GREENING OF THE CANADIAN ENGINEERING PROFESSION (1970-2009): A COMPARISON OF PROFESSIONAL ENVIROSPONSIBILITY IN BRITISH COLUMBIA, ALBERTA AND ONTARIO

by

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ABSTRACT

How has the profession of engineering ecologically modernised in three provinces from 1970 to 2009? This question is at the core of my empirical cross-section comparative case study of professional envirosponsibility in British Columbia, Alberta and Ontario from 1970 to 2009. Ecological Modernisation Theory (EMT) provides the investigative framework. I first developed a schematic of the profession's environmental governance; followed by discourse analysis; and, finally, carried out a comparative assessment of professional envirosponsibility, a proposed new measure of Ecological Modernisation (EM) in the professions. The counterintuitive empirical findings revealed that the profession in British Columbia achieved moderately strong and deep professional envirosponsibility whereas in Alberta it was weak in both strength and depth and, surprisingly, in Ontario it was weakest and shallowest instead of achieving an anticipated second-place ranking. Results and causal elements were discussed in light of Hayden's normative institutional analysis approach and EMT.

PREFACE

The original impetus for this research was sparked by a recollection I had during the lengthy debate on the proliferation of lists promoting '10 things individuals can to do to help the environment'. I recall that as an undergraduate chemistry student I often poured experiments' liquid outcomes into the laboratory's sink drain. It goes without saying that the university I attended followed all mandatory guidelines on proper handling of chemical and waste materials and we were duly trained on safety and security issues. On a routine basis, however, countless 'safe' laboratory waste products were discharged into the city's sewer system by chemistry students such as me.

Set against the debate on individual responsibility with respect to the environment, the recollection brought me to reflect on the largely invisible interactions professionals and professionals-in-training entertain with the environment. The interactions mostly involve individuals who undertake intensive specialized education and training. Professional duties are also usually performed on a larger scale with greater potential environmental impact, either positive or negative, than is possible for individual actions[1]. My musings then turned to the professions themselves, their sometimes self-regulated governance in Canada and the important role they play with the environment at many critical junctures. The medical, the engineering, the dental and the legal professions were the first to come to mind, each with its own inherently complex professional-environmental interactions.

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[1] By this I do not imply that individual environmental responsibility is irrelevant, nor do I diminish its potential for positive or negative impact. For example, I advance that individual actors hold more direct responsibility over and have greater knowledge of the treadmill of consumption in contrast to the limited responsibility they exert on or knowledge they hold of the treadmill of production.

A series of questions followed. Are Canadian professions and professionals demonstrating reflexivity (Spaargaren et al., 2000) in their interactions with the environment? How are professionals and the professions organized with respect to the environment? How are professionals educated and trained in environmentally-related issues? What environmental governance structures are guiding the professions? Are professional-environmental relationships evolving and, if so, how? These questions were the start in my journey to investigating professional-environmental interactions in Canada.

As a first empirical study in these interactions, I selected the profession of engineering as the focal point for my Master's thesis research. My natural science background and my strong empirical inclinations guided me, I hope, in performing and contributing to reflexive social science research that matters (Flyvbjerg, 2006).

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Collaboration from the engineering community was overwhelmingly cooperative and insightful. I offer sincere thanks and appreciation to Chantal Guay, CEO of Engineers Canada (EC), as well as Lynn Villeneuve, Gordon Griffith, Marie Carter and the staff for allowing me unrestricted access to documents and for exceptional support. To Geoff Thiele of the Association of Professional Engineers and Geoscientists of British Columbia, and to his daughter, I extend heartfelt thanks for the long-distance assistance that saved me a trip to British Columbia. To all of you who are too numerous to list here and who accompanied me on a leg of this journey, please accept my sincere gratitude.

As with any academic undertaking, the arguments put forward and analysis performed herein are my own and do not necessarily reflect the views of the individuals and organizations named above. It is my sincere hope that this research will contribute to the dialogue between environmental sociologists and professional engineers as the issues under study are pertinent to the profession of engineering and to Canadian society.

This thesis is dedicated to my partner and soulmate. *Merci pour ton support et le privilège de partager cette aventure avec toi.*

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LIST OF ACCRONYMS

Acronym	Name
ACDE	Admissions, Complaints, Discipline and Enforcement
APEBC	The Association of Professional Engineers of the Province of British Columbia (former B.C. Association in 1970)
APEGBC	The Association of Professional Engineers and Geoscientists of British Columbia
APEGGA	The Association of Professional Engineers, Geologists and Geophysicists of Alberta
APGO	The Association of Professional Geoscientists of Ontario
B.C.	British Columbia
CCPE	Canadian Council of Professional Engineers
CCPG	Canadian Council of Professional Geoscientists
CEAB	Canadian Engineering Accreditation Board
CEQB	Canadian Engineering Qualifications Board
CGSB	Canadian Geoscience Standards Board
CPD	Continuing Professional Development
CRIRSCO	Committee for Mineral Reserves International Reporting Standards
CSA	Canadian Standards Association
EC	Engineers Canada
EIC	Engineers Institute of Canada
EM	Ecological Modernisation
EMT	Ecological Modernisation Theory
ESC	Environment and Sustainability Committee (at Engineers Canada)
ISO	International Organization for Standardization
NRCan	Natural Resources Canada
OACETT	Ontario Association of Certified Engineering Technicians and Technologists
OSPE	Ontario Society of Professional Engineers
PDH	Professional Development Hours
P.Eng.	Professional Engineer
P.Geo.	Professional Geoscientist
PEO	Professional Engineers Ontario
PIEVC	Public Infrastructure Engineering Vulnerability Committee
QP	Qualified Persons
UN	United Nations
UNFCCC	UN Commission on Sustainable Development and the UN Framework Convention on Climate Change
WFEO	World Federation of Engineering Organizations
WFEO-CEE	World Federation of Engineering Organizations Standing Committee on Engineering and the Environment

CHAPTER ONE: Introduction

I launch my investigation into the 'greening'[2] of the engineering profession in Canada with a call to action made in 1970 by J. H. Dinsmore, then-President of the Canadian Council of Professional Engineers (CCPE)[3]. In his address to the CCPE Board of Directors the discourse touched on a core element of my research: responsibility and the relationship between the profession of engineering and the environment.

> One of the external pressures engineers are continuing to neglect at their peril is the accusation widely expressed linking engineering with environmental pollution. Whether because of unawareness, disinterest, or an individual inability to influence the circumstances, engineers have been largely passive participants in the growing awareness of man's accelerating impact on ecology. If (typically in response to employers or clients), engineers have devised the machines and processes which generate the wastes that may destroy us, we also have the capacity to minimize these undesirable by-products through our technology and to influence political and social attitudes through concerted group action.
>
> To take such positive action, however, requires a fundamental change in our collective personality and in our organizational structures. In terms of personality, we must alter from being responsive to initiating, from a passive mode to an active one. Organizationally, we must be more coherent and more complete. (Dinsmore, 1970, reproduced with permission)

What came of Dinsmore's call to action? Did the profession of engineering change its institutional collective personality and organizational structure to address and reduce environmental problems? Did it become an influential actor in the political and the social spheres with respect to the environment? These questions and many more have fuelled my research over the past two years. It is my hope that my investigation contributes answers to some of them, if sometimes only in part, and sheds light on the

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[2] 'Green' discourse denotes environmentally oriented engineering (Vallero and Vesilind, 2007: 287).

[3] In 2007 the CCPE took on the new business name Engineers Canada (EC) which will henceforth be used in this thesis. EC is the national association acting on behalf of its constituent members, the twelve provincial and territorial engineering associations and the *ordre* in the province of Quebec.

larger puzzle of engineering-environmental interactions in Canada within the framework of Ecological Modernisation Theory (EMT).

Structure of Thesis

In the introductory chapter I present an overview of the profession of engineering, its environmental education and environmental obligations in Canada and the three provinces under study, a review of relevant literature, the research question that guided my investigation, my main and supporting arguments, the details of my methodological approach, the theory and theoretical tools that framed my research, some of my study's limitations and what contributions I believe this study can make in relevant debates.

Next, in chapter two, I develop a local to international level environmental governance structure schematic for the engineering profession in Canada. I then perform cross-provincial comparative analysis of environmental governance within an EMT framework.

Analysis from chapter two paves the way for chapter three where discourse analysis at three levels of the profession's environmental governance sheds further light on the profession's EM in the three provinces and nationally. Chapter three also concludes with a cross-provincial comparative analysis and a national-level assessment.

Building on knowledge generated in chapters two and three, in chapter four I compare and contrast the provinces' professional envirosponsibility, a multi-faceted measure of EM in the profession of engineering. Analysis is based on indicators at three main sites: education, professional obligations and legislation. Two potential causal elements are also explored: environmental controversy and alignment of priorities.

I conclude my investigation with an overview of research findings. The counterintuitive empirical results revealed that from 1970 to 2009, the profession of engineering in British Columbia (B.C.) achieved moderately strong and deep professional envirosponsibility whereas in Alberta it was weak in both strength and depth and, surprisingly, in Ontario professional envirosponsibility was weakest and shallowest, instead of achieving second ranking as anticipated. The investigation also brought into focus the pivotal role the national level played in EM notwithstanding the restricted-title and protected scope of practice engineering profession is provincially mandated and self-regulated. The results, causal factors and the implications for engineering education are discussed in light of Hayden's normative institutional analysis approach and EMT.

The primary claim underlying my investigation is that environmentally-related responsibility focus must shift away from the individual actor to rest on mostly invisible institutional actors and institutions: professionals and the professions. I propose the new concept of professional envirosponsibility to capture professional environmental responsibility as a measure of EM in the professions. A secondary claim supporting the primary is the need to study professionals' education and training that would enable them to fulfil professional envirosponsibility.

Overview of the Profession of Engineering in Canada

In an effort to contextualize my research I paint a brief portrait of the profession of engineering in Canada. Engineers Canada (EC) is the national engineering organization acting on behalf of the twelve provincial and territorial regulatory associations or *ordre*[4] in the province of Quebec. Part of its role at the national level includes delivery of national programs in support of professional engineering education standards, qualifications and practice, inter-province mobility and giving its constituent members a voice at the national and international levels (Andrews et al., 2009: 58).

EC's Canadian Engineering Qualifications Board (CEQB) standing committee proposed that the 'practice of professional engineering' "…means any act of planning, designing, composing, evaluating, advising, reporting, directing or supervising, or managing any of the foregoing, that requires the application of engineering principles and that concerns the safeguarding of life, health, property, economic interests, the public welfare or the environment" (CEQB, 2001a: 6). The CEQB further elaborated that "taking of responsibility" was not explicitly defined because engineers are "…expected to take responsibility for their involvement in any undertaking" (2001a: 8). My research honed-in on the profession's responsibility with respect to the environment.

For geoscientists, the counterpart national Association to EC is the Canadian Council of Professional Geoscientists (CCPG) established in 1996 (Andrews, 2009: 52). The CCPG mandate includes the promotion of licensure and regulation consistency across Canada. The Canadian Geoscience Standards Board (CGSB) subcommittee of the CCPG and the CCPG provides advice to the provincial and territorial associations, in addition to national policies and guidelines, examination syllabi for geoscientist registration and the assessment of geoscientist education (2009: 52).

[4] One *ordre* for engineers and one for geoscientists.

As a restricted title and self-regulated profession[5], the engineering profession itself, through mostly-elected Council members, holds responsibility for licensing, setting standards and ensuring enforcement of Engineering and/or Geoscientist Acts and member discipline at the provincial level through provincial or territorial associations or *ordres* (2009: 8). Engineering and/or Geoscience Acts in all Canadian provinces and territories mandate the associations or the *ordres* to perform these duties. The only exceptions are military and stationary engineers who must adhere to distinct regulations (Andrews et al., 2009: 4). Provincial associations or *ordres* are members of EC or CCPG. A Professional Engineer[6] licensed by an association or an *ordre* holds the right to practice engineering and the right to use the title Professional Engineer (P.Eng.) or Professional Geoscientist (P.Geo.)[7]. With these rights also come professional obligations including the adherence to codes of ethics, guidelines, standards and regulations.

Self-regulation in Canada is highly prized by the profession and is in stark contrast to the United States where the licensing system is State-regulated and there is significant political involvement in the establishment and enforcement of regulation (Andrews, 2009: 30-31). Canadian professional engineers are typically employees, but some choose to provide consulting services (Andrews et al., 2006: 20). Engineering activities fall under the authority of all jurisdictional legislation (local, provincial, federal, and international treaties or legislation when working abroad).

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[5] I revisit this regulation pattern in the context of non-licensing in the engineering profession.

[6] In this study the term "engineer" encompasses geoscience professionals, geoscientists, geologists and geophysicists.

[7] Engineers Canada holds the official marks for the engineering designations in English and in French, including "engineer, engineering, professional engineer, P.Eng., consulting engineer" (Andrews et al., 2009: 4).

The Ontario Society of Professional Engineers (OSPE) was set-up to separate the membership regulation from advocacy work on behalf of engineers, emulating the division of labour in the legal and medical professions (2009: 32-33). Other societies at the provincial, national and international levels cater to professional engineers in specific branches of engineering.

Professional Engineers Ontario (PEO) stated that "[i]t fulfills the same role for engineers as the College of Physicians and Surgeons for doctors or the Law Society of Upper Canada for lawyers" (PEO, 2006a: 1). Unlike physicians, surgeons and lawyers who must hold a licence to practice, however, not all Canadian-educated engineering graduates or immigrant engineers who perform engineering-related duties choose to hold a licence with a provincial association[8]. The Canadian engineering profession falls under the regulation pattern of 'restricted title regulation' (Adams, 2010: 60) with registered members allowed to use the P.Eng. or P.Geo. titles in contrast to members of the completely closed and self-regulated medical and legal professions. Some practitioners work as non-licensed engineering graduates[9] under the unique 'industrial exemption' clause in the *Professional Engineers Act* of Ontario, perform duties that do not fall under the jurisdiction of provincial engineering acts, or choose to be non-compliant with engineering licensure requirements (EC and CCTT, 2009; OSPE, 2007a). Also noteworthy is that a non-licensed engineering graduate working under the supervision of a professional engineer falls under the environmental governance of the profession by

[8] Nationally, an estimated 30% of those working in engineering do not hold a license and are not registered interns (EC and CCTT, 2009: 20). In Ontario between 1999 and 2002 only an estimated 28% of Ontario graduates sought licensure (Mastromatteo, 2009a: 37). In 1994, an estimated 35% of Ontario practitioners worked as non-professionals or under the industrial exemption (ACDE Task Force, 1999: 5).
[9] The designations 'non-licensed engineering graduate' and 'non-licensed practitioner' are equivalent.

virtue of the professional engineer's oath and obligations. Environmental governance gaps can arise, however, where non-licensed practitioners do not work under the supervision of a professional engineer.

The self-declared exemptions exercised by industrialists in Ontario[10], and their potential impact on the environment[11], bring to the fore what I argue is a key structural element at the first step in the governance of the profession of engineering in Canada: national level governance of accredited engineering curriculum, including environmentally-related curriculum. Canadian engineering programs and degree-granting institutions are provided accreditation criteria, including environmentally-related criteria, are granted accreditation, and undergo periodic reviews that eliminate the need for candidates to undergo technical examinations to obtain licensure. EC's Canadian Engineering Accreditation Board (CEAB) standing committee performs the program evaluations (Andrews et al., 2009:58). The governed environmentally-related education content reaches all engineering students regardless if an engineering graduate opts for licensure or not. In chapter two, in the context of environmental governance analysis, I elaborate further on my argument that the accreditation process could be harnessed to further EM and strengthen environmental governance in the profession of engineering when dealing with non-licensed engineering activities.

My investigation focused primarily on licensed engineers, as defined in the Methodological Approach section, but included non-licensed practitioners where I

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[10] The exemption clause is unique to Ontario. Although PEO is mandated by the province to self-regulate the profession and enforce the act it does not administer a program to grant industrial exemptions, these are self-granted by industry. PEO can, however, enforce licensing requirement compliance (PEO, 2009).

[11] In chapter two I analyzed some ramifications in Ontario where the OSPE cited potential environmental impacts as motivators to work toward removing the 'industrial exemption' (OSPE, 2007a).

deemed it pertinent and where data was available. In 2008, there were an estimated 206,300 engineer members[12] in the twelve EC constituency organizations (see list of constituency members in Appendix A; Arcturus Solutions, 2009: 1). The three provinces under study, British Columbia, Alberta, and Ontario, represented 62.8% of the 2008 Canadian engineer membership, excluding students. Some 9.4% were members in the Association of Professional Engineers and Geoscientists of British Columbia (APEGBC), 19.2% in the Association of Professional Engineers, Geologists and Geophysicists of Alberta (APEGGA) and 34.2% in PEO (Arcturus Solutions, 2009: 4)[13]. The requirements to become a licensed professional engineer vary slightly by province, but generally include: holding Canadian citizenship or permanent resident status, possessing a recognized undergraduate degree in engineering, having worked three or four years in engineering, obtaining a passing grade on a professional practice examination (subject to discourse analysis in chapter three), being of good character and reputation and demonstrating sufficient levels of competence in the language required in the jurisdiction (EC, 2009b).

Overview of Environmentally-Related Engineering Education in the Profession

As alluded to previously, the minimum environmentally-related undergraduate curriculum content is set at the national level by EC through the CEAB standing committee. The CEAB dynamics and key actors are discussed in chapter two. The 2008

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[12] The category 'Engineer Members' excluded engineering students but encompassed all other categories of members, including engineers-in-training (referred to as "*ingénieurs juniors*" or "*stagiaires*" in the province of Quebec) although they had not yet technically achieved the status of engineers (Arcturus Solutions, 2009:1).
[13] I located no compatible data for the Association of Professional Geoscientists of Ontario.

minimum environmentally-related graduate attributes and curriculum accreditation criteria for an accredited engineering program are listed in Appendix B.

The 'engineering graduate's attributes' environmentally-related criteria were typically integrated in one or two survey-type engineering courses. At least one of these was usually an introductory[14] course in the first year encompassing other professional practice topics. The second course was either in the first or subsequent year of the degree. University administrators[15], having met the minimum requirements, can increase environmental curriculum voluntarily[16] within the constraints of curriculum requirements for specialized engineering education[17]. In chapter three, discourse analysis of short course descriptions and CEAB Accreditation Criteria sheds light on the engineer's minimum environmentally-related curriculum content evolution from 1970 to 2009.

In 2008, 1.8% of the 34,335 undergraduate engineering students in the three provinces under study were registered in environmental engineering programs with 0.2% in British Columbia, none in Alberta and 1.6% in Ontario, respectively (EC, 2009c: 23). Adding to this number the students registered in environmentally-related engineering streams and options[18] raised the percentage only slightly, including a modest representation from Alberta students.

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[14] Based on observations of short course descriptions in the twenty-one universities in British Columbia, Alberta and Ontario offering accredited engineering programs.
[15] The CEAB Program Environment criteria state that "[t]he majority of the members of the [university engineering Curriculum] committee are expected to be licensed professional engineers in Canada, preferably in the jurisdiction in which the institution is located" (EC, 2008: 22).
[16] See analysis in chapter three on parallel course offerings either excluding or embedding environmental considerations.
[17] See discussion of Environmental Engineering Program length and combined undergraduate and MA degrees granted based on complexity and length of studies.
[18] Incomplete data collection for engineering environmental stream and option programs is discussed in the Methodological Approach section.

Civil engineering is an engineering discipline with a history of environmentally-related curriculum given its role in infrastructure and land use. Students enrolled in civil engineering in the provinces studied represented 12.9% of all engineering students. As discussed in chapter three, however, civil engineering curriculum also varies in its environmentally-related curriculum content. The 2007 study by the Canadian Standards Association (CSA) identified serious gaps in climate change undergraduate and professional development education for civil engineers as well as knowledge gaps expressed by practicing civil engineers (Mortimer and Walker, 2007: 35-39).

In the three provinces under study, therefore, approximately 98% of engineering students were not registered in environmental engineering. When civil and environmental engineering were combined this meant approximately 85% of students were conceivably exposed to the minimal environmentally-related curriculum presented in Appendix B. Students were typically enrolled in the other 33 accredited disciplines in British Columbia, Alberta and Ontario (EC, 2008: 35-38). In 2008, the top five accredited programs based on their frequency in the twenty-one universities analysed were mechanical (19.5% of students), electrical (16.0%), civil (12.9%), computer (6.9%) and chemical (8.5%) while environmental engineering earned seventh place (1.8%) (EC, 2008: 35-38; EC, 2009c: 23). Bolstered by recent research, in chapter two I argue that each discipline holds an inherently complex ensemble of professional-environmental interactions requiring integrated environmental education. In essence, all engineering disciplines ultimately deal with material and resource use, interactions and transfers.

In 1970, engineering students in British Columbia, Alberta and Ontario represented approximately 52% of the 23,289 total undergraduate engineering students at Canadian universities (CUA, 1970). There were no environmental engineering programs in 1970, but civil engineering students in British Columbia, Alberta and Ontario represented approximately 7% of all engineering students.

Professional development was another venue where engineers acquired or maintained environmentally-related education. This option was briefly touched upon in chapters two and four, although deemed complementary to a solid core undergraduate environmentally-related education (Mortimer and Walker, 2007; Hyde, 1999).

Overview of Environmental Obligations/Considerations in the Profession

The shared minimum profession of engineering environmental obligations and/or considerations in British Columbia, Alberta and Ontario included the codes of ethics, guidelines, codes, standards and legislation with variations that were compared, contrasted and analyzed in all subsequent chapters. Professional engineers, as individual actors, are instructed that they hold a responsibility to be aware of environmental obligations/considerations and how these could impact their practice either through codes of ethics or professional guidelines. The environmental governance structure proposed in chapter two and ensuing analysis revealed potential gaps between environmentally-related education and obligations/considerations also identified by Hyde (1999: 10-11, 21), Vanderburg (2007) and again by Mortimer and Walker (2007), the latter more specifically with respect to climate change and the discipline of civil engineering. The power dynamics and the actors involved are also scrutinized in chapter two and three.

Focussing on one example of variations between professions, philosopher Davis' (2002) insightful comparison of the ethics of chemists and engineers led him to conclude that there was a subtle difference between these two professions' ethics. The engineering mandate to ensure society's safety led to greater caution than was demonstrated by the chemist when creating or dealing with potentially harmful chemicals (2002). This example reinforced the critical role played by the code of ethics for professional engineers engaged in professional-environmental interactions.

The code of ethics is an integral component of self-governing professions and it generally serves "…two moral functions as a quality assurance guarantee to society and as a checklist for the initiated members of the profession of the standards and limits of practice" (Sohl and Bassford, 1986: 1175). What of the non-licensed engineering graduate not supervised by a professional engineer? Most graduating engineers today voluntarily choose to take part in the obligation ceremony of The Ritual of the Calling of an Engineer in Canada[19] that "…is a symbol of intention to observe professional ethics" (Camp 6- Corporation of the Seven Wardens, 1993: 1). Haultain, who first proposed the concept of the Ritual, likened it to the medical profession's Hippocratic Oath (1993: 6). The Ritual, however, is conducted completely independently from provincial associations or *ordres* and is unrelated to licensure or demonstrating achievement of acceptable qualifications in the profession (Andrews, 2009: 99). I revisit implications of the role of the Ritual and of non-licensure in chapter two.

[19] The Ritual is administered and maintained by the Corporation of the Seven Wardens via 'Camps' or groups, across Canada (Andrews, 2009: 98-99).

The engineering code of ethics with its "...duty to society to be paramount" (Adams, 2009: 320) also appears not to be as clear as it would seem. When applied in real-life situations professional engineers may face losing their careers in cases of whisleblowing on unethical environmentally-related behaviour (Adams, 2009: 319-327). In an effort to reduce the onus on individuals and enable professional engineers to uphold the code of ethics, unambiguous environmentally-related regulations and standards were proposed solutions (Andrews, 2009: 322). To this I argue the need for enhanced and integrated environmentally-related education for all engineering disciplines.

The Role of Environmental Education in the Professions

The thinking on environmental issues within engineering has progressed on temporal and spatial dimensions, from local to global, and in perspective from treatment to sustainability (Mihelcic et al., 2003: 5315). The latter can be summed-up as follows: end-of-pipe treatment (e.g., waste water treatment), to pollution prevention (waste reduction, recycling) to pro-active design for the environment (e.g., replacing toxic raw materials with environment-friendly compounds) and finally to sustainable development (2003: 5315). These perspectives were integrated in chapter three discourse analysis.

Vanderburg contended that Canadian engineering education and the profession remained focussed at the end-of-pipe stage and had not yet progressed to the preventative stage (2007: 1). An example would be the management of toxic chemical waste with filters instead of modifying the process to reduce or eliminate toxic waste. An active member of the engineering profession and an engineering professor, Vanderburg advanced that the "...profession cannot claim to protect public interest except in the narrowest sense of the term, which could raise questions regarding its ability to regulate itself" (2007: 2). Hyde (1999) proposed similar environmentally-related shortcomings to ensuring public safety by the self-regulated profession (1999: 245-246). I explore these critiques and self-regulation further in chapters two and four.

The trend within the engineering community in Canada and worldwide tends to support Vanderburg and Hyde's view. In 2008, the World Federation of Engineering Organizations' President offered this assessment:

> In light of the wealth of information available to the engineering profession, there is significant impetus to review what we do and how we do it. However, our references to Sustainable Development are for the most part still at too high a level. There must be a greater degree of detail provided by educators so that students have to think very carefully about the issues at hand. It is sobering for our profession to realise that this is not yet the norm for most of our engineers in training. (Grear, 2008 in Desha et al, 2008)

Research to pursue an even more formalized sustainability trajectory within engineering seeking greater environmental/ sustainability-related education, practices and accountability is extensive (small sampling of related articles included Desha et al., 2008; Mortimer and Walker, 2007; Crofton, 1995, 2000; Ludwig, 2006; Thom, 1996; Lucena and J. Schneider, 2008; Subic, 2007; Agardy and Nemerow, 2005; Hyde, 1999).

Suggestions with regard to educational changes included creating a new metadiscipline, *Sustainability Science and Engineering* (Mihelcic et al., 2003; Mihelcic and Hokanson, 2005; Komiyama and Takeuchi, 2006) or adding environmental and sustainability curriculum to all engineering disciplines (Crofton, 1995, 2000; Hyde, 1999). The latter suggestion coupled with professional obligations, responsibility, and accountability, is critical I believe, in order for engineers to be able to fulfill their "...duty to society to be paramount" (Andrews, 2009: 320).

Desha et al. (2008) for their part addressed the 'time lag dilemma' whereby most curriculum change takes upward of fifteen to twenty years thereby unduly exposing engineering departments to risks "...in a rapidly changing industry, regulatory, and accreditation environment" (2008: 186). The authors proposed 'Rapid Curriculum Renewal' that could lead to faster and more adapted deployment of sustainable development education for engineers (2008: 186). In later chapters I explore how the Ontario New *Green Energy Act* spurred educators to create new energy programs.

In Canada, environmental engineering programs that had traditionally been available to all disciplines at the graduate level since the 1950s migrated to the undergraduate level in the late 1980s (Smith and Biswas, 2002: 3). The first undergraduate environmental programs were launched in Ontario in the early 1990s. The intensity of the training often required adding one or two additional years to the typical four-year undergraduate engineering degree and candidates were sometimes conferred Master's and undergraduate degrees simultaneously (2002: 3).

The complexity of environmental and sustainability considerations spawned propositions to rethink the engineering curriculum and its delivery in Canada such as models proposed by Hyde (1999), Crofton (1995, 2000), Vanderburg (2007) and the curriculum overhaul proposed for civil engineering by Mortimer and Walker (2007). The latter was specifically designed to help Canada mitigate, adapt and become resilient to the effects of climate change from an engineering perspective. In subsequent chapters I explore how my empirical research supports propositions for curriculum change.

Vanderburg's (2007) proposition advanced that engineering education must incorporate a new knowledge system linking social-science based disciplines looking into technological consequences with engineering and science disciplines that are located at the core of technology "...in order to create negative feedback loops" (Vanderburg, 2007: 2). By bridging engineering education in such a manner, Vanderburg envisioned that the profession of engineering would be able to command "...a more decisive role in transforming our present situation and to help create ways of life that are more economic, socially viable and environmentally sustainable" (2007: 9), echoing Dinsmore's 1970 call to action. The curriculum Vanderburg helped develop and launch at the University of Toronto's Centre for Technology and Social Development made strides in this direction.

Shifting from an educational to an institutional perspective within which such change would operate, Vanderburg's views reflected Hayden's concern that institutions have forgone the ability to adequately integrate social belief, technological and ecological criteria in their functioning, with detrimental impact on the environment (Hayden, 2009: 115-116). Hayden further argued that "[w]e should not expect otherwise [i.e., technological combinations that have depleted and contaminated water supplies, poisoned wildlife and people, and made the expression of important social norms impossible] if those making decisions about technological combinations are not being guided to provide for criteria commensurate with appropriate social and ecological criteria" (2009: 117), further supporting the need to better understand the profession's environmental governance. Hayden's institutional insights provided the framework to shift the discussion from education-specific to institution-wide.

Moving more broadly to environmental education in the professions, Martin explored the integration of sustainability education in the professions and professionals' lives (2008; Martin et al, 2005; Martin and Juker, 2005). He advocated greater systems thinking of environmental and sustainability issues that would enable professionals to understand the complexity of global environmental issues. Martin's focus on education of professionals or leaders (in all fields) as well as those involved in the professions joined a strong chorus of research touting environmental and sustainability education for all global citizens as fundamental tools to foster knowledge, understanding and long-term pro-environmental behaviour (small sampling of relevant literature: Hungerford and Volk, 1990; Reid and Scott, 2008; Dyment and Reid, 2005; Berkowitz et al., 2006; Jordan et al., 2009; Sherman, 2008; Higgitt et al., 2005).

Mihelcic et al.'s (2006) study of an international Master's program in engineering for civil and environmental students in the developing world context is an example of research where engineering played a central role in implementing sustainability. Although the study is rich in detail and proposed that the Master's program could serve as an example to compensate for what the researchers qualified as inadequate environmental and socially-oriented training in engineering, it does not seek to establish how this could be integrated within the profession as a whole. The study purposely limited its scope to civil and environmental engineering specializations.

Taking a look at one last example, Huber's (2008) recent analysis of what he labelled 'pioneer countries' and their contributions to environmental innovations using technology, based on EMT, concluded that national regulation, the companies themselves and the markets were all important components of success. I contend that he failed to recognize the critical role of the profession of engineering in the dynamics. He qualified what were deemed the more innovative and progressive nations as only being in the "...early rather than later stages of ecological modernisation" (2008: 366). By excluding the profession of engineering, I advance that he excluded those actors most intimately involved which ultimately enable or constrain the transfer of the material, the resources and knowledge leading to EM. My project contributes to shedding light on the piece of this social-environmental relationship puzzle that links the local to the global via actors and interactions within the engineering profession locally to internationally.

Research Question

The main research question this thesis seeks to answer is: "How and why does the profession of engineering adopt and demonstrate professional envirosponsibility in three Canadian provinces?" Three sub-questions that reflect the trend design and the use of EMT are: "In these provinces, has there been change in engineering envirosponsibility from 1970 to 2009?"; "If so, what and how has it changed?"; and "What is the environmental governance structure of the profession based on three provinces?"

Argument

My main argument is that focusing on individual actions and responsibilities with respect to the environment detracts from the critical institutional, structural and mostly invisible responsibility role played by the professions and professionals. Given the legal and professional obligations under which professionals operate, I contend that it is appropriate to envisage professional environmental responsibility, which I investigate with the new concept of professional envirosponsibility.

Moreover, prior to engaging in meaningful research and discussion on EM in Canada, as a first step I advance that it is critical to investigate professions, with the profession of engineering as a primary subject in light of its role as a source of technological expertise and political influence or involvement (Vallero and Vesilind, 2007: 77). This study will help to better understand the profession of engineering environmental governance, how the profession is poised to engage in or is engaging in EM and what factors appear to contribute to its ability or inability to engage in EM, in three provinces. A minor argument supporting the main one is that it is not sufficient to ask professionals to act envirosponsibly; they must be adequately prepared through education, professional governance and on-going professional development to fully comprehend what envirosponsibility means and what is expected of them. I further argue that it is only by studying and comparing a profession across jurisdictions that we can attempt to understand the context-specific professional-environmental dynamics, relations of power and social constructions.

Finally, specifically in response to research cited previously, I argue that the focus on environmental/sustainability education, civil/environmental engineering or regulation/markets/companies alone are too narrow as: (1) environmental or sustainability knowledge does not necessarily lead to pro-environmental behaviour (a sampling of extensive literature: Kaiser et al., 2007; Kollmuss and Agyeman, 2002; Lane and Potter, 2007; Maiteny, 2002), (2) education does not tap into potential professional agency, this has to be looked at from the organizational level, (3) the education studies cited above often combine 'professionals' and those exercising a 'profession' while yet other researchers narrow the focus further to only environmental sub-disciplines, whereas I argue that all specializations within a profession should be targeted, (4) the education strategy, by concentrating on *individual* actors' education instead of structural governance changes within a profession fails to harness the potential of the professions' responsibility and professional obligations and established global to local social networks. This latter argument also taps into EMT's contention that "...all social systems [...] reflexively take into account and (re)organize their relationship with the environment in an era that the classical borders are dissolving to a considerable extent" (Spaargaren et al, 2000), (5) the actors who drive technology and research and development are engineers, not corporations, therefore it is the profession's local to global governance that can be harnessed to increase the pace of EM, and (6) the engineers' global network is the most suitable to transfer developed country technology to developing countries via professional engineer associations worldwide, international engineering associations or programs such as 'Engineers Without Borders'.

Methodological Approach

As I set out to investigate the relationship between the profession of engineering and the environment, I considered several methodologies. Following much deliberation, I retained comparative methodology which I deemed the most suitable for this exploratory study. My decision rested on three critical elements: (1) my understanding that a comparative methodology would best allow me to investigate how a profession regulated at the provincial level might yield socially constructed variations across provinces albeit within a national and international overarching governance, (2) the prevalence and acceptance of the comparative methodology across social science and scientific disciplines, especially pertinent for what I qualify as a conservative profession with which I wish to engage in a dialogue using mutually understood methodological tools, and (3) the foresight to position my research to allow the possibility for future cross-country comparison.

I propose four definitions before proceeding: (1) engineer: "An engineer is a person who uses science, mathematics, experience, and judgement to create, operate, manage, control, or maintain devices, mechanisms, processes, structures, or complex systems, and who does this in a rational and economic way with human, societal, and natural resources and constraints" (Andrews, et al., 2006:4), (2) 'professional engineer' is a licensed engineer member of a provincial association who can perform duties such as defined above by the CEQB under the 'practice of professional engineering', (3) 'profession of engineering' refers to the institutional organisation of professional engineers and non-licensed practitioners supervised by the former, (4) 'professional envirosponsibility' is a multi-faceted measure of EM in a profession measuring how and to what depth environmental considerations are integrated alongside economic and social considerations in education, professional obligations, and governance. As the latter concept is new I welcome critique as well as the challenge of refining it.

Figure 1 depicts my proposed comparative research schematic linking EMT, the concept of professional envirosponsibility and the operationalization of the research indicators at the three main sites of envirosponsibility. The proposed research design is a trend cross-sectional comparative case study of three Canadian provinces, British Columbia, Alberta and Ontario, in 1970 and 2009. Figure 2 illustrates how I bridged the theoretical framework with the concept of envirosponsibility through a hybrid of discourse and institutional analysis. The flow and steps involved in the process are deconstructed in Figure 2.

Figure 1: Proposed Comparative Research Schematic

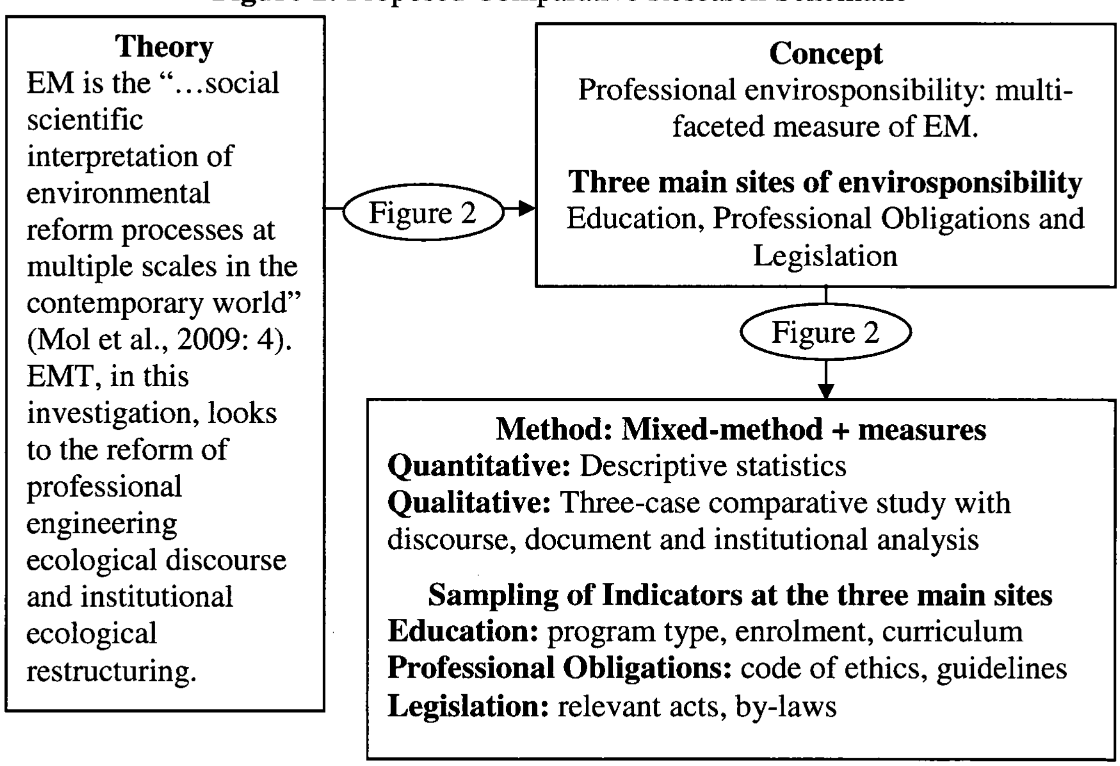
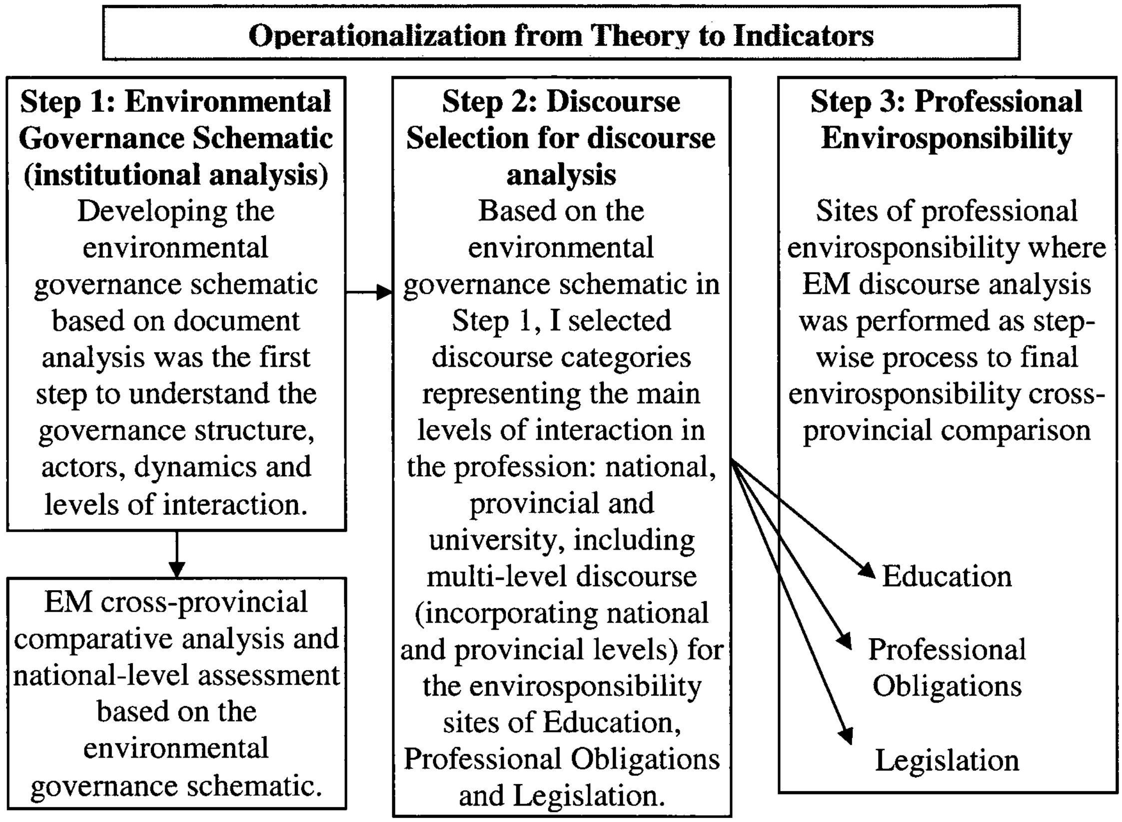


Figure 2: Operationalization of the Theoretical Framework to the Concept and Indicators



One of the strengths of using the comparative methodology with a preponderance of qualitative data in this exploratory study is the rich level of contextualization. This allowed for nuanced comparisons and contrasts all the while creating the potential to reveal small yet critical details in the analysis (Ragin, 1987: 52). The complexity of the professional envirosponsibility concept and EM and the various configurations of causes and demonstrations (Ragin, 1994: 114) would not have easily lent themselves to study using a large number of cases or only a quantitative statistical analysis strategy (assuming such data would be available). The comparison strategy I most utilized was 'variation-finding' (Tilly, 1984: 82) with a goal to be "...both historically interpretive and causally analytic" (Ragin, 1987: 35) the former taking into account the trend aspect of this investigation. The trend component of the study was a strength that allowed me to compare professional envirosponsibility in 2009 with 1970 as a base year.

The unit of analysis in this study is the province. It is the most appropriate given that the educational institutions, many standards, guidelines and legislation regulating the profession of engineering as well as numerous provincial environmental legislations are governed at the provincial level in Canada. Because of the national Association's role in setting engineering national policies, national guidelines, national educational criteria and evaluation and its representative role internationally (Andrews et al., 2009: 58) in addition to providing input into the creation of national Canadian standards, national environmental legislation and policies, I also opted to collect data and perform analysis at the national level. Given that no cross-national comparisons were performed, using national level data does not lead to an embedded design (Yin, 2003: 42-43). Data collected at the university level included all universities within the respective units of analysis and no sampling of universities was performed. Save for select examples of best practices, educational data generated was aggregated to correspond to the provincial unit of analysis. Once more I contend that this did not lead to an embedded design and my proposed exploratory study thus retained its holistic design (2003: 42-43) with one level of unit of analysis, the province.

Case Study Selection: Appendix C lists all Canadian provinces and territories and contains relevant criteria on which the selection was based. Relevant environmentally-related criteria and data go far beyond the examples included in

Appendix C but I deemed these indicators, coupled with engineering program data, sufficient to proceed with the study case selection. The rationale for the selection of the four[20] provinces included in this comparative analysis, by province from Western to Eastern Canada, was the following:

(1) British Columbia was the first Canadian province to introduce a carbon tax and although this tax only came into effect in 2008, the province had a well-documented history of environmental and sustainability commitments including to renewable energies. British Columbia was also the only province where the provincial Association developed a formal sustainability knowledge resource for the engineering profession. The resource was made available on the internet and was aptly named Sustainability Now (APEGBC, 2008). Based on this preliminary assessment, I contend that in this comparative study the engineering profession in British Columbia will lead with the highest professional envirosponsibility.

(2) Alberta, in contrast to other provinces, was one of the country's most polluting provinces both in absolute and relative terms to its population (Pollution Watch, 2008a,b; Appendix C). None of the Alberta universities offered an environmental engineering program in 2008-2009. Alberta also boasted the highest percentage of active engineering services establishments in Canada (taking its population in consideration, but not controlling for the number of geoscientists which are excluded from Ontario and Nova

[20] The case study selection description refers to four provinces. My original project was designed to compare four provinces, including Nova Scotia. Following repeated failed attempts to initiate dialogue with the Nova Scotia provincial association, Engineers Nova Scotia (including letters, telephone calls and enlisting the help of collaborators) it became apparent that this small association was not receptive to participating in my Master's thesis research project. Given that this province's role in the data gathering was built-in redundancy, however, I was confident that removing this province from the analysis and not replacing it with another would not be detrimental to the quality of the research results.

Scotia) in addition to its engineering activity growing faster than that in Ontario in recent years (Arcturus Solutions, 2009: 9). I therefore propose that this will position Alberta at the other extreme of an environmental scale in contrast to British Columbia, and the lowest predicted professional envirosponsibility of the three provinces.

(3) Ontario, in comparison to the previous selections, appeared to be fairly typical of Canadian provinces with no outstanding environmental problems while controlling for its large population. Ontario was included in the comparative study as a contender for the middle-ground of professional envirosponsibility. By including this province I sought to ensure representation of a large population, wide range of institutions and engineering programs and a region where there was the highest percentage of Canadian professional engineers, 38% (of 152 000 in 2002) (Ekos Research Associates Inc., 2002: 4). Controlling for Ontario's population (Appendix C), the ratio of engineers to population was actually typical of most Canadian provinces (excluding Geoscientists).

Quebec was not retained as the median contender for two reasons. First, the language: with Quebec being predominantly French-speaking, the educational programs, organizational design and cultural differences might not be compatible in the case studies. Second, the legal framework: contrary to all other provinces in Canada, Quebec uses the Napoleonic Code, rendering several comparisons incompatible.

(4) Nova Scotia was the first and only province to meet the 2000 target of reducing municipal solid waste in Canada and it achieved this target with the help of engineering solutions (Nova Scotia Environment and Labour, 2004). In 2008 the Minister of the Environment spearheaded a 'Green Economy' cross-province tour

(Province of Nova Scotia, 2008). Nova Scotia was therefore selected to compare and contrast its potential professional envirosponsibility configuration with that of British Columbia, given its demonstrated commitment to the environment in municipal solid waste and other environmental projects. This province was ultimately removed from the analysis (see previous footnote for the justification).

To ensure compatibility of cross-province comparison where associations combined membership of geoscientists and engineers in British Columbia and in Alberta, the Ontario geoscientist Association was included in the investigation. Geoscience professionals undertake undergraduate education at the same accredited institutions as engineers. In Alberta and British Columbia they are governed under the same legislation as engineers, whereas in Ontario they are governed under separate legislation.

Trend Cross-sectional Time Point Selection: the selection of the years 1970 and 2009 was based on the following criteria: (1) 1970, coincides with the beginning of global environmental consciousness and sets a baseline measure for professional envirosponsibility, (2) universities have rigid and lengthy processes in place to create and obtain approval for programs by the provincial education ministries, in addition to the requirements set by EC which means that a narrow timeline between cross-sectional data would not capture change (also confirmed slow rate of change in Europe by Thom (1996: 350)), (3) the profession of engineering itself could be characterized as relatively slow in uptake of change given its legal structure and nested hierarchical organization from the global to the local levels that are the hallmark of the profession's ability to ensure international mobility (with restrictions, but existent nonetheless), especially pertinent for global projects run by multinational corporations, (4) this study is more exploratory than explanatory and therefore I deemed 2009 as an appropriate second cross-sectional year to study the change in professional envirosponsibility which has taken place in the profession of engineering since 1970.

Contextual Analysis Time Frame Selection: The proposed time frame for the contextual analysis also ranges from 1970 to 2009, in line with the time point selection. From a comparativist point of view, this time frame holds cultural and historical significance (Ragin, 1994: 5) because the first earth day was held in 1970 and this event marked the beginning of heightened environmental awareness worldwide. The impact of human-generated environmental problems has gained increasing magnitude since the 1970s and the focus on sustainability is a relatively recent phenomena.

Undergraduate Engineering Selection: I chose to focus my research on undergraduate engineering education for two main reasons: (1) in 2008 it was estimated that 77% of engineers had followed a Canadian accredited undergraduate engineering program (Arcturus Solutions, 2009: 11) and this is where an engineer gathers the bulk of engineering and environmental knowledge (Wilkinson and Walker, 2007: 32), and (2) the undergraduate degree is typically the minimum level of education required to gain access the title of professional engineer and work as an engineer in all Canadian provinces.

Envirosponsibility Sites and Indicators: The three main sites for professional envirosponsibility are: (1) Education at the undergraduate level (operationalized by indicators: program type, enrolment, curriculum content and criteria, environmentally-related library holdings including books, journals and specialized resources[21], specialized faculty[22], environmentally-related awards and scholarships for engineers, environmentally-related research chairs and research centres or units), (2) Professional Obligations (including operationalization by indicators: guidelines, professional practice exam and code of ethics, environmental governance), and (3) Legislation (operationalized by such indicators as: provincial engineering acts and association by-laws). For the three sites, relevant discourse analysis and environmental governance analysis findings were also integrated in the measure of envirosponsibility.

Elimination of Select Indicators: Following data gathering I identified serious flaws in three site of education indicators' findings: (1) enrolment in option, minor, specialization or stream environmentally-related programs, (2) number of faculty members involved in environmentally-related teaching or research, and (3) the count of environmentally-related library resources. Attempts to obtain data through alternative channels either failed or proved to be too time-consuming. I therefore judged it appropriate to eliminate these where unreliable data sources, compatibility issues or missing data proved insurmountable with the resources and time I had at my disposal.

Data Collection: The qualitative data collected were subjected to discourse analysis and/or document analysis. Data collection for discourse and documents commenced in May 2009 and continued through mid-December 2009. The first step

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[21] The 21 accredited engineering university library catalogues were searched for the keywords: "green engineering", "sustainable engineering", "environmentally conscious engineering", "environmental engineering" and "geoenvironmental engineering". Interlibrary loan services were assumed to be equivalent between institutions and were not analyzed.
[22] Specialized faculty either with environmentally-related research or teaching interests were identified from on-line resumes and research summaries.

involved communicating with engineering associations and universities that offered accredited engineering programs in 1970 and requesting access to private archives for the 1969-1970 and 1970-1971 data.

The associations contacted were EC, PEO, OSPE, the Association of Professional Geoscientists of Ontario (APGO), APEGBC, and APEGGA. A listing of the universities with accredited engineering programs that were contacted is in Appendix D. Given the academic year cycle straddles two calendar years, I included both 1969-1970 and 1970-1971 academic years in my archival searches and 2009-2010 in the 2009 search. Save for Engineers Nova Scotia, as noted earlier, all associations and universities collaborated in providing data.

EC provided me with office space, access to a computer and a digital scanner and I performed data collection on-site from July 20th to August 21st 2009. They also appointed a main contact person who helped me get in touch with all departments at EC, in addition to granting me unrestricted access to all archival records on-site and stored off-site. I reviewed the: CEAB annual reports from 1968 to 2008, CEAB minutes from 1970 to 2008, Board of Directors minutes from 1969 to 2008, Executive Committee minutes from 1969 to 2008 and individual project and program files.

APEGGA informed me that they had archived a sizable quantity of their files dating back to the 1930s and directed me to the provincial archives where they were stored. I travelled to Alberta and collected APEGGA data from September 16-20, 2009 at the Provincial Archives of Alberta in Edmonton. I inspected the content of over ninety-five archival boxes. In addition to my field notes I received copies of whole or part of one hundred and five documents following my trip.

A one-day trip to Toronto on August 10, 2009 allowed me to collect data at PEO. Data collection at PEO was precipitated and limited because of a scheduled move for the Association to a new office location, coupled with a minute book digitization project which limited my access to files. Nonetheless, I was able to gather PEO by-laws and minutes dating back to 1970. I compensated the loss of contextual data by accessing electronic copies of PEO's Engineering Dimensions Magazine and Association documentation on the PEO website.

APEGBC provided me with copies of the Association's code of ethics, statutory mandate, laws, regulations and by-laws from 1970 to 2009 by mail. The Association appointed contact person also shared contextual information in email exchanges.

The 1970 archival data collection from universities was coordinated via email and telephone communications. Printed archival materials were sent to me by postal service. Two exceptions to this method of data collection were Carleton University and the University of Ottawa where I visited the archives and collected the data in person. When a university did not have at least one accredited engineering program in 1970, I did not include any other engineering courses or programs (typically non-bachelor engineering programs) in the data collection for 1970 in order to capture only compatible program types accredited by the national engineering Association. In the 2009 data collection I applied the same 1970 criteria requiring at least one accredited program, and if this criterion was met, I included yet to be accredited[23] bachelor engineering programs, while still excluding non-bachelor programs.

In order to gather enrolment data for engineering program streams or options related to the environment that were not reflected in main program statistics I contacted engineering faculty deans directly. Although collaboration from deans was very good, I encountered difficulties with data compatibility (i.e., years of data missing, not all levels incorporated in the statistics) or unavailable data due to data archival methods. In the end I opted to forego full comparison of stream or option program enrolment, but did include trend analysis where I deemed it appropriate and sufficiently justified.

The 2009 data collection was almost entirely performed based on information from the provincial and national organizations' or universities' websites. This electronic data collection mode was optimal as many universities advised me they had discontinued printing program calendars.

Data collected from universities included a description of each engineering program offered including its curriculum with mandatory courses and electives. The course descriptions used for discourse analysis were the short texts included in undergraduate university calendars. The rationale for using these short descriptions instead of full course syllabus was based on three criteria: (1) obtaining full syllabi proved to be an insurmountable task for the short duration of my Master's program as I was advised by most departments and faculties that they did not have a central repository

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[23] Accreditation by EC's CEAB requires that at least one cohort has graduated before the program is granted accreditation. Programs that have recently been launched, therefore, are not yet accredited but are in the process of acquiring accreditation. In British Columbia I excluded the British Columbia Institute of Technology (BCIT) engineering programs as these had not yet received CEAB accreditation.

for syllabi. Any copies I could obtain, therefore, would have been by contacting professors directly, a logistical challenge which would no doubt have left me with gaps in data, (2) short course descriptions were available for all courses in Canadian universities, and were readily available from official registrar website university calendars, and (3) I reasoned that because these short course descriptions had a goal to promote courses, universities would ensure that the most salient elements of the course would be purposely included in the description or the title. Therefore I deduced that if the environment or an environmentally-related topic was included in the short text, this discourse could serve as an indicator of the extent of integration of the environment as a consideration in the courses and curriculum.

Unit Mean Measurement: at the site of education, mean measurements reflected the mean unit measure per institution in the respective province unless otherwise noted. The mean/institution descriptive statistic in contrast to a per-capita mean best portrayed, I reasoned, the provincial unit of measure all the while (1) controlling for provincial population variations reflected in the number of institutions, (2) embodying a measurement of EM for the given indicator, and (3) reflecting potential student population exposure to the unit measured in the respective institutions.

Discourse Analysis Document Selection: selection of the documents I subjected to discourse analysis followed a two-step process as described in Figure 2. In the first step, I analyzed documentation mostly at three levels of the engineering profession's governance in Canada, national, provincial and university levels[24], and developed a

[24] The environmental governance structure presented in chapter two included the international and municipal levels, though not directly within the scope of this research, but of importance in the profession.

schematic of environmental governance for the profession in the three selected provinces. The overall governance schematic is presented in chapter two alongside an analysis of relations of power and a discussion on EM in the profession based on the governance model. Next I investigated the types of documents where environmental discourse was held and made a final selection based on (1) compatibility of documents across provinces to ensure comparative analysis, (2) availability for all units of comparison and, (3) to the extent that it was possible, that they adequately reflected the maximum number of levels of environmental governance in the profession. An abbreviated discourse analysis code book is in Appendix E. I employed AtlasTI software to code and quantify discourse analysis. Interpretation is presented in chapter three.

The final selection of English-only texts[25] included: (a) short course descriptions that included reference to the environment, (1) a total of 536 (88 in B.C., 397 in Ontario, 51 in Alberta) from 2009-2010 official undergraduate university calendars for all engineering programs, including optional courses and approved electives for engineers (i.e., chemistry, biology) collected between September and December 2009 and, (2) a total of 36 (7 in B.C., 23 in Ontario, 6 in Alberta) short course descriptions from 1969-1970 and 1970-1971, excluding duplicates[26] from official undergraduate university calendars for all engineering programs, excluding optional courses and electives that were not engineering-coded (i.e., chemistry, biology)[27], from universities with accredited

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[25] The French-language courses offered within accredited programs were duplicate courses already offered in English and were excluded from analysis to remove language and culture-related discourse variation.
[26] For the 1970 year I investigated 1969-1970 and 1970-71 short course descriptions, excluding duplicates, as these were available in print format and could be analyzed separately. For 2009 this was not possible as web-based university calendars did not always permit differentiation between academic years.
[27] Archival data provided by the Universities did not always contain approved non-engineering electives. I therefore opted to exclude all non-engineering course descriptions from 1970.

engineering programs[28] (university-level texts), (b) four association by-laws and codes of ethics as well as the national guideline code of ethics (provincial and national levels) in 1970 and 2009, as available, (c) four provincial professional engineering and/or geoscientist Acts in 1970 and 2009 (provincial level), (d) one national (EC) and four provincial environmental guidelines for 2009 as they did not exist in 1970 (provincial and national levels), and (e) CEAB curriculum criteria from 1970 to 2008 for engineering program accreditation (national and university levels).

I debated at length whether or not to include the syllabus and preparatory documents for the Professional Practice Exam that all engineering candidates must undertake, in addition to meeting the criteria listed previously in order to become licensed and members of a provincial professional association. After thorough analysis of the key role these exams play in the Canadian profession of engineering (admittance to the profession is contingent on passing the exam) and the lead role of Alberta in its development, I chose to investigate further and subjected the preparatory documents made available by provincial regulatory associations (now item f) to analysis.

Finally, I opted to exclude examination syllabi from discourse analysis as these syllabi are developed, for the most part, to help foreign-educated engineers ready themselves for the examination to join a Canadian engineering association or *ordre*[29]. In 2008 this examination process used by approximately 3.2% (Arcturus Solutions, 2009: 11) of members reported having qualified through the examination process, a percentage that I deemed low. I elaborated further on my decision in the limitations section.

[28] Two universities provided 1970 university calendars with no course descriptions, only course titles. These were coded in function of course titles only.

[29] Mandatory for engineers who did not obtain their undergraduate degree at an accredited program.

Ecological Modernisation Theory and Theoretical Tools

The main theoretical framework guiding my research was EMT. The 1980s marked a major turning point with respect to understanding and knowledge generation on the unrelenting deterioration of western industrial society sustenance bases which prompted European sociologists to investigate how environmental crises were dealt with by modern industrialised societies (Mol and Sonnenfeld, 2000: 3, 5) and how an 'ecological rationality' was developing "...as a relatively independent epistemology alongside economic and political rationalities" (Mol et al., 2009: 7). European sociologist Joseph Huber laid the foundations of EMT and thus moved away from the realm of the sociology of environmental devastation to focus on the sociology of environmental reform (Mol et al., 2009: 3) that he and his contemporaries were witnessing in Europe (Hajer, 1995; Cohen, 2006: 530; Mol et al., 2009: 3). In this reform, environmental issues and concerns were anchored in market and economic activities, shifting the environment from externality to internality. EMT has since developed into a global concerted interdisciplinary effort "...to formulate more general explanations of current transformations of environmental practices, discourses and institutions" (Mol and Sonnenfeld, 2000: 3, 5).

In spite of its shortcomings, some of which I address, EMT appeared to be a well-suited theoretical framework to investigate the profession of engineering in Canada. Figure 1 describes the interaction between EMT and my comparative methodology.

From Huber's early visions of superindustrialisation based on ever-improving technological advances or hyper-technocentric ecological modernisation of old industries

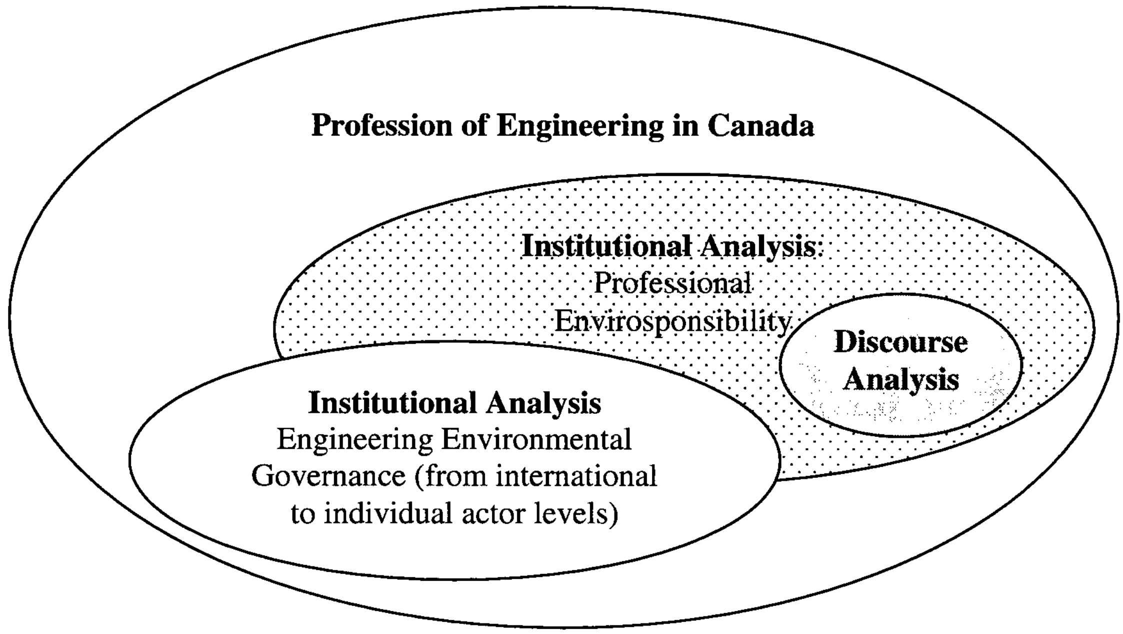
(Cohen, 2006: 530), Mol, Spaargaren and other social science scholars have developed a more comprehensive EMT (Deutz, 2009: 275; Mol et al., 2009: 4) integrating the role of the State, structures, actors and their interactions and corresponding environmental policy. EMT can be said to have progressed through three phases in its evolution. The first phase was industry-focussed on technologically-oriented environmental reform innovations in industrialised countries in the early 1980s. The second phase in the late 1980s to the mid-1990s granted the State and institutional and cultural dynamics their due role all the while reducing the focus from technological innovation as core to EM. Finally, in the third and current phase from the mid-1990s and beyond EM has evolved significantly theoretically and in geographic span to include non-European countries and widened its interdisciplinary theoretical reach (Mol and Sonnenfeld, 2000: 4-5) to "...the study of processes of institutional and societal environmental reform that is globally relevant..." (Mol et al., 2009: 9). This investigation joins the wave of third phase non-European country studies looking at institutional environmental reform in a Canadian profession with local to global environmental governance.

Of particular relevance to my research was Christoff's (1996) characterization of EM as weak when based solely on technological improvement to strong where it integrated policy and structural components that allowed for technological improvements to occur (1996: 490). I adapted Christoff's characterization for this analysis. I identified discourse or restructuring as weak and early stage EM if they were framed as end-of-pipe, whereas comprehensive integration of ecological, economic and social considerations in policy and governance I characterized as strong and mature EM. This scale also allowed me to gauge where the profession stood to contribute to weak or strong EM in Canada within an EMT framework. These characterizations were based on document analysis and the profession's environmental governance structure schematic proposed in chapter two.

To Christoff's characterization of strength, I added depth of EM integration. Where evidence of EM was uncovered, to what depth had EM integrated the profession, did it reach the core or did it remain at the periphery? I investigated depth of EM based on the environmental governance structure schematic proposed in chapter two and discourse analysis in chapter three.

From at least three EM theoretical foundations, systems theory, institutional analysis and discourse analysis (Mol and Sonnenfeld, 2000: 12), I designed my research project to merge discourse analysis and institutional analysis as represented in Figure 3. The institutional analysis facilitated the generation of the environmental governance structure schematic and comparative analysis of the concept of envirosponsibility. Discourse analysis and institutional analysis as well as their related theoretical tools are presented below. The use of hybrid theoretical tools to study EM in the profession of engineering helped me address, at least in part, a recurring critique of discourse analysis as a weaker indicator of EM when contextual, institutional and systemic information is ignored (Davidson and MacKendrick, 2004; see discussion in Mol et al., 2009: 3-14). As depicted in Figure 3, the narrow understanding of the profession of engineering offered by discourse analysis was expanded and to some extent triangulated through the use of institutional analysis with professional envirosponsibility and environmental governance.

Figure 3: Conceptualization of Hybrid Discourse Analysis and Institutional Analysis Tools to Investigate EM in the Profession of Engineering



As a first theoretical tool, I drew on Hajer's (1995) framing of ecological modernisation through hegemonic discourse on the environment which in turn influences social structures or institutional arrangements. Hajer coined this process as "discourse institutionalization" (1995: 61) where EM is incorporated into policies and new institutional arrangements (1995: 61). This approach allowed me to explore environmental discursive construction in the profession of engineering in Canada. I retained the following definition of discourse: "...a specific ensemble of ideas, concepts, and categorizations that are produced, reproduced, and transformed in a particular set of practices through which meaning is given to physical and social realities" (1995: 44). Furthermore, I also adopted Hajer's concept of "story-lines" that "...provides the narrative that allows the scientist, environmentalist, politician, or whoever to illustrate where his or her work fits into the jigsaw" (1995: 63). As an analytical tool, story-lines not only help to socially construct an issue they also help to shape the social and moral dimensions of this issue in the area of interest (1995: 64).

Working from the assumption that environmental issues are socially constructed further reinforced my use of comparative methodology to capture inter-provincial variation (1995: 6). These variations were studied at every step of analysis including environmental governance, environmentally-related discourse and finally professional envirosponsibility.

At its core, EMT-based research peers into how environmental concerns are integrated in institutions' and individual actors' everyday lives and relationships, including relationships with the environment (Mol et al., 2009: 4) or how the social organization has been transformed or adjusted to integrate environmental considerations (Cohen, 1998: 150). Nestled within the EMT framework, I worked in one of three EMT perspectives, investigating change in a core modern science and technology-oriented social institution (Mol and Sonnenfeld, 2000: 5), the profession of engineering in Canada. The EMT lens was also ideally suited to analyze the profession's environmental governance structure including an analysis of power relations and the profession's input in governmental policy-making at all levels, as a starting point to identify texts for discourse analysis. From an environmental governance perspective, changes between 1970 and 2009 could signal a shift toward 'plural regulatory networks' where non-State actors take part in decentralized regulation and take responsibility for public policies (Barkay, 2009: 361).

To perform institutional analysis, I adopted four of five levels of analysis in Hollingsworth's (2000: 601) structured multi-disciplinary approach: (1) 'Institutions' (i.e., norms, rules, conventions and engineering values), (2) 'Institutional arrangements' (including hierarchies, networks, associations, communities), (3) 'Institutional sectors' (in this study the system of education), and (4) 'Outputs and performance' (including regulation, administrative decisions and how the profession regulates professional environmental performance). From the most stable and 'permanent' first level of analysis, institutions, with Canadian and international norms, rules and environmental values (2000: 604), the analysis progressed to institutional arrangements and institutional sectors in chapters two, three and four and finally the most variable and transitory level, the outputs and performance in the profession in chapters three and four.

I also borrowed from Hayden's normative analysis approach to empirical institutional research summarized in Appendix F. Hayden advanced that "[s]ociety has lost the institutional ability to make [social belief, technological, and ecological criteria] consistent with each other and consistent with an instrumental flow of events and actions in its processing institutions. The dominant norms are in conflict; therefore, the subnorms, as well as the consequent rules, regulations, and requirements for directing action, are conflicted" (Hayden, 2009: 115-116). I integrated analysis of the co-existence of social belief, technological and ecological criteria, especially with regard to the profession's environmental governance in chapter two and duty, obligation, responsibility and education in chapters two, three and four. Hayden's institutional analysis tool readily embedded itself into EMT where, I argue, increased incidence and deeper integration of Hayden's three criteria reflected stronger EM in the profession.

As the main focus of my research was not institutional analysis, its theoretical tools played a mainly supportive role to EMT. I also used institutional analysis as a triangulate tool with discourse analysis findings, within comparative methodology.

Limitations

I have identified at least five non-critical limitations in my research project. In this section I briefly address each limitation, the implications for my investigation and how these limitations could be circumvented in future research.

First, by not integrating interviews or other direct contact with actors this research design might have concealed insights into processes and structures. Given the exploratory nature of this study, however, I did not deem this limitation to be a significant drawback. Future investigations would probably gain by incorporating qualitative interactive research methods in the study design.

Second, complete engineering course syllabi for all courses would have enabled me to confirm the inclusion of environmental topics in engineering courses. As previously described, however, gaining access to these was not possible within my Master's short program timeframe. As discussed in the data collection section, this limitation was not deemed critical for this study.

Third, I did not investigate complaints and discipline proceedings used by this profession to enforce professional conduct with regard to environmentally-related infractions. The lack of data from Ontario, for reasons outlined earlier, would have prevented me from engaging in comparison between the three provinces. A more extensive research might consider adding these, keeping in mind that Hyde (1999: 11) cautions their appropriateness as indicators of environmental guideline effectiveness.

Fourth, my analysis limited its focus on Canadian-educated undergraduate engineering students in CEAB-accredited programs and did not take foreign engineers joining the profession into consideration. Given that an estimated 77% of engineers qualified through graduation from a CEAB-accredited program in 2008[30] (Arcturus Solutions, 2009: 11), I was confident my selection represented almost the totality of Canadian-educated undergraduate engineers as well as a large segment of engineering professionals.

Lastly, and related to the fourth limitation, I opted to exclude examination program syllabi from discourse analysis in spite of its environmentally-related discourse. The examination process is used when an engineer did not complete his undergraduate degree in an accredited program. Preparation for the process relies on institutionally-generated syllabi and was used by only 3.2% of engineers in 2008 (Arcturus Solutions, 2009: 11). I deemed this a small set of actors that did not justify the investment in time and resources that would have been required.

Contributions of the Research

My research can contribute chiefly to two environmental knowledge dialogues in sociology: the dialogue on EM in Canada and its relationship with the profession of engineering and the dialogue on environmentally-related engineering education. To a

[30] 2008 data: British Columbia had approximately 77% and Ontario 65% CEAB graduates (Arcturus Solutions, 2009: 20)

lesser extent, my research can also contribute to the dialogues on and knowledge of the sociology of professions and the governance of science. Following is a synopsis of potential contributions to the advancement of knowledge in the two former areas.

Located at the epicentre of EM research this investigation focuses on one of the precursor elements to State EM: the profession and the actors in engineering who plan, design and ensure execution of industrial processes and infrastructure projects and who hold privileged knowledge positions to ensure environmental integration at every step. The investigation thus becomes a unique opportunity to examine if and to what extent environmental considerations were integrated in the Canadian engineering profession nationally and in three provinces from 1970 to 2009. EM as a theoretical framework allowed me to gauge where the profession of engineering was situated vis-à-vis the environment and what role it played or could potentially play in ecologically modernising Canada. My investigation could contribute to a better understanding of pieces of this puzzle at four distinct sites of interaction or expressions of interaction between the profession and the environment: engineering education, environmental governance from the national to the individual engineer level, engineering environmental discourse and comparison of envirosponsibility in three provinces.

By looking at how the profession of engineering generated and governed educational accreditation criteria, the power dynamics and actors involved as well as how these were integrated in the environmental governance of the profession, my research could also contribute to knowledge in the field of environmentally-related engineering education.

CHAPTER TWO: The Profession of Engineering's Environmental Governance

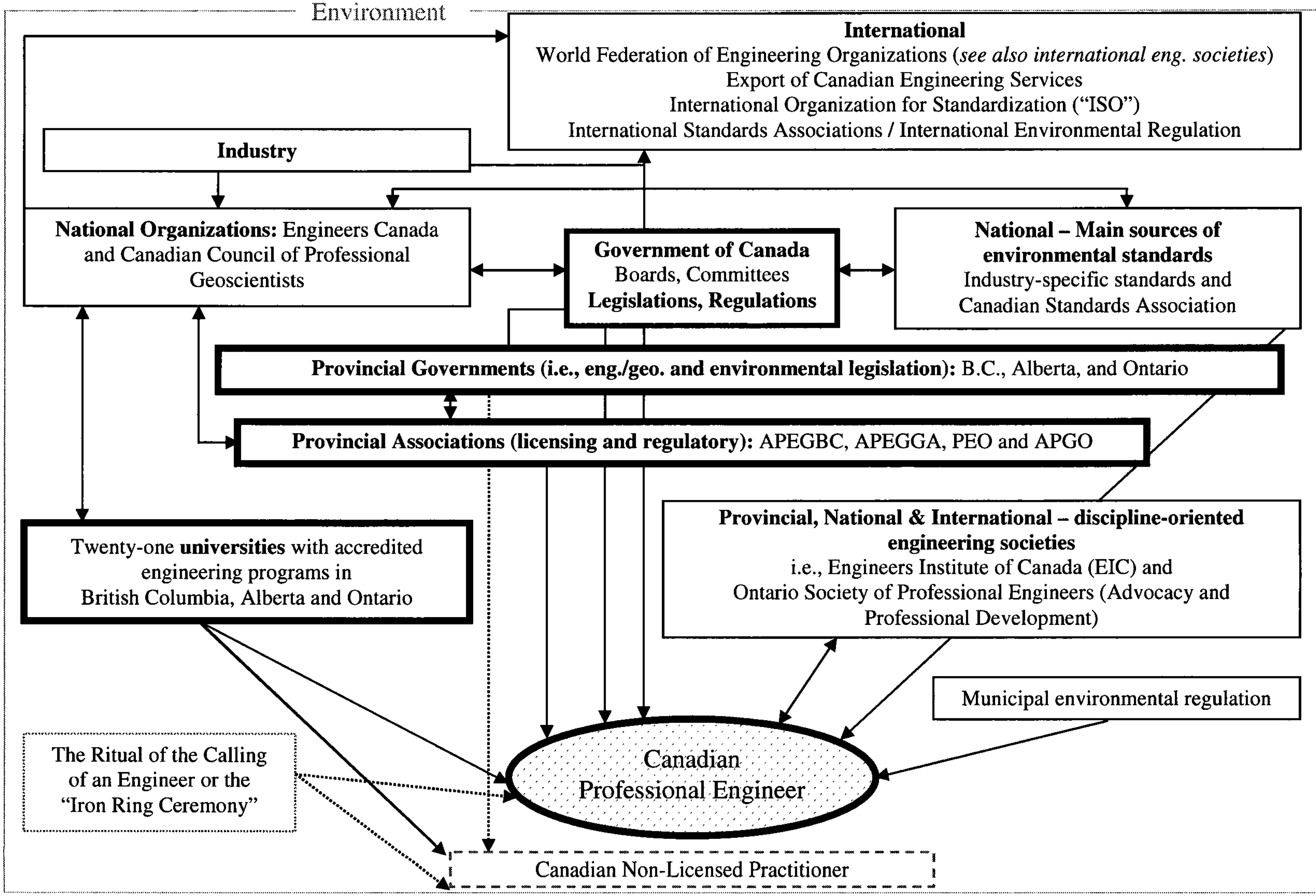
I retained the following definition of environmental governance for the purpose of my research, "…the formal and informal institutions, policies, rules, [and] practices that shape how [Canadian engineers] interact with the environment at all levels of [the profession of engineering's] social organization" (adapted from The School of Global Environmental Sustainability, 2009). My reliance on document analysis narrowed my focus mostly on the formal institutions, policies, rules and practices in the profession. The outcome of this analysis guided the selection of chapter three discourse analysis documents with due consideration for proper representation of the most salient governance levels.

The Canadian profession of engineering's environmental governance structure that emerged from document analysis[31] is presented in Figure 4. Details at the provincial level are based on the three provinces under study, British Columbia, Alberta and Ontario. This analysis allowed me to begin tackling the question, 'has ecological restructuring occurred in the profession of engineering in Canada?', and if so, 'how and to which depth?'

Figure 4 does not imply a governance structure from the international to the individual level; the schematic represents governance from global to local solely for ease of reference. The thick-contoured delineations for the individual professional engineer, the accredited universities, the federal and provincial governments and provincial associations are direct salient links in a Canadian-educated engineer's practice.

[31] Sources include: Andrews, 2009; Andrews et al., 2009, EC archival documents and APEGGA archival documents.

Figure 4: Representation of Environmental Governance in the Engineering Profession in Canada at the International, National, Provincial (B.C., Alberta and Ontario). Municipal, University and Individual Engineer Levels in 2009.



Other levels of environmental governance played constant, intermittent, direct or indirect roles at varying degrees during the professional's career are also discussed.

Under this governance, the Canadian professional engineer encompasses non-licensed practitioners supervised by the latter. The dotted contour for the non-licensed practitioner designation and select arrows emphasize their relative autonomy within the environmental governance schematic. Non-licensed actors are subject to partial analysis.

In order to observe transformation trends in environmental governance, I first investigated the 1970 baseline year: (1) in British Columbia I uncovered reference to the environment in the then applicable code of ethics; (2) at the national level and in Alberta I documented several instances of discourse similar to Dinsmore's opening quote[32]; and (3) provincial environmental legislation was starting. I encountered no other formal environmental committees, policies or structural elements either at the national or at the provincial levels. Environmental governance observed in 2009, therefore, would be evidence of EM and ecological restructuring that occurred over the ensuing 39 years. An assessment of the strength and depth of EM integration is pursued in chapter three.

International Level

From the outset of my investigation, I did not foresee analysis at the international level, but it quickly became apparent that the profession's environmental governance had a global reach with 18.3% of Engineering Services exported to clients outside of Canada (Statistics Canada, 2007). Internationally the interaction between education, industry, individual engineers, regulations and international societies and international standards,

[32] This type of discourse is apparent in the 1970's EC and APEGGA archival materials including meeting minutes and newsletters.

including the well-known International Organization for Standardization (ISO)[33] wove a complex web of professional-environment interactions. Canadian engineers' practice and environmental education's spatial scope spanned from the local to the global.

Of significance at the international level, EC, representing its constituent members at the World Federation of Engineering Organizations (WFEO), has been hosting the Standing Committee on Engineering and the Environment (WFEO-CEE) since 2007 and will conclude its term in 2011 (EC, 2009d: EC3). Through this committee, EC also held a voice at the United Nations (UN) table, the UN Educational, Scientific and Cultural Organization (UNESCO) where Canada's Chair participated in meetings at the UN Commission on Sustainable Development and the UN Framework Convention on Climate Change (UNFCCC) (EC, 2009d: EC3). Additionally, EC's work on the Engineering Vulnerability Assessment Protocol, a tool developed within the Public Infrastructure Engineering Vulnerability Committee (PIEVC) with partners such as Natural Resources Canada (NRCan), was eyed for international release by the World Bank (EC, 2009d: EC1). EC was also involved with the WFEO-CEE to develop international environment and sustainability guidelines for engineers, modelled on Canadian guidelines (ESC, 2008: 5). Exportation of Canadian engineering expertise and profession-environmental interactions was also evident in voluntary involvement with the Canadian branches of RedR (where Canadian engineers were praised for their water and waste water management expertise (RedR, 2009)) and Engineers Without Borders.

Geoscientists were also often called upon to work on international projects. Internationally acceptable practice standards, guidelines and criteria for reporting,

[33] ISO coordinate the environmentally-related ISO 14000 standard series.

including environmental considerations, were made available by organizations such as the Society of Petroleum Engineers and the Committee for Mineral Reserves International Reporting Standards (CRIRSCO) for the exploitation of oil and gas and mineral resources/reserves (CCPG, 2009a). In addition, the CCPG maintained close ties and entered into international co-operative agreements with other regulatory geoscientific organizations worldwide (CCPG, 2009b).

National Level

At the national level I focussed archival research on EC since the CCPG was established in 1996. In 2007 the two organizations entered into a cooperative agreement recognizing their similar objectives and shared membership where provincial organizations represent the same engineers, geologists and geophysicists (CCPG and EC, 2007). The national organizations operate by consensus where all constituent members must agree to decisions, including those that impact national guidelines, codes, standards, policies and, ultimately, engineering practices.

At EC, environmentally-related issues highlighted regional discourse and social constructions that in turn impacted production and reproduction of environmental knowledge and discourse and EM. For example, discordant constituent views such as the APEGGA's hegemonic social construction of climate change as not human-generated (APEGGA, 2009) contributed to EC engaging in 'multi-social construction' professional responsibility discourse. Following is an example of the latter: "Three ways engineers can look at climate change: (1) if you believe the climate is changing and it is caused by man, then mitigate to slow the rate of change to give time to adapt (i.e., mitigation AND adaptation); (2) If you believe the climate is changing but not because of the impact of man, don't bother with mitigation, and focus on adapting to the changes; (3) If you don't believe in climate change at all, consider the public and our clients today have a lower risk tolerance for liability and legal reasons (social impact); Engineers' code of ethics instructs us to perform due diligence to ensure the risks of climate change, if any, have been properly assessed, accounted for, and adapted to, as necessary" (Lapp, 2005: 19-20). Regardless of which climate change social construction constituent members adhered to, EC reiterated the professional's responsibility and obligations. Are the minimal engineering environmental educational requirements sufficient, however, in order for engineers to be able to meet professional obligations set with respect to the environment? I revisit this question in subsequent chapters.

Organizationally, EC first established an environment task force in 1993 that evolved into today's Environment and Sustainability Committee (ESC) working under the CEQB. The ESC initiates, participates in and liaises with government committees and task forces (i.e., PIEVC, Task Force on Climate and Surface Water Design Values, Asia Pacific Partnership on Clean Development and Climate (AP6)) (ESC, 2008: 4-5) and is involved in environment and sustainability-related issues, standards, codes and policy bridging provincial, national and international environmental governance. The first national Environmental Practice of Professional Engineering Model Guidelines[34] were produced in 1995, modelled on the inaugural Canadian Environmental Practice Guidelines put in place by the APEGGA in 1994.

[34] National Model Guidelines are not binding for provincial associations or their membership, but guidelines can be adopted as is or adapted by member organizations.

CCPG for its part did not appear to have an environmental or sustainability committee in its organization chart and offered no national guidelines specifically on the environment or sustainability[35] to its constituent members. Its environmental governance was therefore limited to the international relationships described above and as integrated sub-components of select guidelines, policies and minimum requirements recommendations for the professional practice of geosciences in Canada.

Both national organizations liaised with the federal government and national standard organizations with participation in committees and task forces as well as provided input in legislation, regulations, standards, guidelines and codes. The four main federal government environmentally-related acts are the *Canadian Environmental Protection Act*, the *Fisheries Act*, the *Canadian Environmental Assessment Act* (Andrews, 2009: 313) and the *Pest Control Products Act* (Pollution Watch, 2009). The CSA and industry-specific organizations set environmentally-related standards and codes in Canada and these are sometimes harmonized with international standards (such as ISO) with potential input from EC or CCPG. For their part, national discipline-oriented engineering societies and organizations such as the Engineers Institute of Canada (EIC) provided and coordinated environmentally-related professional development in addition to member activities and knowledge dissemination.

CEAB Members

As discussed previously, EC sets the criteria and approves changes for program accreditation. The EC's CEAB standing committee ensures accredited engineering programs in Canada meet or exceed minimum educational standards acceptable for

[35] Some CCPG national guidelines include environmental considerations.

licensure, including environmental and sustainability considerations, and performs periodic reviews of accredited programs across Canada. CEAB criteria change recommendations proposals are submitted to the EC Executive Committee for approval. The CEAB plays a critical role in all Canadian engineers' education. Therefore it is fitting to ask, who are the CEAB committee members? Given the committee's significance with respect to curriculum content, the make-up of the ten to sixteen-member volunteer committee from 1975 to 2008 is presented in Appendix G. All members must be P.Eng or *Ing.* and, as stated earlier, P.Eng majority requirements were also imposed on accredited universities' curriculum committees (see note 15). Industry-based membership representation fluctuated from as low as 8% of members in 1983 to a peak of 50% in 2002. The petroleum industry never surpassed the 20% of members it held in 1975 and 1976. The largest membership was typically held by universities with the lowest in the 40% range for some years and from 2004 a gradual increase to its strongest representation in 2007 and 2008 of 75% of the membership. What is the potential impact of the CEAB member make-up and curriculum considerations? Following is my attempt to tackle this question.

In Figure 5, I superimposed the timeline of select[36] environmentally-related considerations integration in the curriculum criteria with the CEAB membership composition in Appendix G. The committee composition in percentage of total membership, details the professional engineering actor representation from universities, the private sector (including Oil and Gas), government (from municipal to federal levels)

[36] Selection was based on significance of changes proposed, i.e., new environmental or sustainability requirements or policy statements.

and EC representation. One striking feature of the timeline, notwithstanding 1973 where membership data was unavailable, is that the larger or smaller representation from the private sector did not seem to hinder inclusion of environmentally-related criterion changes, not even the presence of an oil and gas sector member in 2002.

Probing further, could member environmental knowledge levels be a factor? What I believe could be an important element is the seeming absence of environmentally-trained engineers, including civil engineers[37] on the committee. In 2008 civil engineering ranked third in number of programs offered in Canada (Andrews et al., 2009: 7), yet appear underrepresented. A notable presence in the 2008 member list, however, was Hyde[38] who investigated environmentally sensitive education for engineers and noted that "...[critics external to engineering] are rare. Their access to decision-making power in engineering education is not confirmed" (Hyde, 1999: 29). As an insider, Hyde now can now exercise environmentally-informed decision-making power within the CEAB.

The CEAB member analysis tied into Vanderburg's (2007) critique of the profession's challenges in self-regulation when it interprets its duty to protect public interest through a narrow technical lens (2007: 2). The environmental governance and CEAB Member analysis allowed me to uncover some of what I would qualify as 'structural rigidities' (Janicke, 2004: 204) within the profession that would contribute to its reluctance to embrace widespread change. Mastromatteo recently commented, "[f]or

[37] Identifying member discipline was difficult as relevant information was not always available; categorization was performed based on available data and keeping in mind that not all civil engineers hold high levels of environmental engineering education.

[38] Rosamund Hyde performed her doctoral research and subsequently published several articles on environmentally sensitive practice in engineering.

a profession struggling with its moral obligation to use technology for the greater public good, engineers might want to consider developing their own fluency in the wider

Figure 5: Timeline of Select Environmentally-related Accreditation Criteria Content Requests and Modifications and CEAB Membership Composition[39] from 1970 to 2008[40]

	1973	1994	1996	2002
Environmentally-related accreditation criteria requests and modifications	Ontario member suggests adding a mandatory 'Environmental Responsibility' course to all engineering programs (CAB, 1973a: 4). CAB did not see fit for engineering programs to have a specific course dealing with 'environmentalism'. (CAB, 1973b: 6)	APEM requests adding sustainable development in CEAB policy statement and OIQ requested including environmental studies in the curriculum. (CEAB, 1993: 7-8). CEAB modified criterion 2 to include the concept of sustainable development as program content (CEAB, 1994: 3)	Approved incorporating environmental studies and stewardship compulsory components in criteria 2.2.4 and 2.2.8 (CEAB, 2006: Appendix A)	Environmental considerations added to criterion 2.2.3 on Engineering Sciences and Engineering Design (CEAB, 2002: 11-12)
Committee Composition	Committee composition unavailable	1993 – 57:29:7:7 1994 – 50:36:7:7	1996 – 50:36:7:7	2002 – 43:50:0:7

climate debate" (2009b: 32). The unknown environmental knowledge level and input in the CEAB in light of the profession's sole reliance on licensed members who were undoubtedly themselves exposed to minimal environmental education combined with the lack of external oversight are structural rigidities that, I advance, hindered EM in engineering education when contrasted to the multiple levels of environmental governance and professional obligations required of practicing engineers (Hyde, 1999: 7-14; and analysis in this chapter and chapter three).

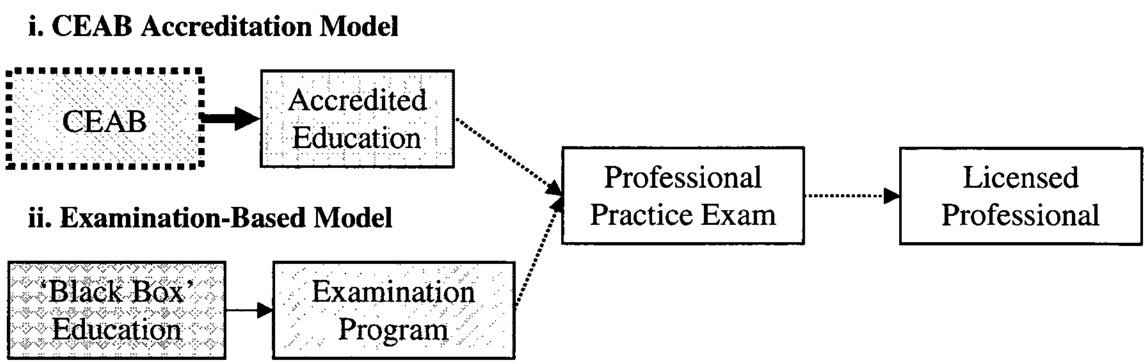
[39] Committee composition in a given year: percentage of members from University: Private Sector (including Oil and Gas): Government: EC representation. See Appendix G for details.

[40] Based for the most part on the analysis of CEAB minutes and annual reports. CEAB membership composition is only available from 1975-2008.

CEAB Accreditation Process

I have alluded to the CEAB accreditation process' EM potential on several occasions. To illustrate the process' untapped EM capacity, in Figure 6, I contrasted the CEAB accreditation process with the examination program process for individuals who did not complete an undergraduate engineering degree in an accredited program. In the examination program process students possess an engineering degree that I label as 'black box' education and their engineering credentials are qualified through an examination program. Where the processes diverge, with the accreditation process leaping ahead in EM capacity, I argue, is by having the potential to expose both future licensed and non-licensed practitioners to comprehensive environmentally-related education that can be readily adapted within the current institutional governance to meet ever-changing environmental challenges and knowledge. This flexibility and potential for in-depth integration of environmentally-related education lends strength to and creates an opportunity to foster strong EM in Canadian engineering education. The CEAB actor members, within the EC institutional framework, hold the reigns of power to this process.

Figure 6: Comparison of Accreditation-Based and Examination-Based Education Processes for Engineering Candidates



I contend, however, that in order to reach strong EM, environmentally-related curriculum would need to move beyond the minimalist typical two survey course environmental content currently in place. To meet environmental demands made of engineers, curriculum EM would need to include integrated environmental curriculum for all disciplines such as models proposed by Vanderburg (2007), Crofton (1995, 2000) or the CSA (Mortimer and Walker, 2007) model specifically for climate change and civil engineers (see discussion in chapter one). Furthermore, software and computer engineering are lauded for their environmental solution capacity with Green IT (Tomlinson, 2010) yet I found no evidence of environmentally-related content in software or computer engineering programs in the three provinces under study. Another example of environmentally-related needs not being met by minimalist environmental education was in electrical engineering. The B.C. Sustainable Energy Association identified electrical engineers' lack of renewable energy training as one of the barriers in the development of small-scale renewable energy in British Columbia (Dauncey, 2010).

With the accreditation process model, the profession has the potential to retain a pivotal actor role in producing and reproducing environmental knowledge and ensuring its dissemination to students and consequently both licensed and non-licensed practitioners. With the examination process, on the other hand, only tested knowledge can be ascertained. Notwithstanding efficient testing methods, knowledge measurement can at best only be partially achieved with limited insight into its comprehensiveness and depth.

Provincial Level[41]

The provincial level analysis involved such indicators as legislation, professional obligations and structural components. A listing of provincial environmentally-related and engineering and/or geosciences acts is presented in Appendix H.

The most recent of these acts is the 2009 Ontario *Green Energy Act* that appeared to have initiated a struggle between British Columbia and Ontario to gain dominance in securing alternative power investments in the respective provinces (Hunter, 2010). Several new energy-related engineering programs were also launched or reframed in Ontario universities in conjunction with the new Act[42] (COU, 2009).

Looking at the engineering and/or the geoscientist acts from a governance perspective, Ontario demarked itself with the only exemption clause in the provinces under study. Environmentally-related acts also varied by province with additional legislation in British Columbia where the only Carbon Tax was enacted in Canada and Ontario with its *Environmental Bill of Rights Act* and the new *Green Energy Act*. A unique feature of the *Environmental Bill of Rights Act* was that it should, in principle, give a voice to the environment, usually a silent actor.

To further probe provincial differences and similarities, I performed an analysis of two tools used under professional obligations, both important components of environmental governance: environmentally-related guideline summaries and the codes of ethics. Discourse analysis is performed in chapter three therefore I focus this

[41] Unless otherwise noted, PEO, APEGGA and APEGBC and other provincial organization data reported in this section was obtained from the respective associations' websites.
[42] An example of a new Ontario-based program is a Mechanical Engineering Program designed following a sustainability framework that includes a wind and solar energy stream (COU, 2009: 20).

comparative analysis on a governance standpoint. This means comparing content for governance-related elements with particular attention to the legally-binding wording used, such as the difference between the terms 'should' and 'shall', with the former used to imply voluntary compliance and the latter usually perceived as enforceable by the association (Andrews, 2009: 316) or use of the term 'may' indicating action that is permitted (APEGGA, 2004: i).

EC's nine environmental guideline precepts in Appendix I are almost identical to those from which they were inspired at APEGGA (Andrews, 2009: 315). Slightly modified EC guidelines were also found at PEO. The APEGBC guidelines broke from the APEGGA model and offered a unique sustainable governance perspective. Due to the generic nature of the guidelines applicable to all engineering disciplines, engineers are also required to comply with their discipline specific regulations (2009: 316).

PEO incorporated its environmental guidelines "Environmental Guidelines for the Practice of Professional Engineering in Ontario" within the PEO "Guideline to Professional Practice". The APGO for its part did not produce stand-alone environmental guidelines although it incorporated some environmental references in select guidelines, including the mining exploration, groundwater, and environmental geoscience guidelines. APEGGA provided its members with the "Guideline for Environmental Practice" whereas in British Columbia APEGBC developed "Guidelines for Sustainability".

APEGGA was the only Association to use the enforceable term "shall" in three of its precepts, perhaps giving the Association more opportunity for enforcement through its code of ethics (Andrews, 2009: 316). The professional engineer's prudent judgement while balancing potentially competing interests still prevailed, however, even in instances of breaches of guidelines using the wording "shall" (APEGBC, 1995: 5). As with the national guidelines, APEGGA incorporated definitions for the environment and other pertinent terms. It defined the environment as "The components of the earth…" followed by a listing of what this included (APEGGA, 2004: 2). The definition proposed appeared vague yet all-encompassing and brought to fore the engineer's educational requirements to comprehend responsibilities and obligations relating to: "air, land and water", "all layers of the atmosphere", "all organic and inorganic matter and organisms" and their "interacting natural systems". As discussed in chapters three and four, environmental education did not appear to have kept pace with governance requirements, including this definition of the environment.

APEGBC for its part reiterated relevant elements of its code of ethics in the introduction stating that the member "…shall: […] "hold paramount the safety, health and welfare of the public, the protection of the environment..." (Section 14 (a) (1))" (APEGBC, 1995: 5) and that even without sustainability guidelines, is to have regard for the environment and sustainability. The shorter list of seven precepts for licensed B.C. engineers focused on sustainability and its concepts, including taking into account short and long-term consequences and direct and indirect consequences that sets it apart from PEO and APEGGA. The APEGBC Guidelines were almost devoid of the multiple restrictive cost-benefit analysis and caveats of activities that "…are likely to have any Adverse Effects" (APEGGA, 2004: 7) found in the APEGGA summary guidelines.

APEGBC opted instead to encompass all engineering activities in its scope, a variation on the APEGGA guidelines also partially espoused by PEO.

As the first to have drafted environmental guidelines, APEGGA was the policy leader with EC adapting the nine APEGGA precepts and guidelines. The unique approach of APEGBC guidelines demonstrated, however, that environmentally-related guidelines did not have to focus primarily on cost-benefit analysis and restrictive or exclusionary clauses. Moreover, I argue, guidelines revealed two inter-related gaps in environmental governance. The first was the profession's guiding role in the "... conformance to ethical norms, and concomitant rules and regulations" (Hayden 2009: 115) and the adequate integration of consistent social belief, technological and ecological criteria in these same ethics, rules and regulations. The second was the need to ascertain the adequacy of knowledge and skills required by engineers to be able to fully comprehend how their everyday practice could impact the environment. In my view limited integration of Hayden's three criteria and minimalist education geared to the acquisition of knowledge and exposure to complex environmental systems analysis hindered the professional's capacity to foresee and grasp long-term and indirect consequences regardless of guidelines or environmental governance.

In comparing provincial codes of ethics APEGBC was the lone Association to already have incorporated environmental considerations in the 1970 code in vigour. The 1970 former Association of Professional Engineers of the Province of British Columbia (APEBC) code of ethics instructed engineers to "guard against conditions which are dangerous or threatening to the environment..." (APEBC, 1969: 11) and to ensure environmental laws were obeyed. In 1970 APEBC was well ahead of its time, but from a governance standpoint, Vesilind et al. (2006: 35) would qualify this element of the code of ethics as 'morality lite' as it only sought to meet the minimum environmental protection proposed by law. In the applicable 2009 code of ethics, APEGBC proved to be an EM leader and incorporated 'protection of the environment' directly into its code of ethics with the combined use of the terms "shall" and "hold paramount" as well as placing safety, health and public welfare on the same footing as the environment.

The APEGBC code of ethics resembled EC's code of ethics guidelines in many respects, save for its failure to incorporate EC's suggestion that professional engineers "be aware of and ensure that clients and employers are made aware of societal and environmental consequences of actions or projects…" (CEQB, 2001b: 2). The latter was, I argue, indicative of the pivotal actor role EC could play in helping shape the profession of engineering's environmental governance with its constituent members by promoting the integration of Hayden's three criteria. The provinces under study, however, had not yet incorporated this particular element of the code.

At APEGGA, the 2009 code of ethics instructed that members "shall hold paramount" safety, health and public welfare but the environment remained peripheral and members were instructed to have regard for it. In Ontario PEO made no reference to the environment or sustainability whereas the APGO instructed its members to have proper regard for the environment. The silence of the environment in the PEO code of ethics did not necessarily mean its absence according to PEO who interpreted "public welfare" to "include our environment" (PEO, 1988 (revised 1998): 27). This interpretation of the environment was, I contend, restrictive in its governance and primarily anthropocentric.

The distinct positioning of the environment in the four provincial codes of ethics revealed important environmental governance gaps. The 1970 APEBC code of ethics paved the way for EM and progressed to the 2009 APEGBC's code of ethics with mature strong EM; the APGO's and APEGGA's code of ethics demonstrated weak EM; and PEO's code of ethics revealed no EM. The differences between the provinces were especially significant when compared against the EC's Guideline on the code of ethics as alluded to above. Both the first EC edition in 1992 and the current 2001 version proposed the following "… professional engineers shall: (1) hold paramount the safety, health and welfare of the public and the protection of the environment…" (CEQB, 2001b: 2) and "professional engineers shall be aware of and ensure that clients and employers are made aware of societal and environmental consequences of actions or projects…" (CEQB, 2001b: 2). Each province exercised its option to adapt national code of ethics guidelines to suit their respective professional-environment social constructions.

Looking to institutional ecological restructuring, I asked the following question: have the provincial associations modified their structure to fully and permanently accommodate environmental governance structures, if so how? The two main indicators I examined to measure potential institutional modifications with the power to engage in proactive environmental knowledge production, reproduction and dissemination were association staff and environmentally-related volunteer member run committees.

The governance organizational structure reviewed at APEGBC revealed significantly deep ecological restructuring with two support staff respectively assigned to the Environment and Sustainability advisory committees: the Director, Investigation and Discipline and the Associate Director Member Services and Communications. At APEGGA the Assistant Director, Professional Practice was listed as a contact person for feedback on the Guideline for Environmental Practice. At PEO, the APGO and at OSPE I did not uncover clearly identifiable environmentally-related staff or organizational resources. Nationally at EC, the role of the Secretary to the CEQB ESC was permanently provided by a staff member. This staff member was also extensively involved at the national and international level in environmentally-related issues, giving presentations and coordinating activities and meetings under the role of Manager, Professional Practice. The latter position did not incorporate these environmentally-related tasks permanently, however, which reveals shallower, short-term EM. The actors whose backgrounds and visions wield much influence on EC staff activities and priorities are EC's CEO and its constituent members through the Board of Directors. The CEO who collaborated for this research held graduate environmental education and appears to have played an important actor role in promoting environmental issues in Canadian engineering during her tenure (EC, 2009d: EC3). I identified no dedicated staff involvement in environmentally-related activities at the CCPG.

In the next step I probed volunteer committees. At APEGBC, the Sustainability Committee[43], the Environment Committee and the recent Climate Change Task Force

[43] The division of labour between the two environmentally-related committees at the APEGBC recently underwent review and both were maintained. The Sustainability Committee "[p]romotes an understanding

were actively engaged in knowledge production and dissemination with members, other associations and technical societies, EC and the provincial government. The APEGBC Climate Change Task Force was the only climate change committee in the three provincial associations under study as both APEGGA and PEO had not yet taken official positions on climate change (Mastromatteo, 2009b: 30). The APEGBC's (2008) sustainability-related web-based knowledge resource "Sustainability *Now*" and extensive sustainability resources on the APEGBC website were also unique resources in the three provinces under study.

In Ontario, the PEO Environment Committee was stood down in 2006 and became a working group of the Professional Standards Committee as part of the new PEO Government Liaison Program (PEO, 2006b: 6). After 2006 I was unable to locate evidence of any environment committee working group activity. The reorganization of the once active stand-alone Environment Committee relegated the environment, I argue, to a secondary role in a regulation-related committee depriving the Association from an EM tool that helped both British Columbia and Alberta achieve stronger EM. No environment or sustainability committee were identified at the APGO. OSPE, on the other hand, established a Climate Change Task Force in 2007 and actively promoted knowledge dissemination and professional development in this area (Mastromatteo, 2009b: 30). In yet another example, OSPE partnered with the McMaster Centre for Engineering and Public Policy to host the 2010 'Engineering in a Climate of Change:

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of the Guidelines for Sustainability and the benefits of their application." (APEGBC, 2010) whereas the Environment Committee "[a]dvises Council on appropriate Association stance on environmental matters including new legislation." (APEGBC, 2010) Minutes from both these advisory committees reveal extensive environmentally-related knowledge production and dissemination at APEGBC.

Making the Lakes Great' conference. The division of labour on climate change between OSPE and PEO with the former promoting knowledge production and dissemination and professional development and the latter not taking a stand all the while being involved with governmental liaison revealed potential EM environmental governance gains achieved with decoupling of professional regulatory and advocacy components.

APEGGA for its part had an active Environment Committee that was first established as a Task Force in 1989 and quickly produced the " 'Philosophy and Responsibilities' of APEGGA and its members to the environment". Similar to committee activity in British Columbia, the APEGGA Environment Committee identifies trends and issues, helps formulate Association responses, organizes conferences and professional development, monitors accreditation initiatives and sets APEGGA environmentally-related requirements for external professionals wishing to join the Association. Also similar to British Columbia, the permanent Committee acted as an EM driver for the profession in Alberta.

Municipal and Regional Levels

At the municipal and regional levels engineers must make themselves familiar with and comply with environmentally-related by-laws, land-use planning and zoning regulations. As with provincial or federal legislation, the self-governance of the profession ensures compliance through its disciplinary process in addition to any applicable fines or penalties set by legislative bodies.

University Level - Education

Universities in British Columbia, Alberta and Ontario were: (1) involved in the CEAB, as described above, (2) administered undergraduate, graduate and post-doctoral engineering education programs, (3) were involved in committees and EC activities, and (4) were involved in research within the university and in collaboration with the public and the private sectors. Within the environmental governance structure universities were quasi-autonomous from provincial or national associations save for implementing the CEAB guidelines if they opted to offer accredited programs.

Association Continuing Professional Development (CPD) requirements, for their part, varied widely by province and none of the three provinces under study required mandatory environmentally-related Professional Development Hours (PDH). In 2009 APEGBC had a voluntary reporting structure but, in 2011, it is due to become mandatory. At APEGGA mandatory reporting required 240 PDH over a three year period. In Ontario PEO had a voluntary CPD program and was investigating a mandatory regime in response to increased regulator pressure to integrate and monitor life-long learning (Mastromatteo, 2010) whereas the APGO required 30 PDH per year.

As will be presented in the Fending Incursions section below, during negotiations with regulators Ontario used the promise of increased environmentally-related CPD as a bargaining tool in order to avert having to meet additional qualification requirements. Ontario's social construction of CPD as a solution in meeting environmentally-related knowledge gaps identified by regulators exposed potential for further EM in the profession. In logical sequence, ecological restructuring of CPD would deepen EM in engineering education environmental governance. Calculating that a professional engineer's career span can reach upward of thirty years and factoring-in the fast pace of environmentally-related knowledge and skills requirements, CPD revealed itself a strategic instrument in Ontario's negotiations. Looking to the profession as a whole, mandatory environmentally-related PDH would, in essence, contribute to maintaining a career-long narrow gap between a professional engineer's environmental knowledge and professional environmentally-related obligations.

Environmental Governance and the Non-Licensed Engineering Graduate

I did not directly investigate environmental governance for non-licensed practitioners[44]. The silence on this topic in Figure 4 therefore does not imply lack of environmental governance for these actors. I deemed three linkages worthy of further study within the scope of my research, however; the links between non-licensed practitioners and (1) engineering duties, (2) accredited engineering programs and, (3) The Ritual of the Calling.

According to PEO one of the three 'tests' that, if not met, does not require a practitioner to be a professional engineer [45] is if "there is no risk to life, health, property or the public welfare if [the engineer's] work is performed incorrectly" (PEO, 2009). How does a practitioner evaluate such risks? Education, training and professional development are three sources that could provide an engineer[46] with the necessary tools to evaluate environmental risk. But as will be analyzed in chapter three, there are gaps in

[44] In great part due to my inability to locate data within the short time-frame of my Master's program.
[45] There is debate in engineering with regard to the restrictive nature of the 'industrial exemption' clause (McMartin, 2003; OSPE 2007).
[46] This assumes that an engineer will be performing the duties under the exemption clause, there are non-engineer practitioners who also perform these duties as will be discussed later.

environmental education for engineers and the professional environmentally-related knowledge and skills that are required of them, as recognized by Mortimer and Walker (2007), Hyde (1999), Vanderburg (2007) and corroborated by my research. These gaps could be narrowed with professional development, but the unlicensed versus licensed divide weighs heavily here. An unlicensed practitioner would not necessarily have access to professional development, nor the desire or the funding to pursue further studies in contrast to a licensed engineer subject to professional obligations and guidelines.

There are at least two other potentially controversial aspects to the debate on the 'industrial exemption' in Ontario, anchored in the sociology of the professions. First, some of the work accomplished under 'industrial exemptions' is performed by engineering technologists and technicians (Fletcher, 2009: 3) that fall under the umbrella of the Ontario Association of Certified Engineering Technicians and Technologists (OACETT). This professional encroachment becomes the site of on-going inter-professional conflict between these two professional bodies that provokes and shapes their respective 'professionalization' (Adams, 2004: 2243). In this instance the OACETT claims that if Ontario removed the 'industrial exemption' the province would lose strategic manufacturing competitiveness to the United States where wider 'industrial exemption' laws allow the practice of engineering to be open to anyone and create conditions where "… entire industries […] function with unlicensed engineers" (Andrews, 2009: 31). Maintaining the 'industrial exemption' might yield significant economic advantages, but this is also potentially coupled with detrimental environmental consequences as voiced by an OSPE (2007a) Task Force.

The second controversial element linked to this debate is that the manufacturing sector has a "...comparatively low incidence of employer policies requiring engineers to be licensed (29.2%)" (EC and CCTT, 2009: 1). Manufacturing, directly involved in the use and transformation of raw materials is a primary site for EM, yet the eroding of engineering licensure and of engineering environmental governance indicate that especially in Ontario[47] in comparison to British Columbia and Alberta, potential EM in manufacturing would not be strongly linked with EM in the engineering profession. Analysis would therefore have to shift directly to the manufacturing sector and the OACETT to understand its members' role and professional envirosponsibility. These are beyond the scope of my present research.

The Ritual of the Calling or more commonly known as the Iron Ring Ceremony is a ritual that can, if voluntarily undertaken by the engineering candidate, instil a sense of duty and ethics (Camp 6, 1993: 1) for the non-licensed engineering graduate. Under an EM stance, however, the environmental governance overarching unlicensed practitioners' work is at best weak, peripheral and non-enforceable. The Corporation of the Seven Wardens, the organization administering the Ritual, is not linked in any manner to the regulatory provincial associations or *ordres*. The iron ring also does not imply holding a degree or a license. For the P.Eng. or P.Geo., the ceremony is portrayed as reinforcing candidates' professional and ethical commitments (Andrews et al., 2009: 50).

The profession's actions to engage in a debate and seek solutions to non-licensure provincially and nationally (EC and CCTT, 2009; OSPE, 2007a) are well-founded, I

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[47] Ontario also has the highest number of potential engineering employers in the manufacturing sector in Canada (EC and CCTT, 2009: 5).

argue, from an EM perspective. In a recent example in Ontario PEO pronounced itself victorious in its ability to obtain recognition of 'limited licensure' engineers and geoscientists on Brownfield remediation work while eliminating non-licensed practitioners from the Qualified Persons (QP) list (PEO, 2008: 9) for such work.

Fending Incursions into the Profession of Engineering's Environmental Governance

Another intriguing aspect of the environmental governance structure developed in Figure 4 was the absence of external environmentally-related licensing or certification where self-regulation and multilevel government legislative bodies and policies dominate. This silence does not signal lack of attempts at 'incursions', from the profession's point of view, into the profession's environmental governance. The silence reflects, rather, the profession's ability to fend off these incursions at the national and provincial levels.

Hovering between the sociology of the professions and environmental sociology, I documented several attempts at incursions into the environmental governance of the profession both at the national and provincial levels and examined the profession's social construction of these incursions and the interventions to prevent them. One example at the national level was the eventual exemption of environmental professional occupational standards or certification[48] for professional engineers (CECAB, 1997: 10). The process to exempt professional engineers was negotiated by the EC Environment Committee and Board of Directors over several years[49]. At the provincial level, in an example linked

[48] The Canadian Environmental Certification Approvals Board operates within ECO Canada (formerly known as the Canadian Council for Human Resources in the Environment Industry).
[49] Based on review of the minutes of the CCPE *Comité sur l'environnement*, the Environment and Sustainability Committee and the Board of Directors from 1996 to 2006.

with the Ontario Brownfield case above, OSPE lobbied the Ontario Ministry of the Environment not to create additional certification requirements for Brownfield QPs. OSPE argued that "...recognizing professional engineers' authority to self-regulate will relieve the Ministry from liability" (OSPE, 2007b: 2) that would have been generated from certification oversight.

Of two analytical perspectives to examine these incursions and the profession's interactions, 'structural rigidities' (Janicke, 2004: 204) or an analysis based on components of responsibility, I pursued the latter. From an EM perspective I argue that on several occasions the profession appeared to have responded in a reactive manner rather than in a responsive manner, by "... arguing for the untimeliness or irrelevance of [the stated] concerns, or by showing that such concerns actually coincide with [the profession's] own [...] and are therefore already addressed" (Pellizzoni, 2004: 558) and by doing so they failed to demonstrate professional envirosponsibility. In the latter example, OSPE cited actions by PEO to increase professional development and tracking of environmentally-related professional development for QP engineers, actions that were apparently instigated by the prospect of external oversight. Rearrangement of professional relations, perhaps with external oversight (greater public participation and democratizaton of science should be approached with caution (Bora and Hausendorf, 2009: 487-488; Lidskog, 2008: 69)), might have been viable options for integration of Hayden's three criteria in some instances and I contend could have led to deeper EM. Incursions warrant further investigation outside the scope of this research.

Critical Junctures in Institutional Analysis

The institutional analysis reflecting four levels of analysis from Hollingsworth's (2000: 601) structured multi-disciplinary approach allowed me to develop the environmental governance structure whereas Hayden's (2009) institutional analytical tool[50] allow me to determine if, where and how social belief, technological and ecological criteria were fully integrated in the profession of engineering's environmental governance. The four critical junctures I identified where the criteria were or could be integrated and contribute to EM were: (1) the curriculum development process, and more specifically in the role and the member composition of the CEAB, (2) environment committees at the national and provincial levels with mandates to monitor and help the profession adapt and respond to societal and ecological criteria, (3) the growth of engineering societies such as the Ontario Society of Professional Engineers that can play a pivotal role in advocacy work without conflicting with a regulatory mandate, and (4) the universities with the programs and courses they offer (this will be discussed in chapter three). The following assessment includes reflection on EM at these junctures.

Ecological Modernisation and Environmental Governance

At this stage I propose a preliminary assessment of EM in the profession based exclusively on environmental governance analysis. A more thorough EM assessment is carried out in chapter four following comprehensive analysis of the cumulative knowledge generated in chapters two, three and four. Combining all levels of governance and using my adaptation of Christoph's (1996) characterization of EM strength and my characterization of EM depth, I qualify EM strength and depth in the

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[50] See Figure in Appendix D for Hayden's portrayal of the dynamic interaction between these criteria.

overall profession of engineering's environmental governance as moderate. Following is a level-based EM assessment incorporating Hayden's criteria at both the national and provincial levels for British Columbia, Alberta and Ontario.

At the national level, I qualify EM strength in the profession as moderate, whereas depth I qualify as weak to moderate. Strengths lay mainly in intensive engagement in internal and external policies, regulations, standards, codes and professional oversight encapsulated in such elements as guidelines, codes of ethics and the workings of environmental committees that appear to reflect social, ecological and technological criteria in their functioning. Two of the main weaknesses that affect strength and depth at the national level and that set off ripple effects through all levels of environmental governance lay in the underutilized potential for EM in engineering education where minimal curriculum requirements and CEAB members' own educational backgrounds do not always integrate Hayden's three criteria and, contrary to professions such as law or medicine, non-licensed practitioners can legally work in Canada[51].

Provincially, again based exclusively on environmental governance analysis, I qualify strength and depth of EM as moderate and deep in British Columbia, weak to moderate in strength and depth in Alberta, and Ontario as straggling with weaker environmental governance and shallower EM in comparison to its counterparts. In Ontario I contend that, in spite of new energy-related engineering programs following the introduction of the 2009 *Green Energy Act*, at least three indicators that reflect the profession's meagre EM progress are the existence of an industrial exemption clause, the

[51] Because licensing is not a national jurisdiction but is rather provincially regulated, this assessment addresses the profession of engineering as a whole in Canada.

relegation of PEO's environmental committee to a secondary regulatory/policy role and the absence of stated environmental considerations in its code of ethics.

I reserved a more thorough contextual analysis and cross-province comparison for chapters three and four. I reasoned that the insights provided by environmental governance analysis were too narrow and therefore sought triangulation from discursive investigation before undertaking more complex context analysis.

CHAPTER THREE: Engineering Environmental Discourse and Ecological Modernisation in the Profession

Discourse analysis as a research tool allowed me to investigate how engineers socially constructed the environment and their professional-environmental relationship and also served as an indicator of EM in the profession. Which hegemonic environmentally-related discursive patterns evolved, if any, from 1970 to 2009? What did these discourses reveal and conceal? Did dominant engineering discursive practices point to ecological modernisation in the profession, if so, how? These were some of the questions addressed in this chapter along with insights into the engineering-environment relationship in the three provinces.

The starting point for discourse analysis coding was Mihelcic et al.'s (2003) categorization of the engineering-environment relationship into four perspectives: end-of-pipe treatment, pollution prevention, pro-active design for the environment and sustainable development. Additional discourse categories that emerged from analysis included framing the environment as a source of alternative energy; concentrating on economic considerations in relation to the environment; focussing on responsibility to society and to the environment; integrating Hayden's (2009) social, technological and environmental criteria; and framing environmental problems as risk, health risk, or regulatory problems.

University Level

At the university environmental governance level it was noteworthy to observe that the 1970s-era short university course descriptions lacked the promotional-oriented discourse of 2009 course descriptions. For the most part, course descriptions in 1970 enumerated course content topics and rarely contained non-technical terms. These enumerations also prevented the use of Hajer's story-lines given the lack of narrative quality to discourse. As an aid to the reader, Table 1 features a synopsis of the 1970 and 2009 hegemonic discourses at the university-level of environmental governance and their relationship with ecological modernisation in the profession. In the three provinces under study, the hegemonic[52] environmentally-related 1970 short course description discourse depicted the engineer-environment relationship as almost exclusively 'end-of-pipe' environmental control or as environmental protection post-destruction or modification.

It is only by comparing and contrasting 1970 and 2009 course description discourse between and among provinces that, in spite of the 1970 small sample sizes, patterns emerged. In 2009 universities in British Columbia and Alberta maintained end-of-pipe discourse at relatively identical elevated 1970 levels (in the 60% to 70% range) in contrast to Ontario where end-of-pipe discourse frequency plunged from 73% in 1970 to 37% in 2009. Although end-of-pipe discourse remained the most prevalent in the three provinces, the drop in Ontario was significant in comparison to the steady levels in British Columbia and Alberta. I explore potential causal factors that could have influenced EM in the context of professional envirosponsibility comparative analysis in chapter four.

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[52] The percentage of end-of-pipe discourse frequency is presented in Table 1, but the course description sampling was small with unequal sample sizes between provinces, therefore I did not believe it was prudent to engage in provincial comparisons based solely on 1970 data. Trend analysis increased my confidence in the validity of 1970 data in spite of the small sample size.

Table 1: University-level discourse in 1970 and 2009 at three levels of engineering environmental governance and EM in British Columbia, Alberta and Ontario.

1970	B.C.	Alberta	Ontario
Hegemonic and secondary environmental discourse	• End-of-Pipe' (71%)* • 'Sustainability' (29%) **(N=7)**	• 'End-of-Pipe' (67%) • 'Alternative Energy' (14%) **(N=6)**	• 'End-of-Pipe' (73%) • 'Alternative Energy' (14%) • 'Environmental Health' (9%) **(N=22)**
EM	Almost non-existent EM with meagre 'sustainability-related' discourse.	Almost non-existent EM with limited 'environment as source of energy' discourse.	Almost non-existent EM with burgeoning 'environment as source of energy' and 'environmental health' discourses, for example.
2009	**B.C.**	**Alberta**	**Ontario**
Hegemonic and secondary environmental discourse	• 'End-of-Pipe' (65%) • 'Regulatory' (15%) • 'Social/Technological /Environmental' (14%) • 'Sustainability/ Stewardship' (13%) **(N=88)**	• 'End-of-Pipe' (63%) • 'Alternative Energy' (14%) • 'Regulatory' (10%) • 'Social/Technological /Environmental' (10%) • 'Sustainability/ Stewardship' (10%) **(N=51)**	• 'End-of-Pipe' (37%) • 'Social/Technological /Environmental' (14%) • 'Sustainability/ Stewardship' (14%) • 'Regulatory' (12%) **(N=397)**
EM	Weak EM reflecting the polarities of elevated 'End-of-Pipe' discourse occurrence mitigated by the relatively high occurrence of social, environmental and sustainability discourse that tends towards reflexivity.	Weakest EM given the elevated 'End-of-Pipe' discourse frequency and the relatively limited inroads of social, environmental and sustainability related discourse.	Weak to moderate reflexive EM with combined lower relative occurrence of 'End-of-Pipe' discourse and moderate incidence of social, environmental and sustainability considerations discourse.

* Percentages refer to percentage of discourse incidence in relation to the number of courses in the sample for each respective province. Course descriptions could contain multiple discourses therefore total percentage can surpass 100%. Conversely, if courses did not have complete descriptions (see methodological approach section) the total percentage can fall below 100% (this only occurred in 1970).

In the absence of full course syllabi, curriculum analysis and multi-year analysis to monitor the decline between 1970 and 2009, my analysis was restrictive. Based on short course descriptions, however, there have been modest EM gains in Ontario engineering education with a clear reduction in end-of-pipe discourse. Ontario and B.C. universities also displayed increased incidence of sustainability/stewardship discourse, greater integration of social, technological and environmental considerations discourse as well as an increased incidence of environmental regulation discourse in comparison to Alberta. The rise in the integration of environmental regulatory discourse in the three provinces was critical, I believe, in increasing engineering students' knowledge on environmentally-related responsibilities and obligations within the profession.

Another element of interest in the short course description discourse analysis was that consolidation of data at a provincial level concealed at least three underlying currents. The first was inter-university disparity in environmentally-related discourse where, for example, in the same province some universities' civil engineering programs fully espouse sustainability and environmental stewardship discourse whereas others remained entrenched in end-of-pipe discourse. The second was the incidence of environmentally-related content and examples integrated horizontally and vertically in economics and mathematics (probability and statistics, differential equations and calculus) courses at select universities that demonstrated these universities' capacity to meet both engineering and environmental educational needs in core courses. The third was a need to probe further into course program breakdown and the linkage with hegemonic discourse in order to be able to fully assess where and to what depth environmentally-related education was entrenched. The latter referred more specifically to programs where only two courses in a full engineering program delivered the essence of environmentally-related education specified by the CEAB.

Overall, based on short course description discourse analysis I assess British Columbia as having achieved weak EM in its engineering programs from 1970 to 2009. The weakness reflects the polarities of elevated 'end-of-pipe' discourse mitigated by the weak to moderate occurrence of social, technological, environmental and sustainability / stewardship discourse that tends towards reflexivity. For Alberta, in comparison to British Columbia and Ontario, I assess EM as the weakest with elevated 'end-of-pipe' discourse and relatively limited inroads for social, technological environmental and sustainability / stewardship related discourse. Finally, in Ontario in contrast to the other two provinces I deem weak to moderate reflexive EM has occurred from 1970 to 2009 with combined lower relative occurrence of 'end-of-pipe' discourse and weak to moderate incidence of social, technological and environmental as well as sustainability / stewardship considerations discourse similar to those in British Columbia.

Provincial and National Levels[53]

National level discourse was intertwined with provincial and university-level discourse where, for example, EC provided model practice guidelines and codes of ethics and oversaw CEAB curriculum criteria. I revisited several key texts from previous chapters with a view to discourse analysis in this iteration, including codes of ethics, environmental practice guidelines and CEAB curriculum criteria.

[53] Data and documents for this section were collected from the provincial associations' respective websites unless otherwise noted.

Codes of ethics discourse once more revealed marked differences in EM between the three provinces under study when viewed through the Hajerian lens of discourse analysis. Already in 1970 the former APEBC had integrated the environment as a consideration in its code of ethics. The environment had then been constructed as an end-of-pipe consideration and the engineer-environment relationship as compliance-based. The 2009 APEGBC code of ethics discourse had evolved, in contrast to 1970, and now repositioned the environment as an integral obligation in engineering activities. Human life, human welfare and the environment were constructed as equal and protection of the environment as paramount. The discourse in British Columbia evolved to an advanced stage and deep[54] EM, I advance, and firmly laid the groundwork for strong EM by fully incorporating environmental considerations in engineering duties and obligations.

In contrast to British Columbia, Alberta's code of ethics discourse constructed the environment as a peripheral obligation. This reflected weak, shallow EM in the province.

In Ontario APGO also positioned the environment as a peripheral obligation that deserved proper regard. APGO added the term 'natural environment', a construction that required further interpretation, I contend, where terms 'natural' and 'environment' could potentially be misconstrued and unenforceable. PEO for its part excluded any reference to the environment in its code of ethics. As noted earlier, however, PEO interpreted its code of ethics' duty to public welfare as also encompassing obligations to the environment (PEO, 1988 (revised 1998): 27). Notwithstanding PEO's interpretation, discourse analysis can only be performed on existing discourse, not implied discourse.

[54] In this instance depth characterization reflects the important role of the code of ethics in professions as demonstrated by Davis (2002).

The absence of environmentally-related discourse in the PEO code of ethics reflected no EM in this regulatory tool. Furthermore, if the code of ethics can only be interpreted literally and is otherwise unenforceable (Willis, 1991: 13), Ontario's omission of the environment in the code of ethics demonstrated, I argue, a critical void in EM in Ontario given the importance of the code of ethics in the profession. The profession of engineering in Ontario was therefore positioned at the opposite end of the spectrum in comparison to the B.C. code of ethics with the weakest, least mature and shallowest EM when combining APGO and PEO analysis.

At the national level, EC guideline code of ethics on which the B.C. code was based included one additional obligation suggesting that engineers include social and sustainability-related issues in discussions with clients. As noted earlier, although none of the three provinces under study included this discourse, EC's role within the environmental governance structure and the consensus required from constituent member actors for national endeavours revealed national EM progress. This could create conditions for ecological restructuring by integrating obligations to discuss social and sustainability issues discourse in the code of ethics. A broader provincial sampling would allow further insight.

Revisiting environmental guidelines with discourse analysis proved to be equally revealing. In a first step I identified no environmental guidelines in the three provinces or nationally in 1970. Following are the 2009 provincial and national analysis.

At APEGBC, the main story-line in the most recent 1995 Guidelines for Sustainability was that sustainability, constructed as the integration of environmental, social and economic considerations, was important and achievable in spite of competing interests. Two subjacent discursive themes were (1) that engineers, constructed as educated professionals who are decision makers or who can exert influence on decision-makers, are best positioned to help society meet this goal and (2) notwithstanding individual engineers' beliefs, it is possible for a professional, equipped with the proper tools and training, to meet the goal of sustainability. A feature unique to the B.C. guidelines was an example checklist for sustainability, co-constructing sustainability and its application as achievable with appropriate tools. Overall, discourse in the B.C. guidelines constructed the environment-engineer relationship as a positive partnership with the capacity to meet sustainability goals to better society.

The Guidelines for Sustainability in British Columbia therefore demonstrated advanced and strong EM with comprehensive integration and harmonization of environmental, economic and social goals within engineering activities. Not only were engineers in British Columbia equipped with comprehensive sustainability guidelines, moving away from environmental guidelines, and provided with a working checklist as a starting point in their relationship with environmental issues, the guidelines themselves were touted as bargaining tools for engineers to secure the required funding in order to properly address sustainability issues (APEGBC, 1995: 9).

In Alberta the main story-line in the most recent 2004 APEGGA Guideline for Environmental Practice was that although environmental considerations are important, cost considerations are equally or more important. Competing with this main story-line two subjacent themes were also discursively constructed: (1) environmental problems and stewardship are the responsibility of all citizens and society, and should not only be shouldered by engineers and (2) it is best to comply with regulations, preferably with cost-cutting technology, or face the risk facing rising costs and public debate later. The guideline socially constructed education as a critical tool in the engineer's ability to meet what it qualified as increasingly complex environmental demands.

The APEGGA main story-line and subjacent themes situated the Association in the early stages of EM, from weak to moderate in strength, where there were not yet clear advantages to harmonizing ecological and economical considerations to yield benefits equally on the environmental, economical and social fronts. I further argue that the insistence on socially constructing environmental problems as societal problems and concerns rather than assuming professional envirosponsibility and involvement for relevant activities prevented the Association from meeting Dinsmore's 1970 call to action and achieving more advanced EM. It was particularly intriguing to see multiple references to education and continuing education as current minimal CEAB requirements would not be adequate, in my view, to meet either the APEGGA's definition of the environment or its guideline. Demonstrated understanding of the difference between short-term regulatory compliance and long-term sustainability (Andrews et al., 2009: 322) set APEGBC apart from and leading ahead of APEGGA.

In Ontario, the PEO Environmental Guidelines for the Practice of Professional Engineering were integrated in the most recent 1988 (revised 1998) PEO Professional Practice Guideline. Partly based on the APEGGA environmental guidelines, the PEO guidelines therefore shared some of the former's social constructions with limited EM evolution and strength. The discourse was not uniform in the PEO guidelines, creating a collage of concurrent discourse. The main story-line was the duty of the engineer to be involved in environmental solutions and dialogues. Where this story-line's EM was compromised, however, was with two co-discursively constructed sub-themes and the abundance of end-of-pipe discourse. The two co-constructed sub-themes were: (1) environmental problems and stewardship are the responsibility of all citizens and society, and should not only be bore by engineers, and (2) the engineer has a duty to comply with regulations. Discourse referring to 'realistic' or 'feasible' knowledge, level of education, or ways of protecting the environment socially constructed these in opposition to being unrealistic. No definitions or parameters were offered to help the engineer understand 'realistic' or 'feasible'. Only partial integration of economic, environmental and social considerations appeared to be achieved in these guidelines thus reflecting weak EM.

Overall, the PEO guidelines, I argue, reflected early stage weak to only moderately strong EM similar to that of the APEGGA. The comprehensive integration of the environment in engineering activities and duties did not always permeate as a winning scenario. In comparison to APEGGA, the PEO guidelines appeared less cohesive and constructed the engineer-environment relationship more frequently as an end-of-pipe relationship.

Nationally, the 1995 APEGBC Guidelines for Sustainability, along with the 2005 APEGGA Guideline for Environmental Practice were sources of inspiration for EC's National Guideline on Environment and Sustainability (CEQB, 2006: 2). The EC guidelines were, for the most part, a replication of Alberta guidelines save for the integration of the term sustainability in the title and differences in introductory and explanatory texts. Given the high level of similarities between APEGGA and EC proposed environmental guidelines, discourse analysis for the EC guidelines provided no further insights into the construction of the engineer-environment relationship or environment in the profession. They did, however, once more reveal the central actor role APEGGA played in spearheading these guidelines as discussed in chapter two.

Next I performed discourse analysis on engineering and/or geoscientists or geological and geophysical professions acts. In British Columbia, the *Engineers and Geoscientists Act* in 2009 and the 1970 *Engineer Act* of the former Association of Professional Engineers of the Province of British Columbia made no reference to the environment.

Applicable 1970 and 2009 Alberta engineering and geosciences acts did not contain any reference to the environment other than the code of ethics analysed above. Closer examination of the discourse in the applicable 2009 *Engineering, Geological and Geophysical Professions Act* in Alberta, however, revealed two-tiered protection for the environment under the law. The code of ethics for members of the Association of Science and Engineering Technology Professionals of Alberta and for Professional Technologists in Alberta was more rigorous with respect to the environment and the discourse, identical to EC's and APEGBC's first element of the code of ethics, discursively constructed the environment on par with the duty to public welfare, including the use of the word 'shall' (Legislative Assembly of Alberta, 2010: 117, 129).

From a sociology of the professions perspective these discrepancies in obligations to the environment merit further scrutiny. Future research might ask how and why do these professions appear to be using the environment to shape their respective 'professionalization' (Adams, 2004: 2243)?

The applicable 1970 *Ontario Professional Engineers Act* included in its definition of the "practice of professional engineering" a list of activities that discursively constructed the engineer-environment relationship as end-of-pipe (i.e., water purification plants, sewerage works, sewage disposal works, and incineration) (PEO, 1968-69: 2). The 2009 applicable Ontario *Professional Engineers Act*, however, excluded any environmentally-related reference. The *Professional Geoscientist's Act* for Ontario Geoscientists in force in 2009, for its part, included one significant reference to the environment. This discourse related to the definition of who is deemed able to practice Geoscience and it socially constructed concerns related to safeguarding the 'natural environment' at par with public welfare, life, health or property (APGO, 2000). Of all the acts reviewed in the three provinces, the Act under which APGO operates was the only one that incorporated environmental considerations on an equal footing to public welfare in the definition of a practicing professional. Was this ecological reform the result of strong EM in the profession? I argue that it was not. The positioning appeared to be at odds with the APGO's code of ethics that only instructed members to have proper regard for the environment. From a sociology of the professions perspective the definition of a practitioner would serve to restrict activities related to the environment from other related professions, but once within APGO, EM reform would be weak.

With respect to discourse analysis of the provincial associations' by-laws, only British Columbia made reference to the environment as the code of ethics was integrated in its relevant 1970 and 2009 by-laws. Given that the codes of ethics were already subjected to discourse analysis above, I did not pursue further analysis.

The professional practice exam preparatory documents yielded only sparse and, when present, fragmented discourse that proved too problematic to subject to analysis. Relative silence on the environment in the exam preparatory documents was, I advance, a significant finding in itself. Short of analyzing actual professional practice exams the preparatory documents revealed minimal or no EM progress made in the three provinces.

Finally, I performed discourse analysis on accreditation criteria presented in Appendix B. Environmentally-related considerations were first discursively integrated in the CEAB curriculum criteria purpose of accreditation text in 1976[55] constructing the engineer-environment relationship as end-of pipe. From the initial 1976 iteration to the 2008 version analysed for this investigation, the discursive variations of this purpose of accreditation discourse maintained the same construction: the need for engineers to learn about a listing of potential impacts, including environmental and social impacts, which engineering could have on society. I observed failed propositions to re-construct the environment-engineer relationship as producing, and reproducing knowledge within the social context, but the end-of-pipe construction remained. In 1993, environmental considerations were integrated in design project criteria, constructed as an additional constraint in the design process with their associated standards and legislation. The need

[55] The data sources for this section are CEAB (and former CAB) minutes and accreditation criteria that I reviewed from 1970 to 2008.

for engineers to learn about sustainable development discourse was first integrated in the 1994 curriculum criteria following environmentally-related requests from provincial associations in Manitoba and Quebec (Hyde, 1999: 27; previous footnote). It was also at this time that the CEAB integrated 'environmental studies' in the list of potential subjects for students constructed as 'pertinent for engineers'.

Over the ensuing years small changes and variations in the curriculum led to the 2008[56] version that I subjected to a more thorough discourse analysis. In addition to the purpose of accreditation discourse described above, environmentally-related discourse was integrated in 'graduate attributes' and 'curriculum content' sections. The former discursively constructed one of the desirable engineering graduate attributes as the ability to pay 'appropriate attention to' environmental considerations at par with health and safety risks, standards as well as economic, social and cultural considerations in engineering design. A second engineering graduate attribute was a reiteration of the purpose of accreditation where discourse constructed an engineering graduate as able to analyse environmental elements of engineering as well as the 'concepts of sustainable design and development and environmental stewardship'. The latter offered no consideration to the level of understanding sought, or its relation to a given discipline.

Environmentally-related curriculum minimum engineering design content included the environment constructed as one of six applicable constraints on design, reinforcing the end-of-pipe engineer-environment construction. This revealed only weak EM potential as the environment was peripheral and constructed as a constraint rather

[56] At the time of data collection the 2009 version was not yet available; I deemed the 2008 version sufficiently recent to proceed with analysis.

than a valuable consideration. The second curriculum minimum content constructed 'sustainable development and environmental stewardship' as mandatory complementary studies to be made available to students. Once more this content was presented without consideration for the level of understanding required or its integration within a discipline.

As discussed in chapter two, environmentally-related curriculum was typically offered in two survey-style courses in non-environmentally related engineering programs. When contrasting the environmental education and knowledge needs voiced in environmental guidelines, laws and codes of ethics with the minimalist environmentally-related curriculum, a wide gap is once more exposed between environmentally-related professional expectations and education in the engineering profession.

In parallel with discourse analysis, I revisited the role of actors and dynamics involved in two instances of CEAB discourse production. Already in 1973, a proposition to create a mandatory 'environmental responsibilities' course for all engineering programs with failure to do so leading to a loss of accreditation, was rejected. The request was reconstructed as a proposition for an 'environmentalism course' (CAB, 1973a and 1973b). This example, I advance, demonstrated the knowledge divide in environmentally-related issues and opposing views on engineering responsibility with respect to the environment. In 1995 the CEAB again declined a proposition for compulsory environmental studies in the engineering curriculum in order avoid introducing non-engineering topics such as environmental law or ecology (CEAB, 1995: 11) as engineering-related. The CEAB opted instead to look into incorporating compulsory studies constructed as 'environmental concerns' as opposed to 'environmental studies' discourse. In closing, I contend that both of these examples highlighted the importance of reaching consensus among constituent members to support national initiatives, including CEAB accreditation criteria, the varying levels of EM evolution in the respective provinces, and the impact of CEAB membership knowledge.

Overview of Discourse Analysis

Based on analysis of discursive practices at three levels of environmental governance in the profession, I propose a preliminary comparative analysis. The profession appears to have achieved moderately strong and deep EM in British Columbia, whereas I deem it weak to moderate and shallow in Alberta and weak and shallow in Ontario.

In Ontario gains made at the university-level with relatively higher EM in its short course descriptions was counterbalanced and weighed down by the silence on the environment in the PEO code of ethics, of primordial importance to the professional engineer's practice, as well as mitigated EM in PEO environmental guidelines while simultaneously being slightly bolstered by weak EM in APGO discourse. The profession in both Ontario and Alberta did not reach the advanced stage of EM demonstrated in British Columbia where environmental, economic and social considerations were harmoniously integrated in the APEGBC policies and regulatory discourse all-the-while not as advanced in short course descriptions.

The types of documents in which discourse was analyzed also offered a window into the depth of EM confirming findings in chapter two. APEGBC's deep-rooted and long track record of EM dating back to 1970 spans regulatory and policy documents.

APEGGA in contrast featured similar depth but a shorter history whereas PEO's EM was deemed shallower, more recent in implementation and less comprehensive in reach in comparison to both British Columbia and Alberta.

At the national level EC played a critical role with its strong advanced EM in the model practice code of ethics discourse, although this discourse was only partially adopted by the profession in British Columbia and diluted to much weaker EM in Alberta. Where the national level demonstrated a weaker EM national actor role, I contend, was in the absence of environmental guidelines at CCPG and in EC's national environmental guidelines having been based on the APEGGA environmental guidelines. The latter, I argue, were weak to moderate in strength and only in the early stage EM, not ideally suited for emulation. With respect to national accreditation criteria and environmentally-related education, the national level's strategic actor role within the national network of constituent member actors, at EC and CCPG, and by extension every Canadian-educated engineer was reaffirmed through discourse analysis.

CHAPTER FOUR: Comparing Professional Envirosponsibility

Data gathering and analysis performed in chapters two and three finally converge at this final stage of my investigation to allow for professional envirosponsibility comparative analysis between British Columbia, Alberta and Ontario. Analysis at the three sites of professional envirosponsibility, education, professional obligation and legislation is organized by site with respective indicators. I focussed primarily on 2009 data because of missing 1970 data for several indicators described in previous chapters. The final element of this chapter, an overview of comparative professional envirosponsibility, also includes causal analysis.

Site of Education

Professional envirosponsibility's site of education was particularly insightful given its environmental governance spanning from the national to the university levels. Indicator measurements in unit mean per institution combined with discourse and environmental governance analysis helped generate comparative EM strength and evolution at this site.

As discussed previously, minimum environmentally-related educational requirements CEAB criteria are set by Engineers Canada nationally and delivery of these minimal requirements often took the shape of two survey-style engineering courses. The indicators I selected shed light on environmentally-related courses offered in the absence of more stringent minimum requirements. How many environmental engineering, civil engineering or other option, minor, specialization or stream environmentally-related programs were available, on average by institution in the respective provinces?[57] Each of the three program category index rankings (environmental engineering, civil engineering or other option, minor, specialization or stream environmentally-related programs) helped compare program category means standardised by the total number of respective educational institutions, across the three provincial cases. The lowest ranking, zero, indicated no program whereas a ranking of 1 or higher indicated an average of at least one such program type per educational institution in the province. The relationship between the index ranking and EM is elaborated in Figure 7.

Analysis revealed that British Columbia had the highest mean of environmental engineering programs, 0.5/institution, Alberta offered none whereas in Ontario the mean was 0.27/institution. The range of civil engineering program means was wider with Alberta leading at 1/institution, Ontario slightly lower at 0.73/institution and British Columbia trailing with 0.25/institution. Ontario was the only province with a mean of 0.13/institution for other environmentally-related programs related to green energy and water. In the area of environmentally-related option, minor, specialization and stream programs, Alberta once more led the pack with a mean of 1.5/institution, Ontario trailing with 0.8/institution and British Columbia behind at 0.5/institution.

How did the program type education indicator relate to EM? I conceptualized a continuum depicted in Figure 7. At the lower end of the EM spectrum, I argue environmental engineering programs were located at the early stages of EM typically concentrating on end-of-pipe solutions to environmental problems created, to some extent, by other fields of engineering. Environmental engineering students in 2008 only

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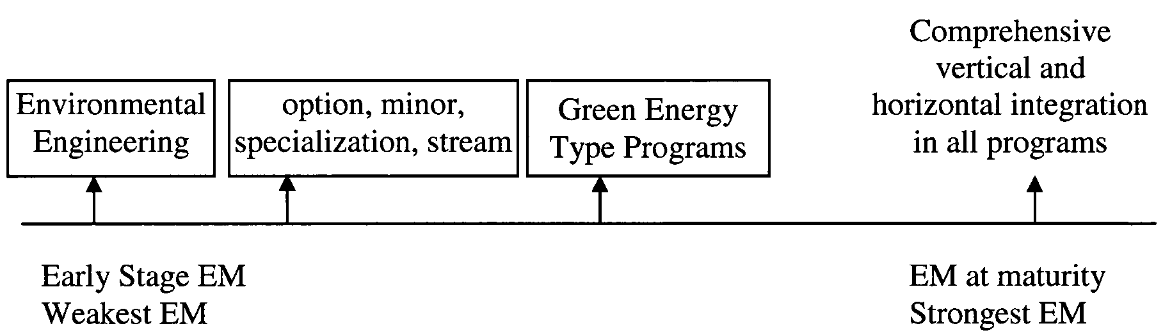
[57] The mean does not consider courses that were restricted to field-specific programs or respective program registration.

represented 1.8% of the 34,335 undergraduate engineering students in British Columbia, Alberta and Ontario (EC, 2009c: 23). At this end of the EM spectrum I also qualified EM as weakest where environmental knowledge is concentrated in one discipline mostly restricted to environmental protection. At the opposite higher end of the spectrum I contend that EM would reach full maturity with comprehensive vertical and horizontal integration of environmental considerations and problem-solving capacity integrated in all disciplines. In contrast to the lower end, higher end EM would be strongest with integrated educational policy and curriculum restructured to fully co-accommodate environmental, economic, social and technological considerations.

Signs of maturing EM in the curriculum included program options, minors,

Figure 7: Engineering Program-Type on a Scale of EM Modernisation Stage and Strength



specializations, streams that involved more disciplines. The optional nature of these add-ons and their peripheral role in core programs, I argue however, only succeeded in yielding weak EM where Alberta led both Ontario and British Columbia. Ontario and Alberta's select few green energy-related environmental programs were an example of further EM evolution, with weak to slightly moderately strong EM. Engineering knowledge in these instances was invested in alternative energy solutions rather than dealing with or trying to reduce the environmental effects of 'traditional' energy sources. EM would achieve its peak strength and maturity with respect to engineering energy program, for example, by integrating social dimensions of energy use reduction in tandem with engineering alternative energy solutions as opposed to substituting traditional for alternative energy sources while maintaining unsustainable energetic needs. This achievement would require strong interdisciplinary cooperation carried through to professional practice.

Did environmental discourse in short course descriptions differ by province? In 2009 the provinces of Alberta and Ontario tied at a mean of 26 courses/institution whereas British Columbia was slightly behind with 22 courses/institution. I further characterized this indicator with discourse analysis that revealed differences in how the environment and the profession-environment relationship was socially constructed. In spite of holding a mean equivalent to that of Ontario, Alberta's discourse revealed the weakest EM in the short course descriptions, whereas Ontario's weak to moderate EM was achieved by a sharp decrease in end-of-pipe discourse in comparison to its 1970 discourse. British Columbia for its part demonstrated weak EM, combined with an only slightly lower mean number of courses per institution. Overall, this indicator's EM yielded the same ranking as proposed in chapter three for discourse analysis.

Combined analysis of the CEAB minimum environmentally-related criteria with short course descriptions exposed no discernable additional environmental content available to all engineering programs in British Columbia, Alberta or Ontario.

Notwithstanding the small number of sub-programs described above, educational institutions in the three provinces under study revealed a 'morality lite' (Vesilind et al., 2006: 35) approach to integrating environmentally-related content in engineering programs. The three provinces overwhelmingly chose to meet, not surpass, minimum environmentally-required content set out by the CEAB. One striking example was the highly integrated environmental content in topic-specific courses, i.e. mathematics, that were not set as the standard for all engineering students but rather remained confined to environmentally-related programs. Furthermore, I identified few environmentally-related continuing education opportunities in the three provinces under study.

The last two indicators, environmentally-related awards and scholarships as well as research chairs and research centres/units yielded identical tendencies. Ontario was ahead with a mean of 3.3 awards or scholarships/institution and a mean of 2.9 research related entities/institution whereas Alberta ranked second with respective means of 1.5/institution and 2.3/institution and British Columbia placed third with 0.75/institution and 1.75/institution respectively. How can these results be understood in terms of EM? I argue that these rankings are consistent with previous findings. Contrary to conventional wisdom, higher rankings reflected earlier stage and weaker EM than lower rankings. Although environmental considerations appeared to be at the forefront in higher rankings, they were actually singled-out and not integrated in mainstream engineering considerations with economic and social dimensions. To some extent, I venture that the satellite characteristic of environmental considerations constructed in the higher means of these indicators reflected a social construction of environmental problems as catastrophic and requiring ghettoized focussed interventions outside 'normal' engineering duties therefore contributing to lower EM. For these indicators Ontario's and Alberta's EM were therefore the weakest and at the earliest stage. British Columbia indicators did not demonstrate this weakness, although I do not venture to characterize the inverse lower ranking observed as indicative of stronger EM.

Site of Professional Obligation

At the site of professional obligation, environmental governance and discourse analysis converged and allowed me to triangulate findings and analysis. In comparison to the site of education, professional obligation occupies a more substantive role in envirosponsibility as it figures in the day-to-day practice of Canadian engineers and is at the core of the profession's working relationship with the environment.

Incorporating analysis from previous chapters, the three professional envirosponsibility indicators, guidelines, code of ethics and environmental governance, yielded consistent EM rankings in the three provinces. Overall British Columbia demonstrated moderate to strong and deep as well as advanced maturity EM. This assessment was based on strong and advanced EM in the guidelines, advanced and strong EM in its code of ethics and moderate strength and depth in environmental governance. Alberta's global professional obligation ranking was weak to moderately strong and deep with early stage EM when combining weak to moderately strong and early stage EM in its guidelines, weak and early stage EM in its code of ethics and weak to moderately strong and deep EM in its environmental governance. Ontario lagged behind in professional obligation demonstrating weak strength, shallow depth and early stage EM.

The composite measure in Ontario reflected weak to moderate strength and early stage EM in guidelines, extremely weak and extremely early stage EM for codes of ethics, and weakest and shallowest EM in environmental governance.

The professional practice exam discourse analysis contributed little to the measure of envirosponsibility as discussed in chapter three. It did, however, reify the EM strengths of the accreditation model as presented in Figure 6 where environmentally-related knowledge criteria are produced and reproduced by CEAB actors.

Site of Legislation

The third and final site of professional envirosponsibly, legislation, involved provincial engineering and/or geoscience acts and association by-laws as indicators. Environmental governance analysis, for its part, revealed only slight variations between provinces with respect to legislation: Ontario had a greater number of environmental legislation as well as the new *Green Energy Act* that encouraged the creation of several university-level green energy environmental engineering programs whereas British Columbia was the only province with a carbon tax.

Based solely on 2009 data, British Columbia incorporated its code of ethics in its by-laws whereas Alberta incorporated its code of ethics in the professional act. Excluding EM based on code of ethics discourse analysis, the incorporation of environmental considerations in the legislative documents governing these respective provinces' engineering bodies demonstrated EM strength and depth as well as maturity. In Ontario, the limited integration of environmental considerations in the *Professional Geoscientists Act*, its silence in the *Professional Engineers Act* and PEO's by-laws contributed to extremely weak EM strength and depth. Combined with provincial legislation environmental governance analysis, EM in Ontario was moderately weak in strength and depth.

Overview of Professional Envirosponsibility and Causal Analysis

Combining indicator analysis at the sites of education, professional obligation and legislation I propose the following overall professional envirosponsibility comparative ranking for the profession of engineering. British Columbia ranked highest with moderately strong and deep professional envirosponsibility and advanced EM. Alberta, for its part, ranked second with weak EM in strength and depth as well as only early stage EM. Contrary to expectations, Ontario ranked lowest with weak, shallow and early stage EM instead of achieving a second-place ranking. The latter was mitigated by EM strides at the site of education.

What clues could causal analysis provide to further understanding of the empirically observed professional envirosponsibility rankings that proved contrary to the predicted outcome for Ontario? My original prediction of British Columbia leading professional envirosponsibility with Ontario in a middle position and Alberta with the lowest ranking proved to be based on faulty reasoning. I had erroneously assumed that higher levels of environmental degradation with significant engineering involvement would signal lowest EM. The professional envirosponsibility ranking and the empirical investigation of potential causes that contributed to the development of observed professional envirosponsibility proved me wrong.

In this section I focussed primarily on two causal elements that can play a role in environmentally-related change – environmental controversy and alignment of priorities each with accompanying social constructions and public debate. I proceeded with a three-step comparative investigative process. First I performed contextual analysis for APEGGA, probing for relevant causal elements. In a second step I focused on the differences and similarities between APEGGA, APEGBC and PEO. Finally, I compared and contrasted provincial electronic knowledge dissemination practices and its potential link with controversy and public debate. This exercise exposed the intricacies of causal complexities (Ragin, 1987: 20) in my comparative methodology strategy. I attempted to overcome oversimplification and tackled Ragin's problem of 'order-in-complexity' by focussing on the two principal causal elements above and their interactions with Hayden's normative criteria therefore uniting case similarities and differences under one explanatory framework (Ragin, 1987: 19).

Since at least the 1970s[58] APEGGA has been engaged in internal engineering and external professional and public debates and social constructions of environmental issues. Three recurring environmentally-related constructions and debates were water as a resource and its management (independently or sometimes linked with the oil sands), the oil sands[59] development and the oil and gas industry. I focused primarily on the oil sands and identified at least three discursive phases in relation to the Alberta oil sands: (1) the

[58] My archival research in Alberta spanned from 1970 to 2008. APEGGA archival documents reviewed including newsletters, conference proceedings, position papers and committee meeting minutes provided numerous accounts of the interactions, reactions and changes by APEGGA in response to public and internal debate on environmental issues.
[59] Tar sands was the first socially constructed discursive designation in the 1970s. I was not able to document the transition to the oil sands designation in the documents reviewed.

tar sands are useless for humans other than for oil extraction (early 1970s), (2) tar sands must be developed but there are environmental problems to be considered including sulphur dioxide emissions, sterile sand reclamation and water recycling (1980s), and (3) the more recent construction of the oil sands contributing to global warming. In this context, APEGGA has continually been called upon or has been proactive in liaising with governments and industry as well with the public on environmental issues. The sustained worldwide attention directed at oil sands activities touching on the relationship between engineering and the environment prompted the Association, I argue, to continuously be in a position to have to publicly address these issues which stimulated EM discourse and environmental governance progress. The weaker, shallower, less mature EM characteristics observed betrayed the discordance between Haydon's three criteria. In comparison to Ontario, however, Alberta's EM was not retrenched, I argue, due to sustained global external pressure from Hayden's social belief criteria. In the section on electronic knowledge dissemination I explored how global surveillance of Alberta's engineers also contributed to changes in the manner in which they organized and diffused environmentally-related knowledge on the internet.

The overt conflict between normative social belief, technological and ecological criteria (Hayden's, 2009: 115-116) in oil sands development reflected the conflicting Alberta profession of engineering institutional subnorms and resulting regulations and guidelines for professional practice. In terms of EM, the latter still placed economic considerations, a provincial and professional priority, ahead of instead of alongside ecological considerations as demonstrated through discourse analysis.

In British Columbia, the profession of engineering had already incorporated environmental considerations, though still in the early stages of EM, in its 1970 governance code of ethics. British Columbia and Alberta ecologically modernised along different paths from 1970 to 2009. The B.C. path yielded stronger, deeper and more advanced EM than found in Alberta. Contextual analysis revealed no controversial or on-going environmental conflict or issues that would have prompted EM in British Columbia. Looking more closely at the time-frame during which British Columbia wrote its sustainability guidelines and revised its code of ethics it appeared the changes could have reflected alignment with and co-construction of environmental priorities. British Columbia and the profession's provincial and national bodies were socially constructing the environment as a priority with environmentally-related initiatives and guidelines. The absence of economic development linked with a controversial environmental issue eased the alignment of the institution's norms and subnorms and reduced potential conflict between Hayden's three criteria. B.C. engineering policy and governance documents also followed an institutional EM evolution aligned with the APEGBC's 1993 Council resolution socially constructing the organisation as seeking to be actively involved in sustainability. This meant giving due consideration to economic, environmental and social elements in engineering activity. The 2009 APEGBC member survey on sustainability, a first step in the process of revamping the guidelines, demonstrated the Sustainability Committee's key role in the APEGBC's EM but also reinforced the apparent absence or silence of external EM drivers in British Columbia.

Notwithstanding the alignment of criteria in British Columbia, environmental problems involving professional engineers have and could still arise. This was aptly demonstrated by the early 2000s Ladyfern case of wasteful natural gas depletion on a grandiose scale where the APEGBC Guidelines for Sustainability were wilfully ignored (Andrews, 2009: 377-383). Cases such as Ladyfern's occurring in a province with the highest professional envirosponsibility return us to a fundamental question posed by Vanderburg (2007: 2) and Hyde (1999: 245-246): is the profession able to self-regulate with respect to the environment? The question, with accompanying debate and research, though intricately tied to professional envirosponsibility, remain beyond the scope of this investigation.

For Ontario I first investigated environmental controversy and ensuing public debate as a causal element. In contrast to Alberta I found no evidence that the profession of engineering in Ontario had been involved in extensive debates with external actors at a local, provincial, national, global scale with respect to the environment. The Guideline for Use at Contaminated Sites in Ontario (Brownfields) sparked several intra- and inter-professional debates as well as profession-regulator debates that appeared confined to the provincial level. An example of potential change following the prospect of external provincial oversight in Brownfields debates was the commitment by OSPE and PEO to increase professional development and tracking of environmentally-related professional development for QP engineers. I was not able to locate these new tools, but they would merit investigation. These profession-regulator negotiations represented a different type of environmentally-related controversy, though not international in scale and not involving the public. The negotiations, I advance, prompted the profession to envisage environmental governance change with ecological restructuring when faced with professional incursions.

The lack of engineering-environment public conflict and the absence of the social construction of environmental priorities such as that observed in British Columbia, I argue, contributed to the overall lack of impetus to undergo EM in the profession at PEO. OSPE compensated for this void with some measures of success as demonstrated by its involvement in the climate change debate and in providing environmentally-related professional development opportunities. Alternatively, could the industrial exemption and manufacturing sector priorities have also contributed to the slow EM update? I did not explore this venue for my investigation but I propose venues for such evidence in the final chapter.

Looking more particularly to the site of education in Ontario, comparisons with British Columbia and Alberta were insightful. I contend that two potentially important causal elements generating public debate that spurred modest university-level EM in Ontario engineering education were the significant recent provincial economic investments in green energy and the role of influential socio-engineering research actors (including Hyde (1999) and Vanderburg (2007)). Green energy initiatives with provincial support, public funding and related public debate no doubt influenced the creation of green energy engineering programs and research centres. In contrast to Alberta's oil sands development, there was minimal potential conflict between Hayden's criteria at the site of education as green energy technological criteria were not in conflict with the ecological and social belief criteria. In comparison to British Columbia, Ontario's site of education demonstrated how economic, social and technological considerations could be aligned to strive for mature EM. Vanderburg and Hyde, for their part, as influential insider actors in the profession published extensively, provoked public debate (Vanderburg, 2007: 2) and retained active roles in the profession's environmental governance (Hyde, CEAB member; Vanderburg, university professor in Ontario).

Electronic knowledge dissemination on association websites followed the same causal patterns described above. APEGGA featured a top-level environmental consideration link on its website welcome page constructing the environment as a primary consideration for Alberta engineers. This link directed website visitors to a listing of categories where the Association featured environmental knowledge or considerations. No other provincial association created this type of top-level link. I argue that unrelenting external requests for environmentally-related information in public debate and the need for APEGGA to demonstrate EM globally motivated Alberta to organize and disseminate this information in this manner. At APEGBC and in Ontario at OSPE, PEO and APGO, environmental considerations were integrated in relevant sub-institutional areas. Though not accessible from the top-level, APEGBC demonstrated the highest and most organized integration whereas Ontario demonstrated the least integration in comparison to the other provincial associations.

Focused contextual analysis helped further understanding of diverging EM trajectories in the provinces under study. Environmental controversy and alignment of priorities and their respective debates as causal elements of EM proved insightful to gain greater understanding of the patterns of similarities and differences in professional envirosponsibility. In the next chapter I propose how further research and potential new sources of evidence could help better account for the observed professional envirosponsibility patterned ranking.

CHAPTER FIVE: Conclusion

My empirical investigation revealed that the profession of engineering in Canada ecologically modernised from 1970 to 2009 bringing about ecological institutional reform. The new concept of professional envirosponsibility, with data gathered at the sites of education, professional obligation and legislation, allowed me to compare and contrast the stage of evolution as well as how and clues as to why EM varied between British Columbia, Alberta and Ontario. Overall British Columbia comparatively ranked highest in professional envirosponsibility with moderately strong, deep and advanced EM. Alberta, for its part, ranked second with early stage EM, weak in strength and depth. Falling short of an anticipated second-place standing, Ontario ranked lowest with demonstrated weak, shallow and early stage EM.

Looking back to the base year, 1970, weak and early stage EM transpired in Alberta and Ontario. British Columbia in contrast had already achieved a weak yet slightly more advanced EM stage with a professional code of ethics that incorporated environmental considerations. The 1970 engineering-environment relationship had been overwhelmingly socially constructed as end-of-pipe in the three provinces.

Thirty-nine years later, in 2009, I observed much wider provincial variations in EM strength, depth and evolution. Starting in British Columbia, unpacking its professional envirosponsibility revealed that APEGBC ecologically modernised its environmental governance structure to a moderate strength and depth whereas its governance policy and self-regulation documents and legislation reached mature and strong EM. B.C. governance instruments and environmental governance structure elements overwhelmingly constructed the environment and the engineer-environment relationship as fully integrating economic, environmental and social considerations in engineering activities. British Columbia EM faltered at the site of education, however, where in 1970 and in 2009 educational institutions predominantly portrayed the environment and engineer-environment relationship as end-of-pipe. In addition, educational institutions in British Columbia overwhelmingly chose to only meet minimal environmentally-related curriculum requirements in non-environmentally-related engineering programs. The latter was consistent with empirical observations in the provinces of Alberta and Ontario.

Unpacking Alberta's professional envirosponsibility exposed more modest EM gains for the profession with weak to moderate strength and depth EM lower in comparison to British Columbia, but stronger than that found in Ontario. The APEGGA's environmental committee showed no signs of relenting in its activities and involvement in pan-association undertakings and EM in the profession. Early stage EM was evident in governance policy and self-regulation documents and legislation where end-of-pipe discourse and the domination of economic considerations over ecological considerations hindered EM maturity. The APEGGA's code of ethics also revealed only weak EM where the environment remained at the periphery of the engineer-environment relationship. Furthermore, at the site of education Alberta maintained end-of-pipe discourse in 1970 and in 2009 but demonstrated evolution in 2009 by integrating environmentally-related options in its engineering programs.

Professional envirosponsibility in Ontario concealed contrasting trends between its provincial associations as well as between its environmental governance, professional obligation documents and policies and the site of education. Ontario's unique industrial exemption, PEO's silence on the environment in its code of ethics, its early-stage weak to moderate EM in its guidelines and its ecological 'demodernisation' of environmental governance with the removal of its stand-alone environmental committee, were only moderately bolstered by EM gains at APGO and OSPE. The division of labour between OSPE and PEO on climate change, for example, revealed the potential EM environmental governance gains that can be achieved when regulatory and advocacy components of a profession are decoupled. Similarly, APGO's inclusion of environmental considerations in its code of ethics and in its guiding provincial legislation, though demonstrating early stage EM, were nonetheless signs of ecological institutional reform. End-of-pipe discourse dominated discourse analysis at all professional envirosponsibility sites. The site of education incurred the sharpest decline in end-of-pipe discourse from 1970 to 2009, though still dominant, in comparison to the steady higher rates in British Columbia and Alberta.

The changes I observed in EM from 1970 to 2009 were also indicative, I contend, of the shift toward 'plural regulatory networks' where non-state actors, in this case the profession of engineering, took part in decentralized regulation and took responsibility for public policies (Barkay, 2009: 361). This decentralization might require adjustments, however, as demonstrated by the limitations of self-regulation in meeting the need to protect the public or the environment in engineering-environment interactions.

One of the sites where I encountered the debate on limitations of engineering self-regulation was in engineering education. Looking to the future, changes in the CEAB governance could perhaps help the profession further ecologically modernise and address self-governance critiques. What form could an environmentally-informed CEAB governance oversight model take? CEAB oversight could involve, I contend, social science technology and environmental knowledge experts in fields such as science and technology or environmental sociology and environmental economics in conjunction with environmental science knowledge experts outside the realm of engineering. This type of oversight would espouse Vanderburg's (2007) vision of a new knowledge system for engineering based on the strengths of interdisciplinarity to deal with the consequences of technology and reflect harmonization of Hayden's social, ecological and technological criteria for institutional decision-makers.

Contextual analysis provided insights into why the three provinces engaged in EM yielding varying strengths, depths and levels of maturity. The predicted professional envirosponsibility ranking I had originally proposed with the highest ranking in British Columbia, Ontario in a middle position and the lowest ranking in Alberta proved to be based on faulty reasoning. I had erroneously assumed that higher levels of environmental problems involving professional engineering services, such as the oil sands in Alberta, and higher polluting ranking would yield lower EM. The empirically observed professional envirosponsibility ranking and the causal analysis proved me wrong.

The two causal elements investigated for their influence on EM, environmental controversy and alignment of socially constructed environmental priorities were revealing. I argued that the Alberta oil sands activities and intensive local to global surveillance and public controversy and debate continuously called on APEGGA to publicly address these issues which in turn stimulated EM discourse and environmental governance change. Weak in strength and early in developmental stages, EM in Alberta displayed conflict between normative social belief, technological and ecological criteria (Hayden's, 2009: 115-116). With respect to oil sands development, for example, the conflict was salient between social beliefs and Alberta's profession of engineering institutional subnorms and resulting regulations and guidelines for professional practice. The latter placed economic considerations, a provincial, commercial and professional priority, ahead of ecological and social considerations.

In contrast to Alberta, the profession of engineering in British Columbia had already incorporated environmental considerations in its 1970 code of ethics. Both British Columbia and Alberta ecologically modernised from 1970 to 2009, but EM in British Columbia was stronger, deeper and more advanced, why? Contextual analysis revealed no outstanding environmental conflict or issue similar to the Alberta oil sands issue that would have prompted EM in British Columbia Looking more closely at the time-frame during which British Columbia wrote its sustainability guidelines and revised its code of ethics it appears the changes could have reflected alignment of APEGBC socially constructed environmental priorities with provincial and the profession of engineering national and provincial social constructions of environmental priorities. The absence of large-scale provincial or private economic development linked with a controversial environmental issue and the absence of conflicting goals no doubt could have facilitated the alignment of the institution's norms and subnorms integrating Hayden's three criteria.

The British Columbia Ladyfern case of wasteful natural gas depletion on a large scale served as an example of problems that can still arise, however, in spite of stronger, deeper and more mature EM. This example prompted me to return to a controversial question posed by Vanderburg (2007: 2) and Hyde (1999: 245-246), is the profession able to self-regulate with respect to the environment? The question and ensuing debate and research, I concluded, though intricately tied to professional envirosponsibility, remained beyond the scope of this investigation.

For Ontario causal analysis revealed that the lack of engineering-environment relationship public conflict and the absence of environmental leadership as demonstrated at the APEGBC contributed to the lack of motivation to undertake EM. At the site of education in Ontario where modest EM was achieved with Ontario ahead of British Columbia and Alberta, I explore two causal factors. The first was the significant provincial economic investments in green energy and the second was the involvement of key social-engineer actors (including Hyde and Vanderburg). The two elements provoked public debate that might have motivated university-level EM in Ontario engineering education. The parallels between B.C. provincial priorities and Ontario's new green energy provincial priorities were evident in the change in green energy engineering programs. In contrast to Alberta's oil sands development, there were few potential conflicts between Hayden's criteria at the site of education as the technological, ecological and social beliefs criteria were integrated that contributed to a drop in end-of-pipe discourse.

Electronic knowledge dissemination on associations' websites followed the same patterns of provincial differences and similarities described above, I further argued. I contend that Alberta's response to constant external gaze prompted the Association to consolidate and feature top-level environmentally-related content, the only overt profession-environment knowledge display compared to the other provinces. In contrast, B.C.'s environmentally-related content was knowledge-rich, but deeply integrated throughout their website. In Ontario, PEO's website contained the least accessible and most scarce engineer-environment relationship knowledge, but OSPE and APGO's modest knowledge dissemination efforts mitigated for the latter.

My analysis of causal influences to explain the patterned ranking of professional envirosponsibility in British Columbia, Albert and Ontario was restricted to mostly internal elements for which I had gathered data. Looking more broadly to external influences, what political, economic, ideological or social structure and movements could have contributed to the ranking? Further research could investigate these influences by looking at evidence not uncovered in this investigation. Such evidence to help account for the variation could include: review of the Ontario manufacturing sector, its environmental priorities and practices and its relationship with engineering; provincial and national political actors and dynamics including Ministers, political parties in power, environmentally-related policies; provincial and national economic priorities and policies; industry-specific relationships with the profession of engineering and the environment; and environmentally-related social movements and their governance and influence such as the David Suzuki Foundation in British Columbia.

Ecological restructuring at the national level, though not integrated in envirosponsibility comparative analysis, provided important insights into actors and power dynamics in the profession at national and international levels. Whether national EM and ecological restructuring was initiated by constituent members (i.e., the first integration of environmental considerations in engineering curriculum requirements was initiated by requests from the provinces of Manitoba and Quebec), by national and international staff involvement in environmental committees or by actors in roles of power (i.e., EC who set minimum curriculum requirements, the CEAB, or the CEO with graduate environmental education who authorized access to EC archives for this investigation), the change from 1970 to 2009 was significant, though moderate overall.

The site of education's inverted professional envirosponsibility rankings reflected its quasi-autonomous environmental governance from the profession. Going beyond the province-specific analysis above, empirical analysis revealed that in order to help reduce the gap between elevated professional environmentally-related obligations and lower minimum nationally-set education environmentally-related curriculum requirements, engineering environmentally-related education would need to move beyond the minimalist typical two survey course environmental content currently in place. Curriculum EM models included those proposed by Vanderburg (2007), Crofton (1995, 2000) or the CSA (Mortimer and Walker, 2007) model specifically for climate change and civil engineers. The absence of EM in the disciplines of software and computer engineering and electrical engineering were explored in function of the social construction of environmental needs related to these fields.

The site of education revealed a second environmental governance gap, CPD. Based on a professional engineer's typical career span, I concluded that CPD, currently not requiring mandatory environmental PDH, was an underutilized environmental governance instrument to help achieve and maintain a narrow gap between a professional engineer's environmental knowledge and professional environmentally-related obligations. Mandatory environmentally-related PDH, I argued, could help meet this goal.

I now turn my attention to methodological and theoretical considerations. Starting with methodology I offer this reflection on my first comparative investigation. It was only in the throes of investigation and writing that I finally understood Ragin's observation that comparative methodologists who opt for case-oriented methods combine causal and interpretive analysis with concept formation (2007: 51). This insight surfaced in my data gathering phase, but resurfaced with more intensity during the thesis writing process where concurrent and competing comparative analysis activities proved challenging to coordinate.

Shifting focus to EMT perspectives, I revisit my use of a hybrid discourse and institutional analysis approach to measure EM in the provinces. The step-wise approach I selected was successful, in my view, as the first step of producing an environmental governance structure not only helped me establish which levels and which elements were most appropriate for the profession but it also doubled as a rich source of insight into EM depth. Selection of discourse analysis in the second step demonstrated a more accurate reflection of the profession, I believe. The consistent patterns of similarities and differences across cases allowed for triangulation of the two analytical perspectives. In comparison to environmental governance analysis where I had access to an abundance of sources with high quality data, discourse analysis sometimes proved more difficult to execute when discourse was short with limited opportunity to generate story-lines.

The case-oriented method, for its part, proved well-suited for this investigation. The consistent patterns of similarities and differences matched across sites as well as across analysis types, environmental governance and discourse analysis. Combining the latter also allowed me to understand the engineering profession provincial cases as a whole, not only in parts (2007: 52), which contributed to a richer causal analysis.

Another theoretical consideration that merits further review is the combination of discourse analysis with institutional analysis (using Hollingsworth's structured multi-disciplinary institutional approach (2000: 601) and Hayden's normative institutional analysis approach) that provided complementary strengths to the investigation and to causal analysis. The challenge and potential reliability limitations of discourse analysis based on the short discourse sources described above were mitigated by comparable institutional analysis. Hayden's approach also proved adept at furthering understanding as to why EM occurred at different rates, strengths and depths across provinces.

Furthermore, this investigation bolstered my optimism, though still cautious at this stage, for the concept of professional envirosponsibility's analytical potential in understanding EM in the professions. This first trial was successful, in my view, in spite of a few faulty indicators. The concept of professional envirosponsibility also allowed me to at least partially address an EMT critique that ecologically modernised discourse can hide the absence of implementation or of ecological restructuring (Davidson and MacKendrick, 2004). Incorporating environmental governance as a measure of EM depth partially addressed this critique. A more thorough measure of depth would link environmentally-related professional activities with EM. For engineers this could have entailed analysis of disciplinary action by the profession in cases of breach of environmentally-related guidelines, laws or other applicable professional governance tools such as the code of ethics. For reasons outlined in the methodology section this type of analysis was not possible in this investigation.

My cautiousness concerning the concept of professional envirosponsibility and its potential use by other social researchers also reflects the need to: (1) further theoretical and analytical knowledge on the link between responsibility, the environment and the professions (2) test the concept's applicability with other professions, (3) adapt the selection of sites and respective indicators appropriately for each profession.

I would be remiss not to touch on reflexivity and my attempts as a novice researcher to ensure that I actively engaged in it. At the start of my investigation I recognized that my research endeavours would include reflections of my professional and educational background, my inclinations and my environment in all aspects of the research from planning to final dissemination (Mauthner and Doucet, 2003:415; Gibbs, 2007: 91). With these influences in mind I explicitly stated my position in the Preface. Throughout the research process I attempted to systematically review my position and my motivations therefore actively engaging in reflexivity given the power bestowed to my position as researcher in the social relations of research (Walby, 2007: 1009).

I was undoubtedly only able to achieve 'degrees of reflexivity' (Mauthner and Doucet, 2003: 425) in my research activities, however, in spite of sustained attempts to be reflexive of my motivations, my involvement and my justifications as well as for the dynamics I witnessed. This Master's research experience contributed to my understanding of the complexity of engaging in reflexivity and of the ease with which I was sometimes tempted to ignore motivations and justifications that disregarded one or several aspects of that data collected or EM patterns that emerged.

In closing, I return to Dinsmore's 1970 call to action or perhaps better framed as an early call for ecological modernisation. Did the profession heed Dinsmore's advice? Based on my empirical investigation the advice appears to have been followed with some measure of success by the profession in British Columbia and at the national level whereas I observed more modest EM and institutional ecological reform in Alberta and in Ontario. It is my hope that my investigation will contribute to the dialogue and research into the engineering-environment relationship and to better understanding of responsibility in the professional-environment relationship.

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APPENDIX A

Listing of Engineers Canada Constituent Members and Association/*Ordre* Acronyms (EC, 2009a).

APEGBC	**Association of Professional Engineers and Geoscientists of British Columbia**
APEGGA	**Association of Professional Engineers, Geologists and Geophysicists of Alberta**
APEGS	Association of Professional Engineers and Geoscientists of Saskatchewan
APEGM	Association of Professional Engineers and Geoscientists of the Province of Manitoba
PEO	**Professional Engineers Ontario**
OIQ	*Ordre des Ingénieurs du Québec*
APENS	Association of Professional Engineers of Nova Scotia
APEGNB	Association of Professional Engineers and Geoscientists of New Brunswick
APEPEI	Association of Professional Engineers of PEI
PEGNL	Professional Engineers and Geoscientists of Newfoundland and Labrador
NAPEG	Northwest Territories and Nunavut Association of Professional Engineers and Geoscientists
APEY	Association of Professional Engineers of Yukon

APPENDIX B

Table 2: 2008 Minimum Environmentally-Related Accreditation Criteria for the Engineering Graduate Attributes and Curriculum Content (EC, 2008).

General Purpose of Accreditation	
"The engineering profession expects of its members competence in engineering as well as an understanding of the **effects of engineering on society**. Thus, accredited engineering programs must contain not only adequate mathematics, science, and engineering curriculum content but must also develop communication skills, an **understanding of the environmental**, cultural, economic, and social impacts of engineering on society, the **concepts of sustainable development**, and the capacity for life-long learning" (2008: 11)	
Category and Criteria	**Minimum Environmentally-related Graduate Attributes and Curriculum Content**
Engineering Graduate's Attributes	
Design	Ability to design demonstrates "***appropriate attention*** to the environment" amongst other considerations (2008: 12).
Impact of engineering on society and the environment	"An ***ability to analyse*** social and environmental aspects of engineering activities" (2008: 13).
Ethics and Equity	"An ***ability to apply*** professional ethics, accountability, and equity" (2008: 13).
Curriculum Content	
Accreditation Units* in Design	Includes ***consideration for*** relevant constraints, including standards and legislation with respect to the environment (2008: 17).
Accreditation Units in Complementary Studies	Curriculum ***must include*** choice of studies in "Sustainable development and environmental stewardship", "The impact of technology on society" and "Professional ethics, equity and law" (2008: 18), along with four additional mandatory studies choices.

*The concept of 'Accreditation Units' standardizes hours of curriculum teaching in function of total teaching time at an institution enabling cross-institution comparison (EC, 2008: 15)

APPENDIX C

Table 3: Overview of Select Criteria related to Engineering, by Province from Western to Eastern Canada.

<table>
<tr><th>Province</th><th>2007 Pop.[60] ('000)</th><th>University Programs(ALL | Civil+Enviro)[61]</th><th>% Prog/Pop. (ALL | Civil+Env.)</th><th>% (civil+env.)/ all prog.</th><th>Active Eng. Services[62] (% of pop)</th><th>Air Pollution-NPRI[63] (ratio:total(kg)/pop | total (kg), ('000))</th><th>Air Pollution-Greenhouse Gases[64] (ratio:total(tonnes)/pop | total(tonnes), ('000))</th><th colspan="2">% Engineers in the province or territory[65 66]</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>%</td><td>Ratio: pop/ 100,000</td></tr>
<tr><td>YK</td><td>31.0</td><td>N/A[67]</td><td>N/A</td><td>N/A</td><td>24 (.08)</td><td>5 | 140,493</td><td>N/A</td><td>0.1</td><td>3</td></tr>
<tr><td>NWT</td><td>42.6</td><td>N/A</td><td>N/A</td><td>N/A</td><td>22 (.05)</td><td>184 | 7,844</td><td>8 | 359</td><td>0.2[68]</td><td>5</td></tr>
<tr><td>Nunavut</td><td>31.1</td><td>N/A</td><td>N/A</td><td>N/A</td><td></td><td>146 | 4,530</td><td></td><td>N/A</td><td></td></tr>
<tr><td>B.C.</td><td>4,380.3</td><td>UBC (12 | 2)
NBCU (1 | 1)
SFU (1 | 0)
UVic (4 | 0)</td><td>.41 | .068</td><td>17</td><td>3426 (.08)</td><td>125 | 548,772</td><td>3 | 12,444</td><td>9</td><td>2</td></tr>
<tr><td>AB</td><td>3,474.0</td><td>U Alberta (9 | 1)
U Calgary (9 | 1)</td><td>.52 | .058</td><td>11</td><td>5238 (.15)</td><td>386 | 1,339,425</td><td>32 | 110,781</td><td>19</td><td>5</td></tr>
<tr><td>SK</td><td>996.9</td><td>U Regina (5 | 1)
U Sask (7 | 1)</td><td>1.20 | .20</td><td>17</td><td>273 (.03)</td><td>254 | 253,518</td><td>23 | 22,870</td><td>1.7</td><td>2</td></tr>
<tr><td>MB</td><td>1,186.7</td><td>U Manitoba (6 | 1)</td><td>.51 | .084</td><td>17</td><td>251 (.02)</td><td>355 | 420,852</td><td>2 | 2,941</td><td>2.5</td><td>2</td></tr>
</table>

60 Statistics Canada, 2008, Table: 2007 Population by year, by province and territory, Persons (thousands)
61 Engineers Canada, 2008, Accredited Engineering Programs, List by Institution, active in 2008
62 Statistics Canada, 2008, Table: 2006 Engineering services, by province and territory, Active Establishments
63 Pollution Watch, 2008, Ranking Provinces by Total Reported Releases & Transfers with Combined Air Release for 2005
64 Pollution Watch, 2008, Ranking Provinces by Total of All Gases for 2005, Total of All Gases (tonnes - CO2 equivalent)
65 Canadian Council of Professional Engineers (CCPE) and the Government of Canada, sponsors, 2002 National Survey of Professional Engineers, incl. geologists, geophysicists and geoscientists in provinces where they fall under the same legislation as professional engineers
66 Geoscientists are excluded in Ontario, Quebec and Nova Scotia
67 n/a is not applicable
68 Professional Engineers, Geologists and Geophysicists of the Northwest Territories (NAPEGG) includes Nunavut

<table>
<tr><td>ON</td><td>12,803.9</td><td>Carleton U (9 | 2)
Guelph U (4 | 2)
Lakehead U (5 | 1)
Laurentian (2 | 0)
McMaster U (10 | 1)
UOIT (3 | 0)
U Ottawa (6 | 1)
Queen's U (10 | 1)
RMC (5 | 1)
Ryerson (7 | 1)
UofT (9 | 1)
U Waterloo (10 | 2)
Western U (7 | 1)
U Windsor (5 | 2)
York U (3 | 0)</td><td>.74 | .12</td><td>17</td><td>6823 (.05)</td><td>87 | 1,118,002</td><td>6 | 78,400</td><td>38</td><td>3</td></tr>
<tr><td>QC</td><td>7,700.8</td><td>Concordia U(7 | 1)
ETC (7 | 0)
U Laval (14 | 2)
McGill U (10 | 1)
Polytechnique (11 | 1)
UQ-AT (1 | 0)
UQ-C (5 | 0)
UQ-M (1 | 0)
UQ-O (1 | 0)
UQ-R (1 | 0)
UQ-TR (5 | 0)
U Sherbrooke (6 | 1)</td><td>.89 | .078</td><td>9</td><td>3022 (.04)</td><td>82 | 634,659</td><td>3 | 22,101</td><td>25</td><td>3</td></tr>
<tr><td>NB</td><td>749.8</td><td>Moncton (4 | 1)
UNB (9 | 1)</td><td>1.73 | .27</td><td>15</td><td>260 (.03)</td><td>189 | 142,013</td><td>17 | 12,611</td><td>1.4</td><td>2</td></tr>
<tr><td>NS</td><td>934.1</td><td>Dalhousie U (10 | 2)</td><td>1.1 | .21</td><td>20</td><td>345 (.04)</td><td>183 | 171,294</td><td>13 | 12,015</td><td>2.4</td><td>3</td></tr>
<tr><td>PEI</td><td>138.6</td><td>N/A</td><td>N/A</td><td>N/A</td><td>N/A</td><td>22 | 3,034</td><td>1 | 104</td><td>0.1</td><td>1</td></tr>
<tr><td>NFL</td><td>506.3</td><td>Memorial U (5 |1)</td><td>.98 | .20</td><td>20</td><td>199 (.04)</td><td>152 | 76,958</td><td>10 | 5,216</td><td>1.2</td><td>2</td></tr>
</table>

APPENDIX D

Listing of Universities with accredited engineering programs in 1969-1970/1970-71, 2008-2009/2009-2010.

Province and University	Data - 1969-1970/1970-71[69]	Data - 2008-2009/2009-2010
British Columbia		
University of British Columbia	Obtained	Obtained
University of Northern British Columbia	N/A[70]	Obtained
Simon Fraser University	N/A	Obtained
University of Victoria	N/A	Obtained
Alberta		
University of Alberta	Obtained	Obtained
University of Calgary	Obtained	Obtained
Ontario		
Carleton University	Obtained	Obtained
Guelph University	Obtained	Obtained
Lakehead University	N/A	Obtained
Laurentian University	N/A	Obtained
McMaster University	Obtained	Obtained
University of Ontario Institute of Technology	N/A	Obtained
University of Ottawa	Obtained	Obtained
Queen's University	Obtained	Obtained
Royal Military College	Obtained	Obtained
Ryerson University	N/A	Obtained
University of Toronto	Obtained	Obtained
University of Waterloo	Obtained	Obtained
Western University	Obtained	Obtained
University of Windsor	Obtained	Obtained
York University	N/A	Obtained

[69] The absence of accredited engineering programs in 1969-1970/1970-1971 does not imply these universities did not offer engineering-related courses or programs. Those unaccredited programs that were offered did not fall within the scope of this study and were not reviewed.

[70] N/A is Not Applicable.

APPENDIX E
Abbreviated discourse analysis code book.

This abbreviated discourse analysis code book contains methodological decisions and considerations and coding lists and details, by discourse analysis type. Coding and quantification was performed using AtlasTI software based on word processing documents in which discourse was compiled by discourse analysis type.

I performed coding over the period of several months. In the absence of an intercoder reliability process, I performed select re-coding of discourse in an effort to ensure reliability.

Keyword Approach
Discourse was subjected to extensive readings[71] in addition to automated searches for keywords related to the engineer-environment relationship, including, but not limited to: environment, environmental, nature, natural, sustainable, sustainability, sustainable development, pollution, recycling and waste. Keywords to capture social considerations included: social, socially, society and societal. Once identified, depending on the type of discourse analysis performed, these keywords and accompanying discourse were subjected to further analysis as described by analysis type.

One of the challenges I encountered during discourse analysis was the range of meanings engineers attribute to the word 'environment'. A course titled 'environmental health engineering', for example, focussed on the health of workers in artificially created and confined mining environments where ventilation, temperature and exposure to radiation are engineering priorities. This type of usage did not make reference to the 'environment' in its wider sense but rather referred to the 'workplace environment' and was therefore excluded from my sampling.

Short Course Descriptions
Course descriptions containing relevant keywords were included in the sample. Sample sizes and details are presented in the Methodology section.

The starting point for the short course description coding list was Mihelcic et al. (2003: 5315) categorization of perspectives with respect to engineering and the environment: end-of-pipe treatment (e.g., waste water treatment), pollution prevention (waste reduction, recycling) pro-active design for the environment (e.g., replacing toxic raw materials with environment-friendly compounds) and sustainable development (2003: 5315). I reasoned that the researchers' categorization, developed through empirical research of the engineering field, was a solid basis on which to build my coding list.

---

[71] Manual readings were essential to capture discourse pertaining to the engineer-environment relationship that did not exactly reflect keywords used in an automated search.

I expanded on the core short course description coding list based on extensive review of discourse and an analysis of environmentally-related themes that emerged. The coding list for short course descriptions included breakdowns with respect to the code as 'discipline-specific' or 'generic' in order to attempt to capture tailored discipline-focused discourse. Collapsing of multiple codes into sub-totals was performed on select groups of codes as detailed in the coding list below.

There were striking differences in discourse between 1970 and 2009 short course descriptions. The latter were for the most part technical listings of engineering-related terms with almost no sentence structures. The 2009 course descriptions, on the other hand, were highly descriptive and promotional in nature. All the years analysed, however, contained insufficient discourse to generate story-lines.

Coding List for Short Course Descriptions
dual economic/environmental impact/analysis/consideration
economic focus of alternative energy
economic focus of environmental engineering process
nuclear power as renewable energy
environment as energy source - renewable, alternative and conventional (1)
alternative fuels and energy (2)
technological, economic considerations of alternative energy (3)
Sub-total alternative energy (Sum of 1 + 2 + 3 above)
environment as object of engineering practice
environmental consideration as problematic
environmental considerations integrated in topic-specific curriculum
environmental impact - assessment/considerations
environmental problems as end of pipe
environmental problems as health risk
environmental problems as local to global problems
environmental problems as regulatory perspective/issues/problems
environmental problems as risk
environmental systems analysis approach
hands-on environmental-related engineering (lab/research)
pro-active design for the environment
resource recovery/prevention approach (reuse-recycle-pollution prevention)
responsibility to society
responsibility to society and in general
responsibility to society and to environment
social, technological and environmental dimensions, discipline-specific (4)
social, technological and environmental dimensions, generic (5)
social, technological, environmental and economic dimensions, discipline-specific (6)
Sub-total social/tech/enviro (Sum of 4 + 5 + 6)
sustainability/stewardship approach, discipline-specific (7)
sustainability/stewardship approach, generic (8)

Sub-total sustainability (Sum of 7 +8)
technological and environmental dimensions, discipline-specific

Environmental Guidelines
The nature of the environmental guidelines discourse contained in lengthy documents lent itself to story-line analysis. The first step of the analysis was the keyword approach (described above). When discourse contained keywords touching on the engineer-environment, I further analysed discourse to identify the main story-line for each province. Given the complexity of the environmental guideline discourse, I deemed it appropriate to go one step further and extract supporting story-lines.

Of all the discourse analysis coding, the environmental guidelines offered the biggest challenge for me. The discourse was both technical and philosophical and writing styles, especially in Ontario, appeared to reflect consolidation of texts from multiple authors. I revisited my coding numerous times over the course of several weeks to ensure I understood the discourse and was adequately capturing its socially constructed story-lines.

Association by-laws, codes of ethics, provincial engineering and geoscience acts, curriculum criteria and syllabus and preparatory documents for the Professional Practice Exam
The first step for analysis of these five discourse categories was once more keyword analysis. The low incidence of keyword identification rendered discourse analysis more manageable but added a layer of complexity in interpretation in the absence of built-in redundancy. I engaged in academic transparency with keyword identification and/or related discourse analysis by including the almost totality of the resulting analysis and/or keyword identification directly in the thesis text or in appendices.

National-Level Analysis
Using the same keyword criteria, I performed discourse analysis on national-level discourse (including curriculum criteria that is only available at the national level), where available and relevant, in order to capture national-provincial variations and observe influence patterns from national to provincial or vice-versa. Although national-level analysis was not incorporated in the professional envirosponsibility comparison, it nonetheless revealed important insight in the profession's environmental governance and the engineer-environment relationship.

APPENDIX F

Hayden's (2009: 108) portrayal of the interaction between social, technological and ecological criteria in institutional analysis. Reproduced with permission.

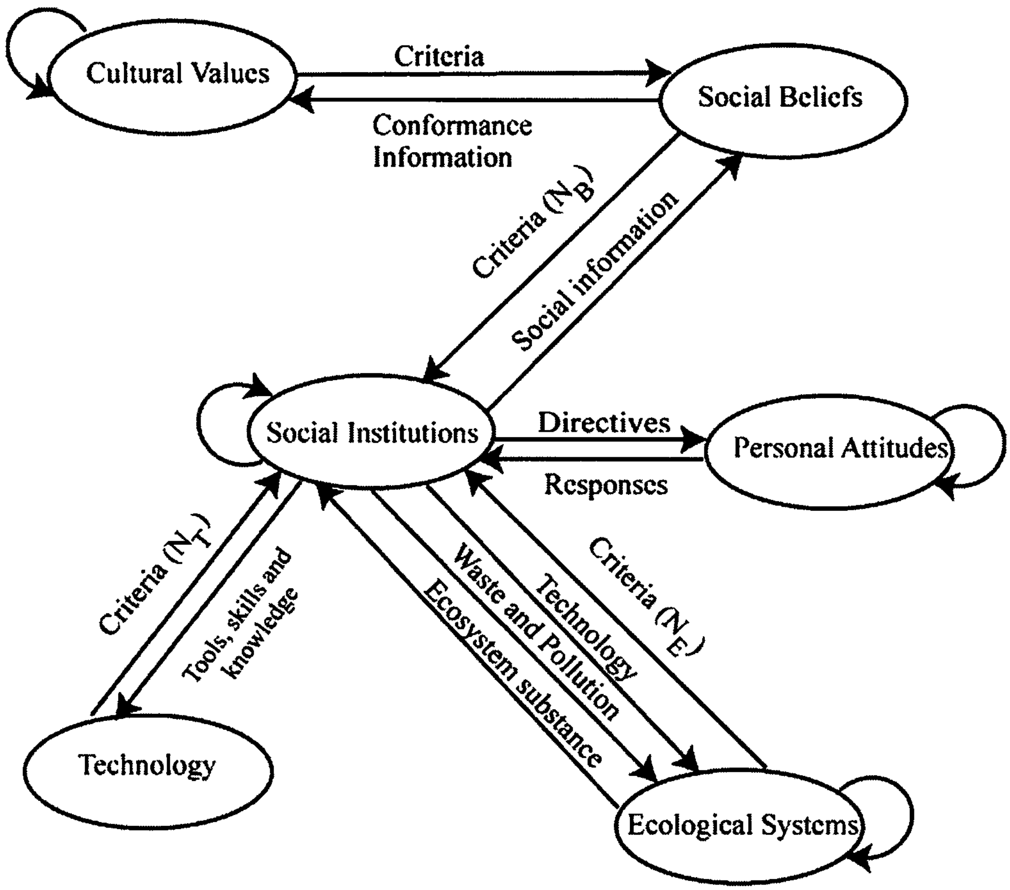

Fig. 1 Relationships among values, beliefs, attitudes, institutions, technology, and the ecological system

APPENDIX G

Listing of CAB/CEAB Members by Type from 1975 to 2008[72].

Year	U	(Civ.)	*U %*	Priv.	*%*	Petr.	*%*	Gov	*%*	EC	*%*	*SUM %*
1975	4		*40*	3	*30*	2	*20*	0	*0*	1	*10*	*30*
1976	5		*50*	2	*20*	2	*20*	0	*0*	1	*10*	*40*
1977	7		*70*	1	*10*	1	*10*	0	*0*	1	*10*	*20*
1978	7		*64*	1	*9*	1	*9*	1	*9*	1	*9*	*18*
1979	7		*58*	3	*25*	1	*8*	0	*0*	1	*8*	*33*
1980	7		*58*	4	*33*	0	*0*	0	*0*	1	*8*	*33*
1981	8		*67*	3	*25*	0	*0*	0	*0*	1	*8*	*25*
1982	8		*67*	2	*17*	0	*0*	1	*8*	1	*8*	*17*
1983	8		*67*	1	*8*	1	*8*	1	*8*	1	*8*	*8*
1984	8		*67*	1	*8*	1	*8*	1	*8*	1	*8*	*8*
1985	8		*67*	2	*17*	0	*0*	1	*8*	1	*8*	*17*
1986	9	(1)	*64*	3	*21*	0	*0*	1	*7*	1	*7*	*21*
1987	9	(2)	*64*	2	*14*	0	*0*	2	*14*	1	*7*	*14*
1988	8	(1)	*57*	3	*21*	0	*0*	2	*14*	1	*7*	*21*
1989	8	(1)	*57*	3	*21*	0	*0*	2	*14*	1	*7*	*21*
1990	8	(1)	*53*	4	*27*	0	*0*	2	*13*	1	*7*	*27*
1991	9	(1)	*64*	3	*21*	0	*0*	1	*7*	1	*7*	*21*
1992	8	(0)	*57*	4	*29*	0	*0*	1	*7*	1	*7*	*29*
1993	8	(1)	*57*	4	*29*	0	*0*	1	*7*	1	*7*	*29*
1994	7	(0)	*50*	5	*36*	0	*0*	1	*7*	1	*7*	*36*
1995	6	(0)	*43*	5	*36*	0	*0*	2	*14*	1	*7*	*36*
1996	7	(0)	*50*	5	*36*	0	*0*	1	*7*	1	*7*	*36*
1997	9	(0)	*64*	2	*14*	0	*0*	2	*14*	1	*7*	*14*
1998	10	(0)	*71*	2	*14*	0	*0*	1	*7*	1	*7*	*14*
1999	10	(0)	*71*	3	*21*	0	*0*	0	*0*	1	*7*	*21*
2000	8	(0)	*57*	4	*29*	0	*0*	1	*7*	1	*7*	*29*
2001	9	(0)	*64*	3	*21*	1	*7*	0	*0*	1	*7*	*21*
2002	6	(0)	*43*	6	*43*	1	*7*	0	*0*	1	*7*	*50*
2003	7	(0)	*47*	6	*40*	1	*7*	0	*0*	1	*7*	*47*
2004	9	(1)	*56*	5	*31*	1	*6*	0	*0*	1	*6*	*37*
2005	10	(1)	*63*	4	*25*	1	*6*	0	*0*	1	*6*	*31*
2006	11	(1)	*69*	2	*13*	1	*6*	1	*6*	1	*6*	*19*
2007	12	(1)	*75*	2	*13*	0	*0*	1	*6*	1	*6*	*13*
2008	12	(1)	*75*	2	*13*	0	*0*	1	*6*	1	*6*	*13*
Mean	*8.1*	*0.6*	*60.2*	*3.1*	*22.6*	*0.4*	*3.6*	*0.8*	*5.8*	*1.0*	*7.4*	*25.0*

Legend: U – University-Based Members (including Professors, Deans and Emeritus Professors)
Civ. – Discipline identified as Civil Engineering for University Member (data was not available for all members, no Environmental Engineering identified)
Priv. – Consulting or Engineering Firm and P.Eng. with no specific affiliation. No Civil or Environmental Engineering firms identified.
Petr. - Oil and Gas Industry
Gov. – Government member from municipal, provincial or federal levels
EC – Committee Secretary is always from Engineers Canada
SUM% - Percentage sum total of Priv. (Consulting or Engineering Firm) and Petr. (Oil and Gas Industry)

[72] Based on Members Lists in CAB/CEAB Annual Reports from 1975 to 2008 from CE Archives. Total percentage may not add up to 100% due to rounding.

APPENDIX H

Listing of Provincial Environmentally-Related or Engineering/Geoscience Legislation in British Columbia, Alberta and Ontario[73].

Province	Legislation
British Columbia	**Engineering or Geoscientist** B.C. Engineers and Geoscientists Act (this joint Act became law in 1990, former Acts were 'Engineer Acts', therefore in 1970 I refer to the Engineer Act and the former Association of Professional Engineers of the Province of British Columbia) **Environmentally-related** Carbon Tax Act Environmental Management Act Water Act Water Protection Act
Alberta	**Engineering or Geoscientist** The Engineering, Geological and Geophysical Professions Act **Environmentally-related** Environmental Protection and Enhancement Act Water Act Climate Change and Emissions Management Act
Ontario	**Engineering or Geoscientist** Ontario Professional Engineers Act Professional Geoscientist's Act **Environmentally-related** Clean Water Act Environmental Protection Act Environmental Bill of Rights Act Environmental Assessment Act Green Energy Act (repeals the Energy Conservation Leadership Act, 2006 and the Energy Efficiency Act) Ontario Water Resources Act Guideline for Use at Contaminated Sites in Ontario (Brownfields)

[73] Data collected from Andrews (2009: 314) and provincial legislation websites (BC – www.leg.bc.ca/legislation/index.htm, Alberta – www.environment.alberta.ca, and Ontario – www.e-laws.gov.on.ca/index.html)

APPENDIX I

Summary of EC's Environmental Guideline Precepts for Professional Engineers (CCPE, 2006: 13-14). Reproduced with permission.

Professional Engineers:

1. Should develop and maintain a reasonable level of understanding, awareness, and a system of monitoring environmental and sustainability issues related to their field of expertise.

2. Should (at the APEGGA, this is *SHALL*) use appropriate expertise of specialists in areas where the professional engineer's knowledge alone is not adequate to address environmental and sustainability issues.

3. Should (at the APEGGA, this is *SHALL*) apply professional and responsible judgment in their environmental and sustainability considerations.

4. Should ensure that environmental planning and management is integrated into all their activities which are likely to have any adverse effects.

5. Should include the costs of environmental protection among the essential factors used for evaluating the economic viability of projects for which they are responsible.

6. Should recognize the value of environmental efficiency and sustainability, consider full life-cycle assessment to determine the benefits and costs of additional environmental stewardship, and endeavour to implement efficient, sustainable solutions.

7. Should engage and solicit input from stakeholders in an open manner, and strive to respond to environmental concerns in a timely fashion.

8. Should (at the APEGGA, this is *SHALL*) comply with regulatory requirements and endeavor to exceed or better them by striving toward the application of best available, cost-effective technologies and procedures. Should (at the APEGGA, this is *SHALL*) disclose information necessary to protect public safety to appropriate authorities.

9. Should actively work with others to improve environmental understanding and sustainability practices.