Building Tomorrow's Society
Bâtir la Société de Demain

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HERE AND NOW

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Abstract: The pace and potential impacts of climate change are now recognized by all major engineering and scientific societies as a crisis requiring urgent and immediate action. There are new and innovative technologies being developed to mitigate and adapt to the situation. The overarching question, however, is will there be sufficient renewable energy to permit all 11 billion humans on earth in the next 100 years to enjoy a modern energy and infrastructure dependent quality of life similar to the one enjoyed by only the 2 billion in advanced economies now. Very likely, the answer is "no", as CSCE President Claude Johnson predicted in 1994. As a society, and as professional engineers, we must look beyond mitigation and adaptation, and instead focus on avoiding and eliminating carbon energy utilization and GHG emissions in the "here and now". Otherwise the trajectory of atmospheric CO_2 concentrations, and corresponding ocean acidification, will result in an environmental catastrophe for the planet. Civil engineering education and practice must address this issue in education and practice, and the CSCE can play a vital role in this mission.

1. Introduction

Carbon dioxide (CO_2) concentration in the atmosphere now exceeds 145% of pre-industrial levels and corresponding ocean acidification has also increased (World Meteorological Organization 2017). With the projected population and economic growth in this century, GHG emissions contributing to these effects will likely be 3-4 times what they are now. Simply put, it is not just climate change. This magnitude of change in the earth's oceans and atmosphere simply cannot be sustainable within the earth's carrying capacity.

There is a strong possibility that we are close to the "tipping point" in terms of unpredictable consequences on climate, civil infrastructure, and human society. Given that the current climate change situation has resulted from approximately 2 billion persons on earth enjoying a modern energy dependent lifestyle, and that within this century the global population is expected to reach 9-11 billion, it does not take much analysis to realize that a crisis is upon us.

Civil engineers must therefore devise new ways to reduce, avoid and eliminate energy utilization, and associated GHG emissions. This must be considered in policy development and implementation, as well as in infrastructure planning, design, construction, and operation, even if green renewable energy proves sufficient to meet our needs in the future (Perks et al. 2016). It is important for CSCE to continue to work

with universities to raise awareness of this issue in the profession, and especially in civil engineering education.

2. A Quality of Life that can be Sustained

The CSCE Sustainable Development Committee (SDC) has been fostering awareness of the need for change in civil engineering practice for the last 25 years since President Claude Johnson first raised the alarm (Johnson and Kramer 1994). In 2007, a "call for action was advanced by the CSCE in the form of Guidelines for Civil Engineering Practice – "Entrusted to Our Care" (Perks et al. 2007). The same "call to action" was issued at the 2015 Triennial Summit in London, UK. The society's efforts should be continued to promulgate sustainability awareness to members of the Civil Engineering profession, to other professions, to all levels of the government and to the public.

One important strategy is to consider what can be done in the short term, in the "here and now", to effect change, even in small ways, such that policies and infrastructure are engineered in a manner that supports a desirable quality of life, but one that can also be sustained for the benefit of both ourselves and our future generations.

Several key principles that should be considered actively by all civil engineers to promote more sustainable communities, include:

- Optimize first; losses and inefficiency gains may defer costly new facilities; it is okay to NOT build something or to NOT implement a new policy if doing what we already do can be done in a smarter way that stretches already stressed taxpayer dollars.
- Long term (lifecycle) operation and maintenance costs, may exceed capital cost;
- Recognize that Standards and Building Codes are "minimal", usually for safety; exceeding them enhances ambiance for and comfort of the long term users, who impact our reputation and future professional success.
- Think small and simple first. Innovation and creativity can result from doing new things in old ways, as well as doing old things in new ways; we can learn a lot from our Forefathers and our First Peoples.
- Formulate clear, understandable, social cost-benefit analyses (SCBA) that the public can understand; internalize the externalities such that we enhance the value to society of what we engineer.
- Consider energy, GHG emissions and ocean acidification as part of the triple bottom line of all our SCBA, in addition to local sustainability contexts within which our projects are proposed.

Our objective should be to design for maximum sustainability utilizing the least resources, as well as to avoid environmental and social impacts by focusing on all of society's basic needs. We need to question clients and owners asking for projects that could result in excessive resource utilization and pollution, and present alternatives. We need to leave behind our tarnished 'build it and they will come' reputation, and become known as stewards and champions for enhancing social and environmental value in every project that we engineer.

3 Incorporating Sustainability in Practice

Preparing civil engineering students and young professionals to incorporate this sustainability thinking more fully into practice should be a focus of educational efforts. This includes environmental and resource stewardship, sustaining quality of life, considering social justice issues, and developing carbon-neutral infrastructure systems. However, what should our younger and new practicing Civil Engineers consider when addressing their social, economic and environmental responsibilities? The following concepts are not usually incorporated in civil engineering curricula; they should be, as follows:

1. Recognize that there is a choice, especially at the planning and design stage, to better define the need and form one's own definition of the problem to be solved, rather than simply accept the definition of others without question. While the highest level of technology can make for improved levels of service,

the most sustainable solution may be the oft-referenced 80% solution offering significantly lower cost and environmental impact.

2. There may well be lower lifecycle cost, easier to operate systems, and/or more sustainable solutions that will meet the needs in both short and long terms. And most importantly, ensure that the existing infrastructure has been fully optimized and efficiently operating before embarking on costly upgrades and expansions to meet growth needs. Reducing water losses and/or re-using waste effluent may avoid entirely the need for a capital upgrade.

3. Civil works must reflect not only technical excellence, but also public acceptance, financing ability, and operational and maintenance capacity of the ultimate end user. There is an ethical and professional duty to society, the environment, and all stakeholders to explain all possible solutions. Clients and owners, especially smaller municipalities and their councils, often are not familiar with the alternative policy and infrastructure approaches.

4. Decision making must not dwell only on monetary 'bottom line' approaches. Sustaining a desired quality of life requires consideration of non-monetary costs and impacts over time, such that Multiple Account Evaluation using Analytical Hierarchy Process (AHP) techniques to reduce bias must be used in all analyses, to ensure consideration of non-monetary externalities is done, to 'internalize the externalities' (Vaidya and Kumar 2006).

5. Engineers need the communications skills to be able to explain civil engineering projects in clear, understandable terms, to the press and the public. Sound judgment and a keen awareness of the public's concerns will help to guide the client to the most appropriate one, and the 80% solution may well be good enough when properly explained.

4 The Capstone Process

Most university engineering curricula in Canada now include practice-based learning projects in the final year of studies towards an engineering degree. These projects try to integrate academic learning with practical experience, under the mentorship of working professionals in industry and government.

Capstone projects therefore help equip civil engineering students with experience in interdisciplinary teamwork, modern business practices, and a better understanding of how civil infrastructure projects are designed under complex social, environmental and economic pressures.

By working in interdisciplinary teams and in collaboration with outside engineering firms and agencies, students learn to apply academic knowledge in an entrepreneurial manner, and to develop the teamwork, problem solving and communication skills essential for professional and career development.

Important steps in the Capstone process include problem identification and generation of alternative solutions. It is at these stages that students can be encouraged to consider engineering approaches that are suitable for a low-carbon economy (Perks and Rennie 2017). The Capstone process can also help to provide civil engineering students with a better understanding of how to convey those solutions to clients and the public. In this way, they will be better prepared not only to mitigate and adapt solutions to climate change impacts, but also be to eliminate and avoid solutions that push society and the global environment further into the danger zone.

5 EXAMPLES IN PRACTISE

Around our CSCE SDC, we offer a few examples from our respective areas of expertise to drive home what we've been talking about. More such examples and case studies, together with a broader discussion on the topic of 'engineering sustainable communities' can be found in the 2017 book by the same name published by our colleagues in the American Society of Civil Engineers. Of note, several of its chapters were co-authored by CSCE SDC members.

Clean drinking water - Recognizing that pumping water is a major energy use in most Canadian municipalities, should we not perhaps do what the Romans did 2,000 years ago - build aqueducts to convey water at higher elevations so that water treatment and sewage treatment plants might operate primarily with gravity. Designing infrastructure to meet hourly peak human demands is most often inefficient and expensive, compared to providing demand management alternatives. Complete recycling and re-use of wastewater is now feasible, as is being done in cities in Texas where sewage is being treated and injected directly into the drinking water distribution system.

Healthier lifestyles – The Public Health Agency of Canada, and Medical Health Officers across Canada have labelled obesity as the 'new nicotine'. Obesity is caused in part by our carbon dependent, auto dominated lifestyles, which can be directly related to our sprawling traditional development patterns that civil engineers have helped build. SMARTer Growth Neighborhoods can both address this obesity problem while at the same time reducing energy use, land consumption, and air/water pollution. SMARTer Growth succeeds using a system engineering focus that includes: denser, mixed focused land use integrated within a matrix of green restorative, socialization spaces, and supported by high quality active transport services (walk, bike, and bus) and efficient, safer road networks. It allows aging in place, eliminates social isolation, quieter/safer local streets, and short home-work-shop trip distances. Results from around the world suggest fewer crashes, and less driving, all at development and lifecycle costs below traditional development patterns.

Methods for informed application of ENVISION to enhance sustainable development - In order to guide the profession in the sustainability direction when planning, designing and constructing transportation and other infrastructure, work is underway to develop methods for informed applications of the ENVISION program. For example, new or rehabilitated highway infrastructure is expected to address economic, environmental and social needs of society. To strengthen these sustainability criteria, it is becoming necessary to make the infrastructure as a direct instrument of sustainability. The ENVISION program was developed for the purpose of improving the sustainability of infrastructure projects. This tool can be applied during planning, design, construction, or at all stages of a project. Following consultations, a revision of the ENVISION program is underway at the Institute for Sustainable Infrastructure (ISI) in order to produce Version 3 with the intent to enhance the scope of the sustainability objective (ISI 2017).

In order to apply a number of sustainability metrics, well researched methods are needed. Research is underway to develop such methods and models that can be used in professional practice to quantify the achievement of a number of sustainability metrics by infrastructure alternatives. Examples are risk and resilience of infrastructure, risk analysis of life cycle costs and benefits, treatment of the equity criterion, and estimation of greenhouse gas emissions.

6 CONCLUSIONS

Recognizing the very serious environmental changes facing all human societies, to the point of fouling the air we breathe, the water we drink, and the land we use, the CSCE Sustainable Development Committee, in cooperation with the Civil Engineering departments at Canadian Universities, is working towards a broader awareness of the need for change in how policies and infrastructure are designed and implemented. Civil engineers must provide bold and creative responses to the changes we now see in the global environment - air, land and water. The CSCE Sustainable Development Committee advocates that all engineering works be viewed through the lens of the changes surrounding us.

The CSCE could contribute to fundamental change by:

- Working with all levels of government to build greater awareness of the problems and the role civil engineering can play in their resolution, even if it means less civil works.
- Encouraging CSCE chapters to undertake activities to better inform the public about civil engineering and the role it plays in environmental solutions.

- Communicating that innovation can be achieved by doing “new things in old ways”, in concert with a focus upon research and new technologies.
- Working with universities to use the Capstone process to prepare new civil engineers to be more aware of these issues and to have the confidence to explore more sustainable solutions as soon as opportunities present themselves in their careers.
- Working with First Nations and other interested communities to both recruit local students into civil engineering as a profession, as well as to encourage graduate civil engineers to help their First Nations and local communities to address the enormous infrastructure deficit problem.

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