passed seven billion. It is expected to reach nine billion by 2050. Companies have seen major shifts in energy pricing, and the scarcity of water resources in many parts of the world has demonstrated the improved resilience that comes from reduced demand for both of these resources. Interest in the ethics of business and government behavior has been stoked by internet communications and by a public that can and will make purchasing and electoral decisions on the basis of what they perceive. Renewable energy and recycling of material resources are concepts that are now firmly anchored in our society. Environmental protection remains a major issue and significant improvements have been made. Human rights violations are tracked and reported in regard to businesses and governments alike, and those who find themselves on the wrong side of the issues are damaged in the court of public opinion – sometimes beyond repair. Climate change is widely accepted now that the predicted consequences of these changes are beginning to take place[9]. There is renewed interest in both adaptation and mitigation.

[8] Issues such as equality under the law for men and women, protection of cultural heritage, freedom of association, protection from forced relocation and the like had already been embodied in law and regulation.

[9] There is a particularly significant Canadian initiative in this regard developed under the auspices of Engineers Canada with Natural Resources Canada support. It is a formalized risk assessment tool known as the PIEVC Engineering Protocol for evaluating the impact of climate change on infrastructure and for including adaptation to these changes in projects. The initiative included case histories, formal training and widespread publication, and is a tool that all consultants in this country should consider and use on their infrastructure projects (see www.pievc.ca).

2.2.3 Today's Environment for Sustainability in Canada

Over the past decade responsible clients are increasingly asking for more sustainable solutions, and recognizing that failure to do so will have long-term negative effects on their organizations. The international engineering industry has developed a variety of tools that help to deliver a more sustainable set of products – some as in house systems and calculators and databases, and some as association products that are aimed at the entire industry. Clients have looked at the way sustainability principles affect their organization and have developed a focused interest in specific aspects of the subject.

As a result, engineering projects are beginning to have added dimensions. Sustainability has placed additional demands on design objectives and indeed on the whole process of project delivery. Nevertheless, the list of critical issues to be addressed to achieve sustainability remains highly varied – particularly in Canada.

Canada is an enormous country with diverse geographical characteristics and an even more diverse population. Sustainability is a political, economic, and technical consideration, so the country's diversity and the division of responsibilities between federal, provincial and municipal political levels is enough to ensure that there is a wide range of opinion about what is important in the issue.

At the national level, there is a Federal Sustainable Development Act that designates responsibilities and discusses "ecologically efficient use of natural social and economic resources, and acknowledges the need to integrate… (these factors) … in the making of all decisions by government." There is also a periodically updated strategy, progress reports, and tracking indicators. The current strategy has four themes:

- Addressing climate change and clean air,
- Maintaining water quality and availability,
- Protecting nature, and
- Shrinking the environmental footprint – beginning with government.

At the provincial level, four provinces (Nova Scotia, Quebec, Manitoba, and British Columbia) have sustainability acts either passed or under consideration. Other provinces have legislation that pertains to specific aspects of sustainability. All of the acts, designate responsibility and some (especially the Quebec legislation) provide a reasonably comprehensive definition of the issues. Because of the provincial responsibilities for the environment and energy, many of the details are dealt with by the relevant departments and rightly reflect the focus of issues in those regions.

At the municipal level, there is a huge range of activity, corresponding in part to the international focus over the past decade on sustainable cities.

2.2.3.1 Sustainable Cities

In 2011, 81% of Canadians lived in urban areas, a figure that is projected to rise to 88% by 2050[10]. With this percentage of the population resident in cities, it is clear that there are major opportunities to improve Canada's sustainable performance by improving the success of urban areas.

Population density provides the opportunity for economical provision of collective solutions that lower the average impact of human activities on the planet. Services that were traditionally offered in cities through individual buildings – water and wastewater, energy, waste collection – may be more sustainable if provided through district facilities where population density makes that viable. Heating and cooling at a district level makes the use of non-conventional energy sources more attractive, and there is interest in diversifying water supply beyond the conventional use of potable water for all purposes, to include grey water and collective initial handling of waste water. Waste disposal services have undergone a transformation to include waste separation and material recycling, and composting including the collection and use of methane gas, produced by the decomposition process, as a fuel.

[10] See www.siemens.com/entry/cc/features/greencityindex_international/all/en/pdf/report_northamerica_en.pdf

There is increasing recognition that urban sustainability is tied directly to the quality of life of the population – which is improved by convenient, efficient, and accessible public transportation, recreation, shopping, and educational and medical facilities. There is growing interest in small communities within the urban landscape where all of these (appropriately scaled) services are located in close proximity to one another, and where residents can live and work without having to travel great distances.

Sustainability issues for cities tend to be focused on the delivery of these communal needs. A recent research publication by the Economist Intelligence Unit (EIU) supported by Siemens looked at the environmental performance of 27 major North American cities by considering nine categories – CO2 release, energy, land use, buildings, transport, water, waste, air and environmental governance –further subdivided into a total of thirty-one indicators and aggregated to provide an overall score for city performance.

Even with a straightforward system of aggregation, the results of comparative evaluation have to be taken somewhat cautiously because extenuating factors that might be beyond the direct control of the city may have a major impact on its perceived performance. The EIU report looked at issues such as the impact of urban wealth (average per capita GDP) on performance and a number of other factors including overall population size, population density, area, and mean outside temperature.

One of the consequences of external factors that can affect city sustainability is that plans for improving the sustainability of each urban area tend to be focused on the issues that are specific to that area and diverge somewhat from area to area. While there are issues in common, there are also issues that are unique to the area and there is a different emphasis from region to region.

As an example, the City of Calgary[11] and the City of Vancouver[12] have both published plans to improve their sustainability over the period to 2020. Both plans discuss diverting waste from landfills, improving air and water quality, better transit, and reduction of greenhouse gas emissions, but Calgary also specifically mentions control of storm water discharge, distinctive complete communities with mixed housing, a resilient economy, and attractive jobs for a high quality workforce. Vancouver is focused on communal heating, increases in population density, reduction in fossil fuel use, green carbon neutral buildings, access to nature, and improvements to urban food systems involving reduced transportation.

There are other similarities and differences, and these cities are not the only ones to have plans to improve sustainability or improve the components of sustainability, but the comparison has interesting implications for the consulting engineering industry. Work with municipal governments is a major component of industry activity and it is important that whatever tools are used to measure sustainable performance in the industry should tie closely to the objectives of the client(s). In examining the plans for Calgary and Vancouver, and the EIU study, it is clear that there are many interpretations of sustainable development for urban areas and a lot of divergence in the relative importance of different issues depending on the city in question.

It is also clear that of the total list of issues that are important for each of the examples above, a third to a half would be improved simply by more sustainable consulting engineering, and another half would fall directly under the control or influence of the city through its regulations, bylaws, and decisions about which projects to implement. These issues might impact consulting engineering through the specific requirements of a request for proposal or the design and construction of a new facility to directly address one of the concerns. The rest are fundamentally outside the sphere of influence of consulting engineers except for their activities as citizens of the city in question.

[11] See www.calgary.ca/CA/cmo/Pages/The-2020-Sustainability-Direction.aspx

[12] See www.vancouver.ca/files/cov/Greenest-city-action-plan.pdf

It is also clear from the examples that city government looks at sustainability through the lens of the services that are being provided. Public transportation systems, for example, affect sustainability in many ways – a few of which relate to the engineering services that might be provided by the industry – but all of which affect the opinion of the general public on the usability and hence the success of the system. Urban population density has a major impact on the feasibility of certain sustainable solutions, but the controls are mostly in the hands of city government and only affect engineering once specific buildings and services are to be designed within the context of the bylaws and other regulations. This separation of interest and difference of perspective could be a limitation on the effectiveness of the industry and the city government in delivering more sustainable projects. A conscious effort to work together is needed to enable engineers to understand the implications of the city's priorities and enable the city governance to understand the possibilities that can be brought forward by the engineering industry. Some of the systems that are examined in the following sections try to bridge this gap but generally do not cover the breadth of issues that are part of the municipal toolbox.

There is a good example of cooperative interaction in regard to sustainable buildings. The US Green Building Council originated a system for describing the sustainability of buildings called LEED© which has been around for a number of years and is used broadly throughout North America (there is a Canadian Green Building Council and a Canadian version of LEED©). Because the system deals with buildings, a type of infrastructure on which cities focus to improve their sustainable performance, LEED© is included in the Vancouver 2020 plan as a defined component of the intent to deliver more sustainable structures.

2.2.3.2 Green Procurement

One of the crosscutting aspects of municipal sustainability comes from the recognition that collectively municipalities are responsible for huge procurement activity. It has been estimated that the fifteen largest municipalities in Canada procure in excess of $10 billion in goods, services, and capital projects annually[13]. This represents a huge opportunity, not only to improve the sustainability of municipal activities but also to affect the sustainable performance of all of the downstream organizations that contribute to this flow of economic activity. Because consulting engineering is one of the procured services, it behooves the industry to understand what sustainability means in this context in Canada.

Sustainable procurement has been defined to mean "placing procurement priority not only on price, quality and service but also on the environmental and socio-economic impacts of a product or service." This includes considerations ranging from manufacture to disposal and includes all of the issues below:

- Green procurement encompasses packaging, renewable material use, GHG emissions, toxicity, water use and pollution,
- Ethical purchasing precludes sweatshop labour, unfair labour practices, and corruption in procurement, and
- Socio-economic purchasing includes consideration of health and safety, local economic development, minority groups, Fair Trade products, etc.

Some of these aspects are clearly outside the scope of engineering projects but some are not, and many fall within the range of issues considered within the four systems described later in this document.

So far, efforts to collectively improve the sustainability of municipal procurement is limited to a small number of municipalities spread randomly across the country, with one or two putting the most effort into their activities and seeing the most benefit. An organization has been formed (the Municipal Collaboration for Sustainable Purchasing) with fifteen participating municipalities to date. Many other municipalities are outside the organization and are attempting to make their procurement activities greener in an informal and less focused way.

[13] See www.reeveconsulting.files.wordpress.com/2011/05/2012-state-of-munic-sust-proc-canada.pdf

2.3 Summary

The gradual evolution of sustainable development from a concept into a driver of client behavior is now beginning to affect the design and execution of the consulting engineering industry's projects. To this point, the industry has not explicitly incorporated sustainability into the wide range of its activities in spite of the close relationship between engineering and the achievement of sustainable behavior. The definition of sustainable project performance is now becoming clearer, at least insofar as engineering activities are concerned, and it is time for the industry to define what it means by the term and how it should be handled in delivering client services.

3.0 ROLE OF THE CONSULTING ENGINEERING INDUSTRY IN THE DELIVERY OF A SUSTAINABLE FUTURE

3.1 The Connection between Sustainability and Engineering

The list of sustainability indicators developed by the United Nations Commission on Sustainable Development following the Rio Conference in 1992 (see Appendix A), and which have evolved since, are in many respects an operational definition of the issues of sustainability, as seen from a United Nations perspective. Perhaps better than in any other document, the indicators illustrate the connection between consulting engineering projects and sustainable development.

In some cases an engineering project will have a consequential effect, however small, on the indicator in question. As an example, poverty is a major issue in developed and developing countries alike, and engineering projects provide jobs at all stages. Sometimes the connections are more direct, because the indicator becomes a design parameter in the project. Energy and water use, greenhouse gas emissions, and material recycling are all examples of sustainability indicators that may become design parameters on specific projects. Sometimes the project itself is intended to address specific sustainability issues such as the provision of health care through the development of hospitals, education through the provision of new schools, and improved freshwater quality and quantity through water supply and wastewater treatment facilities. In many cases, it is not the engineering phase of the project that has an impact but the operating effect of the facility after it has been constructed. Issues of employment equity, local economic benefits, participation in project investment and the like are examples of these types of impacts throughout the operating stages of a project. Indeed, examination of the current United Nations indicator list shows consulting engineering involvement though consequential effects, design parameters, project types and operating effects for every one of the indicators listed. The consulting engineering industry has a significant role to play in the delivery of a sustainable future.

3.2 The Responsibility and Authority of Engineers to Deliver Sustainable Projects

In Canada, professional engineers are granted a license to operate in exchange for a commitment to the protection of members of the general public in regard to engineering works. Their code of ethics states "…professional engineers shall… hold paramount the safety, health and welfare of the public and the protection of the environment … (and)… be aware of and ensure that clients and employers are made aware of societal and environmental consequences of actions or projects and endeavor to interpret engineering issues to the public in an objective and truthful manner" (Engineers Canada[14]). Although this statement is generally worded, it is clear that the responsibility to understand the consequences of projects in respect of environmental and societal implications is part of the engineers' code of ethics.

[14] See www.engineerscanada.ca/sites/default/files/guideline_code_with_1.pdf

In practice 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 with 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.

3.3 Sustainability as a Performance Indicator

The performance of engineering tasks has been traditionally judged on the basis of suitability for intended purpose, minimization of cost, and delivery to a fixed schedule. This performance model has been extended over the past forty years to include considerations of environmental safety. As sustainable development moves into the mainstream of political and business thought, there are signs of a further fundamental shift in the way engineering performance is judged, bringing broad resource, ecological and social issues into the mainstream of engineering design.

The implications are significant. In the same way that the environmental revolution greatly broadened the spectrum of expertise required to deliver a project, sustainability demands additional project capabilities. Engineers are expert in the application of science to the technical design and planning of their projects with a focus on the initial operation of the facilities they design, but are not used to thinking about the downstream consequences to society of the work they do. Sustainability will require the industry to develop expertise in project consequences because, to a very large extent, the issues of sustainability revolve around long-term implications and consequences.

Balancing the choices to optimize a design for technical or financial performance is a relatively straightforward process with established methods and evaluation tools. Balancing those choices with societal and environmental requirements is much more difficult and the tools and methods that are required are still the subject of research and development with no broadly accepted metrics with which to measure performance.

3.3.1 Needs of the Client

Clients are increasingly interested in sustainability. They may be prompted by considerations of corporate reputation, of competitiveness, or of resilience in the face of wildly changing material and energy prices. They may be driven by their stakeholders – citizens (in the case of government), competitors, investors, or employees (in the case of business) – to improve their operations. It is commonplace to find endorsements of more sustainable operations on government websites at all levels in Canada, and many of the major private business clients have committed to volunteer annual reporting of the sustainability of their operations through the Global Reporting Initiative (5500 major corporations worldwide).

3.3.2 Needs of Society

In order for consulting engineers to respond to this client interest, it is necessary to have a straightforward and stable engineering definition of the issues to be considered under the heading of sustainability, and an idea of how they affect the design process. Efficient operation of an engineering company throughout a project also requires a degree of stability of design objectives. In the case of a project with sustainability implications, the required extensive stakeholder involvement can make stable design objectives difficult to achieve. In recent years, public participation has become a familiar aspect of environmental projects but the timing of that participation has often come as part of the environmental assessment process – at least part way through the project development stage, if not at its conclusion. Stakeholder involvement in projects with a sustainability implication needs to commence almost at the project initiation stage and continue throughout project development. Stakeholder issues need to be uncovered early in the project and a dialogue initiated about the feasibility of responding to these issues, and the nature of the possible responses. Throughout, there is a commitment to monitor indicators of all of the issues and to report those indicators to the stakeholders as well as to the client.

The need to broaden the team of diverse specialists required to deliver a sustainable project has been referred to earlier. Most authorities recognize[15] that the opportunities for improved sustainable performance come early in the project process as the early decisions often determine what remains possible at a later stage. Identifying opportunity is often a matter of thinking "outside the box", questioning automatic assumptions, and looking for performance levels on targets that at first glance seem impossible.

The process is straightforward. The issues of sustainable development are reviewed in respect of the project, to answer the question "How can we apply this issue to the current project?" The sustainability goals for each issue are then reviewed to answer the question "How can we achieve this goal on the current project?" Those that are relevant, economically achievable, and of interest become objectives of the project, and for each, indicators are chosen, targets are set, and the stakeholders have a defined role in receiving and reviewing indicator performance.

3.3.3 Needs of the Industry

The Canadian consulting industry has always been a major player internationally. In order to continue to be successful in this market, it needs ongoing credibility – credibility that is earned by delivering services in challenging projects. Since sustainable development is so dependent on innovation, it is important that Canadian companies are seen to innovate in their home markets. That means that they need to be challenged – to be asked to do things that seem at first glance to be impossible, and to have market conditions that are conducive to innovation. There will be no request to deliver something challenging in an overseas project unless the industry has been seen to deliver clever project solutions at home.

At the moment there are substantive efforts internationally to provide more sustainable solutions to common problems – and the effort is more significant outside Canada than inside. While some urban areas are putting effort into sustainability improvements, the same level of effort is not being seen across all urban areas or provinces or indeed in the federal government. Without the challenge of improving project sustainability, the future of the industry and its international presence is under threat.

[15] Presentation on the Integrated Design Process by Nils Larssen of iiSBE in Rome, May 8 2011.

3.4 Summary

There is a close connection between the achievement of a more sustainable way of living and the delivery of supportive consulting engineering services – to such an extent that the former cannot be realized without the latter. Not only is there an opportunity to be a major participant, there is also an ethical responsibility to understand and communicate to clients and members of the general public alike the consequences of the projects that are being delivered. The performance of the industry will increasingly be judged on how well these services are delivered.

Clients are interested in these services and members of society want to participate in setting project objectives so that maximum benefit is achieved. Finally, the credibility of the consulting engineering industry outside of Canada rests in part on the solid performance of innovative sustainable projects inside the country.

4.0 MEASURING AND DELIVERING SUSTAINABILITY

In order to deliver more sustainable projects, the consulting engineering industry requires a working definition of sustainability in the form of an agreed list of those aspects of sustainability that are affected by the engineering design process. Although sustainability engineering is an essential part of the delivery of a sustainable future for the planet, it does not cover all of the issues that would be considered on a typical project. Clients bring other issues to bear that go beyond engineering considerations or are outside the realm of engineering decision. As an example, a municipal government might be concerned about integration of the project into existing infrastructure such as a transportation system. A business client might be concerned with its international reputation or the resilience of a supply chain. Society also brings additional issues either in the form of regulatory considerations (perhaps in support of a provincial or national sustainability objective) or stakeholder

concerns about the integration of the project into the local community. Some of these additional issues fall within the range of engineering influence, and some do not.

These non-engineering issues also affect the project and the way in which it is executed. Although it is possible to imagine what these concerns might be, unless they are the subject of existing regulations, or public pronouncements of existing policies, or recurring issues brought forward by members of the public on current projects, it is difficult to compile a comprehensive list. This is particularly true in a country like Canada where the issues of concern vary so widely in different geographic regions. If it is so difficult to produce a comprehensive list of issues that affect clients, perhaps consulting engineers should begin by considering those issues that are specific to their own actions as designers and constructors.

4.1 Sustainability Issues Affecting Design and Construction

The International Federation of Consulting Engineers has demonstrated with their Project Sustainability Management Guidelines[16,17] that the UNCSD indicator list can be replaced, for engineering purposes, with six principal issues: usage of energy, water, and materials, and protection of the environment, health and safety, and human rights. Engineers in Canada routinely work with five of these six issues, since the human rights aspect is, for the most part (although not completely) handled by Canadian laws and customs.

Sustainability requires a new perspective for each of these issues. Consider energy as an example. Engineers are normally concerned with power requirements, reticulation on a project, and safety issues. Sustainability thinking requires a focus on reducing energy usage to the extent possible, replacing non-renewable sources with renewable ones, and examining the impact of project energy use on the availability and affordability of the resource to others.

The six sustainability issues and their perspectives are shown in table 4.1.

Table 4.1: Issues and perspectives of engineering sustainability

ISSUES	PERSPECTIVES
Water	Usage, availability, affordability
Energy	Usage, renewability, availability, affordability
Materials	Usage, recycling, durability, renewability, waste
Environment	Physical, chemical, biological, ecosystem
Health & Safety	Worker, community
Human Rights	Food, shelter, law, culture, development – *see table 4.2*

The human rights issue requires further clarification. Each of the aspects of the human rights issue has its own set of perspectives shown in table 4.2. It might appear that engineering projects do not directly affect human rights, or that their effect is covered by law and custom in Canada, but this is not the case. As an example, natural and built heritage protection is a major consideration of many projects both within Canada and in other countries. The impact of engineering projects on food availability is another example. The diversion of significant quantities of corn to ethanol production had an impact on food availability and costs. Forced relocation is an aspect of many megaprojects. Legal issues are also important and engineers can have an impact on criminality by putting in place controls over the construction bidding process to minimize corruption and fraud and by operating their own companies in an ethical manner. The benefits of development should overwhelm the negative impacts, an objective that is helped by detailed impact evaluation and efforts to free the project from irritants such as noise, odour, light pollution, etc.

[16] Project Sustainability Management Guidelines, FIDIC, 2004.

[17] Key Concepts for Project Sustainability Management (A draft FIDIC guideline), FIDIC, 2011.

Table 4.2: Perspectives on human rights

ISSUES	ASPECTS	PERSPECTIVES
Human Rights	Food	Availability, cost
	Shelter	Availability, cost, forced relocation
	Law	Equality, security, criminality, exploitation, freedom of association
	Culture	Natural and built heritage protection
	Development	Community benefits, convenience, freedom from irritants

PSM II is still a work in progress, but even in its current form it provides a useful checklist of the issues of sustainability that have a direct impact on engineering practice – and it is closely linked to the items that are normally considered in the design of projects. The PSM perspectives would impose a supplementary list of design considerations that are parallel to but different from those in normal engineering practice. Furthermore the checklist provides a good basis for discussions with clients, regulators, and stakeholders in order to bring forward their additional sustainability issues that should be included in the particular project under consideration.

4.2 Sustainability Goals

Although efforts to implement sustainable solutions have increased substantially in recent years, most experts agree that the overall rate of improvement is not adequate. Engineers recognize the importance of incremental improvement, but major efforts should be made to stimulate the kind of breakthrough thinking that would deliver major advances in the important issues. On a day-to-day basis, engineering actions are key to project performance that will deliver a more sustainable world. Conversely, if a conventional project product is delivered, negative effects will be felt for a long time because projects and their consequences last for a long time.

The FIDIC system defines zero impact as true sustainability and sets its goals to recognize several different possibilities ranging from improved performance beyond established regulatory levels, through metastable sustainability (sustainable under present circumstances but likely to become unsustainable if further development occurs in the region), to restorative performance (which solves a preexisting sustainability problem beyond the boundaries of the current project).

A useful project approach might provide for a range of targets of increasing aggressiveness. A project's contribution to sustainability would then be measured by the aggressiveness of its goals, and by demonstrating that it has achieved them.

4.3 Sustainable Project Processes

The practice of sustainable engineering is beginning to provide consulting engineers with indications of methods and processes that when used on projects lead to better outcomes. Early and comprehensive engagement of stakeholder groups, including feedback of performance indicators, has already been mentioned. So has the early engagement and use of a diversity of experts in planning the sustainability aspects of the project.

Experience has shown that it is important to incorporate a broad range of perspectives on the design team. Sustainability crosscuts a wide range of issues and the achievement of a sustainable design rests on wide ranging expertise – often from skill sets beyond those of traditional engineering. Depending on the project and the knowledge of the individuals involved, a broader design team should do a better job of delivering a sustainable project, but the use of such a team does not in itself determine whether a project will turn out to be sustainable.

Three other factors should be considered in planning sustainable projects. Project implementation has many stages including concept, design, construction and commissioning, operation, redevelopment, and closeout, and each stage has its own sustainability opportunities and implications that affect the overall performance of the project. Furthermore, in addition to the client (owner) and the regulators, the consultant also works closely with contractors and there are other opportunities for a more sustainable final product with the contractors' active involvement in the sustainability efforts. Finally, the engineer is traditionally involved in the early stages of project development, but

most of the opportunities for sustainable outcomes relate to the continuing operations of the facility, after it has been constructed and commissioned. Processes to ensure that the measurement and reporting of indicators continues during operation and that the plans for sustainable decommissioning are carried out to achieve overall project objectives are also important.

Finally, the negative implications of years of unsustainable behavior are beginning to be felt as climate change alters the environmental circumstances on which engineering design is based. Changes in rainfall quantity and storm intensity, flooding, sea levels, temperature averages and extremes, permafrost thawing – all have an effect on infrastructure design. Not only do engineers have to incorporate reduced greenhouse gas emissions in their designs (thereby contributing to climate change mitigation), but they also have to allow for changes in environmental circumstances that have taken place and will take place in future, causing impacts to the designs themselves (adaptation). Traditionally, engineers use compiled climate records as the basis of establishing the environmental conditions within which their designs are executed, but reduced certainty of the predictive usefulness of such records demands new approaches.

The importance of new tools such as PIEVC7 to provide a consistent risk methodology to deal with this uncertainty has been referred to earlier in the report, and its use or the use of other similar tools should be considered mandatory until such time as new standards can be drafted.

4.4 Summary

The measurement and delivery of sustainable projects relies on a broadly accepted list of the issues of sustainability that affect engineering projects. The FIDIC Project Sustainability Management Guidelines, particularly in their second version – PSM II – provide a useful framework for such a list, especially since the themes are linked to standard engineering issues that are routinely considered in engineering projects in Canada. The differences brought by sustainability considerations amount to a different "sustainability" perspective on these issues.

In addition to a compiled list of issues, goals should be developed that not only encourage incremental improvement, but also support breakthroughs – necessary if sustainability is to be achieved soon enough to avoid the worst of its consequences.

Finally, it should be recognized that in addition to agreed issues and aggressive goals, recent experience has shown that there are a number of project processes that are helpful in achieving a more sustainable project outcome.

5.0 EVALUATION OF TYPICAL ASSESSMENT SYSTEMS

5.1 Systems to be Considered

In recent years there have been many tools developed to assist engineers in the delivery of more sustainable designs. Some are guidelines (such as PSM, above), some are decision support tools, some are calculators, and some are engineering sustainability assessment rating systems. The latter have normally appeared in the market with the intent of satisfying a need in the country that introduced them. This report considers four such systems – Envision™ from the United States, CEEQUAL© International from the UK, AGIC IS from Australia, and CBDD from France. Envision™, AGIC IS (now called ISCA) and CBDD are relatively new. CEEQUAL© International is a more generic outgrowth of the CEEQUAL© system that is specific to UK practice and has been around since 2003. CBDD is not, properly speaking, an assessment system at all since it does not provide a score for the project for comparison with other systems, but is rather a logbook of sustainability intentions coupled with recorded sustainability experience that focuses on the owners' perspective of the project.

Many of the sustainability assessment systems are proprietary, either because they are specific to a company or client group, or because they were created by a group of practitioners involved in a particular type of work. These systems provide recognition of contributions to sustainability and a mark of distinction that can be broadly recognized and affects the valuation of the constructed project. The LEED© system for sustainable designation of buildings is one such example that has contributed to the sustainability of projects constructed under its auspices, and has been successfully applied in a way that positively impacts the value of the buildings so designated. CEEQUAL©, and indeed any of the other systems that have been available over time, have made similar contributions in their area of application.

5.2 Issues Affecting All Systems

5.2.1 The Professional Dimension

In the early stages of the development of such tools, there is a legitimate concern for the consistency and quality of the assessments under which the performance awards are provided. Typically the originating group that designed the system administers and updates it, and controls both the education and designation of professionals who are deemed competent to use it. In addition, the originating group decides which project will qualify for one of its awards having done an evaluation of the merits of the project by the rules of the system. This level of comprehensive control goes one step too far.

Part of being a professional engineer in Canada relies on the self-imposed constraint of practicing only in fields in which you are expert – and being subject to disciplinary review by the professional association if you err. Expertise in sustainability should be handled the same way. Considerable effort has been taken by all of the systems groups evaluated here to produce excellent documentation describing exactly what is required to design to the group's criteria. The designation of experts who are qualified to design to the system's objectives or need to be represented on the design team (CEEQUAL© Assessors) should be unnecessary[18]. Hopefully, this aspect of assessment systems will gradually disappear as the systems come into regular use.

5.2.2 Weighting and Aggregation

Most of the assessment systems considered here produce a single aggregate score from the collective assessments of each aspect of sustainability that the system considers. CEEQUAL© produces a score from the answers to a series of questions; Envision™ produces a score by comparison with lists of performance descriptors. Both require documentation that is submitted to support the evaluation. Scores from each of these tests within a particular category are then added, scaled[19] for relative importance and summed to produce a project score that is then compared with a standard to denote overall performance.

The benefit of this approach is simplicity, consistency and clarity. The comparators are well described and the questions are well considered so that it is possible for trained evaluators to review the same project and arrive at the same score. Even untrained project participants can make a reasonable estimate of the conclusion of the process and adjust the project activities to improve its performance. The degree of success in meeting the objectives of the system is clear and expressed by a single number within the range of possible outcomes.

There are however three limitations inherent in this approach – the usefulness of the aggregate score in the context of project's contribution to sustainability, the weighting of components that is part of the integration process, and the aggregation process itself.

What does it mean if two or more projects achieve the same final score? By implication they have contributed a similar amount to sustainable development yet the scores may be the same for very different reasons. One project might have been particularly effective in dealing with environmental issues and the other may have been much more efficient in the use of materials or energy. Are these equivalent contributions? In some respects a comparison of the individual components of the aggregate would be much more revealing of project performance, and grouping of like projects before this comparison is made would be even more revealing. The aggregate score is really a measure of how well the project conformed to the demands of the particular system in use.

[18] Roger Venables (personal communication) from CEEQUAL© pointed out the considerable efforts that have been made to increase awareness of their project write-ups as examples and to work with the universities to use the system in education to get students thinking about improving design.

[19] Scaling in CEEQUAL© is explicit – rigorously chosen factors are used to normalize the contribution of each aspect considered. In Envision they are implicit – and governed by the number of items and number of points awarded in each category.

Limitations of the scoring system are well understood by the proponents of the systems outlined here and are reflected in the performance descriptors incorporated in each system. CEEQUAL© for example, recognizes that a performance outcome of about 5% amounts to minimum legal compliance and a very high score (say >90%) represents the pinnacle of best practice with 80% indicating that the project is three quarters of the way between bare compliance and best practice[20].

Improvements in sustainable performance are location and circumstance dependent. An urban area in a region of low rainfall might be expected to place a premium on minimizing the use of water. If this region was also one of high sunlight, renewable power from photovoltaic sources might permit much better than average performance in the energy use category. If projects in this area were compared with similar projects located on the rainy slope of a mountainous region where cloud cover limits photovoltaic generation of renewable energy, the same aggregate score might not provide much information about the relative contribution of each project to sustainability considering the difficulties that had to be overcome.

The weighting process, although carefully considered, also tends to distort the outcome and limit system usability. An examination of municipal or provincial sustainable development goals across this country (see Sustainable Cities above) shows quite different objectives and a considerable range of emphasis within the objectives that are held in common. To be most useful, weighting systems should be adjustable to the needs of the user community[21] – which of course would limit their application as a coast-to-coast project comparator. This problem is not unique to infrastructure systems but is also embodied in the IISBE SBTOOL protocol[22] for buildings. SBTOOL avoids the problem with a two part system which uses a pair of linked Excel spreadsheets – the first in which relative weights, benchmarks and standards are set and certain criteria are either included or not, and the second which is specific to the project.

There is also a third issue with aggregate scoring. What does it mean to add indicators that cannot be measured in the same units[23]? By implication they are of equal importance, but that judgment is location and circumstance dependent. Weighting systems are intended to balance this consideration and are fundamental to the perspective that each system brings to the projects.

If there were an agreed way to measure sustainable performance then the contribution of each issue to that measurement would permit their aggregation but at this point in time such a system does not exist. Eventually there may be agreement on what sustainability looks like and how it might be measured leading to such an approach but the necessary tools are not yet available. Of the three assessment systems, the Envision™ guideline presents the concept[24] in the clearest terms. It suggests that getting and maintaining a high quality of life is the objective of sustainability and shows that achievement by means of the Human Development Index[25], an indicator developed by the United Nations. It goes on to use the Ecological Footprint[26] as an indicator of the efficiency with which the infrastructure of a particular country operates to deliver that quality of life then sets the objective of delivering a high quality of life with a low ecological footprint. Unfortunately, at this point neither the Human Development Index nor the Ecological Footprint have been broadly accepted as indices for use in this manner.

5.2.3 A Sense of Balance

The intent of the rest of this chapter is to outline the issues that the developers of the four systems believe to be important and to illustrate their approach to the measurement of sustainability. At this stage in the evolution of thinking on the subject there are no right or wrong approaches. All of

[20] Roger Venables (personal communication): "What we think is important at this stage of sustainability-driven design and construction, and of sustainability assessment tools, is (that) the project teams aspire to excellent performance relevant to the nature, scale, location and context of the project."

[21] This argument flies in the face of the purpose of assessment systems and is strongly disputed by the proponents of such systems who see consistency as a strength rather than a weakness.

[22] Lecture by Nils Larsson "SB Method and SB Tool for 2012" University of Toronto, January 31 2012.

[23] Indicators for Sustainable Development: Theory, Method, Applications - A Report to the Belaton Group, H. Bossel, 1999, IISD.

[24] Envision Version 2.0, A Rating System for Sustainable Infrastructure, 2012, Institute for Sustainable Infrastructure, Zofnass Program for Sustainable Infrastructure.

[25] See www.hdr.undp.org/en/statistics/hdi

[26] See www.footprintnetwork.org

the systems that are reviewed represent thousands of person-hours of effort by highly committed individuals whose primary goal was to deliver a better world. Regardless of their use as a tool to measure project sustainability, all of the systems reported here can be used effectively to further understanding of the current 'the state of the art'.

5.2.4 The Critical Questions

In the end there are eight questions that have to be satisfied before any given project commits to the use of a particular system.

1. Does it cover all of the issues of engineering sustainability?
2. Does it use state of the art processes that support sustainable outcomes?
3. Does it set significant goals for each issue?
4. Is performance measured against these goals?
5. Is the weighting system adjustable to allow for different regional/local targets within a particular set of goals?
6. How does the system guarantee consistency and evaluation accuracy and does this diverge from normal professional practice?
7. Can the system gracefully migrate to a new version?
8. Is there a set, test, measure, reset development process?

5.3 Evaluation of the Envision™ System

The Envision™ system is intended to provide assessment of infrastructure projects not simply for sustainable design but to provide a holistic framework for evaluating and rating infrastructure projects against the needs and values of the community. In this it has set a precedent that is shared to a more limited extent by CEEQUAL© version 5. The current Envision™ system (version 2) addresses design and planning with construction, operations, and decommissioning phases to follow. The system was produced by collaboration between the Institute for Sustainable Infrastructure (ISI) and the Zofnass Program for Sustainable Infrastructure at Harvard University. ISI is a not for profit education and research organization founded by the American Public Works Association, the American Council of Engineering Companies and the American Society of Civil Engineers.

The system organizes objectives in categories, subcategories and credits and by meeting the credits the project earns points towards an overall rating. There are five levels of performance ranging from "improved" performance (slightly above regulated level) through "enhanced", "superior", "conserving" and "restorative". "Conserving" behavior is considered to achieve zero negative impact or neutral impact – sustainability in the context of the PSM II guidelines.

Envision™ does not deal with buildings or facilities because these are considered to be covered by existing rating systems. Interestingly, the authors of the system indicate that it was designed to cover the US *and Canada* notwithstanding the fact that no Canadians or Canadian organizations were apparently involved in its preparation[27]!

In addressing project 'fit' within community needs and values, the system distinguishes between a performance contribution, in which the project is optimized for sustainable performance, and a pathway contribution that considers how well the project aligns with the community, with sustainable development, and with other related forms of infrastructure.

Other issues that are recognized and addressed include the traps and vulnerabilities that would tie the community into high costs or resource reliance that might become expensive in future. The issue includes extreme weather events, natural disasters, changing economic conditions, and background environmental conditions at the project site that are changing as a result of climate shifts.

The Envision™ system organizes credits into five categories and fourteen subcategories as per the following table. The sixty credits in the system are rated according to the five levels described above – from enhanced to restorative. Innovation (exceeding credit requirements) is added as a separate credit in each category.

[27] APWA has as a constituent the Canadian Public Works Association, but there is no indication in the documentation that representatives of the Canadian arm of this association participated in the development of the system. In a way this makes the case for very cautious use of any system that goes beyond engineering practice to include client sustainability objectives.

Table 5.1 Categories and Subcategories of the Envision™ System

CATEGORY	SUBCATEGORY	NUMBER OF CREDIT ISSUES
Quality of Life	Purpose	3
	Community	6
	Well being	3
	Innovation	1
Leadership	Collaboration	4
	Management	2
	Planning	3
	Innovation	1
Resource Allocation	Materials	7
	Energy	3
	Water	3
	Innovation	1
Natural World	Siting	7
	Land and Water	3
	Biodiversity	4
	Innovation	1
Climate	Emission	2
	Resilience	5
	Innovation	1

For each of the credit issues there is a thorough description that provides the intent of the credit, a description of the different levels of achievement, an indication of the evaluation criteria and documentation requirements, a short description of the criteria for measurement, an indication of the source of the concept and a listing of related credits. The documentation is extremely thorough, is easily understood, and shows the very considerable amount of effort that went into its development. It should be noted that the marking system is progressive – it gives very much higher point scores for performance close to sustainability and thereby encourages the adoption of aggressive project targets.

5.3.1 Issue Focus

There are sixty issues that are examined by the Envision™ system, and they are an interesting mix of engineering design targets, policy issues (that would in Canada normally be dealt with by municipal authorities), design organization and methodology (the design process), and normal good engineering practice. The issues are silent on health and safety affecting workers in the facility that is being constructed, and on water use and energy use impacts on the affordability of those services to others in the community. They are also silent on many of the human rights issues such as food, shelter, and law which presumably are dealt with by normal American laws and customs.

Thirty-four of the issues are directly related to design engineering and stem naturally from the issues identified in PSM II. A further seven are not specifically associated with the issues of PSM II, but reflect good engineering practice in today's environment. These include the commissioning of energy and water systems, planning for monitoring and maintenance of the infrastructure (especially infrastructure designed with unconventional sustainability implications), assessing climate change threats, preparing for short-term hazards and adaptability, and avoiding traps and vulnerabilities. While all of these items might have an impact on the project, they do not necessarily all govern its success or failure in the context of sustainable development but in many cases simply reflect good practice in carrying out the assignment.

A further eight issues are items that fall directly into the municipality's interest and responsibility. These include improving the community's quality of life, improving community mobility and access, encouraging alternative modes of transportation, enhancing public areas, improving infrastructure integration, and addressing conflicting regulations and policies. They also include minimizing noise, vibration, and light pollution that would normally be covered by municipal bylaw, but in this case clearly indicate the desire for more substantive performance in these areas. This is a significant departure from normal practice in this country where such issues might form part of the terms of reference for the assignment, rather than something that the engineering firm would do automatically in the context of delivering a more sustainable project. A knowledgeable consulting firm might identify these issues from the sustainability objectives of the client municipal organization

and include some aspects of them in its competitive proposal. The issues that are presented could well be relevant depending on the circumstances of the project, but there are many such issues that are not on the list, and it is not clear why these were particularly singled out.

There are a further six issues that relate to the design process itself including stakeholder involvement, collaboration and teamwork, effective leadership and commitment, the implementation of a sustainability management system, support for sustainable procurement processes and steps to reduce net embodied energy in the materials used on the project. The latter two are important for downstream sustainability considerations and certainly stakeholder involvement is of major importance in achieving a sustainable outcome.

5.3.2 The Critical Questions

In addressing the critical eight questions (see section 5.2.4 above), the Envision™ system rates quite highly. It covers most of the issues of sustainable engineering, but not all. It misses the effects of water and energy use on the affordability of those resources, and fails to mention forced relocation and the need for protection against corruption in bidding processes. It mixes state of the art processes that have been successfully used in sustainable projects with issues that directly contribute towards the sustainability of the project design. Its goal structure and the associated scoring and marking system are aggressive and a leader amongst similar systems promoted by others. The system is only adjustable by removing aspects that are not considered to be part of a specific project. It incorporates many of the issues that concern municipal clients but misses some others. The originators of Envision™ are involved in training of users and recognition of project performance. Time will tell how effectively and gracefully it moves to new versions.

5.4 Evaluation of the CEEQUAL©[28] System

5.4.1 Issue Focus

Although the approach used in evaluation is somewhat different and the categories are different, there is a great deal of similarity between Envision™ and CEEQUAL©. Both deal extensively with the process and management of sustainability projects, both recognize a gradation of achievement on the various issues (from studying the possibilities to implementing them), and both encourage follow-up to ensure that the design concepts have been implemented. The implied objectives of CEEQUAL© are not as aggressive as Envision™ nor is the point count so heavily weighted in favour of radical change. In the case of CEEQUAL©, there is a distinct distribution of points and focus of certain questions depending on whether the organization being evaluated is the client, the designer, or the contractor.

The origins of CEEQUAL© are very apparent in the focus on issues that are of particular interest in the UK and the EU. While this is not to say that these issues are unimportant in other areas, nevertheless the effort and points awarded do not necessarily fit in another part of the world (Canada). Other issues that are relevant for sustainability are not handled explicitly by the system but are (probably) assumed on the basis of law and custom. In particular, some of the human rights issues are not dealt with, nor is there a comprehensive assessment of environmental issues.

The international version, which was not seen prior to this evaluation, deals with this issue in a number of ways. It requires "Assessors or project teams to undertake a weightings exercise in the locality of the project, or use a regional wide exercise, unless they believe that the UK weightings are sufficiently representative… Secondly, we recognize that the question set is generic… and that country or region-specific guidance will need to be developed… Thirdly, we are open to the idea that… it will be appropriate as use develops… to create a separate version for… country X."[29]

[28] CEEQUAL Scheme Description for Projects (Version 5), Revision 0, May 2012 © CEEQUAL Ltd. The author was kindly allowed access to a draft version of this document for the purposes of review.

[29] Roger Venables (personal communication)

CEEQUAL© provides a useful model for a truly international system because of its extensive base of experience and the thought processes that have gone into it, but there would be a very considerable amount of work required to broaden the emphasis and restructure the weighting to suit specific regions.

The following illustrates the issues that have been included in each section of interest.

5.4.1.1 Project Strategy

This section of the evaluation assesses the links between the project and the wider issues of sustainability. It looks at two aspects, the overall strategy for the project and its design, and the strategy for the construction phase of the project. The questions address the leading activities necessary to embed sustainability considerations into the project design and construction, such as environmental economic and social impact assessments, adaptation to climate change, and considerations of a project resource strategy. The construction stage considerations are intended to ensure that design stage sustainability concepts make their way to the construction stage including attempts to minimize social and environmental impacts on the community.

5.4.1.2 Project Management

This section is intended to demonstrate how environmental and sustainability issues are embedded in the management of the project. It covers assessment, responsibility, identification and prioritization of impacts, achieving the economic delivery of social and environmental benefits to the community, contractual and procurement processes, and management systems to measure the delivery of project intentions. This section ensures that management processes are in place to deliver environmental and social intentions.

Up to this point in the system, none of the questions apart from adaptation to climate change have dealt with the actual delivery of a more sustainable project, and all relate to the processes and activities necessary to prepare for the delivery of a more sustainable project. This focus on doing the project in a manner that improves the likelihood of a sustainable outcome is held in common with the other systems reviewed.

5.4.1.3 People and Communities

This section brings together two of the social aspects of civil projects, namely effects on the community and stakeholder engagement. Its seven sub-sections are organized into three broad considerations – design, plan and consult, implement and monitor. Its overall focus is on considerate behavior that goes beyond the limitations imposed by regulatory permits to manage and mitigate impacts and annoyances to the community. It looks for opportunities to enhance community benefits and to use the responses from consultation in the project. The community and stakeholder engagement process includes the explicit consideration of community diversity not only to improve communication but to improve access. Health and safety considerations are included.

Once again the emphasis is on process although stakeholder engagement is a key factor in the delivery of sustainable outcomes.

5.4.1.4 Use of Land (above and below water) and Landscape

This section addresses competition for land use in the crowded UK environment whether offshore or onshore. The appropriateness of the location and the design concept are reviewed but other aspects including water resource management, ecology and the like are treated elsewhere in the system. There is a detailed sub-section dealing with preexisting contamination and its cleanup and another dealing with floods and flood resilience. Preservation and maintenance of landscape character including vegetation and implementation of landscape design proposals are also considered.

5.4.1.5 The Historic Environment

The EU perspective on the historical environment is that "the constituent parts are a non-renewable resource that not only provides an essential educational and academic resource for humankind's development but also an historic context and framework for new development." This section deals primarily with the methodology, processes, and reporting required to deliver this perspective.

5.4.1.6 Ecology and Biodiversity

This section deals with the concern that development necessarily destroys wildlife habitat and damages the species that occupy it. It begins with the identification of problem areas and the development of plans. It then encourages steps to conserve and monitor ecological features and develop new habitats or facilities that help wildlife. Finally it recognizes steps for monitoring and ongoing ecological management.

5.4.1.7 The Water Environment

Protection of the marine and freshwater environment is the focus of this section. It begins with the existence of a plan to control impacts and the inclusion of the necessary elements of that plan in the design and during construction. It also includes legal requirements for consultation and regulation in the UK. It considers development impacts on water resources and protection and enhancement of the fresh and marine water environments. Impacts on flood risk are partly looked after in the land use section, but drainage and runoff management are included in the water environment section.

5.4.1.8 Physical Resources – Use and Management

This section brings together considerations of material resources and water use in construction along with waste generation, energy and carbon emissions. The use of life cycle assessment in the development of the project as a tool to reduce embodied impacts is encouraged. The use of new materials on the project should be minimized and the use of materials already available on site should be maximized. Other objectives include durability and low maintenance, soil management, design for future disassembly and reuse, and the maintenance of a materials register. The issue of designing for reduced energy consumption and carbon emissions during operation includes the targeted use of renewable energy. The same issue is also applied to the construction process. Reduction in water use is also a target of the system with two parts – water use during construction and operation and reduction in the embodied water (total water used in producing the product) content of products and materials used in the project. Responsible sourcing, reuse and recycling of materials are also included. Hazardous material use should be minimized for health and safety and long-term environmental considerations. Waste management planning and handling including material generated by the construction are also dealt within this section.

5.4.1.9 Transport

The objective of this final section is to strike the best possible balance between the benefits and adverse impacts of transportation related to the project. This includes the movement of the construction workforce and materials and waste and has as its objective minimized disruption to others during construction. The section covers the requirement for engagement with the community and an effort to design out the negative impacts.

The application of this section depends in part on whether the project applies directly to the construction or reorganization of elements of the transportation network, projects that will become destinations of the transportation system, and projects that will involve a limited amount of operational traffic.

5.4.2 The Critical Questions

The critical questions (see section 5.2.4) provide a very positive picture of CEEQUAL©, which covers most of the issues of engineering sustainability identified by PSM. Those that are missing are presumed dealt with by local law and custom. Indeed it goes beyond the PSM issues list to look at specific aspects such as preexisting contamination and to encourage specific types of outcomes from some of the considerations such as the avoidance of hazardous material use.

The system is very process-oriented and shows its thorough evaluation of case histories to identify approaches that work. It could in fact be used as a training resource for those involved with managing sustainable projects. As with Envision™ there is no distinction between points earned for project design elements that actually contribute to sustainable operations and those awarded because the process used by the project team and management was conducive to the achievement of a sustainable outcome.

The goals for sustainable achievements set by CEEQUAL© are somewhat less aggressive than those set by Envision™ but there is a record of frequent updates that strongly supports the assumption that as society's understanding of the issues improves, the goals will similarly evolve. The issues list can be adjusted by removing items that are not relevant thereby providing some elasticity, and the process of providing a version specific to a given country would allow for both a shift in emphasis and a changing of reference materials.

CEEQUAL© still controls the training process and recognition of Assessors and Verifiers so the issues raised in regard to the Professional Dimension (section 5.2.1) still apply. Steps are being taken to evolve the system further in this respect.

5.5 Evaluation of the AGIC IS System

The Australian Green Infrastructure Council (AGIC) developed an Infrastructure Sustainability (IS) rating tool that was released[30] over the course of 2012. The originating organization subsequently changed its name to the Infrastructure Sustainability Council of Australia (ISCA) at the end of 2012 but the original context as issued (essentially unchanged but now completed) is used in this description. The tool was intended to evaluate sustainability across three phases of a project's lifetime – design, construction, and operation – and covered most types of infrastructure in Australia from modest projects to very large ones that might be subdivided into smaller ones with multiple ratings. It consisted of a rating tool based on Excel spreadsheets with a technical manual. The system was intended for self-assessment (with limitations – see below) with independent verification and certification by AGIC which would also provide training programs in its use. The intended users were all industry stakeholders – designers, contractors, legislators, and owners, etc.

The approach that has been adopted to phased development is a phased award system. At the end of planning and design an interim award may be granted recognizing the inclusion of design elements and construction requirements for sustainability in the project documentation. At the end of construction, the design elements and construction requirements from the design stage are combined with measured sustainability performance during construction and built into the asset. An award that supersedes the design rating may be granted. After 24 months of operation a further award with a five year validation may be granted based on measured sustainability performance of the infrastructure asset. Infrastructure may apply for the operation rating without submitting for the design and construction awards.

The process involves self-assessment but there is an involvement with AGIC (ISCA) in the initial phases following registration in the form of a workshop "to clarify scope, timing and reference design". Self-assessment using the IS tool follows with technical support from AGIC. At major milestones, projects are submitted for independent verification by industry specialists arranged by AGIC with feedback to allow improvements to be made prior to final submission, verification, and certification. An appeals process will be available.

The rating tool aggregates performance achievements to a 100 point scale and categorizes the rating levels as follows:

- Projects with less than 25 points are ineligible for rating
- 25-50 points is rated as "Good"
- 50-75 points is rated as "Excellent"
- 75-100 points is rating as "Leading"

5.5.1 Issue Focus

The IS system considers six themes: management and governance, use of resources, emissions pollution and waste, ecology, people and place, and innovation. These are further subdivided into a set of fifteen categories and are in turn addressed with a set of fifty-one issues, with an additional credit for innovation that allows for a total score of 105. For each issue, there is a graded series of achievements that are carefully described and provide both an indication of expectations for the issue and also a graded set of levels. In the event that an issue is not relevant to the project at hand, the issue can be removed from the assessment.

Because the manual was not reviewed (it was not available at the time of writing this report), the following analysis is based on interpretation of the fact sheets and a little "reverse engineering" of the spreadsheet tool.

The management and governance theme covers two process-related categories, one dealing with management systems and one assessing the extent to which sustainability has been considered in project procurement. In addition this category addresses considerations of climate change risk and adaptation.

[30] See www.agic.net.au, then www.isca.org.au

Table 5.2 Project management systems

THEME	CATEGORY	CONSIDERATION
Management and Governance	Management systems	Sustainability leadership and commitment
		Management system accreditation
		Risk and opportunity management
		Organizational structure
		Roles and responsibilities
		Inspection and auditing
		Reporting and review
		Knowledge sharing
		Decision making
	Procurement and purchasing	Commitment to sustainable procurement
		Identification of suppliers
		Supplier evaluation and contract award
		Managing supplier performance
	Climate change and adaptation	Climate change risk assessment
		Adaptation measures

The theme "use of resources" covers energy and carbon, water, and materials and is directly tied to normal consulting engineering design activities. High performance on these issues would result in significant improvement in the sustainability of the asset. A few of the lower achievement categories are for studies rather than actual implementation of more sustainable solutions.

Table 5.3 Project Use of Resources

THEME	CATEGORY	CONSIDERATION
Use of Resources	Energy and Carbon	Energy and carbon monitoring and reduction
		Energy and carbon reduction opportunities
		Renewable energy
	Water	Water use monitoring and reduction
		Water saving opportunities
		Replace potable water
	Materials	Materials lifecycle impact measurement and reduction
		Environmentally labeled products and supply chains

The theme "emissions pollution and waste" is similarly direct in its applicability to sustainable projects. The category "discharges to air, land and water" includes a number of community environmental issues such as noise, light pollution, and vibration, as well as the more conventional issues of water and air pollution. The land category rewards land reuse, conservation and restoration of previously contaminated sites, conservation of site resources and designs to reduce the possibility of flooding. The waste category encourages waste reduction, diversion of waste from landfills, and planning of waste minimization for the eventual closeout and deconstruction of the facility.

Table 5.4 Emissions, Pollution, and Waste

THEME	CATEGORY	CONSIDERATION
Emissions, Pollution, and Waste	Discharges to air, land and water	Receiving water quality
		Noise
		Vibration
		Air quality
		Light pollution
	Land	Previous land use
		Conservation of onsite resources
		Contamination and remediation
		Flooding design
	Waste	Waste management
		Diversion from landfills
		Deconstruction/ disassembly/ adaptability

The ecology theme emphasizes various aspects of site development intended to protect or enhance the ecology and biodiversity of a site and its surroundings.

Table 5.5 Ecology

THEME	CATEGORY	CONSIDERATION
Ecology	Ecology	Ecologically sensitive sites
		Ecological value
		Biodiversity
		Habitat connectivity

The people and place theme has four components: community health, well-being and safety, heritage, stakeholder participation, and urban and landscape design. The first is aimed at delivery of enhanced outcomes from the integration of the infrastructure into the community. The second ensures that heritage is preserved, promoted and enhanced by the project. The third is aimed at capturing local knowledge to improve project outcomes and ensuring that the stakeholders remain engaged in the project throughout its lifetime. Finally, urban design focuses on the value of analyzing planning and designing the project in the context of its community and environment.

Table 5.6 People and Place

THEME	CATEGORY	CONSIDERATION
People and Place	Community health, well-being, and safety	Community health and well-being
		Crime prevention
		Community and user safety
	Heritage	Heritage assessment and management
		Monitoring of heritage
	Stakeholder participation	Stakeholder engagement strategy
		Level of engagement
		Effective communication
		Addressing community concerns
	Urban and landscape design	Site and context analysis
		Site planning
		Urban design
		Urban design framework and capability implementation and management

The final theme is innovation and is intended to reward innovative strategies and technologies that are "a 'first' in that state or the nation, contribute to broader market transformation towards sustainable development, or address a sustainability issue outside of the current scope of the IS rating tool."

5.5.2 Weighting and Assessment

Each issue addressed in the system has an associated score depending on the performance level that corresponds to the descriptions in the spreadsheet. The available scores differ from item to item and the total number of issues related to each category also differs from item to item. The total number of points available is also dependent on the list of issues that are considered to be relevant to the project. As a result the maximum issue scores vary from 0.39 to 6.26, the categories from 5 to 10.5 and the themes from 5 to 24.49. While these ratings were probably derived for reasons that make sense in the Australian context, their transfer to a Canadian context would require some significant changes.

5.5.3 Use of the Tool in Canada – The Critical Questions

The Australian system has a very elegant and simple human interface in the form of an Excel spreadsheet and the descriptions of achievement levels are quite clear and straightforward. There is a limited reference to Australian practices and standard methods that would no doubt have Canadian substitutes or could be developed as required. The phased use of the system for design, construction, and operating stages along with sequential awards (and a requirement to renew the operating recognition on a five year basis) has considerable appeal. The target levels set for each issue are moderately challenging but in all likelihood fall short of those required for complete sustainability. Presumably over time, the targets, and even the issues list, would be adjusted to reflect experience with the system and the evolution of the sustainability concept.

The issues list includes processes as well as items that really reflect the sustainability of the finished project, as the documentation provided in the fact sheet acknowledges. Since the system is intended for the use of developers, contractors and owners as well as engineers, some of the issues relate to operations and would not fall within the control of the consulting engineer. As with the other systems examined so far, most of the human rights issues that are mentioned by the United Nations are missing from the IS system, because most of them are handled by local law, regulation and custom. It was appropriate to see crime reduction identified as an objective although the description of activities in support of the issue failed to mention corruption in the bidding/ contract award process.

The environmental considerations were handled somewhat lightly with emphasis being given primarily to ecological issues and waste handling and only in passing to chemical pollution and physical destruction of the environment.

As noted, the weighting system effectively allocates relative importance to the various issues and some of these allocations are difficult to understand and would probably not translate well to Canadian values. Air quality, noise and vibration are given identical scores – less than half the value of stakeholder participation that is scored the same as urban and landscape design. Water is clearly a major issue for Australians – understandable given their experiences with a protracted drought. A fixed weighting system would probably not adequately reflect the wide variation in emphasis on sustainability issues in Canada.

5.6 Evaluation of the CBDD System[31]

The Carnet de Bord Développement Durable is a system for collecting the objectives and challenges of sustainability specific to a particular built asset that would accompany the project through all of the stages of its lifetime – essentially a project sustainability logbook. The current system Version 2010 was published by the AITF (Association des Ingénieurs Territoriaux de France), SYNTEC-Ingénierie and the CSTB (Centre Scientifique et Technique du Bâtiment) in 2010.

Its particular advantage over the rest of the systems reviewed here is its automatic handling of the multistage nature of infrastructure projects from concept to decommissioning. Other systems deal with this issue by reference to separate protocols for each development stage – most of which have not been completely developed as yet.

PSL is intended as a tool primarily for owners but is included in this review because of the possibility of integrating the design process with the owners' logbook, i.e., by paying attention during design to the same set of issues that will be noted in the log.

[31] The review that follows was based on a draft translation of the document into English by Peter Boswell as the Project Sustainability Logbook (PSL) in November 2011.

PSL goes beyond the three traditional goals of built assets – namely optimization of time, cost and performance – to include initiatives that address economic, social, environmental, best practice, and governance dimensions. It is intended to facilitate discussions between clients, project owners, engineers, designers, contractors and operators, and to track the inevitable changes that occur within a project from concept to end of life. Because it is developed under the authority of the owner, there is a set of economic issues that encourage accumulation of the entire cost of an asset and a set that considers the economic justification for the project in the short term, its capacity to evolve, the quality of the user experience with the facility and the overall investment efficiency. This focus is different than the rest of the systems under consideration here.

PSL comprises three sections:

- A scalable description of the works and their sustainable development challenges,
- A monitoring spreadsheet from the perspective of sustainable development comprising fourteen or more parameters or indicators and the manner in which each is evaluated, and
- A schedule of documents comprising a list of benchmarks and the procedures that are used, records detailing changes and statements of earlier measures and, indeed, any document that is useful for maintaining the logbook.

The first part defines the main objectives and issues for sustainability and keeps track of changes that take place in the operation of the asset, including renovation, new technology, regulations, strategies etc. The second part monitors progress according to the selected themes and specific features of the works using parameters drawn from ISO 14001 (environmental management) and ISO 26000 (guide to social responsibility). As updates occur in a project the earlier versions of the logbook are kept as part of the project archives. The documents are expected to remain attached to the asset regardless of changes in ownership and logbooks can also be created for existing assets. It can be used for any infrastructure project.

5.6.1 Issue Focus

There are four domains of sustainability considered: governance, social, environmental, and economic. These are further subdivided into fourteen themes and sixty issues. The governance domain focuses much of its attention on the process of stakeholder involvement including monitoring, communications, and efforts to comply with certification schemes. It also considers the engagement of expertise, originality, resilience, strategic choices and risk management. Consulting engineers delivering a sustainable project would certainly be interested in considering these issues but apart from stakeholder involvement, a number of these issues lie outside the sphere of engineering aspects of sustainable development.

Table 5.7 Governance Themes and Issues

THEME	ISSUE
Oversight	Risk Management
	Broad involvement of experts
	Innovation (originality and resilience)
	Strategic choices (site, materials, Life Cycle Analysis, etc.)
Stakeholder Involvement	Response to local perspectives
	Information, consultation and interaction process
	Specific aspects of construction phase
	Staff and user awareness of sustainability objectives
Transparency	Implementation of monitoring
	Implementation of certification scheme
	Dedicated communications

The social domain includes health and safety of the community and of project employees, cultural heritage and identity, and the integration of the site into the community in regard to visual impact, noise, thermal effects, and other sources of negative impact on the neighbours.

Table 5.8 Social Themes and Issues

THEME	ISSUE
Health and Safety	Impacts on air quality
	Other health risks (electromagnetic waves, lasers etc.)
	Safety, access, operation etc. (neighbours, users, etc.)
	Ensuring safety during maintenance
Social Cohesion and Employment	Implementing training opportunities
	Job creation
	Equality and diversity of employment
	Facilitate access to services
	Project access for the handicapped
Way of Life	Minimizing negative impacts on neighbours
	Thermal comfort, climatic comfort
	Acoustic comfort, neighbours, users etc.
	Visual comfort
	Quality of surroundings (internal, external)
	Integration into site and landscape
Cultural Diversity	Enhancing cultural identity
	Landscape quality
	Respect for built heritage
	Respect for natural heritage

The environmental domain includes biodiversity, climate change issues, resource management, and waste considerations. There are some interesting omissions from the list of environmental considerations, but they would of course be included in environmental regulation even if they are not mentioned directly in this list.

Table 5.9 Environmental Themes and Issues

THEME	ISSUE
Biodiversity	Preservation of natural habitat
	Maintenance of ecological corridors
	Fighting light pollution
	Supporting inherited species
Climate Change	Controlling works emissions
	Controlling emissions from induced traffic
	Reducing dependence on fossil fuel derived energy
	Adaptation to climate change
Resource Management	Controlling energy consumption
	Renewable energy use
	Controlling water consumption
	Controlling raw material's consumption
	Consideration of life cycle of materials
Waste Management	Limiting air pollution
	Waste management (type, volume, separation)
	Protection of water tables, water courses, soil
	Limiting hydraulic and hydrogeological impacts

Most of the economic domain has been discussed above except for economic development issues.

Table 5.10 Economic Themes and Issues

THEME	ISSUE
Economic Justification	Viability of the constructed works in the short term
	Envisaged future of the works, capacity to evolve
	User quality
	Investment efficiency
Economic Development	Direct economic impacts
	Indirect and induced economic impacts
	Provincial development
	Job creation
	Partnerships
	Synergies with other developments
Global Cost	Simple evaluation (investment, operations, maintenance)
	Extended life cycle costs (including external costs, dismantling, and costs avoided)
	Risk limitation costs

Because of the intent of PSL, there is no point scheme attached to the system and there are no stated targets for any of the issues and no weighting system. PSL is intended to be completely voluntary and self directed. Users are encouraged to set targets and to track them and report results to stakeholders but the targets remain specific to the asset reports.

5.6.2 Application of PSL in Canada – The Critical Questions

The concept of a project sustainability logbook would be applicable in Canada if owners were interested in its development. It would probably require some customization particularly in the area of the environmental domain and would benefit from a joint effort between consulting engineers and owners so that the issues held in common between the logbook and an engineering project sustainability system could be made internally consistent. Alternatively, a linkage between PSL and the Global Reporting Initiative might encourage owners to adopt PSL and GRI. Widespread adoption would probably require some form of encouragement at the political level.

5.7 Summary of Sustainability System Review

There are many systems and tools that are currently in use around the world to assess engineering projects for sustainability and it would certainly be an advantage for the Canadian industry to select one of them and adopt it for use in this country. It would minimize the time and reduce the cost of developing one for Canadian use and it would provide the opportunity for close links to another region to share training and experiences in the operation of the system. Unfortunately it would also mean using somebody else's system that might not entirely suit the Canadian environment, would limit ongoing control over the evolution of the system, and would mean accepting the limitations that have been outlined in the previous sections of the report. It would also mean passing up the opportunity to look at what has been done before, learn from others' experience, and improve. Most importantly, it would miss the opportunity to get together with clients and contractors to share knowledge and experience and devise something that dovetailed nicely with the needs of those client groups and partners.

There are major similarities in the systems that have been reviewed because when developing something new, everyone looks at what has happened before, and tries to include the important parts. This pattern is very apparent when examining the various systems for sustainable buildings that are available internationally – LEED© from the US, BREEAM from the UK, HQE from France, Green Star and NABERS from Australia, CASBEE from Japan, and SBTOOL from Canada. Some of the international systems have Canadian versions (LEED© and BREEAM) but these local systems have limited flexibility because it is essential to keep the core tool evolving in a coherent manner and the local version has to take second place to the main system.

The four systems that have been reviewed here were picked because they are typical and because they originated in countries that have close ties to Canada and many similarities with the Canadian consulting engineering industry. All have strengths and weaknesses.

Envision™ from the US is also fairly recent and has a couple of features that make it unique. Because it is intended for use across a broad range of parties including developers, owners and contractors, it includes a number of issues that would in Canada be under the strict control of municipal clients or other owners. In addition, the concept of a project review that covers "doing the project right" (usually under the purview of the engineer) and "doing the right project" (under the strict control of the owner) flies in the face of practice in this country except for those relatively rare circumstances in which the consultant is providing program services rather than project services. The built-in range of objectives from *improved* to *restorative* is very attractive and the whole system is very well described and thoroughly documented. Matching of the issues and scoring to Canadian interests would, as with the Australian system, be required but there are major business links between Canada and the US and that fact would give Envision™ a degree of attraction.

The CEEQUAL© international system from the UK – that has been around in domestic form for nine years – has benefitted from recent work to understand the changes that would be necessary to remove the UK references and regulatory environment. Part of its attraction is a thoroughly documented procedure based on a considerable amount of experience, a well-established system of training and verification, and an expressed willingness to assist in the formulation of a uniquely Canadian version. Its three-column approach to the phased aspect of projects is also attractive. The objectives for improved performance, however, are not very aggressive and the system requires consideration of nearly 180 different issues and extensive documentation. Customization would definitely be required both on the issues list and on the weighting.

The AGIC IS from Australia (now ISCA IS) is the most recent and perhaps the most streamlined, relying as it does on a spreadsheet approach to score the project. Its method for handling project phases – requiring separate submissions for awards at the design, construction and operating level – is attractive and clear. The issues list would need to be reviewed and probably revised before it could be transferred to Canada, and there would have to be some significant revisions in scoring and weighting in order to rebalance the system for use in this country.

Finally, the CBDD system from France takes the unique approach of creating an asset logbook that is primarily driven by the owner and thereby has some aspects that are outside the purview of the consulting engineering industry. It has the potential to be the most comprehensive and useful of the four, but may also be the most demanding to maintain a quality record. Leaving aside the details, an approach of this type in Canada would have to be driven either by a large set of owners (municipalities, provinces?) or by legislation that required such a set of records to be kept.

In addition to these specific concerns, there are also generic ones. All of the systems that provide a project score do so by mixing project performance on (numerous) issues that are not related to one another and are not measured on the same scales. The final score therefore has no real meaning outside of the details of the system that gave rise to it.

Although the systems are mostly quite similar, they are not comparable. An engineering firm working in different countries would have to master a whole range of different systems to deliver an indication of sustainable performance to their various clients. High performance on one system would not necessarily be called high performance on another because the rewarded levels of accomplishment vary widely.

Points are given for processes and methodologies that may or may not result in tangible improvements to the sustainability of the project.

For reasons of consistency and quality control, the originating organization(s) control the system details, the training of users, and the verification of reward claims, and as a result add narrowly focused training overhead to the industry. The first legal cases based on implied performance claims from the use of these systems are beginning to appear in the courts.

6.0 CONCLUSIONS

6.1 Sustainable Development as an Issue in Canada

After a protracted and somewhat rocky beginning – mainly because of difficulty in translating definitions into action – sustainable project performance is now a driver for the consulting engineering industry. Regardless of whether the client is a business or a public body, consulting engineers are being asked to deliver projects that are demonstrably more sustainable than those they delivered in the past.

These requests effectively add layers to the demand for performance from the client. Not only does the project now have to meet the client's needs and the regulator's rules, but it also has to satisfy the demands of society as a whole. Those demands are different, depending on location and circumstance, and require an element of consultation in setting project goals and priorities that go beyond previous experience.

It is clear that Canadian engineers have an ethical obligation to meet this challenge, and its essence is a comprehensive understanding of the downstream consequences of design and construction activities. It begins with knowing a set of issues and goals that are largely under the control of the engineer but it extends to a deeper appreciation of the client's objectives and a process of factoring those objectives into the project deliverables.

6.2 Systems for Project Sustainability Assessment

In this document four existing systems for project sustainability assessment have been examined, initially to see if they fit the industry's requirements, and then to see if they would suit the industry's clients. None worked perfectly in this regard, although all had elements that were worthwhile and thought-provoking.

Perhaps it is not reasonable to expect any single system to meet all of the requirements of the industry at this stage in the development of this subject. It may be that a series of narrower approaches that are specific to certain client groups and interests would be more successful – such as the application of LEED© and other approaches to the challenges of sustainable buildings.

For the present, although none of the systems is recommended as a universal panacea, a study of any or all of them would help in developing an understanding of the subject. Likewise, it does not make sense for the Canadian associations to try to develop their own tool, simply because they will run into the same problems, frustrations, and limitations that others have experienced.

6.3 Dealing with Project Sustainability

Although the search for a single ideal system that meets the requirements of all of the parties has failed, project sustainability is a critical ongoing issue and it is far more productive to focus on the elements that are specific to the consultant's project contributions. Throughout the report, FIDIC's PSM II guideline has been used as a check for completeness of the list of issues considered by the reviewed systems. PSM II is not an assessment tool for project sustainability *per se*, but it is a useful way to look at the issues that comprise project sustainability. A modest amount of work could turn it into a tool that would be suitable for project goal setting internal to the industry. With it in hand, company discussions with clients on specific projects could be simplified, and industry discussions with groups of clients to find common ground for project assessment could be facilitated.

6.4 Moving Forward – A Sustainable Consulting Engineering Industry

Working with a client on a sustainability project is different than a more conventional service offering. The key to success is innovation – doing the project differently than the last time. Innovation is inherently riskier than copying previous successes – the possibility of failure of some or all of the project components increases simply because there is no previous experience with them. More time is required to develop ideas and turn them into plans and specifications because there is no previous body of knowledge or experience on which to draw. Finally, the payoff for the client is often further into the future – sustainable projects often save operating expenses, sometimes with increased costs for initial development.

The relationship between consultant and client has to reflect these realities – the work will be more expensive, may take longer, and will carry higher risk, with the payoff at some point downstream. In particular, the higher risk needs to be shared in a sensible manner in the contractual arrangement, bearing in mind that the client will receive the benefits of success for the project lifetime, and the consultant only gets a one-time fee.

Improved project performance – for sustainability or any other reason – is obviously in the interest of the client. Less apparent is the benefit of the sustainable innovation challenge to the consulting industry. In the 1980's the Canadian industry was pushed to become more environmentally sensitive earlier than anywhere else except the United States. Being on the leading edge of the environmental revolution equipped Canadian firms to be more competitive than others internationally, and many firms benefitted from that impetus. The industry can be a major force in finding more sustainable solutions, but clients need to understand that potential, and push for delivery of the seemingly impossible.

7.0 APPENDIX A

7.1 A Brief History of the Sustainable Development Concept

The idea that humans can plan and take an active part in ensuring the sustainability of their activities can be traced to antiquity, but the modern idea of sustainable development is of much more recent origin.

The roots of the concept were established by two events that occurred in 1972. One was the publication of the report "Limits to Growth" by five Massachusetts Institute of Technology scientists for the influential think tank, *The Club of Rome*. It examined a model of a world future of unchecked economic and population growth in an environment of finite resources (based on the kind of economic growth witnessed in the 1960's and1970's). The report was based on reasonable estimates (at the time) of the availability of key resources such as oil, copper and gold and it predicted the consequences of diminished availability of these resources on world economic activity. Over time these projections have proven to be inaccurate, but the report was instrumental in anchoring the concept of future limitations of worldwide resources in an environment of continuing population growth.

The second key event in 1972 was the United Nations Conference on the Human Environment held in Stockholm, which brought industrialized and developing nations together to debate and delineate the rights of humanity to a healthy and productive environment. Although the linkage between the environment and development issues was not strong in this conference, there were clear indications that the form of economic development would have to be altered in future to ensure the ongoing success of humanity.

In the years following this conference, the environment and development were increasingly linked[32], and in its report of 1980 (the World Conservation Strategy), the International Union for the Conservation of Natural Resources stressed the interdependence of conservation and development. Unless the fertility and productivity of the planet were safeguarded, humanity's future would be at risk.

7.1.1 The Brundtland Commission – A Definition of Sustainable Development

By the middle of the 1980's world opinion had identified a number of concerns about the sustainability of human activities. In no particular order they were:

- Widespread environmental contamination
- Inevitability of environmental impact arising from all forms of development
- Accelerating rate of use of non-renewable resources and questions about the ongoing availability of those resources, especially fossil fuels
- Worries about crossing a "threshold of resource use" and endangering the basic integrity of nature

[32] Sustainability and Sustainable Development: Historical and Conceptual Review, Desta Mebratu, 1998, in Environmental Impact Assessment Review, vol. 18.

- Increased intervention in the natural patterns of water distribution (dams)
- Desertification, tropical forest destruction, and reduction in genetic diversity
- Air pollution issues such as acid rain, destruction of the ozone layer, greenhouse gas effects leading to sea level rise and disruption of agricultural production
- Nuclear contamination
- Nuclear war and the arms race spreading to space
- Unintended consequences in the widespread use of chemicals and synthetics; disposal of toxic wastes
- The global nature of economic and environmental links – the location of an economic benefit is not linked to the location of its environmental consequences and such consequences are not included in the evaluation of its economic benefits
- Ecosystems do not respect national boundaries, environmental degradation moves (air, water, accident consequences)
- Increased incidence of disasters
- Linkages between social and political problems and environmental and economic problems, protection of women, protection of vulnerable groups, promotion of local participation in decision-making.

As a response to these concerns, in 1983, a special independent commission of the United Nations (the World Commission on Environment and Development) was created, chaired by Gro Harlem Brundtland, the Prime Minister of Norway. The commission was to critically re-examine environmental and development problems around the world and formulate realistic proposals to address them. A second goal was to strengthen international cooperation on environmental and development issues. And, finally, the commission aimed to raise the level of understanding of and commitment to sustainable development on the part of individuals, organizations, businesses and governments.

The commission carried out extensive hearings around the world and in 1987 produced its report *Our Common Future* in which sustainable development was defined as *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs."* It concluded that ongoing development was essential to the future of humanity and pointed out that "Far from requiring the cessation of economic growth, (sustainable development) recognizes that the problems of poverty and underdevelopment cannot be solved unless we have a new era of growth in which developing countries play a large role and reap large benefits."

7.1.2 Climate Change – A Specific Aspect of Sustainability

The specific concerns of climate change were handled separately. In 1987, the Montreal Protocol – an agreement that was intended to deal with the issue of ozone degradation – was formulated. It was signed by 197 countries. It required elimination (apart from a small number of agreed critical applications) of the use and manufacture of chlorofluorocarbons and a number of other chemicals known to degrade atmospheric ozone in a series of steps culminating in the phasing out of the production of methyl bromide in January 2015.

In 1988, the Intergovernmental Panel on Climate Change (IPCC) was formed to provide a scientific, technological, and socio-economic assessment of the risk of climate change caused by human activities, along with the possibility of adapting to these consequences or mitigating their effects. It carries out no research on its own, nor does it monitor climate or atmospheric changes but rather provides summaries of scientific work by others and maintains a database of relevant monitoring results. It has produced four assessment reports respectively in 1990, 1995, 2001, and 2007. The fifth assessment report was released in March 2014.

The IPCC is extremely careful to provide best estimates of its conclusions and qualify its findings by their confidence level. It is organized into three working groups and a task force – one group assesses the scientific aspects of the climate system and climate change, one group assesses the vulnerability of socio-economic and natural systems to climate changes, consequences, and adaptation options, and the third group assesses options for limiting greenhouse gas emissions and otherwise mitigating climate change. The task force is responsible for the National Greenhouse Gas Inventories Programme.

In interpreting IPCC reports, it is important to recognize that, depending on the subject, some conclusions are inherently less certain than others. As an example, detection – is the climate changing – is considered to be quite reliable. Attribution – are humans responsible for the change – is a compelling argument but is somewhat less reliable. Consequences – projections of future climate in various parts of the world and the impacts of those changes on socio-economic indicators – are somewhat less reliable still. It is also important to recognize that as scientific understanding of climate phenomena and models of climate behavior improve and collected data increases, these uncertainties are diminishing.

In 1992, the United Nations Framework Convention on Climate Change was signed. This was the international treaty that first acknowledged the possibility of harmful climate change and called upon the signature countries to cooperatively consider what they could do to limit average global temperature increases and to limit impacts, and was largely founded on the basis of the First Assessment Report published by IPCC. There are 195 parties to the convention.

7.1.3 The Rio Conference

Following the issue of the Brundtland Commission report, the United Nations began preparations for the UN Conference on Environment and Development (UNCED) – also known as the "Rio Conference" or the "World Summit" – that was held in Rio de Janeiro in 1992. The conference was chaired by Maurice Strong from Canada, and was an outstanding success with a number of key documents and declarations signed as a result. These included Agenda 21, the Rio Declaration on Environment and Development, the Statement of Forest Principles, the UN Convention on Biodiversity, and the Framework Convention on Climate Change. The conference was attended by official delegations from 172 countries, by many heads of state (108), by 2400 representatives of non-government organizations and almost 10,000 journalists.

At the Summit, the UN was also called on to negotiate an international legal agreement on desertification, to hold talks on preventing the depletion of certain fish stocks, to devise a programme of action for the sustainable development of small island developing States, and to establish mechanisms for ensuring the implementation of the Rio accords.

In addition, the UN Commission on Sustainable Development (UNCSD) was created to ensure full support for the implementation of Agenda 21 worldwide. Agenda 21 – the principal outcome of the conference in regard to the concept of sustainable development – was a programme of action to achieve sustainable development in the 21st century. It included a call for the development of local versions of Agenda 21 – essentially a call for the public, through their local government, to define what would have to be done to make their communities sustainable into the future. Some 2000 local communities and municipal governments responded. Its final chapter also called on countries, as well as international, governmental and non-governmental organizations to develop indicators of sustainable development that could provide a solid basis for decision-making at all levels. These indicators were important because they constituted a first attempt to measure the sustainability of human behavior, and because they indirectly identified the set of issues that were considered to be components of sustainability.

The first draft set of indicators (134 in number) was produced in 1996. Initial attempts by a volunteer group of countries to use these indicators provided the feedback necessary to revise and restructure the initial indicator set (which was found to be too large for convenient use), and a revised set, reduced to 58 indicators, was published in 2001. In 2005 the system was revised again to reflect ongoing experience in their use and to satisfy a need for indicators to measure progress in achievement of the Millennium Development Goals. This work was completed in 2006 and published in 2007 and is the current form of the CSD indicator set. It contains a core set of 50 indicators that are part of a larger set of 96. Core indicators fulfill three criteria. First, they cover issues that are relevant for sustainable development in most countries. Second, they provide critical information not available from other core indicators. Third, they can be calculated by most countries with data that are either readily available or could be made available within reasonable time and costs. Conversely, indicators that are not part of the core set are either relevant only for a smaller set of countries, provide complementary information to core indicators, or are not easily available for most countries.

In addition to the guidelines on indicators, the United Nations also publishes a much more detailed document describing the methodology or means of application of the individual indicators. For each indicator, its name, description, and measurement is described, along with its purpose, relevance to sustainable development, international conventions governing its use, targets, and relation to other indicators. In addition there is a detailed methodological description including definitions, concepts, measurement methods, limitations, state of development, alternatives, required data, references, agencies involved and other reference documents. If the list of indicators provides the skeleton of sustainability, the methodology document fleshes it out and makes it a useful resource. Current systems of sustainability assessment within the international consulting engineering industry mostly adopt a similar approach.

The UN indicator sets are important because to date they are the only fully international set of parameters describing sustainable development. There are many other indicator sets that have been produced in the meanwhile by nations, special interest groups, industries, and non-government organizations. The UN list is the basic reference to the complete set of issues of sustainable development and provides a useful reference for validating special purpose definitions. This is an important concept for those who would use and develop special purpose tools – particularly in the consulting engineering industry – because the requirement to incorporate sustainability principles in design demands a comprehensive list of targets that remain reasonably static throughout the design process. Without something like the UN core list, project targets could shift continuously throughout the development stage as additional parties become interested in the project.

7.2 Progress in Sustainability

The United Nations Commission on Sustainable Development (UNCSD) was assigned the task of following up on progress on the issue. The follow-up process included a review at the UN General Assembly in 1997, a follow-up conference held in Johannesburg in 2002 (The World Summit on Sustainable Development or WSSD, or Earth Summit), and a scheduled conference to be held in 2012 in Rio de Janeiro (Rio+20).

Outside the UN, governments became involved in the development of local Agenda 21 reports, and even investment groups began to encourage selective investment in companies that had embraced sustainability as one of their objectives. In 1997, CERES, a non-profit organization in Boston, originated the idea of a disclosure framework for business to report sustainability indicators. UNEP (the United Nations Environmental Programme) joined in 1999 as a partner and they jointly published the first version of their guidelines, the Global Reporting Initiative in 2000. Version 3.1 was published in 2011 and nearly 3500 companies provide public reports according to their standards. Many of these companies are clients of the Canadian consulting industry.

In 2002, nine international banks and the International Finance Corporation (IFC, an arm of the World Bank) agreed to voluntarily develop a banking industry framework for addressing environmental and social risk in project financing that could be applied globally across all industry sectors. It was called the Equator Principles and was based on the IFC environmental and social safeguard policies, pollution prevention and abatement guidelines and risk categorization screening criteria. They were launched in 2003, updated in 2006 and were updated again in 2012. The current threshold for implementing the Equator Principles is a project investment of US $10 million. There are 77 financial institutions involved.

In the first few years after the Rio conference, numerous other organizations developed concepts for a more sustainable future. There were problems associated with this proliferation of sustainability concepts – in fact many of them were mutually contradictory. Although the definition of sustainable development ("*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*") was very clear, it was not a definition that helped anyone to focus on exactly what was required to achieve a sustainable end state. As an example, the concept of "needs" is subject to a wide possible range of interpretation from "anything you want" to "essentials to sustain life". Indeed there is no certainty that the environment is able to tolerate the development required to meet those needs at any given level of global population.

As a result there has been a huge range of interpretation of the concept and of its issues, and of the expected end point – an end point that is anchored in social values, politics, and economics. By implication, the steps to a sustainable future came to depend for a while on the social, political and economic circumstances of those who were in the discussion – a situation that the UN sought to avoid by the publication of its indicator lists and guidelines.

7.2.1 Evolution of the Climate Change Issue

Publication of the Second Assessment Report by the Intergovernmental Panel on Climate Change in 1995 provided the key input to the negotiation of the Kyoto Protocol in 1997, a treaty to reduce emissions of serious greenhouse (GHG) gases – carbon dioxide (CO2), methane (CH4), nitous oxide (N2O), hydrofluorocarbons (HFC's), perfluorocarbons (PFC's), and sulphur hexafluoride (SF6). Kyoto required the involvement of 55 parties accounting for at least 55% of GHG emissions so it only came into force in 2005. It was set to expire in 2012, but has been extended to 2018. It called upon governments to reduce emissions of GHG's to 5.2% below 1990 levels by 2012, calculated as an average over 2008-2012. It also launched a series of annual conferences amongst the parties (COP) to the protocol (COP17 was held in Durban, South Africa in 2011). Kyoto also mandated the development of the Green Climate Fund – a fund of $100 billion per year to assist the least developed countries to adapt to or mitigate the consequences of climate change within their boundaries.

The Kyoto Protocol was a seriously flawed agreement, mostly because of the indicators it used. Efforts to fix, improve, and extend it have occupied the efforts of most of the COP series of meetings since, with notably limited success. Developing countries were exempt from the GHG limitations (including China and India!) and the Protocol had no mechanisms to adjust targets for the huge change in worldwide economic circumstances that have happened since its negotiation. There is no differentiation between countries whose economies have remained static and those whose economies have grown significantly, nor does the Protocol differentiate between countries with a static population and those that are growing. The Protocol does not include GHG emissions associated with the huge imports of products from China and other parts of Asia. The Protocol will not, in all likelihood, be fixed, and as a result GHG reductions will depend on nationally developed targets that will likely differ significantly from one another.

7.2.2 Ten Years After Rio

The 1997, UN review acknowledged that progress on sustainable development was erratic. By the time of the Johannesburg conference in 2002, the general failure of the process to achieve its stated objectives was widely acknowledged – underlined by a critical report in December 2001 that had been prepared by the secretary general, Kofi Annan. This unsatisfactory situation was attributed to lack of specific, narrow objectives with a defined timetable. In the 2002 conference, the formal declaration spoke of globalization and the unequal distribution of costs and benefits of integrated markets. It specifically targeted poverty reduction, nutrition, access to safe drinking water and sanitation, trade barriers that acted against the developing nations, and basic health care and education (Anderson and Morgenstern, 2003). The response was the creation of the Millennium Development Goals, a set of eight specific goals, 21 targets, and 60 indicators, with delivery dates in 2015. A recent summary by the UN (Millennium Development Goals 2011 Progress Chart) acknowledges that while progress has been made, more than half of the goals will fail to achieve their targets on time.

7.2.3 Twenty Years after Rio

The objective of the conference (Rio+20) in 2012 was to secure renewed political commitment for sustainable development, assess the progress to date and remaining gaps in the implementation of the outcomes of the major summits on sustainable development, and address new and emerging challenges. The preparations for the conference highlighted seven areas that need priority attention and these included: decent jobs, energy, sustainable cities, food security and sustainable agriculture, water, oceans, and disaster readiness. These priority areas, in many respects, reflect events of concern over the last decade.

8.0 APPENDIX B

8.1 About the Author

John Boyd, P.Eng., Ph.D. was in the consulting engineering business for 35 years with Golder Associates and served on the boards of numerous industry organizations including ACEC and FIDIC.

For the past twelve years, John served on FIDIC's Sustainability Committee and was a key participant in the development of their Project Sustainability Management System. He has provided sustainability training for consulting engineers in Canada, the United States, China, the Philippines, New Zealand, Australia, India, Iran, Mexico, Belgium, and Germany. He currently teaches Sustainability for Engineers at the graduate level for the Engineering Faculty of the University of Toronto.

John has strong opinions on the role of engineers in society and in particular on engineering responsibilities in solving societal problems and is a regular guest speaker on these issues. He is the recipient of the President's Award of the Irish Consulting Engineering Association for his contributions towards sustainability in engineering. John is also the recipient of the Chairman's Award and the Beaubien Award from the Association of Consulting Engineering Companies - Canada for his exceptional contributions to the Canadian consulting industry.

8.2 About the ACEC

The Association of Consulting Engineering Companies - Canada (ACEC) represents over 400 companies that provide professional engineering services to both public and private sector clients across Canada. These services include the planning, design and execution of all types of engineering projects as well as providing independent advice and expertise in a wide range of engineering and engineering-related fields. Through offering these services, ACEC member companies have a direct influence on virtually every aspect of our economic, social and environmental quality of life in Canada.

Consulting engineering in Canada is a $28.4 billion a year industry. ACEC member firms directly employ over 72,000 Canadians. Canada is globally recognized for its engineering services and is the second largest exporter of engineering services in the world. ACEC is an influential member of the International Federation of Consulting Engineers (FIDIC).

ACEC promotes a business and regulatory climate that allows its members to provide the highest level of services and best possible value to its clients.