Energy Management and the Environment: Challenges and the Future

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Every industry, including the energy sector, is involved with some sustainability initiatives. What is really interesting is that similar industries have adopted different approaches to addressing their environmental responsibilities.

On its website “Energy for Sustainable Development,” United Nations Environment Program (UNEP) reiterates that energy services are essential for sustainable development. However, the way in which these services are produced, distributed, and used affects the social, economic and environmental dimensions of any development. Aligning the global energy system with the principles of sustainable development will require major changes to the way energy is currently delivered and used, including relevant and current information, policy changes, technology innovation and new investment. This shift towards a sustainable energy economy needs sound analyses and good decisions by policymakers and the sharing of experience and knowledge of individuals and organizations. Further, the activities to attain this shift are needed in both industrial as well as developing countries.

Unfortunately, there is little written that documents actual best practices in the energy sector in different parts of Canada and the world. At this time, most of the books on environmental sustainability are about what can be done. Environmental sustainability reports generated by international bodies at best capture what is logical to do. This field of study lacks case studies and commentary from practitioners on what is working.

This book brings together practitioner-authors to share energy management practices that are successful in their organizations and regions in Canada. It presents a compilation of articles
highlighting government and corporate initiatives for promoting environmental sustainability in the energy sector and showcases relevant public policies and management practices.

The chapters in this edited book revolve around developing

- familiarity with the different types of environmental issues in the energy and natural resources sectors;
- an understanding of the rationale for environmental regulation: that markets – left to themselves – will not deal satisfactorily with many environmental and resource issues from a societal point of view;
- familiarity with the types of market-based mechanisms currently being used to replace traditional “command-and-control” regulation; and
- a better understanding of the business challenges created by environmental issues and how these challenges affect business strategies and choices.

**Acknowledgements:** The Editors would like to take this opportunity to thank all the authors who participated in this book project. Thanks are due to the Editorial Board for writing the final commentary for each chapter. The Editors also thank the reviewers who took time to review the papers and helped with their constructive comments to raise the quality of this book.

Finally, we would like to thank Ms. Dawn McVitte for preparing the book website and coordinating the activities for the release of this book.

October 2007

Anshuman Khare
Joel R. Nodelman
Energy is the life blood of modern society. It pervades every aspect of our lives, our work and our play. Most of our energy comes from fossil fuels and therein lies the problem. As the president of a Canadian not-for-profit, Climate Change Central, I am increasingly aware of both the blessings and concerns associated with our current energy mix.

Ever since humans started harnessing fuels for energy, there have been worries about their supply and impact on our world. Today, the overwhelming concern surrounds the issue of climate change. Not a day passes without the media reporting some dire prediction about the quickening effects of greenhouse gases on the earth we share with so many species. All of us in developed nations are heavy energy users and all of us have a role to play in addressing the issue of climate change.

This book serves to address that issue and its wider dimensions. The various authors address concerns about security of supply, long term availability and how we squander this bounty of stored energy, to name just a few. We are living on the stored capital of ancient sunshine that ultimately has a finite end -- what are we doing about moving to a low carbon and renewable energy future?

This diverse group of contributors attempts to address these concerns and suggest changes to our policies, practices and behaviour. This is a complex task and helps to illustrate both the opportunities and obstacles currently before us. The transition awaiting our fossil-fuelled nations remains unclear, but we know that our current energy sources of coal, oil, gas and nuclear energy will be with us into the foreseeable future. We must design solutions to cope with their impacts and finite supply in order to continue to enjoy their benefits.
In reading this book I found much useful information and possible solutions to help our way forward. My hope is that books like this will engage more people in the crucial energy debate to help shape our societies’ life blood well into the future.

Simon Knight
President and CEO
Climate Change Central

October 2007
Universities have an obligation not only to engage in research, but to engage students and the wider community in that research. Furthermore, and even more important, university scholars have an obligation to share that research. *Energy Management and the Environment: Challenges and the Future* most certainly does that. Anshuman Khare and Joel R. Nodelman bring together students, practitioners, and faculty from a number of universities, including Simon Fraser and the University of Alberta, to explore what has surely become the single most important issue of this and the next generation – energy sustainability. Many of the authors, for example, Darin Tucker, David P. Williams, Frank Lenarduzzi, Ken Jackson, and Lisa Dechaine, are outstanding graduates from Athabasca University’s Centre for Innovative Management, which is providing leadership in the study of sustainability issues facing the energy industry. As important, Khare and Nodelman have provided links between those involved in the not-for-profit environmental and in the for-profit energy sectors. Only through careful collaboration and sharing like this can universities perform their fullest obligations to challenge and enrich society. By so doing, *Energy Management and the Environment: Challenges and the Future* captures the richness of the energy management field in all its dimensions.

Another important aspect of this book is that it is open access. In the last decade, the incredible rise in the cost of information has made much university-based quality research unavailable to the globe’s citizens. This book is part of the new movement that believes that publicly funded research must be made available at no additional charge to the public. *Energy Management and the Environment: Challenges and the Future* has its copyright in the creative commons, and is available to anyone to download at no cost. I am firmly convinced that this must be the wave of the future, and Athabasca University has committed itself to the open source, and open access movement by creating Canada’s first open access press, Athabasca University Press.
Universities have a real obligation to provide research and insight to the problems facing their societies. In Alberta—and particularly in Northern Alberta, the home of Athabasca University—energy is the key economic driver and is causing impacts on its water resources, forests and wildlife that are not yet wholly understood. Sustainability and a more reasonable scale of oil sands exploitation are key to the province’s and nation’s survival.

The sustainability problem is evident in Athabasca’s backyard – and our faculty, students and alumni have made the most of their obligation to advance research that is relevant to the province and the region. Certainly their findings will help drive the newly founded Athabasca River Basin Research Institute at Athabasca University. Dr. Khare has more than helped push its mandate.

Not everyone will agree with everything that is said in the book, and that is as it should be. But if debate results in better solutions to achieving an environment of sustainability, then Energy Management and the Environment: Challenges and the Future will have been the success envisioned by its authors.

Dr. Frits Pannekoek
President
Athabasca University

October 2007
Anshuman Khare is a Professor of Operations Management at Athabasca University. He teaches courses such as Operations Management, Sustainable Development and Business and Corporate Social Responsibility.

Dr. Khare completed his post-doctoral research at Ryukoku University on a Japanese Government Scholarship (1995-97). In 1998 he was awarded a Research Fellowship of the Alexander von Humboldt Stiftung at the Johannes Gutenberg-Universität Mainz. In this capacity, he worked on environment-related technomanagerial issues in automobile manufacturing. Before entering academe, he worked as a Research Scientist for the University Grants Commission, India.

Dr. Khare’s research interests are Japanese business philosophy and responsible manufacturing. He has published four books and over a 100 articles in scholarly and professional journals. His last book, Emerging Dimensions of Environmental Sustainability – A Canadian Perspective of Innovative Practices has found acceptance by Environment Canada, Environment Alberta and Industry Canada. Canadian firms have also shown interest in the book by recommending it to their employees. Dr. Khare is listed as an academic expert in the area of Environmental Strategy and Sustainable Development, Environmental Manufacturing and Responsible Manufacturing on Environment Canada, Government of Canada’s Academic Expertise Database.

Joel Nodelman is the President of Nodelcorp Consulting Inc. Before establishing Nodelcorp Consulting Inc. in 2002, Joel Nodelman acquired over 25 years of progressive experience in engineering and management of energy, environment, climate change and sustainable development projects, including industry compliance, emission reduction and other risk mitigation strategies.

Mr. Nodelman assists clients in making key technology investment decisions, developing greenhouse gas management programs and preparing regulatory applications in support of multi-million dollar investments in energy technology.

Mr. Nodelman’s serves as a founding member of boards of directors of the Greenhouse Emission Management Consortium (GEMCo), and Alberta’s Greenhouse Gas Emission Trading Exchange (KEFI), and managed a number of carbon credit trades including the first trans-Atlantic carbon credit trade.
Mr. Nodelman has developed major policy papers for Alberta Environment on the Role of Renewable Energy in Emission Credit Trading and on Mechanisms for Stimulating Investment in Environmental Research and Development. He also provided ongoing strategic advice to Environment Canada regarding mechanisms to encourage Alberta’s involvement in a national greenhouse gas reporting program.

As an Assistant Adjunct Professor of Engineering at the University of Alberta, he presently teaches two courses; Engineering, Environment and Society and Fundamentals of Engineering Management.

Mr. Nodelman is the author of numerous articles and papers on sustainable development, climate change, and environmental affairs including a chapter in a university level textbook on sustainable development which was published in 2005.
Jim Dunn is a Professor of Marketing and Finance at Athabasca University. He teaches courses such as Strategic Marketing, Financial Management, and Business Economics and Society.

Dr. Dunn received his PhD from the University of Oregon and joined the Faculty of Business at the University of Alberta in 1970. From 1976 to 1980, he served as the Associate Dean of the MBA program and as the Chairman of the Management Advisory Institute. He also served as the Associate Dean of the undergraduate program in 1983/84 and as the Director of the Management Education Centre from 1994 to 1996. Over his career, Dr. Dunn has presented 25 sessions at the Banff School of Advanced Management and over 140 sessions for the Institute of Canadian Bankers.

Dr. Dunn’s current research interest is social responsibility (ethics, productivity, sustainable development, business and society interface). His recent management consulting work has resulted in over 180 manuscripts and reports.

Joan Nodelman is currently vice-president and chief financial officer of Nodelcorp Consulting Inc. A graduate of University of Toronto (BSc) and Queens University (BEd and MBA), Joan has utilized her background in sciences, education and business to provide management and strategic advice to Nodelcorp’s clients.

Nodelcorp provides policy development and strategic advice to private industry, government agencies and associations. In conjunction with policy work, Joan and her partner also provide facilitation services in government consultation processes. They provided reports and other research material for clients. Nodelcorp Consulting is actively involved in both greenhouse gas mitigation and adaptation policy work.

Paul D. Hunt is the Vice President of Climate Change Central, where he works with key stakeholders in developing strategies and taking actions with respect to climate change risk mitigation and adaptation in Alberta. He is the past Chairman of the Board of Governors of the Emerald Foundation, an organisation that recognises environmental excellence in Alberta and a former member of the National Advisory Committee that reports to Federal and Provincial Ministers of Environment on environmental matters relating to the North American Free Trade Agreement (NAFTA).
Roger Harris is a petroleum engineer with a major Canadian Oil and Gas producing company. He has 28 years of experience in the sector, and has held various engineering and operations roles in the past. He is currently working on an oil sands development in Northern Alberta. He holds a BEng degree in Chemical Engineering from Lakehead University and an MBA degree from Athabasca University. His primary professional interests are management of large capital projects, and sustainable development of energy resources.

Sid Carlson is a public policy analyst currently visiting the School of Business at the University of Alberta and doing research on energy and climate change policy at CABREE. She also teaches courses on the energy industry, the environment, and government and business regulation.

Prior to joining the University, Dr. Carlson was the Senior Economist at the Alberta Department of Energy, where she spent seven years developing and implementing government policy to restructure Alberta’s electricity industry. Dr. Carlson was one of the designers of Alberta’s original Power Pool. She has given invited talks in Ontario and Texas on wholesale market design and market surveillance methods.

After receiving her M.Sc. from the California Institute of Technology in 1980, she joined the Jet Propulsion Laboratory in Pasadena, California for three years to do cost-benefit analyses and simulations of renewable energy technologies. Dr. Carlson received her Ph.D. in economics from the University of Iowa in 1989.
Anne Papmehl is a senior writer with Decision Partners, a company specializing in behavioural research, strategy, and communications. Anne’s professional background spans academic administration, financial services, teaching, consulting and business journalism. An award winning writer and author of more than 100 articles, research papers and reports, Anne has built a substantial portfolio of work in the field of environmental sustainability and has presented extensively on the topic. Anne contributed a chapter to an earlier-published book through Athabasca University’s Centre for Innovative Management in 2005 called, Emerging Dimensions in Environmental Sustainability: A Canadian Perspective of Innovative Practices. Anne holds a B.A. in Russian and Italian and a M.A. in Italian Studies from the University of Toronto and lives in London, Ontario. She has maintained an interest in her original academic discipline of Italian by teaching courses on Italian language and Italian opera at the University of Toronto, School of Continuing Studies.

Chris Bataille took his undergraduate degree in economics and political science at the University of British Columbia. His Master’s degree is from Simon Fraser University. For his Ph.D. at SFU, Chris added a system of general equilibrium feedbacks to a version of the ISTUM technology simulation model, thus creating the CIIMS model. Since completing his Ph.D. he has worked as a consultant with and recently director of M.K. Jaccard and Associates Ltd., an energy and environment consulting firm that advises the Canadian government on climate change policy. He has also maintained a research profile, having edited and published in a special issue of The Energy Journal on hybrid technology simulation and CGE modelling, as well as published in The Energy Journal on quantitative methods to measure the varying capabilities of countries to reduce their GHG intensities.

Darin Tucker has worked in the energy and environment industry for 17 years. He started working as an environmental consultant in Toronto, Ontario, but for most of his career, Darin has been employed with TransCanada PipeLines Ltd. of Calgary, Alberta. He also spent two years assisting Imperial Oil Resources Ltd. with development of their Mackenzie Gas Project in Canada’s arctic. During his career, Darin has helped develop, construct and maintain both natural gas and oil pipelines as well as power generation facilities in Canada and the United States. He has held roles in Environment, Health and Safety, Facilities Engineering and most recently, Supply Chain Management. Darin holds a diploma in environmental biology from Canadore College in Ontario as well as an MBA degree from Athabasca University in Alberta, Canada. He lives in Calgary, Alberta with his wife and two children and enjoys many outdoor activities including skiing, hiking and mountain biking.

David P. Williams earned an undergraduate economics degree from the University of Victoria, and an MBA graduate designation from Athabasca University's Centre for Innovative Management. He is also a member of the Certified General Accountants Association of Alberta. His MBA applied project
was on corporate governance and social responsibility. His field of study focused on the administration and delivery of federal government programs.

Over the past fourteen years with the federal government, he has developed considerable expertise in excise tax legislation as an excise rulings officer, and with business transactions and accounting and operating systems as a business auditor. He is currently consulting on projects in the energy industry.

At various times he has worked as soils technician on large water diversions and hydro-electric projects, newspaper columnist and photographer, heavy equipment operator, costing clerk for an international materials manufacturer, office manager for a national public service organization, construction worker, stock-broker, and child-care worker.

He has managed receiving homes for children in crisis. He was a staff counsellor at a facility for juvenile offenders and documented programs for profoundly retarded and autistic children. He has also done volunteer work for children with cystic fibrosis and Down’s Syndrome.

Career interests include freelance writing and teaching. He believes in placing people back into the business model, and is always interested in discussing a more holistic theory of economics.

Frank Lenarduzzi is a registered Professional Engineer in Ontario and a MBA graduate from Athabasca University. He works for Hydro One as an analyst, reporting on fault events that occur on the bulk electricity system in Ontario. Frank is a former member of the Environment & Energy Team involved with the development of energy efficient strategies and concepts at the research division of the former Ontario Hydro. His knowledge of heat pumps and heating systems includes developing a patented direct-expansion earth energy system. His expertise in metering and monitoring systems includes work on direct digital load control of electric loads using the Internet as a control network. The investigation of advanced Web-based monitoring and control systems has led to a novel patent-pending device to auto load-shed end-use customers under emergency conditions or during high-priced periods.

Gilman Chi Keung Tam is a Ph.D. candidate at ESC Lille (France). He has gained extensive practical experience on electrical plant construction, commissioning, and maintenance in power station projects in Hong Kong and China. He has also developed a good track record in the development of coal-fired power project in China and floating of company’s shares in the Growth Enterprise Market in the Stock Exchange of Hong Kong. Gilman is a member of The Institution of Engineering and Technology (IET) in the U.K.; member of The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE); and member of Project Management Institute (PMI) in the US. He is a PMP (Project Management Professional from PMI) and PRINCE2 Practitioner (from APM Group, UK). He holds MSc degree with distinction in Energy from the Heriot-Watt University in the UK and MBA degree from the Newport University in the US. His major research interests include the development of sustainable project environment in the energy sector.

Kenneth Jackson is a Registered Canadian Safety Professional residing in Salt Spring Island, British Columbia, Canada. He is currently on international assignment as a Manager of Health, Safety, Security and Environment for a major global energy firm.

Ken graduated from the British Columbia Institute of Technology with a diploma in Natural Gas and Petroleum Technology (1979) before entering into a long-term career in the global petroleum industry with assignments in engineering, operations and the safety and environmental
departments. His career was initially working with Canadian operations but since 1992 Ken has held working assignments in the USA, China, U.K., Egypt and Russia. In 2005 Ken graduated from Athabasca University’s Executive MBA program. He is a Registered Canadian Safety Professional since 1992 and long-term member of the Canadian Society of Safety Engineering. He has made presentations at the American Society of Safety Engineering’s Professional Development Conference.

**Lenore Newman** is an assistant professor at Royal Roads University and has designed courses on global environmental change for Athabasca University. Her interests include alternative energy and climate change, community sustainable development, and sustainable technologies. Lenore is particularly interested in social attitudes towards energy production and community efforts to embrace alternative energy. She has published articles in numerous journals including *Futures, Local Environments*, and *Sustainability: Science, Practice, and Policy*. She is currently working on a book about Energy and Sustainable Development. Lenore holds degrees in physics and environmental studies.

**Lisa Dechaine**, P.Eng., has been practicing in the environmental field for fifteen years. Her career started out as an environmental consultant where her work took her throughout Western and Northern Canada. She was involved in projects ranging from environmental assessments to site remediations. She is currently working as an Environmental Specialist with Edmonton Airports. In this role she is responsible for a large and varied portfolio that combines environmental issues within an aviation setting. Ms. Dechaine has just completed her MBA through Athabasca University.


**Mark Polet**, a professional biologist, has 27 years applying environmental principles in the oil and gas industry, being one of the first biologists to be hired by an oil company in the 70’s. Since then, his work has taken him throughout Europe and North America setting up environmental management systems, including a tenure as Vice-President, Operations at the Alberta Special Waste Management Treatment Centre. Mark is currently president of Ecomark Ltd., an integrated environmental consulting firm based in Alberta, Canada.

**Nic Rivers** is a Ph.D. student in the Resource and Environmental Management Program at Simon Fraser University. Nic also works as a consultant and researcher on projects related to energy and climate change. Specifically, his work uses quantitative analysis and has focused on policy analysis and evaluation, technology analysis, and emissions reduction analysis. He has published articles in many leading academic journals, and has participated in dozens of studies for the public and non-profit sectors, and for industry. Nic holds a Bachelor’s of Mechanical Engineering degree from the
Memorial University of Newfoundland and a Master’s of Resource Management degree from Simon Fraser University.

**Paul D. Hunt** is the Vice President of Climate Change Central, where he works with key stakeholders in developing strategies and taking actions with respect to climate change risk mitigation and adaptation in Alberta. He is the past Chairman of the Board of Governors of the Emerald Foundation, an organisation that recognises environmental excellence in Alberta and a former member of the National Advisory Committee that reports to Federal and Provincial Ministers of Environment on environmental matters relating to the North American Free Trade Agreement (NAFTA).

**Robert Mancini** has been engaged in the field of Consulting Engineering for his entire career. He has been responsible for many local projects as well as projects in Kuwait, the Bahamas, South Africa and United Arab Emirates. Robert Mancini earned a degree in Mechanical Engineering from the University of Toronto in 1973. He is currently President R. Mancini and Associates Ltd. Consulting Engineers, Bolton, Ontario, Canada. His experience is extensive in the field of heating, ventilating and air conditioning. He has been responsible for the design of over 10000 tons of ground source heat pump systems across North America since 1984. He has served on a committee responsible for the development of CSA 447 “Design and Installation of Commercial Ground Source Heat Pump Systems”, CSA 448 “Design and Installation of Earth Energy System” and is a corresponding member of ASHRAE’s Ground Source Technical Committee. In addition, has been a member of the Washington based Geothermal Heat Pump Consortium and is one of two consultants chosen for their Design Assistance Program aimed at improving the geothermal heat pump infrastructure in the United States.

**Rose Murphy** is a Ph.D. student in the Resource and Environmental Management Program at Simon Fraser University. She holds a Master’s degree from the same program. Prior to returning for her Ph.D., Rose worked as a research associate with the Energy and Materials Research Group at Simon Fraser University, and was a partner in M.K. Jaccard and Associates, a consulting company that undertakes national and international research in areas related to resource and environmental management with a focus on the energy field. Rose has published and given talks on technology assessment and climate policy design, electricity supply planning, and energy policy and international development. Her consulting experience includes applying the CIMS hybrid energy-economy model to assess the impacts of climate policy for the Canadian Government as part of its National Climate Change Implementation Process.
The authors in this section have identified that there is a need to develop tools for achieving sustainability and have presented a number of examples to show how to take innovative concepts into the field and workplace. These papers do not focus on policy options but rather offer workable practitioner tools. They help people in the field translate complex issues into sustainable solutions.

The papers in this section give us a sense of how to go about sustainability in practice. The papers offer a path forward translating strategic level theoretical concepts in workable tools for practitioners.

In many instances, the authors take conventional ideas and extend them to the new field of energy sustainability. Throughout the papers in this section there is one unifying and encouraging message - although sustainable energy development is still an emerging field, we already have the practical tools to deal with challenges presented by this new approach to the energy business.
ABSTRACT

The ‘wedges approach’ is a simple and elegant method of illustrating how unabated growth of greenhouse gas emissions (GHGs) might be stabilised. Wedges, based on different types of technologies, are used to sub-divide this otherwise monumental reduction challenge, into smaller more actionable components. Thus far, wedges have been used to illustrate emissions and reduction possibilities from an international, national and sectoral perspective. This paper describes how the wedges approach can be adapted and applied to individual corporations.

‘Corporate Wedges’ provide a framework that can be customised to an organisation’s specific structure and activities. Once identified, components of corporate wedges can be disaggregated and analysed for GHG emissions reduction and offset potential.

Customised corporate wedges will be a valuable strategic planning and management tool for organisations, as they will enable:

- Identification of emission sources and associated liabilities
- Evaluation of multiple reduction options
- Cost comparisons of internal options with the market price for offset credits, and
- Optimisation of GHG reduction and offset activities over time.

This approach will identify GHG reduction and compliance options and be of interest to organisations that are likely to have their GHG emissions regulated in the future.

Keywords: GHG, planning and management tools, reduction wedges.

The Wedges Approach of Stabilizing Greenhouse Gas Emissions: Application to Corporations

Paul D. Hunt

The author in the lead article of this book translates the work of two Princeton University professors into a practitioners’ guide which lays down a roadmap for the future.

The problems we face today are because of our over reliance on one resource for energy and a very narrow vision about the future direction on meeting the energy demands which are continually growing. To maintain an environmentally acceptable level of growth and standard of living, we need to think differently about ways the demand for energy will be met at all levels of society.

This powerful strategic planning concept directs the corporate planners not to overemphasize the single-resource solution but start thinking about multiple-resource solutions. An optimal mix of strategies for different resources and different industries would make it easier to address the GHG and emissions problems we are encountering today.

Anshuman Khare
The Wedges Approach of Stabilizing Greenhouse Gas Emissions: Application to Corporations

Paul D. Hunt

1.0 Introduction and Overview

“Rather than watching to see if and how much temperatures and tides will rise, it’s high time for immediate action by businesses and governments to combat climate change. And it’s time for radical innovation in the way we make, use and dispose of products.” This statement appeared in a recent edition of Scientific American, in an article by the World Business Council for Sustainable Development (Stigson, 2006), and serves to introduce the subject of this paper, namely the application of a straightforward method to illustrate necessary reductions in greenhouse gas emissions and divide this massive undertaking into more manageable components.

In 2004, Steve Pacala and Robert Socolow, two professors from Princeton University published a paper in Science, called Stabilisation Wedges: Solving the Climate Problem for the Next Fifty Years with Current Technology. Greenhouse gas (GHG) emissions growth over the next 50 years was described and illustrated, together with reduction opportunities. These options were grouped, based on different types of technologies and each group shown as a ‘wedge’ that can reduce the overall increase in GHG emissions. Collectively the reduction ‘wedges’ show how global GHG emissions can be stabilised at current levels (Figure 1).

The Canadian National Round Table on the Environment and the Economy (NRTEE) applied the wedges approach to Canada, and in 2006, released a report entitled Advice on a Long-term Strategy on Energy and Climate Change (NRTEE, 2006). Eight focus areas or ‘wedges’ for Canada are being suggested (Figure 2):

1. Energy Efficiency & Conservation
2. Co-generation
3. Urban Form
4. Energy Intensity
5. Renewable Electricity
7. Carbon Capture & Storage
8. Nuclear
The wedges approach of dissecting the GHG emissions reduction challenge can also be adapted and applied to corporations having GHG emissions liabilities. From a corporate perspective, wedges would represent a variety of management and technological measures aimed at lowering emissions and concurrently contributing to efficiencies and energy savings. As such, the wedges approach can be used by companies for strategic planning and as a management tool.
In Alberta, legislation limiting GHG emissions has been enacted. The Federal government as well as some other provinces are expected to follow suit. Businesses, beginning with the large emitters (more than 100 Kt/a) will have regulatory obligations to reduce their net GHG emissions.

As this ‘regulatory threshold’ is lowered over time, organisations having lower emissions (less than 100 Kt/a) will also be obligated to decrease their GHG emissions. Meeting these requirements will involve one or more of the following: source-reductions; lowering GHG intensity; creating or acquiring offset credits; or contributing to a government-sanctioned financial compliance mechanism.

Considering emitting organisations generally, there are six key GHG areas or wedges that provide an array of compliance options for lowering net GHG emissions:

1. Design & Construction
2. Power / Energy Supply
3. Operations
4. Administration
5. Offset Creation or Purchases
6. Financial Compliance Mechanisms

The first four options are GHG reduction measures and are internal to an organisation. Efficiency optimisation generally and efficiency in energy production and use specifically, are common to these four wedges. The last two options involve opportunities external to an organisation, through the acquisition or purchase of GHG offset credits (although organisations may choose to develop offset credits themselves) and contributing to a financial compliance mechanism like a Carbon Trust or a Technology Investment Fund (see Section 4.6).

Company-specific information can be used to customise the wedges to create plans and management tools tailored to individual organisations.

In the same way that wedges help industrialised nations assess their GHG emissions and then sub-divide the GHG stabilisation goal, so too will the wedges approach help organisations by providing a framework to:

- Identify emission sources and associated liabilities
- Evaluate reduction options
- Compare the costs of those internal options, relative to the price of offset credits on the market, and
- Strategically plan and manage GHG reduction and offset activities.

2.0 GHG Stabilisation Wedges

Recognising that there is no single solution to the reduction of GHG emissions, two professors from Princeton University, Robert Socolow and Steve Pacala, have developed a simple and elegant way of illustrating projected GHG emissions growth and potential stabilisation and reduction opportunities from a variety of low-carbon and carbon-reducing technologies. They propose sub-dividing the enormous challenge of GHG stabilisation, into less daunting, yet still demanding actionable components, that need to be implemented over the next 50 years.

Historically, GHG emissions globally have increased significantly (Figure 1) (Pacala et.al., 2004). The combined total from all the industrialised countries is over 25 billion tonnes a year. Pacala et. al. (2004) also note that Canada’s contribution is about 3% of this total, at 750 million tonnes a year (Figure 3).
Looking forward, GHG emissions increase because of population and demand growth globally (Figure 1). The dashed line represents unabated emissions growth or a “Business-as-Usual” scenario. In an attempt to curb this growth and stabilise GHG emissions at current levels, a “Stabilisation Triangle” is formed.

As Pacala et. al. (2004) point out, there’s reason for optimism that global emissions in 2055 need not exceed today’s emissions, because:

- The world today has very inefficient energy systems
- CO₂ emissions have just begun to be priced, and
- Most of the 2055 physical plants have not yet been built.

In order to narrow the focus of GHG reduction activities and provide direction, the Stabilisation Triangle is sub-divided into ‘Stabilisation Wedges’ based upon different technologies and reduction options.

Considering GHG emissions globally, Pacala et. al. (2004) suggest that the stabilisation target can be achieved through seven reduction wedges (Figure 4).

- Improved Energy Efficiency in Heating, Transportation and Electricity Generation
- Fuel Switching from coal to natural gas for electricity and heating
- Carbon Capture & Storage associated with coal-fired electricity generation and Hydrogen production. CO₂ would be stored in geological formations rather than being released to the atmosphere
- Increased Nuclear power for Electricity and Hydrogen production
- Increased use of Renewables for Electricity and Hydrogen production
- Increased use of GHG-neutral bio-fuels such as ethanol and bio-diesel, and
- The use of natural CO₂ sinks like forest plantations, and conservation tillage of croplands.
3.0 Recognition and Use Of The Wedges Concept

The use of the wedges approach to illustrate the GHG stabilisation challenge and the mix of solutions that can be implemented to reduce emissions is gaining credibility and interest.


The Round Table suggests that for Canada, GHG reductions wedges that can collectively stabilise Canada’s emissions involve significant deployment of:

1. Energy Efficiency & Conservation
2. Co-generation
3. Urban Form
4. Energy Intensity
5. Renewable Electricity
7. Carbon Capture & Storage
8. Nuclear

For the purpose of this paper, the eight NRTEE wedges have been condensed to six, which have greater application to corporations and industrial activities (Figure 5). Descriptions of each of the wedges follow, with examples of some of their key components.
3.1 Buildings and Communities Wedge

The manner in which Buildings and Communities are planned and designed, influences the amount of energy required to operate them and move individuals and materials to and from them. All of which affects the amount of GHGs that are produced.

Emissions reduction opportunities exist through using energy more efficiently in existing residential, commercial, institutional and industrial buildings, as well as new structures to be built. This includes all buildings, from single-family homes and apartment complexes to office buildings and warehouses.

In addition to how buildings are designed and the type of material used in their construction, where a building is sited is also important, particularly in relation to other buildings. This consideration is captured through integrated land-use and planning, which can:

- Decrease dependency on personal vehicles and minimise travel times,
- Reduce the number of trips necessary,
- Encourage the use of Public Transit, and
• Facilitate the development of District Energy, where electricity and space heating needs can be met at the neighbourhood level by small local distributed energy / combined heat and power (CHP) stations.

Improvements can be made to existing structures by upgrading building components and systems, some of which are listed below. Similarly, these efficiency elements should be designed into new structures:

• Insulation & Sealing materials,
• Windows & Doors,
• High Efficiency Furnaces & Setback Thermostat Controls,
• Water Heaters,
• Lighting,
• Household Appliances like Fridges, Freezers, Washing Machines, and
• Other Equipment.

Information and guides on energy efficiency and buildings are available from:

• Natural Resources Canada’s Office of Energy Efficiency which will soon release their EcoEnergy for residences and renewables,
• Leadership in Energy & Environmental Design (LEED) standard for sustainable buildings (Guides for Residences, New Buildings, Existing Buildings, Commercial Interiors, and Neighbourhoods),
• EnergyStar labelling for buildings, equipment & appliances, and
• DOE and other US-based energy efficiency guidance documents.

A further consideration is tree-planting in urban environments. This has a number of benefits as trees are not only aesthetically pleasing, they help moderate extreme temperatures by providing shade and a wind barrier, and also like all plants, take CO₂ out of the atmosphere and convert the carbon to biomass.

3.2 Lower Carbon Electricity Generation Wedge

Options for generating electricity while emitting less GHG include:

• **Co-generation** where applicable, which combines the production of both power and heat while consuming the same amount of fuel as power generation alone.

• **Renewable energy** from large and small hydro, wind, tidal, and solar (photovoltaic and thermal), bio-mass, geothermal and landfill gas, are either GHG-neutral or have low or no emissions associated with them.
• **Clean coal** refers to the technologies that facilitate the separation and capture of CO₂, a product of combustion. Three of the more promising technologies being developed are:
  
  o **CO₂ Capture** using stripping agents such as amine or solvents. Development efforts are focussing on optimising the processes and reducing process costs;

  o **Oxyfuel** involving the removal of nitrogen from the air and combusting coal in an oxygen-rich environment. The resulting flue-gas has a high CO₂ concentration, which can be more easily captured and is virtually absent of nitric oxide(NO) and nitrogen dioxide (NO₂), collectively referred to as ‘NOₓ’, a smog precursor, and

  o **Coal Gasification** where coal is treated in such a way as to liberate a methane-like gas referred to as syn-gas (synthetic gas), leaving half of the coal’s carbon content as well as a number of potential air pollutants in the solid residue that resembles a coke or clinker-like material. The ‘syn-gas’ is refined to remove impurities, before it is used as a fuel to generate electricity and/or heat. The residual solids can be returned to the mine-site and buried. The gasification process produces an almost pure stream of CO₂, which facilitates capture.

  The captured CO₂ can be utilised in a number of ways, as described in the following Section – *Carbon Capture and Storage*, and

• **Nuclear power** which doesn’t produce any GHGs but has some issues of concern with respect to safety, security and the acceptable disposal of spent radio-active fuel.

3.3 Energy Intensity Wedge

Energy Intensity is derived from the amount of energy consumed per unit of industrial output or Gross Domestic Product (GDP).

Reducing Energy Intensity of goods produced, will result in a corresponding lowering of emissions. Reduction in Energy Intensity has to be tailored to individual facilities and operations. However, there are a number of generic opportunities potentially available to commercial and industrial facilities, in the areas of:

  • Fuel Switching,
  • Developing and Applying Energy Efficient Technologies,
  • Process Optimisation, and
  • Operating Practices.
3.4 Transportation Wedge

Road transportation accounts for a quarter to a third of developed countries’ GHG emissions and can be grouped into personal modes for getting individuals from one place to another and commercial, related to the delivery of services or freight. These modes equally contribute to this sector’s GHG emissions.

Emissions reductions from personal transportation are possible from:

- Trip reductions through Car-Pooling and Teleworking, and
- Alternate modes of Transportation – Walking, Bicycling, or using Public Transit.

Commercial vehicles will also benefit from higher efficiencies, and with respect to freight deliveries, improved inter-modal transport optimising the use of rail and road is possible.

All vehicles, personal and commercial, are powered by hydrocarbon fuel. The purchase of right-sized ‘best-in-class’ vehicles for fuel-efficiency and low emissions is desirable. In addition, the use of alternative transportation fuels, particularly from plant materials, such as bio-diesel derived from vegetable oils (canola) and ethanol from corn and straw, have a lower carbon intensity, and will result in reduced GHG and other emissions.

Electric Hybrid and Flex-fuel vehicles provide other options for fossil-fuel reductions. Hydrogen continues to offer great promise for future emissions reductions from vehicles.

3.5 Alternative Fuels Wedge

In addition to liquid alternative fuels, primarily for vehicles, there are also alternative solid and gaseous fuels. As referenced in the earlier Section, the combustion of fuels derived from plant materials is essentially GHG-neutral.

That is, the amount of CO₂ released when plant material is burned is equal to the CO₂ that they absorb when growing. Examples such fuels include:

- **Wood**, especially wood-waste, which is increasingly being used as a fuel source for electricity & heat generation needs, by saw mills, pulp & paper and other operations. Additional energy needs could also be supplied from waste wood if the haul distances and related costs are reasonable

- **Straw, stubble, and specially grown crops** like switch-grass and fast-growing willows and hybrid poplar trees are other types of bio-mass from which energy can be produced, and
• **Bio-gas** is the product of anaerobic decomposition of organic material. When this gas is collected and refined slightly, its properties are similar to natural gas. Sources of bio-gas include livestock manure, food processing wastes, and landfills.

### 3.6 Carbon Capture and Storage Wedge

An emerging suite of technologies are being developed to facilitate the process of capturing CO₂ from large emission sources, preventing its release to the atmosphere, and injecting it deep underground in geological formations.

Given Canada’s and Alberta’s abundant reserves of coal and unconventional oil, the ability to significantly reduce GHG emissions from the production or use of these important energy resources is of great significance.

In addition to just storing CO₂ underground in saline aquifers and exhausted oil and gas reservoirs, its injection into selected geological formations can be used to enhance the recovery of oil and natural gas from low-producing depleted reservoirs, and in other cases facilitate the extraction of coal bed methane from coal seams deep underground. In this manner, not only will CO₂ emissions be reduced but valuable energy resources will be recovered.

### 4.0 Adapting the Wedges Approach to Corporations

The wedges approach can be used to apportion GHG emissions to specific sources and activities which helps identify options (technological and behavioural) to reduce those emissions over time. Like society as a whole, industries and other organisations also produce GHG emissions from a number of different activities. The following is an illustrative representation of GHG emissions from a generic organisation, with a description of a number of potential management and technological emissions reduction measures. Considering GHG-emitting organisations generally, GHG compliance options can be grouped into six key areas or Corporate Wedges (Figure 6).

The first four Corporate Wedges are GHG reduction measures that can be implemented internally within an organisation, and focus on emission sources and opportunities for reductions. The fifth wedge involves options that are external to corporations’ core activities, involving the self-generation of GHG offset credits, or their purchase from valid offset generating projects, the market, or directly from an organisation that has surplus credits. The last wedge, Financial Compliance, is a developing opportunity that would provide flexibility to emitters by permitting them to ‘buy’ their compliance through contributing to government sanctioned instruments such as a Technology Investment Fund and a Carbon Trust (see Section 4.6).

The balance of this paper describes each of these Corporate Wedges, which represent unabated or business-as-usual GHG emissions and opportunities for reductions. Although necessarily generic, options for lowering emissions exist within each wedge, and are illustrated by ‘slices’.
Application of the Corporate Wedges approach to individual organisations is possible using company-specific information. Such an exercise would yield GHG reduction options and opportunities that are tailored to the organisation in question.

4.1 Design, Engineering and Construction Wedge

Providing facility services with respect to heating, cooling and electricity consumption together with industrial processes (Section 4.3) are the main activities that generate GHG emissions, either directly or indirectly from buildings. Design, Engineering and Construction of start-up and expanded operations therefore have a significant influence on GHG emissions associated with building operations.

Incorporating emissions-minimising equipment and techniques as part of these early stages of new facilities is in most cases, a less expensive option than trying to retro-fit once the facility is constructed and operating.

Figure 7 shows the interior of a building in which design strategies focussing on water conservation, daylight, high performance windows and exterior walls, renewable building materials and geothermal heating and cooling, have been integrated. These attributes create a highly desirable and environmentally-sound working environment for staff and visitors.
Figure 7: Boreal Centre for Bird Conservation, Slave Lake, Alberta. Manasc Isaac Architects Ltd.

The main considerations here are:

- Incorporating energy efficiency into the design, orientation, materials, and equipment of the building in question, and
- Adopting environmentally-sound criteria for the Design and Construction of buildings. One of the best-known guides and standards in North America is Leadership in Energy & Environmental Design (LEED), where different grades of certification are granted based on site-selection and orientation, building materials, and equipment for heating, cooling, lighting and water management.

4.2 Power Supply Wedge

An organisation’s electricity use is often one of the more significant sources of GHG emissions, either directly (if they generate their own power) or indirectly (if power is purchased from an off-site provider).

The source of power greatly influences overall emissions from organisations. Emissions reductions from a “business-as-usual” scenario are possible through the following options:

- **Fuel Switching** - from a higher carbon-intensity to a lower one. Rather than focusing fuel switching activities exclusively on natural gas, consideration should be given to using renewable and other non-renewable alternative fuels (Figure 8). Long-term purchase agreements with suppliers of renewable power can result in costs that are competitive with conventionally produced electricity.

- **Co-generation** – or Combined Heat & Power, is the simultaneous generation of both electricity and useful heat. Conventional power plants waste the heat that’s produced as a by-product of electricity generation, by venting it to atmosphere as flue gas or routing it to
cooling towers, etc. In co-generation, this heat is captured and used for domestic or industrial purposes, where appropriate. Co-generation is the most efficient use of fuel (Figure 8)

**Figure 8: Canadian Hydro Developers’ Wood Waste Co-generation Plant, Grand Prairie**

- **Renewable Energy** – from Small Hydro, Biomass (Figure 8), Wind, Geo-thermal and Solar have negligible or no net GHGs associated with them. Incorporating renewable power into its energy portfolio, a company can reduce the overall carbon intensity and emissions from the power it consumes; and

- **New Technology** – can facilitate addressing both new and old issues in an improved manner. **Coal Gasification, Oxyfuel** and **Carbon Capture & Storage** technologies (Section 3.2) are being developed in response to GHG concerns. Generally, new technologies are more efficient and allow us to do more with less, which results in less energy use and a decrease in emissions. Simple examples of these are: High-efficiency lighting; High Efficiency Furnaces; Variable-Drive Electric Motors; and Hybrid vehicles, etc.

4.3 **Operations Wedge**

GHGs are released from the various processes associated with storage, handling, production and transportation activities involving raw materials, finished goods, by-products and wastes. Fugitive emissions, as well as those from plant upsets, spills and leaks also contribute to overall emissions. Consequently, emissions reduction activities should focus on these processing steps.

Process optimisation and selection of feed-stocks or raw materials as well as changing, modifying and maintaining process equipment are other measures that can have multiple benefits, including energy, emissions and cost reductions.
In addition, process efficiencies can be enhanced through a variety of measures including: Improved process integration and controls; Waste heat recovery; Use of sensors and automation; Power factor correction; Demand management systems; and Insulation to maintain temperatures.

Efficiencies in the way energy is produced, transmitted and used have a direct influence on emissions. So, energy savings or conservation measures are important factors that have demonstrated not only reduced power bills but also overall gains in productivity (Stigson, 2006).

Using Best Practices and Best Available Technology Economically Achievable (BATEA) also contributes to achieving greater efficiencies and therefore lower emissions.

Although there are costs associated with these and other improvement measures (energy efficiency, clean technologies, and fuel switching to lower carbon intensities), there are also savings and co-benefits. The cost of not taking action needs to be considered, in light of public concerns and pressure on governments to address emissions issues.

4.4 Administration Wedge

The manner in which an organisation is managed and administered has a significant bearing on the degree of engagement of its stakeholders, from shareholders and Board of Directors, to employees at all levels. This should be viewed as a resource that should be tapped. Done appropriately, action can be inspired creativity unleashed, and innovation harnessed.

Senior leadership sets the tone and expectations for organisations and influences the corporate culture. Management support for, together with employee awareness and understanding of, operational targets is a prerequisite for overcoming constraints of current practices and working towards ‘Continuous Improvement’.

Creating an atmosphere of continuous improvement will encourage employees to think how processes and procedures can be upgraded or even re-invented.

Proven engagement techniques include:

- Team “brainstorming” and cross-fertilisation of ideas involving multi-disciplined individuals often results in new understanding and approaches leading to solutions; and

- Establishing reasonable stretch-targets that encourages and motivates involvement, particularly if incentives or performance bonuses are attached to suggestions that are implemented.
Linking emissions minimisation actions for GHGs to a more familiar and accepted issues such as Health & Safety or Energy Efficiency would facilitate increased awareness and acceptance required for getting the desired results. Traditionally, companies develop operational Procedures, Practices and Programs to enhance performance in productivity and protect the health & safety of workers. Similar suites of measures can be used to maintain and improve the environmental performance of an organisation as well. Areas where GHG management can be integrated include:

- Purchasing or Procurement Policies (process equipment, electric motors, electronics, vehicles, office furniture and supplies, etc.)
- Procedures for process start-up, operation, and shut-down
- Procedures for handling and storage of raw materials, products and by-products
- Procedures for emergency or upset conditions
- Practices for material recovery, re-use and waste disposal
- Maintenance scheduling
- Conducting periodic mass balances, energy audits, and environmental audits
- Monitoring & Record-keeping
- Tracking technology development
- Comparing performance to ‘best-in-class’.

These measures not only ensure consistency, they also serve as prompts for environmental responsibility, which is another way to limit the amount of direct and indirect GHG emissions.

4.5 GHG Offset Credits Wedge

In addition to taking action internally to reduce GHG emissions, an organisation will be able invest directly in projects that generate offset credits or purchase credits from another organisation either bilaterally or through an Emissions Trading System.

Such a system will allow a company or country to meet its reduction obligation by buying surplus “credits” from another country or company. The unit commonly used is a tonne of carbon dioxide-equivalent or CO2e.

Emissions trading is a low-cost efficient solution to meeting an overall reduction target. A trade occurs when a buyer purchases a reduction credit from a seller who then transfers its ownership to the buyer. The simplest form of trade will be one that is bilateral. However, like other commodities, it will be possible for trades to be conducted through agents, aggregators and exchanges.

The goal of GHG Emissions Trading or purchase, is to permit industrial growth and expansion and at the same time meet reduction targets economically, efficiently and with flexibility. This compliance mechanism is expected to enhance air quality, encourage new technology, and foster the most efficient use and management of resources, including Clean Air.
For an offset credit to be officially recognised, it must be: Real, Verifiable, Measurable, and Surplus to the needs of the vendor, with clear Ownership (IPOG, 2007).

In Canada, the generation of credits are likely to come from:

- **Bio-sequestration** through Agriculture or Forestry, where trees and soil sequester carbon from the atmosphere
- **Geological storage** which involves the injection of CO₂ into geological formations where it is stored, rather than being vented to the atmosphere
- **Fuel Switching** to lower carbon intensity sources that could include renewable energy where it replaces energy (fuel, electricity or heat) that would produce GHGs; and
- **Energy efficiency** where an organisation can sell credits derived from avoided emission associated with implementing efficiency measures

### 4.6 Financial Compliance Mechanisms

Additional compliance mechanisms are currently under consideration. These options will provide organisations increased flexibility in achieving some of their GHG reduction obligations. Two such mechanisms are:

- Credits granted by governments to organisations that contribute to a **Technology Investment Fund**; and

- A **Carbon Trust**, to which companies will be able to contribute. Operating independently, the Trust’s funds would be used to identify and financially support GHG offset projects, and in some cases actually manage reduction / offset projects. Such projects would be selected to minimise risks and maximise the GHG offsets generation and acquisition, and would likely focus on energy efficiency, renewable and alternative energy, transportation efficiency, agricultural and forestry initiatives.

The pending regulations for large final emitters (LFEs) and subsequent obligations for other emitters, will facilitate these mechanisms being a viable and credible GHG management option for organisations.

### 5.0 Applying Corporate Wedges

Two examples of applying Corporate Wedges are provided. The first case-study is of a medium sized enterprise, emitting under 100 000 tonnes CO₂e annually and the second is of a large final emitter (LFE), producing more than 100 000 tonnes CO₂e a year.

Facility profiles for each case study, have been derived from information submitted to the Canadian GHG Reductions Registry ([www.csa.ca/climatechange/production](http://www.csa.ca/climatechange/production)) and from Annual Reports of the companies in question. Following the company profiles, GHG reduction options are listed and grouped under the Corporate Wedges described in the previous Section.
5.1 Case-Study 1: Pulp Mill

Profile:
- Number of employees: 350 to 400
- Annual production: 475,000 to 500,000 tonnes Kraft pulp
- Land-base managed: 9 million hectares
- GHG emissions: 85,000 tonnes CO$_2$e

Buildings:
- Use recovered low-grade heat for space heating
- Optimise day-time light to reduce need for electric lighting
- Insulate to minimise heating and cooling requirements
- Install efficient lighting and equipment to minimise power consumption
- Require LEED Certification for new buildings

Energy & Power Supply:
- Self-generation
- Co-generation to provide for the facility’s heating requirement and some, all or more* that the power requirement
- Displacement of natural gas with wood residues
- Wood-burning or gasification technology
- Sale of surplus power to the grid
- Sale of certified ‘green power’ at a premium

Operations:
- Continual improvement and optimisation of processes
- Tracking and application of best practices and BATEA
- Maximise boiler efficiency and the efficiency of other energy conversion / consumption equipment
- Optimise heat recovery and use
- Maximise chemical recycling and re-use
- Outsource feedstocks (pulp & wood residue) to optimise economies of scale and added value / revenue generation
- Consider in-field portable chipping

Transport:
- Roadbed stabilisation and surfacing
- Use right-sized ‘best-in-class’ vehicles for fuel efficiency and reduced emissions
- Reduce drag of empty trailers (‘piggy-backing’, raising axles, light-weighting, etc.)
- Wider tires and adjustable tire pressure
- Bio-diesel
- Diesel-electric hybrids (future considerations)

Administration:
- GHG training & awareness for all employees
- Establish a GHG Reduction Taskforce
- Consider energy efficiency in all activities and processes
- Conduct periodic environmental audits and energy audits to identify potential areas on improvement
• Take advantage of simulation and planning tools (Growth-yield models, Carbon budget model, etc.)
• Forest fire prevention
• Integrate land use planning (Co-ordinate with other land users, multiple use of roads, etc.)
• Conduct research and collaboration regarding energy consumption / emissions reductions
• Adoption of best practices in silviculture techniques and forest management strategies in consideration of climate change impacts and adaptation. (i.e.: Shelter-wood or selective harvesting rather than clear-cutting and ‘under-story planting’ where new growth is protected by the remaining trees; mixed wood management; and two-pass harvesting, etc.)

GHG Offsets:
The following activities can be implemented internally, or offsets credits derived from the same initiatives purchased from external parties.

• Afforestation (Tree-planting where there was no forest before)
• Reforestation (Tree-planting where there was once forest)
• Avoided de-forestation
• Energy efficiency
• Renewable energy

Financial Compliance:
• Contribution to a Carbon Trust (Refer to Section 4.6)
• Contribution to a Technology Investment Fund (Refer to Section 4.6)

5.2 Case-Study 2: Coal-Fired Electricity Generating Plant

Profile:
- Number of employees - 280
- Annual production - >1 200 MW capacity / ~ 9 900 000 MWhrs
- Land-base managed - 9 250 hectares
- GHG emissions - ~ 9 million tonnes CO₂e

Buildings:
- Optimise day-time light to reduce need for electric lighting
- Insulate to minimise heating and cooling requirements
- Use recovered low-grade heat for space heating
- Install efficient lighting and other equipment to minimise power consumption

Energy & Power Supply:
- Ensure correct power factor for station services and administration offices

Operations:
- Continual improvement and optimisation of processes making existing generation units and infrastructure more efficient
- Tracking and application of best practices and BATEA
- Heat recovery and use for additional power generation, pre-heating, space heating, etc.
- Use of advanced technology (i.e.: supercritical combustion) for new units
- Track and participate in the development of other thermal conversion technologies
- Track and participate in the development of CO₂ Capture technology
• Co-firing with biomass (i.e. wood waste)
• Integrated gasification combined cycle (future consideration)

Transport:
• Use right-sized ‘best-in-class’ vehicles for fuel efficiency and reduced emissions
• Use of bio-diesel
• Diesel-electric hybrids (future considerations)

Administration:
• GHG training & awareness for all employees
• Implement measures to reduce energy consumption
• Establish a GHG Reduction Taskforce
• Conduct periodic environmental audits and energy audits to identify potential areas on improvement
• Track and research improved / cleaner technologies
• Adoption of improved / cleaner technologies
• Diversify electricity generation portfolio with low- or no emissions sources (i.e. Wind, bio-mass, small hydro, geo-thermal, landfill gas, solar, etc.)
• Integrate land use planning if possible (cooling pond, mine site land holdings, etc.)
• Mine-site reclamation to original or better condition (in consultation with the regulatory authority and local stakeholders
• Conduct research and collaboration regarding energy consumption / emissions reductions
• Track and participate in the development of other thermal conversion technologies
• Track and participate in the development of CO₂ Capture technology

GHG Offsets:
• Energy efficiency (implemented internally, or offsets credits purchased from external parties derived from the same initiatives)
• Renewable energy (implemented internally, or offsets credits purchased from external parties derived from the same initiatives)
• Bio-sequestration (Section 4.5)
• Geological storage (Sections 3.6 and 4.5)
• Purchase credits from the market or another organisation

Financial Compliance:
• Contribution to a Carbon Trust (Section 4.6)
• Contribution to a Technology Investment Fund (Section 4.6)

6.0 Conclusion: GHG Reduction Wedges As Planning Tools

The preceding description outlines wedges of GHG reduction and offset options that organisations can consider. Corporate wedges are derived for their compatibility with the structure and activities of organisations. They provide a framework that can be customised to individual corporations and facilitate the decomposition and analysis of the wedges into meaningful reduction and offset options. As such, tailored corporate wedges represent useful planning and management tools. They permit organisations to:

• Identify their emission sources and associated liabilities
• Evaluate multiple reduction options
• Compare the costs of those internal options, relative to the price of offset credits on the market; and
• Strategically plan and manage GHG reduction and offset activities over time

In addition to being useful planning and management tools, tailored corporate wedges represent an easily understood way to communicate GHG emissions levels, reduction options and progress to both internal and external audiences.

GHG emissions in Canada will soon carry a price, and investors are beginning to recognise that CO₂ liabilities are part of a corporation’s balance sheet (CIBC, 2007). Despite this growing pressure, there is no simple or obvious solution for reducing the energy intensity at an organisational scale or for national economies to ‘de-carbonise’ the energy supply, which is fundamental to lowering GHG emissions to stabilise and then reverse global warming. However, a framework to do just that has been suggested.

The demands to reduce GHGs are going to produce ‘winners’ and ‘losers’. By addressing the issue pro-actively, organisations will have a much greater chance to be among the ‘winners’.

7.0 References


ABSTRACT

Electricity production in Canada is nowhere near sustainable. Inexpensive primary input fuels like oil, coal and nuclear fuel have created a false sense of optimum efficiency. Most thermal coal-fired and nuclear-fired generating facilities have an overall conversion efficiency of approximately 33%, based on energy “in” (consumed) and electricity “out” (produced). The potential to increase this overall efficiency depends on finding a suitable use for the vast amount of low-grade heat produced. A district heating system can help recover this low-grade waste heat.

Conventional district heating systems are expensive to install and maintain. The infrastructures costs and service costs are some of the reasons for their limited success. The authors suggest that using a low-temperature water-based distribution network significantly simplifies the installation and the maintenance of the system. Similar technology is being used in remote communities to demonstrate heat recovery from diesel generators. Distributing low-grade heat and using heat pumps at the customer end is a promising alternative.

Keywords: District Heating, Heat Pumps, Thermal Generation, Heat Recovery

This paper rationalizes the need for and value of district heating systems, to make use of otherwise wasted low-grade heat from centralized thermal electricity generating facilities. To overcome the expensive installation and maintenance costs of traditional district heating systems, the authors propose low-temperature district heating loops without sophisticated insulation, in combination with heat pumps installed at the customers’ end. This latter technology can both heat and cool as required. A number of applications and cost-comparisons are suggested.

Paul Hunt
1.0 Background

1.1 Central Plant Electricity Production

Typically, the central plants that generate electricity in Canada and the USA do not heat-recover any of their waste heat streams. Not surprising then, North Americans are among the highest per capita energy users in the world (Jacobs, 1993). While there are some have some regional variations, there is a high depends on fossil fuels for our heating and electricity needs (NRCan, 2006).

The opportunity to capitalize on the concept of combined heat and power (CHP) is immense, given our significant need for space heating. Once heat is captured at the CHP facility it needs to be transported to the end-use customer. District heating (DH) is the distribution mechanism to deliver heat to the heating load. The concept of CHP and DH is well established in many Nordic countries in Europe and Asia (Nordvärme, 2006). Appendix A provides additional information on conventional district heating systems and their importance in other markets. In Canada, low-cost heating systems, low-cost energy and our large dispersed populations have made DH impractical in most cases. Advances in low-cost plastic pipe and the increase in fossil fuels prices have renewed interest in this country. Several small-scale projects are successfully using CHP for district heating applications (CANMET, 2006). The concepts being presented in this paper can applied to either large-scale or small scale CHP applications. More importantly, global warming and the desire to become more energy efficient are new drivers that is sparking renewed interest in both CHP and DH.

1.2 Earth Energy Systems (EES)

Taking heat from the ground for space heating and cooling has been around for over 50 years (Lenarduzzi, 1993). Like solar and wind energy this renewable energy source is well developed and proven. Like solar and wind energy, earth-energy systems (EES) have higher capital costs compared to fossil-fuels alternatives. Integrating CHP and DH with EES could overcome this capital cost issue.
This paper investigates the benefits of integrating the heat pump delivery system of EES with the waste-heat distributed from a CHP DH loop. The analysis shows a significant drop in the capital cost for EES making them cost-competitive with the conventional heating and cooling alternatives. In addition, thermal load on the CHP DH loop increases the overall generation efficiency and provides secondary revenue stream for the generation company. To retrofit the CHP DH network into an existing power plant may prove to be cost-prohibitive. Additional research in this area is recommended. However, the need for new electric generation to meet growing load and to replace aging plants presents a golden opportunity to evaluate the benefits of a holistic approach to new central plant designs. CHP DH and EES are three technologies that if integrated correctly could significantly improve of overall energy efficiency.

1.3 **Ground and District Heating Loop Temperatures**

Ground temperature ranges from 4 to 12C across most of the populated areas in Canada. To make use of the ground as a heat-source requires a heat pump to upgrade this low-grade ground energy. The terms “ground collector” or “ground heat exchanger” are used to define the network of buried pipes required to perform the heat extraction. This paper calls on the use of combined-heat-and-power (CHP) district-heating (DH) system to replace the ground heat exchanger. Earth energy system (EES) is the term used to describe ground-source heat pumping (GSHP) systems. Prior work with EES has found the cost and complexity of the ground collector to significantly reduce the “market potential” of these renewable systems, especially in dense urban areas. District heating systems, common to Nordic countries, require high population densities to help off-set the high costs of distributing high-grade heat. For this reason, Canada has relatively few CHP/DH schemes. In addition, our need for cooling in the summer makes a heating-only DH network impractical. Thus, the DH network needs to be able to both deliver heat in the winter and reject heat in the summer. Based on these requirements and the temperature limitation of the heat pump technology, the desirable loop operating temperature is approx. 20C (target temperature). To avoid freezing issues and/or antifreeze issues, the loop would need to operate above 5C. To minimize heat pump limits, the temperatures should be below 30C. Thus, maintaining a loop temperature between 5C and 30C becomes the requirement of the central plant. This flexible low-temperature distribution requirement means the DH loop does not need sophisticated insulation to minimize losses over the network, since far-field ground temperatures are normally less than 10C, from the loop temperature. In contrast, a high-temperature hot water or stream DH loop operates at approx. 100C, requiring significant investment in the piping material and the piping insulation.

The low-temperature district-heating (LTDH) loop design provides two significant benefits. It

1. lowers the cost of the EES system; and
2. provides for a low-cost heating and cooling distribution system that can be extended long distances into low-density urban areas.

Centralized power plants process enormous amount of water to maintain their Rankin cycle efficiencies. Diverting a modest amount of water for the LTDH loop is not seen as a major obstacle to their normal electricity generation business.
2.0 Low-Temperature District Heating Design

The main considerations in a hot-water or steam distribution system are construction material, construction costs, heat losses and serviceability of the distribution network. A low-temperature distribution system allows the designer to use existing materials and established construction techniques used for water and sewer networks. The main objectives are to significantly reduce costs for the district heating piping systems, and improve serviceability and reliability.

Plastic, insulated, underground pipe is used to distribute the water at temperatures between 10C and 30C. A heat pump is used to deliver the final space conditioning temperature conditions. The LTDH loop temperature will vary throughout the year based the load requirements, which are dependent on seasonal variation.

Keeping the system operating temperature low reduces losses from the pipes and is more compatible with the heat pump efficient. No special air-handlers are required to extract heat from the district-heating loop, thus simplifying the overall design. In the cooling, mode the loop rejects heat into the district heating loop. An enhancement to the LTDH loop is to incorporate some kind of thermal energy storage system into the overall design. This enhancement is described in greater detail in Appendix B.

3.0 Target Markets for Low-Temperature District-Heating (LTDH)

The target markets listed below are based on a LTDH that can provide a reliable heat sink or heat source over the target loop temperature of 20C. Secondary heat exchangers may be required and/or heat pumps to deliver the required heating or cooling loads to the target markets.

1. Agricultural soil heating/greenhouses
2. Aquaculture
3. Irrigation
4. Residential Space Heating and Cooling (includes pool heating and water heating)
5. Commercial Space Heating and Cooling
6. Industrial Space Heating and Cooling
7. Institutional Space Heating and Cooling
8. Multi-Residential Space Heating and Cooling
9. Indoor Sport Centres, including swimming pools, ice rinks, gymnasiums and other recreational facilities.
10. Outdoor pools and stadiums park walkways etc.
11. Snow melting on select roads and/or intersections (winter)

4.0 Analysis of Two Typical Target Markets

4.1 Heating and Cooling Load Requirement

An economic evaluation of the LTDH concept requires an understanding of the heat and cooling needed by the loads represented in the “Target Markets”, listed above. Detailed analysis of each
target market is beyond the scope of this paper. An evaluation of the typical residential and commercial loads should be sufficient to determine the merits of the concept.¹

4.2 Typical Residential Home

An average residential home is assumed to have a heating load of approx. 10 kW peak, consuming approx. 20,000 kWh/year. The summertime cooling load is estimated to be 7 kW, rejecting approx. 10,000 kWh/year of thermal energy and consuming approx. 3000 kWh/year of electricity (Lenarduzzi, 1993).

4.3 Typical Commercial Building

An average commercial building of 1000 m² has a heating load assumed to be 100 kW peak, consuming 200,000 kWh/year. The summertime cooling load is estimated to be approx. 100 kW, rejecting 150,000 kWh/year (Mancini, 1995).

4.4 Costs for the End-Use Components

Costs are divided between capital requirements to install the necessary hardware and operating costs. A significant amount of information is available on both capital costs and operating costs of EES, natural gas-fired equipment, electric heating and air-conditioning (ASHRAE, 1999). The information below is presented for the typical residential home and for a typical commercial building of 1000 m². Scaling these average values is then used to determine the size of the LTDH loop.

Operating costs are derived from the heating loads given above and electricity costs. Electricity costs are assumed to be $0.1/kWh, with natural gas priced at 30% less.²

4.5 Capital Cost for Typical Residential Heating and Cooling Systems

The alternative system for the residential home is a natural-gas furnace and gas water heater with a central air-conditioner. For the typical residential home the capital cost of this system is estimate to be $10,000.

The LTDH heat pump system provides space-heating, water heating with an electric backup plus high-performance central air-conditioning. Figure 1 is a schematic representation of a typical water-to-air heat pump system. The heat pump system is estimated to cost $5000 and the piping to the LTDH system to cost $2000 for a total of $7000.³

¹ Results for the residential and commercial sectors can be easily applied to the industrial and institution sectors, with respect-to-space conditioning and water heating.

² Electricity prices are based on an analysis of residential bills in both Toronto and Oakville, Ontario for 2007. The rate does not include GST or the applied loss factor. The natural gas cost-factor may vary from 50% to 70% of electricity costs on an equivalent kWh bases (based on the geographic area and heating efficiency).

³ In most cases installing a ground heat exchanger can cost up to $10,000, for a total of $17,000 for the complete EES.
4.6 Operating Cost for the Typical Residential Heating and Cooling Systems

The heating and cooling operating cost for the conventional natural gas system is $1700/year. The heating and cooling operating cost for the LTDH heat pump system is $998/year, for the equivalent heating/cooling effect. Thus, annual savings are $702/home/year, compared to a conventional natural gas system and over $1300/year compared to electric resistance heat.

4.7 Capital Cost for Typical Commercial Heating and Cooling Systems

For the typical commercial building described above, the alternative conventional system is a packaged rooftop natural-gas furnace/air-conditioning system. The typical costs for such systems are $500/kW. The commercial build has peak consumption of 100 kW. Thus, alternative conventional system cost is $50,000 (for the 1000 m² commercial building) (Mancini, 1995).

The proposed LTDH heat pump system for the commercial building is schematically shown in Figure 2. Each of the individual units shown in Figure 2 would look approximately like the water-to-air unit shown in Figure 1. Commercial heat pumps systems cost approx. $300/kW. Loop connections are estimated to be $6000 (per 1000 m² building), for a total capital cost $36,000/building. The capital cost savings for the LTDH system is $14,000 less than the alternative conventional packaged rooftop natural-gas furnace/air-conditioning system (Mancini,
A significant cost savings is also realized compared to an earth-energy ground loop system (EES).4

**Figure 2: Schematic Showing the Deployment of Heat Pumps inside a Commercial Building**

4 The cost of installing a ground heat exchanger for the commercial building (1000 m$^2$) is estimated to be $30,000 (Mancini, 1995).
Table 1: Operating Cost Savings & Capital Cost Savings

<table>
<thead>
<tr>
<th></th>
<th>Operating Costs/year</th>
<th>Capital Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Heating</td>
<td>Cooling</td>
</tr>
<tr>
<td>Residential Dwellings Load</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conventional Heating/Cooling</td>
<td>$1,400</td>
<td>$300</td>
</tr>
<tr>
<td>Heat Pump Costs</td>
<td>$571</td>
<td>$210</td>
</tr>
<tr>
<td>Loop Cost to Utility for Water Fee</td>
<td>$143</td>
<td>$74</td>
</tr>
<tr>
<td>Total Heat Pump Costs</td>
<td>$714</td>
<td>$284</td>
</tr>
<tr>
<td>Savings</td>
<td>$686</td>
<td>$17</td>
</tr>
<tr>
<td>% Savings</td>
<td>49%</td>
<td>6%</td>
</tr>
<tr>
<td>Commercial Building Load</td>
<td>200,000 kWh</td>
<td>150,000 kWh</td>
</tr>
<tr>
<td>Conventional Heating/Cooling</td>
<td>$14,000</td>
<td>$5,000</td>
</tr>
<tr>
<td>Heat Pump Costs</td>
<td>$5,714</td>
<td>$3,500</td>
</tr>
<tr>
<td>Loop Cost to Utility for Water Fee</td>
<td>$2,000</td>
<td>$1,500</td>
</tr>
<tr>
<td>Total Heat Pump Costs</td>
<td>$7,714</td>
<td>$5,000</td>
</tr>
<tr>
<td>Savings</td>
<td>$6,286</td>
<td>$-</td>
</tr>
<tr>
<td>% Savings</td>
<td>45%</td>
<td>0%</td>
</tr>
</tbody>
</table>

5.0 Low-Temperature District Heating (LTDH) Loop

The low-temperature district heating distribution network has three major components to the design, Trenching, Piping and Pumping. Trenching and piping costs are estimated between $200/m to $500/m to bury two 12” HDPE (high density polyethylene) pipes. Included in the cost is a minimal amount of thermal insulation to lower the heat loss from the top of the trench. Typically, central generating facilities are located several kilometers from the potential thermal load. Thus, the assumption is made that the LTDH loop must run 2 km to reach the thermal load. A typical residential load, on a subdivision scale, is shown schematically on Figures 3 and 4.

The capital cost of the LTDH loop is estimated to be $400,000 per km, including the pump and heat exchanger at the generation plant end. Such a system would have the capacity of supplying over 3000 home and 300 commercial building. The calculated fee per home for supply of the treated water to the heat pumps is $216/year based on a cost of $10/MWh ($0.01/kWh). For the typical 1000 m$^2$ commercial building the annual cost to the utility for using the LTDH loop is $3500/year. Thus, based on a total LTDH loop cost of $800,000 and a simple payback of 5 years the number of homes need to breakeven could be as low as 400 homes and 20 commercial buildings.

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5 Estimated cost for waste heat from the power plant.
Figure 3: Typical LTDH Loop Distribution for a Residential Sub–Division

Source: Drake Landing Solar Community, Natural Resources Canada (McClenahan, 2006).

Table 2 shows the number of homes and/or commercial building required to calculate a simple payback of 5 years on the LTDH capital cost. Alternatively, the end-users could afford to capitalize the LTDH loop-expense based on the significant 1st cost savings for the heat pump system. The LTDH pumping cost at the generation plant will vary depending on the number of end-use customers. Pumping costs, water treatment costs and maintenance costs are expected to be much less than conventional DH systems.

Table 2: Expect Utility Revenues from Water Fees – Showing Simple Payback

<table>
<thead>
<tr>
<th>Table 2: Utility Revenue</th>
<th># of Home</th>
<th># of BLDGS</th>
<th>Simple Payback</th>
</tr>
</thead>
<tbody>
<tr>
<td>12&quot; HDPE piping loop Capital Cost</td>
<td>$ 800,000</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Annual Revenue per Home, Loop-water fees</td>
<td>$ 216</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Annual Revenue per Comm Bldg, Loop-water fees</td>
<td>$ 3,500</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Annual Utility Revenue from Loop-water fees</td>
<td>$ 160,000</td>
<td>740</td>
<td>0</td>
</tr>
<tr>
<td>Annual Utility Revenue from Loop-water fees</td>
<td>$ 160,000</td>
<td>0</td>
<td>46</td>
</tr>
<tr>
<td>Annual Utility Revenue from Loop-water fees</td>
<td>$ 156,543</td>
<td>400</td>
<td>20</td>
</tr>
<tr>
<td>Annual Utility Revenue from Loop-water fees</td>
<td>$ 169,907</td>
<td>300</td>
<td>30</td>
</tr>
<tr>
<td>Annual Utility Revenue from Loop-water fees</td>
<td>$ 501,450</td>
<td>700</td>
<td>100</td>
</tr>
</tbody>
</table>
6.0 Conclusions

The low-temperature district heating (LTDH) loop concept can lower electric peak-demand by over 35 percent. Essentially, we get all the benefits of an EES at a capital cost that is less than the conventional system. The savings associated with the operation of earth-energy systems have been well documented at over 50% in heating and over 20% in cooling. The expectations are that the proposed low-temperature district heating (LTDH) system will achieve similar results, while using less capital.

For commercial buildings capital costs are expected to be 28% less than the conventional gas-fired/electric heat/cool units. Similar capital and operating cost savings are expected for industrial and institutional applications.

7.0 References


Appendix A – Conventional District Heating

“An important method of heating buildings is by hot water produced during electricity production and piped around whole districts, providing both heat and hot water. This extremely efficient use of fossil fuels demands a co-ordination of energy supply with local physical planning, which few countries are institutionally equipped to handle. Where it has been successful, there has usually been local authority involvement in or control of regional energy-services boards, such as in Scandinavia and the USSR. Given the development of these and similar institutional arrangements, the cogeneration of heat and electricity could revolutionize the energy efficiency of buildings worldwide” [Our Common Future World Commission on Environment and Development (The Brundtland Report), Oxford: Oxford University Press, 1987, pp. 200 (IEA, 2004)].

Nordic countries like Finland, Iceland, Norway and Sweden, have all embraced district heating as a viable way to increase overall electricity generation efficiency from less than 40% to over 80% by reclaiming waste heat for space heating. The amount of electricity produced remains unchanged the waste heat is reclaimed by re-circulating hot water or steam.

Nordic cities like Copenhagen in Denmark have used cogeneration of heat and power for more than 50 years, mainly based on supply of steam. While convenience, profitability, and energy conservation have been the major driving forces, protecting the environment is becoming more important. Global warming requires a concerted effort to evaluate not just the cost benefits in terms of energy supply prices, but to also evaluate overall energy efficiency. To achieve these significant efficiency improvements requires a better understanding of supply and demand and an integration of the delivery mechanism with the producers and end-users. Nordic countries have been most successful when the transmission companies played a pivotal role in the heat distribution system.

Danish Results

Because of integrated district heating systems, during the last 10 years the SO₂ emissions per TJ energy produced from Danish combined-heat and power (CHP) stations have decreased by 50%.
Appendix B – Enhancements: Heat Recovery & Thermal Energy Storage (TES)

The recovery of rejected energy from a generating plant and a LTDH system as described in this document can be further enhanced with the integration of Underground Thermal Energy Storage (UTES). This will allow recovery and storage of summer rejected energy for use during the heating season. Integration with UTES will permit higher overall generating system efficiency; and will allow a larger LTDH system for the same size plant. Figures 4 and 5 shows a schematic representation of the many options that can be accommodate from either a thermal energy storage (TES) system or LTDH loop in combination with TES.

A UTES system is a closed loop ground heat exchanger comprised of many vertical boreholes (150mm dia.) drilled in the earth and loaded with U-tube exchangers that are grouted in place and tied together at the top into a grid pattern. The choice of pipe material will depend on fluid temperature. This is not unlike the bore-field designed for the Drake Landing Solar Community in the Town of Okotoks (McClenahan, 2006).

Figure 5: Intelligent Heat Recovery and Storage System Flow Diagram
Web-Based Data Acquisition and Control for Electric Utilities

Frank Lenarduzzi

ABSTRACT

The Internet and Intranet offer electric utilities control connectivity down to the customer level. These networks can also expand their internal data acquisition and control systems. The major issues are system security and availability. Emerging technologies like, wireless and low-cost high-speed fiber present a huge opportunity to improve overall efficiency both at home and at work. Automation and load control can help shape electrical load profiles to create significant economic savings, and improve system security and reliability. With two-way communication both the customer and the utility can match demand with supply to optimize performance. This type of load control is also called demand-side management (DSM) or demand response (DR). It is also important to realize that energy conservation by itself may be “good”, but if consumers do not also consider peak demand, the energy generation and delivery problems will get worse. Web-based technologies offer the opportunity for real-time control and monitoring of the electricity system. In addition, these high-speed links can increase the surveillance of the bulk electricity system to help improve physical security and system security by improving response-times to serious events like the Blackout of August 14, 2003 that affected both Canada and the USA. The same Web-based network could also be used to feed back system conditions to operators.

Keywords: Electric Utilities Web-Based Control, Conservation and Demand Management

Demand management is an important tool to address sustainable electricity system management. This paper identifies the problems associated with our historic electricity system management practices and some of the hurdles encountered in the electricity system deregulation that has occurred across North America. The author then identifies how advanced computer based communication technology can be used to address many of these concerns.

Many of the problems that electricity systems face arise from viewing the systems in silos. Power generation is treated as an entirely different business from power distribution that in many cases is completely separate from customer relations and billing. This situation often leads to discontinuity between the customer and the electricity supply chain. Incentives to reduce electricity use are lost or not available within the system design. As a result, rather than maximizing the utility of the existing system capacity, power companies often focus on increasing generation capacity that can exacerbate social and environmental issues.

The demand management approaches articulated in this paper would go a long way to addressing some of these broader issues as they relate to power generation and consumption in North America.

Joel Nodelman
Web-Based Data Acquisition and Control for Electric Utilities

Frank Lenarduzzi

1.0 Introduction

This paper proposes that the Internet and advanced communication technology can make a significant contribution to the security, reliability and price efficiency of our electricity markets. Advanced Internet technology can provide low-cost demand response and improve the physical security of the existing infrastructure. The importance of demand response and load control can be found in numerous published papers and Web sites. Workshops at The McMaster Institute for Energy Studies (MEIS), in 2004 and 2005, actively promoted the concept (Mountain, 2005). The Ontario Power Authority (OPA) is looking for proposals and stakeholders to submit ideas for funding, to help develop programs1. Several USA and Canada experts are willing to share their insight on how to achieve practical demand savings (Lenarduzzi, 2006). In some parts of the USA, customers are generously compensated for providing demand response. The primary objective of this report is to help identify the benefits of demand response and demand management. In addition, the report will list applications and enabling technologies that can bridge the growing gap between generation, transmission, distribution and energy efficiency interests. In some cases, the issue lies with regulators that need to provide the necessary drivers to promote entrepreneurial improvements. If the Ontario electricity industry is representative of the North American electricity market, existing programs fall short of their potential.

On the physical security side, events post-9/11 have significantly increased the awareness on the vulnerability surrounding infrastructure assets. Our open society has made us vulnerable to potential terrorist attacks. The August 14, 2003 blackout event in the northeast also exposed our vulnerability (US - Canada Power System Outage Task Force, 2004)2. While cyber security has increased significantly over recent years, physical security has by-and-large remained unchanged.

The objective of this report is to summarize the business environment for promoting several forms of load control and demand response over the Internet, in order to achieve greater system security and system reliability. The report outlines a number of barriers that need to be

1 The Ontario Power Authority (OPA) has research funds for non-profit groups like Universities to investigate end-use technologies (http://www.conservationbureau.on.ca).

addressed to integrate the demand-side with the supply-side. Both conservation and demand management (CDM) require an integrated plan to achieve the results being required by government and regulators. The growing need for energy has placed several important constraints on traditional approaches. New approaches are needed to replace aging electricity plants and to meet the growing demand for power. Improving communication with end-users is one approach that is gaining acceptance as a viable alternative in improving overall system efficiency.

2.0 Overview of the Electricity Industry in Ontario with Respect to Demand-Side Issues

Peter Love the Chief Energy Conservation Bureau Officer for Ontario had three main messages about the electricity industry in the Province (Love, 2005).

1. Major new investments in the electricity system are needed.
   - 25,000 MW in new capacity/demand reduction over next 20 years

2. Energy Conservation and Demand Management have a major role to play.
   - Ontario government has set a target of 5% reduction in demand growth by 2007 (about 1,350 MW)

3. Role of the Conservation Bureau in Ontario must be to:
   - Lead efforts to build Conservation Culture and Energy Efficiency
   - Facilitate Demand- and Load-Reduction Procurement

2.1 Benefits of Conservation and Demand Management (CDM)

Some of the major benefits of conservation and demand management (CDM) are listed below. Despite this impressive list many in the electric industry are not committed to the CDM strategy or do not see the strategy aligning with their business plans. The challenge is to find ways for traditional electric utility leaders to incorporate a more sustainable strategy into their business model. For example, some utilities are spending significant resources (capital) to bring a CDM message to their customers, at the specific request of government. However, these same utilities are allocating virtually no internal budget to upgrading their own buildings and infrastructure (to become “greener” and more sustainable). The CDM message ends up ringing hollow without a demonstrated top-to-bottom commitment to sustainability. Major CDM benefits include:

- Improved air quality - Health benefits
- More efficient use of our energy resources - Environmental benefits, Resource conservation
- Reduced energy costs for consumers - Consumption is a controllable part of the bill
- Reduced operating costs for industry
- Increased competitiveness of the economy – creates jobs
- Improved system reliability (NARUC, 2001)

2.2 Ontario Energy Board (OEB), Bill 100 Objectives for Electricity

As utility regulator, the Ontario Energy Board (OEB) has an important role to make sure utilities not only follow government directives, but that they also show a true commitment to the spirit of
CDM and suitability. So far the OEB has not adequately addressed the objectives listed below which are set in the Electricity Restructuring Act of 2004 (OEB, 2007), specifically the issue of changing the corporate culture of utilities with respect to CDM.

- “To protect the interests of consumers with respect to prices and the adequacy, reliability and quality of electricity service.
- To promote economic efficiency and cost effectiveness in the generation, transmission, distribution, sale and demand management of electricity and to facilitate the maintenance of a financially viable electricity industry.”

2.3 What is Conservation, Demand Management & Demand Response?

Conservation and demand management (CDM) is managing loads. The load management classifications are:

- **Load reduction**: (a) Reduces demand at all hours of the day by encouraging efficiency of energy usage; and (b) depends on local generation and energy conservation technologies.
- **Load leveling**: (a) Smoothes out the peaks and dips of demand curves, including peak clipping, valley filling and load shifting; and depends on technologies associated with load control and the use of energy storage devices.

Demand response (DR) is a subset of load management where the electrical consumption changes are based on either imposed market conditions (price signals) or because of a system emergency (auto load rejection).

The four common methods to manage loads are listed below and graphically shown in Figure 1. All these load management methods could all be significantly enhanced using low-cost Web-based control devices. Instead, the current approach by conventional utility thinking in Ontario is to drive change by imposing costly “smart” metering on customers to force price signals to do all the work. Other jurisdictions that have tried this approach (without load control) found customer backlash to be too great to overcome.

1. **Peak Clipping** - reduce the system load by load shedding
   - e.g. Thermostat Setback or Set-Forward Programs

2. **Load Shifting** – move or shift load from one time period to another
   - e.g. Moving production to the nighttime period or setting the dishwasher for after-hours

3. **Conservation** – reduce the overall consumption of energy
   - e.g. Install T8 fluorescent light to replace T12 lighting, use compact fluorescent lighting in the home

4. **Valley Filling** – add New Load to increase load factor (lowers average $/kWh)
   - e.g. Use thermal energy storage systems to take advantage of off-peak rates or find other electro-technologies to boost production and productivity
Some Advantages of Load Management and Demand Response are:

- Energy savings;
- Delay/reduce investments in generation and transmission due to lower demand;
- Reduce electricity prices;
- Help control price volatility (particularly with price-response programs); and
- Reduce congestion, i.e. increase system security margins and hence reliability.

Load Control and Demand Response is not new. In the past, utilities offered special rebates or lower rates to encourage load leveling and electricity sales. Now price signals are being used to drive demand response (new). The problem is that many customers do not have the sophistication to monitor and respond to 5-minute or hourly prices signals.

A few example of the equipment that can deliver load control and demand response are shown in Figures 2 and 3. The figures show the advances required in metering, communications (telephony, Internet), smart appliances and end-user applications to deliver demand response to end-use customers. Unfortunately, utilities are spending large sums of money to install smart meters and a negligible amount on load control devices. Of the over 30,000 “Smart” meters deployed by Hydro, none are able to provide load control as shown in Figures 2 or 3.
Figure 2: Residential Example of Load Control & Demand Response (DR)

Typical Smart Meter with Load Control
Load Management controlled by the Utility or a 3rd party

Figure 3: Commercial/Industrial Example of Load Control & DR

Typical Commercial Setup
Load Management controlled by the Utility or a 3rd party
According to Cañizares (2004), the disadvantages of using Real-Time Electricity Pricing are:

- In most cases, prices have gone up;
- Auction mechanisms do not work well with a limited number of suppliers and “inelastic” load, leading to market power and gaming;
- Market rules change often reacting to political pressures;
- Unlike generators, customers do not have the resources to follow or understand the market rules.

3.0 Electricity Networks and Physical Security in General

The objective is to demonstrate the ability of Web-Based products to increase system security and efficiency by improving the two-way communication path between security firms, customers, transmitters and generators. This paper investigates the economic drivers and the regulatory framework then suggests improvements.

Figure 4 is an example of the technology that can be used to communicate information across a large customer base (Smith, 2005). In the example a WiFi network is used to support “smart” metering. Note that the diagram does not show the control of the final end-use devices. Control of the end-use device is an important component of the overall strategy for demand response to be effective. Smart meters just enable “smart” prices to be passed on to consumers without helping them to react to price-spikes or price-signals.

Three points to consider are:

1. Ontario electricity procurement is extremely complex, especially with respect to placing a value on demand response and load control;
2. There are purchasing risks with respect to spot prices and hedged contracts that cannot be eliminated;
3. Load control offers an innovative method to gain some control over electricity costs.

Issues that hold back Load Control Implementation for businesses include:

1. It does not address organization’s core business objectives;
2. It fails to link reliability of operations and mitigation of risk to businesses;
3. It considers life cycle approach but fails to match up life cycle with natural business cycle;
4. It competes for internal capital; and
5. Is perceived as a risky investment.

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3 WiFi was originally a brand licensed by the Wi-Fi Alliance to describe the embedded technology of wireless local area networks (WLAN) based on the IEEE 802.11 standard.
4.0 Internet Technologies

Several Internet technologies already exist that can be used to help move data and information from remote locations to central-monitoring hubs for processing. Consideration is given to multiple partners to administer the data retrieval and data management over several different market sectors. In some cases, the combination of more than one service onto the gateway could improve the breakeven for the enabling technologies. The focus will be on the following industries: Utilities, Security Firms and Network Management Firms.

4.1 For Utilities

Many of the current data acquisition systems used by utilities are based on outdated phone-based systems or require manual data retrieval methods. Included in this list are access to customer meters and access to data recorders that store vital information on electricity-system performance. Web-based technologies offer the opportunity for real-time control and monitoring of the electricity system. In addition, these high-speed links can increase the surveillance of the bulk electricity system to help improve physical security and system security by improving response-times to serious events like the Blackout of August 14, 2003 or other unexpected conditions. The same Web-based network could also be used to load manage consumption by providing feedback on operating conditions.

4.2 For Security Firms

Firms that provide low-cost physical security could use technology to increase the effectiveness of their patrol coverage. In addition, firms looking to purchase security services could use technology to lower their costs and increase their coverage.
4.3 For Network Security

Network security involves monitoring incoming and outgoing communications traffic to make sure communication systems are not being compromised. Typically, network security systems monitor incoming and outgoing channel traffic and/or probe communication networks.

In light of the events of September 11th, 2001 and the Northeast blackout of 2003, the US and Canadian governments leverage standards established by the North American Electric Reliability Council (NERC) for protecting and regulating cyber-security for the electric sector (BT Counterpane, 2006).

5.0 Driving Force for Load Control

Deregulation has increased electricity costs and price volatility. Price volatility does not encourage long-term investments in new supply since business plans can’t predict long-term price trends. Supply shortages force regulators to consider demand-side solutions at least as short-term solutions.

5.1 Secondary Objective

To strengthen and expand Canada’s commitment to energy efficiency in order to help address the challenges of climate change.

5.2 Canadian Commitments

The Climate Change Plan for Canada, Kyoto Protocol, and other international agreements put pressure on utilities and regulators to consider novel demand-side solutions. The utility industry is forced to consider reducing its footprint, versus blindly expanding supply as the only alternative. The essential goal is CO₂ reduction to reduce global warming, by conserving and managing fossil fuel consumption. The electricity industry can make a significant impact on the overall consumption of fossil fuel by promoting the wise use of electricity. There leadership is on this issue varies from province to province. It seems deregulation has had a negative effect with respect to developing novel demand-side solutions (Young, 2007).

5.3 Drivers for System Security

The 9/11 terrorist attacks in New York and other post-9/11 terrorist events exposed the vulnerability of our electricity system to sabotage. Losses due to the theft of copper wire at transformer stations are significant in Ontario. These acts of theft and vandalism also expose the general public to increased risks when the copper wires are safety grounds that must be in place to reduce fault damage. In addition, the costs of fixed assets like trucks and mobile heavy equipment increase security risks and costs.

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4 The Kyoto Protocol objective is the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous changes to the overall climate system, (essentially CO₂ reductions to reduce global warming.). (Wikipedia, 2007)
5.4 Drivers for Advanced Monitoring and Improved Productivity

Advanced Web-based technology allows for improved monitoring of the system conditions surrounding electrical equipment. In many cases faulty equipment can be diagnosed, repaired or isolated remotely. This lowers labour costs and improves troubleshooting and error detection. Improved monitoring reduces the risk and liabilities associated with faulty equipment and or systems. This is particularly true for remote sites that may be several hours away from a manned station. For transmission companies with miles of isolated tower lines, real-time monitoring could significantly decrease repair and outage times following a fault condition.

5.5 Technology Gaps, Time to Market, Internal Inertia

Satellite technology already exists that can provide Web access, virtually anywhere. Yet many data retrieval systems at utilities rely on out-dated phone-based telecommunication devices. New concepts in this field encounter several barriers:

- Reluctance to test prototype concepts
- Capital financing (venture capital)
- Shortage of skilled workers (resources)

To overcome some of these barriers utilities need to make greater investments in R&D. Pre-deregulation utility R&D spending was low. Post deregulation it is even lower (negligible). The post deregulation mind-set has been to purchase off-the-shelf technology and severely curtail investment in emerging (novel) technology. The result is an industry that tends to follow rather than lead.

6.0 Contemporary Approach to Change in the Electricity Markets

The essence of electricity deregulation in Ontario focused on the following:

1. The evolution of a new regulatory framework;
2. The use of market-based mechanisms;
3. The adoption of market rules controlled by the Independent Electricity System Operator (IESO);
4. Build an understanding of the business challenges to determine constructive ways to influence business strategies that will lead to more electricity supply.

It has become come clear over the last few years that the lack of innovative technology is not the primary issue. Rather, management thinking and practices seem to impede the flow and implementation of novel solutions. In the past, command-and-control regulations were effective when leadership was in the hands of technical experts. The politicization of energy decision-making has reduced the influence of engineers in positions of authority. The shift has been to “market-based mechanisms”, which do not satisfactorily deal with environmental and resource issues. A better understanding of the business challenges and technical issues is needed to help explore solutions that rely on developed expertise. Breaking down barriers based on historic misconceptions or out-of-date thinking will be the challenge in going forward. In many cases
there is more than one solution. Selecting one option (supply) at the exclusion of alternatives (demand response) will hide the optimum integrated solution.

7.0 Background on the Electric Utility Perspective

The competitive electricity market in Ontario opened over five years ago, on May 1, 2002. Unlike other jurisdictions, both wholesale and retail sectors in Ontario were subjected to competition, at the same time. A very hot summer increased the demand for electricity and led to dramatic electricity price-spikes well into September 2002. By the fall, the Provincial Government froze retail costs for small users in an effort to limit price volatility. The retail market failed because demand response and load control were not implemented at the time of market opening. This despite predictions at the time that demand response was an integral part of deregulation, which needed advanced support, instead of being an after-thought.

Wholesale consumers were given the same status (same rights) as generators within the market. While wholesale consumers were afforded equal treatment, they did not have the knowledge, training or desire to participate equally in the market. In addition, the market did not provide the incentives necessary for consumers to participate fully. Wholesale consumers (loads) had the option to be dispatchable; that is, to become subject to dispatch by the control authority, just like generators, based on the prices of their bids into the real-time market and the clearing price of energy in the real-time market. Unfortunately, wholesale market participation has a high cost associated with the metering and communications systems linked back to the control authority. Since generators do not have a choice in market participation, they must invest in the infrastructure needed to carry on business in the new market.

At the retail level, customers have fewer choices and depend on retail suppliers to negotiate their electricity costs. In most cases, the local distribution company (LDC) is the default supplier. They used a “pass-through” method to arrive at the retail price. The LDC has little or no incentive to provide innovative rates to consumers or to encourage retail customers to negotiate better rate terms by aggregating customers into dispatchable groups. In fact, LDC plays a passive role since their revenue stream is based on the peak demand and energy used by their customers. They do not derive any benefit and in fact lose revenue if customer load control creates lower market costs. Most retail customers receive the “spot-price pass through”\(^5\). Since most retail customers do not have an interval meter, individual customer load-profiles cannot be determined. An additional complication was introduced by the government. They imposed a flat-rate of 4.3 cents/kWh for some low-volume retail customers. This fixed charge (flat-rate) provides even less incentive for consumers to alter their load-profile in response to peak pricing or emergence conditions. Despite the use of flat-rate (fixed) charges customers can still receive an incentive to reduce load, by using direct digital load control.

To help consumers participate in the market, barriers have been identified. Some changes have been proposed primarily to help industrial customers. New measures allow both dispatchable and non-dispatchable load to exist at the same location (separate metering not a requirement).

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\(^5\) Consumers were to pay the market price for energy under spot-price-pass-through arrangements even though they typically do not have interval metering (i.e. time-of-use metering). For example, the consumption of residential consumers who typically have aggregate metering could have been profiled and their payments based on the spot price and their profiled consumption. As a result the use of aggregate meters inevitably mutes market-pricing signals.
In addition, the communication requirements and notice periods have changed to help customers to react on short notice. Despite these changes, dispatchable load is still less than 100 MW in Ontario.

However, under emergency conditions and public appeals, a significant amount of demand response has occurred. This good-will response by the public is a good measure of potential magnitude of the customer demand response. It suggests that demand-response has a key role to play, if the right drivers and incentives are integrated into the market.

7.1 The Market Surveillance Panel of the IESO made the following comments on Demand Response

McFetridge et.al. (2006) state

- “Customers are not well equipped to respond to high prices by lowering their consumption, and therefore lack the power to discipline price increases from suppliers.”
- “Energy users require accurate and timely information about prices, as well as pricing plans that reward them for modifying their demands in response to such information.”

Electricity markets throughout North America have had, and continue to have problems with a lack of demand-side price-response, which is a concern especially during periods of high demand or when supplies are limited. A lack of price response is understandable if consumers are not exposed to real-time prices. However, real-time pricing is not essential to reduce demand. Direct digital control of select customer loads can provide the control authority with a powerful tool to control demand, thus the wholesale price. Unfortunately, the control authority prefers to use electricity pricing to drive the demand response. They fear direct digital load control might cause market manipulation. The opposite seems true – customers are less likely to use demand response to increase electricity prices. Conversely, generators have been known to withhold supply to increase prices. It is too much to ask load aggregators to participate in the market like generators, subject to all the rules and regulations. In the USA, the local distribution company (LDC) signs up their retail customers to participate in load control initiatives. Thus, the cost-burden to invest in demand response equipment and rebate customers is incremental to the LDC’s other functions. Several initiatives are proposed to overcome the limited motivation by the majority of customers to reduce demand.

It is becoming clear to regulators in both the USA and Canada that for a truly competitive market to exist, price responsiveness on the demand side is necessary (McFetridge et.al., 2006). Going a step further, any electricity market (regulated or unregulated) can operate more efficiently by weaving customer demand response as an integrated part of the overall electricity system. Historically, central electricity planners focused on load forecasts to schedule the timely addition of new supply and new transmission. Demand response initiatives actually help the supply planning process by managing demand. Usually, smaller electricity networks do a better job of integrating demand response and innovative rates in their electricity system. Often the impact of a new source of supply will result in a short-term surplus that needs innovative marketing strategies to boost electricity consumption. Alaska Power is a good example of a utility that promoted off-peak heating and demand response to help with supply issues, in time of surplus (Stone et.al., 2006). The supply-demand issue is almost never perfectly balanced. New sources of supply might take long-term planning and significant capital investment, while demand will vary
based on overall conditions in the economy. Since boom/bust cycles are difficult to predict it is prudent to have both supply and demand options readily available.

This report identifies actions that could improve and/or increase demand response. Attention to the following items is required:

- Encourage participation from both the wholesale and retail sectors of the electricity market in Ontario;
- Recognize that load management and energy conservation are an integral part of demand response and should not be separated;
- Recognize that emerging technologies require support to remove barriers;
- Recognize that the technology that delivers demand response can apply to both economic (i.e. market price sensitive) and reliability-related demand response programs; the controlling authority should promote both and not differentiate between economic demand response and reliability demand response. To do so defuses the impact of demand response;
- Recognize that current “market-ready” products, services and technologies enabling demand responsiveness are not complete and require continuous improvements;
- Run technology pilots to value demand responses, both its measurement and its worth;
- Promote legacy demand side resources like interruptible electric water heater loads and identify measures needed to encourage new interruptible loads like off-peak electric-resistance heating;
- Recognize that interval metering is a punitive measure for customers that do not have adequate training or resources to become price responsive;
- Recognize that direct digital control of electric loads can provide more direct benefit than an interval meter. In addition, direct digital control has less of a punitive impact on the consumer;
- Integrate the proposals into a single recommended plan of action including key implementation details to add program credibility.

Fundamental changes to the design of the Ontario electricity market are not beyond the scope of this report. Aspects that are missing from the market which inhibit demand response must be identified.

Usually we need all of the following three components for success (Mountain, 2005):

1. Technology and a business plan - Can we enhance the technology?
2. Policy - Are there other possible/more creative policies?
3. Customer’s behavioral response - Have we perfectly anticipated the range of behavioral responses?

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6 In the U.S. Northeast markets, programs exist that address both reliability and market pricing related programs, e.g. “price responsive” and “emergency demand response” programs, respectively. The former is intended to mitigate price, the latter to mitigate shortages in supply. An emergency demand response program has been initiated in Ontario, but there is presently no price responsive program.
Consumers don’t ask for interval metering, smart metering, time based rates, conservation, and load control. They do ask for energy information, cost information, fair rates, cost control, and security.

7.2 Creating an Integrated Plan for CDM in Ontario

The report strives to identify the following market requirements:

- Encompass both the wholesale and retail sectors of the electricity market in Ontario;
- Identify the roles that market participants, the IESO, the OPA, the OEB and government should play in promoting demand response;
- Recognize the new roles and relationships and other impacts as they relate to demand response contained in Bill 210, an Act to amend various Acts in respect of the pricing, conservation and supply of electricity (e.g. sections 27.1 and 28.1 identify the potential for directives by government with respect to the promotion of energy conservation, energy efficiency and load management);
- Recognize the measures remaining within the current Ontario market design (e.g. spot-price-pass through, dispatchable loads) that enhance, improve or facilitate demand side responsiveness;
- Recommend ways of encouraging more, or removing barriers to dispatchable loads beyond those presently in use within the IMO-administered market;
- Consider both economic (i.e. market price sensitive) and reliability-related demand response programs;
- Identify demand response programs within other markets (e.g. Alberta, Nevada, Washington State, BC, Manitoba and overseas) and in particular the U.S. Northeast markets that have potential relevance for application within the Ontario market currently and into the future;
- Identify any current “market-ready” products, services and technologies enabling demand responsiveness;
- Value demand responses, both its measurement and worth;
- Identify demand side resources that existed before market commencement that are not now in productive use (e.g. interruptible electric water heater loads), and identify what measures (regulatory and other) are needed to bring back such resources to productive service;
- Identify metering and rate tariff practices in Ontario that may impede price responsiveness, i.e. Nighttime demand charges by LDCs;
- Recommend potential solutions; and identify associated requirements to ensure effective implementation;

7 In the U.S. Northeast markets, programs exist that address both reliability and market pricing related programs, e.g. “price responsive” and “emergency demand response” programs, respectively. The former is intended to mitigate price, the latter to mitigate shortages in supply. An emergency demand response program has been initiated in Ontario, but there is presently no price responsive program.
• Integrate the measures into a Plan-of-Action including key implementation details.

8.0 Conclusions: Missing out on the “Culture of Conservation”

The challenge lies in creating an Integrated Plan for Conservation and Demand Management.

The current electricity shortage in Ontario has resulted in higher electricity prices. People are starting to see higher bills partially because of a rate increase and hotter summer weather. The true electricity costs might become much higher as gas-fired electricity production is being added to the generation mix to offset the loss of coal-fired generation. Gas-fired generation will need to make use of the waste heat associated with electricity production (combined-cycle) to moderate the price and environmental impact.

In other jurisdictions like California, electricity shortages forced people to conserve and use demand management to avoid rolling blackouts and brownouts. Recently, Ontario experienced forced voltage reductions (called “brownouts”) for the first time in over 30 years. Like California, Ontario will find conservation and demand management are important low-cost quick solutions that provide immediate relief, while more expensive supply options are brought onboard. To their credit, the Provincial Government has initiated a culture of conservation. Unfortunately, they are slow to deliver results because deregulation has pushed back conservation and load management initiatives at the local distribution level.

The Provincially owned utility, Hydro One, gets the bulk of their revenues from demand charges. Demand charges are measured as the peak electricity consumed for the month, normally the peak hour. The energy portion is collected separately and does not affect Hydro One revenues. Thus, energy efficiency, conservation and demand management all adversely impact the utility’s bottom line; and consequently, conservation and demand management (CDM) initiatives are missing key economic drivers. In fact, some electricity distribution rates punish customers that shift load to take advantage of lower energy costs at night. Clearly adjustments are needed in several areas to encourage CDM.

Conservation and Demand Management can increase the security of Ontario’s electricity market and make positive contributions to Ontario’s environment. The Ontario government has targeted a 5% reduction in Peak Electricity usage by 2007 and a 10% reduction in government buildings. This includes public utilities like Hydro One, and Ontario Power Generation.

Competitive markets are based on the interaction of supply and demand in response to appropriate price signals. Failure to harness the ability of customers to change their consumption pattern in response to prices or other system stability conditions reduces overall market efficiency.

There is a serious shortage of generating capacity to meet Ontario’s growing demand for electricity. Energy efficiency and demand response are key options in meeting future energy needs.

• Demand Management can increase system security by offering load control;

• Demand Management can help the electricity market operators schedule customers’ loads in order to mitigate shortage conditions.
The next step is to turn the words into action. The Province needs to “Create an Integrated Plan for Conservation and Demand Management.”

Those organizations tasked to deliver CDM must market, promote and sell demand response for it to be an effective force in the market place. Direct digital load control is the most effective way of introducing load control. Web based controls use an existing two-way communications system to deliver a low-cost solution. Secondary methods like smart meters, time-of-use rate and off-peak discounts are less effective and potentially offer less value to the overall electricity system.

Programs that promote deployment of efficient end-use technology should not be sacrificed in favour of peak management programs. Long-term energy efficiency and short-term load response are complementary resources, and both are needed. Many innovative ideas need to be researched to allow customers loads to play a bigger role in demand response. For example, thermal energy storage devices that store heat or cold can significantly increase demand response and help lower the infrastructure cost of load control devices.

The current mindset favours the supply-side while many barriers restrict innovation on the demand-side. Legislative action may be required to ensure adequate development of demand-side options. In the end it becomes a question of balance, between supply-side and demand-side options. Web-based control systems offer a powerful solution to help demand response program deliver results.

9.0 References


ABSTRACT

Canada has the potential to shift to an electricity generation network that is carbon neutral, but no one renewable, carbon neutral electricity production method will supply the required energy. A “pantheon” of generation techniques and demand displacement technologies that compensate for each other’s weaknesses will have to be employed together. Overcoming the intermittency of many renewables is a central challenge, and will require grid expansion, the encouragement of innovation through public-private partnerships, and a reliable base-load producer. A description of deep water cooling in Toronto, Ontario is given as an example of a public private partnership in demand displacement. Lessons from a diverse electricity market can be applied to other energy markets that are far more dominated by fossil fuels, such as the transport sector.

Keywords: Sustainable energy, renewables, intermittency, demand displacement, peak oil, climate change.

In her well written paper discussing the need and opportunity for clean power generation, Leone Newman presents an informative discourse of the options and opportunities for Canada. The environmental merits for conversion cannot be argued given the consensus of the scientific community that fossil fuel combustion is a primary factor in global warming. However, the challenges for converting to a carbon neutral society will likely be the high capital cost of conversion and the continued plentiful supply of cheap fossil fuels. In the North American transportation sector, which accounts for the majority for CO2 emissions, the additional issue of slow consumer acceptance will be an important factor. As such, progress will likely be slow, and not particularly helped by the lackluster support for action by some North American governments. Despite these challenges, the author presents sound evidence that show Canada is uniquely positioned to be a world leader in this area.

Roger Harris
1.0 Introduction

As concern grows over the predicted global peak in oil production and the potential impacts of global climate change, interest in our society’s future energy prospects has grown. The stakes are high: modern society is wholly dependent on a constant and reliable supply of electricity, gas, and liquid fuels. Energy is absolutely central to our economic and social survival. Disruption of this supply very quickly brings our economies and societies to a halt.

Our energy infrastructure has evolved in an environment dominated by cheap and plentiful fossil fuels. Power generation is currently quite centralized in most regions, and has been since the adoption of Tesla’s alternating current generators and the perfection of high voltage transmission allowed the long distance transmission of power. Large central plants have dominated electricity generation, whether fueled by hydropower, nuclear, oil, gas or coal. At present hydropower accounts for over half of Canada’s electricity generation, which gives us a major advantage in the move towards a carbon-neutral energy system, but the United States produces the majority of its electricity through the combustion of coal. Transport is almost totally dominated by the use of fossil fuels in the form of gasoline, diesel, propane, and natural gas.

The switch to a sustainable energy network is challenging as no one alternative technology that fits the requirement of being renewable and carbon free can supply the amount energy we need in a reliable fashion, at least given the current available options.

This chapter will focus on the generation of electricity, but the challenges faced by our transportation networks are similar, though more severe. The basic premise of this chapter is that electrical generation on the scale needed by an industrial society is possible beyond the petroleum age, but that generation network will need to embrace a diversity of energy generation techniques compared to what is in use today. We will need to weave together a “pantheon” of generating techniques in which the weakness of one generating method is compensated by the strength of another, much as members of the ancient pantheons of Gods and Goddesses possessed powers and weaknesses that complimented each other. One can think of this pantheon as consisting of members that produce clean electricity just about anywhere but only part of the time, other members that have an ability to provide a constant variable flow of electricity, but only in certain areas, and the “generation” created by demand displacement. Together these elements can provide the reliable electricity supply that modern society needs.
There is heavy debate as to exactly when fossil fuels will become scarce and to what extent climate change mitigation will limit our energy options, but there are certainly two very good reasons to move toward an electrical system that is not fossil fuel based; firstly, evidence for climate change is growing, and recent analysis has suggested that the impact of ignoring carbon emissions will be much more severe than the impact of taking action to reduce carbon emission. Secondly, even if technology is developed to mitigate the effects of consuming the Earth’s remaining stores of oil and coal, these fuels might be better used to create liquid fuel for transport given the technological challenges of a carbon-neutral transport sector are more difficult than those of a carbon neutral electrical sector.

Canada is remarkably well positioned to develop an electricity system based upon renewables and demand displacement techniques that not only meets domestic needs but allows for a robust export market, mainly because of our large endowment of hydroelectric power. The key to this future is the construction of an efficient, resilient, high capacity cross country grid, a project well suited to a public private partnership of some kind. Beyond this one rather large element of infrastructure, the playing field must be leveled to encourage the development of private generation projects from the micro level to the large scale. It is very possible that the move towards renewable generation will continue to be very slow until the need to address climate change begins to impose concrete economic disincentives to further fossil fuel use. For example, a carbon tax on fossil fuel use could increase the competitiveness of renewable energy sources. A lack of supply, for reasons explored below, is unlikely to constrain Canadian fossil fuel use in the near future on the scale needed to encourage widespread change, though rising prices will also spur the development of alternative sources and efficiency measures. An example of a successful public private partnership at the local generation level is included at the end of the chapter.

2.0 Fossil Fuels and the Grid

Fossil fuels have come to dominate many electricity networks as they are currently plentiful, cheap, available all of the time, and the technology for turning them into electricity is very simple. Fossil fuel plants also benefit from the rule of increasing returns; the bigger the plant, the cheaper each unit of electricity becomes. Over the last century, we have seen a shift to large-scale plants generating large amounts of electricity for distribution over a wide area through a transmission grid. This centralized model is not well suited to renewable forms of energy, which, with the exception of hydroelectric generation, tend to be more dispersed. Even in the case of hydroelectric generation, the number of potential small hydro projects is far greater than the number of massive dam complexes. Many former small hydro stations that once powered local grids now sit idle and abandoned, bypassed in favour of larger scale generation facilities.

As it is not practical to generate electricity on site for every application, a grid is necessary. When we talk about the electrical grid, we are really talking about two grids; the local low voltage distribution grid and the high voltage long distance transmission grid. The problem with centralized production of electricity is that energy is lost over distance due to resistance in the lines; energy loss rises with the square of the current, so losses can be substantial. The partial solution to this problem is to transmit electricity over long distances at a high voltage and a low current to reduce loss, but high voltage electricity is not suitable for home use. Thus the electricity is “stepped down” to a lower voltage through transformers and distributed in a local grid at a voltage suitable for home use.

The reason this obscure bit of knowledge is important is that if we move from huge generation stations to many smaller renewable energy stations, both grids need updating (Wilks, 2003). The reasons for expanding the transmission grid are discussed in detail below, but it is important to note
that the distribution grid also must be updated if we are to add micro-producers to the generation mix. It makes no financial sense to construct the needed infrastructure to allow the connection of a single wind turbine or solar panel to the transmission grid; such micro sources of electricity need to be connected directly to the local distribution grid (Wilks, 2003). Strengthening both grids is necessary if many different sources of electricity are to be added to the grid, particularly at the micro level.

Before proceeding with the argument for a diversity of generation techniques, it is worth considering the one fossil fuel that will not run out during this century; coal. As Jaccard argues, the fossil fuel supply is much more plentiful than the pessimists would suggest (Jaccard, 2005). Could we simply run our electrical grids on coal, perhaps using technology and regulation to reduce the worst effects of coal combustion? There are two good reasons to avoid this route if at all possible; there is enough coal to fuel expansion of our energy needs for several centuries, but almost one kilogram of carbon dioxide is produced per kilowatt hour (Zeswitz et.al., 2003). As carbon sequestering technologies are not yet advanced enough to displace this carbon dioxide, burning coal is a luxury we cannot afford. Secondly, even if we can mitigate the negative effects of coal combustion, we might need to use that coal to provide synthetic liquid fuels for our transport system. Providing electrical energy without the use of fossil fuels is not as difficult a technological problem as the replacement of liquid fuels; we should attempt it first if possible.

Eventual tapping of coal would require expansion of “clean coal” technologies. Fuels such as coal can be superheated under pressure and broken down into their component parts. Pollutants such as mercury and sulphur can be captured, leaving streams of hydrogen and carbon dioxide. Electricity is created by burning the hydrogen and also by capturing waste heat from the gasification process. The carbon dioxide given off is concentrated, and thus can be captured before it goes into the atmosphere. Currently researchers are experimenting with injecting this carbon dioxide into empty oil wells and other stable geological formations. Depending on the source of the heat used to gasify the coal, the plant can be virtually emissions free.

Coal gasification is still very much an experimental technology. Much work remains to be done before we will be sure that sequestered carbon will stay where we put it. Also, the cost of gasification is still high. An advantage, however, is that this technology produced hydrogen. Hydrogen might prove to be the holy grail of energy technologies; a plentiful substitute for petrochemical transport fuels. However “clean coal” is not likely to be an option in the near term, and electrical generation using coal must be re-costed to include carbon mitigation. Policy to include the cost of global climate change and other environmental impacts of coal (It is estimated that reducing emissions from current coal generation could save tens of thousands of lives (Brand, 2004)) is likely to spur innovation, but in the meantime coal is not a practical option as it fails the requirement for no net carbon emission and ultimately it is also a limited resources. We need to think of how we can do better.

3.0 Beyond Fossil Fuels

What generation techniques will we use in the future to provide electricity to an expanded grid system? Over the next century the way we generate electricity in Canada will change. As oil declines it will cease to be a practical fuel for electricity generation, and even if those more optimistic about supply such as Jaccard (2005) are correct, we will need our remaining liquid fuels to power our growing transportation networks. Natural gas, currently a popular generation fuel, might become scarce or needed for other purposes as well. However we are not wanting for potential alternatives; there are literally hundreds of technologies to choose from (Sims, 2004). Ultimately what we are
doing in almost all cases is capturing the energy of the sun and concentrating it in a form useful to us. The amount of solar energy at our disposal is for practical purposes unlimited; plants, for example, tap only 0.12% of the solar energy arriving from the sun. The rest is either reflected back into space or remains to warm the Earth and atmosphere (Ayres, 1999). Concentrating and storing this energy is the challenge, and though some of these technologies are just being developed, some of the main alternatives will be quite familiar to us.

In the next few decades we will almost certainly go directly to the source for energy by generating more electricity using solar power. The most familiar solar applications are active solar energy applications such as photovoltaic cells that turn sunlight into electricity. Photovoltaic cells are composed of semiconducting materials that absorb sunlight and release a flow of electrons. Individual cells are arranged into modules that are connected into solar arrays that then feed energy into a battery or grid. Traditionally, these modules came in the form of flat plates, but recent designs include thin films of solar cells that could be used as roofing material or wall covering. As thin films contain much less of the expensive semiconductor, they are much more cost effective. In the future we might be able to cover almost any spare surface with such cells, generating micro amounts of power in literally millions of locations.

Solar cells are rated by their ability to turn the solar energy falling upon them into electricity. This efficiency is currently around 15%, but this number continues to rise. At the same time, the cost of solar cells continues to fall, though it is much higher than conventional electricity generation techniques. Potentially solar could provide a large amount of electricity. There are at least 1500 square kilometers of roof space in the United States capable of hosting solar arrays (Jeppesen, 2004). Recently, Google announced that it would be installing arrays on the rooftops of its main campus, generating enough energy for up to one thousand homes. In the past, it was only cost effective to install solar electric systems in remote places far from a conventional grid, but costs have already fallen enough to make solar competitive as a grid supplement in sunny locations. The use of photovoltaics is growing by 20-25% yearly (Fiscbach, 2004).

In places where solar power is not practical, often wind power is. Harnessed for centuries to pump water and grind grains, wind energy installations are now at the forefront of energy technology. Turbines come in all sizes, but an average utility turbine can produce one megawatt of electricity, enough to power about three hundred households. The amount of energy produced depends upon blade size, and of course wind speed. The power available in the wind rises with the cube of the speed, so windy sites are much better than less windy sites. To capture as much wind as possible at desirable sites, these turbines are quite large, with rotor diameters as high as 75 meters and tower heights of 135 meters. Because very windy sites are so much better than less windy sites, turbines are often grouped into wind farms. Europe has pioneered the construction of large scale wind power, but it is interesting to note that Canada is one of the few places where development of micro wind turbines that can sit on a roof top is being studied.

Wind Energy has many advantages. It has a very small physical impact, and is often compatible with other land uses. In flat areas a one hundred acre plot of land can support a megawatt of wind power, and only a few percent of the land is actually used by the turbines and the supporting infrastructure. It is environmentally very clean, giving off no emissions. Wind power is also the cheapest of the alternative energies, with prices very close to conventional sources. The cost continues to fall as turbine manufacture become more large scale. Wind power has only a few environmental negatives, most of them extremely local. In cold climates, turbines can shed ice and snow, and they do create some noise, though it is minimal compared to most electrical generating plants. The most serious environmental worry concerning wind power is the potential for bird and bat kill. Tower design can
greatly reduce this worry; for example smooth towers limit a bird’s ability to roost. There is also a growing interest in offshore wind farms, as the winds off shore blow harder and larger turbines can be used. Costs are slightly higher due to the harsher environment and increased difficulty connecting to the grid, but offshore farms are very attractive in crowded areas such as continental Europe. Care must be taken during construction to ensure that marine life is not disturbed, but once construction is complete offshore wind farms have little environmental impact.

Even though wind and solar power are very clean, they do have one rather obvious disadvantage: they are intermittent (Asmus, 2005). Provision must be made for back-up generation capacity for the times when renewables are not available. Better prediction of wind and sunlight conditions can help to stabilize electrical supply (Asmus, 2005), but ultimately an industrial society needs a certain “base load” of electricity available, and so we cannot survive on wind and solar alone. Utilities must ensure that they have enough electricity to cover demand at any time, and the consequences of a fluctuating electrical grid can be extremely dire. In general, about ten percent of a grid’s energy sources can be intermittent without destabilizing the grid. Variations at this level are smaller than variations in energy needs. If wind makes up 20% of a utilities power, wind forecasting must be used to ensure constant supply. Despite this restriction, wind energy could likely generate about 20% of North America’s needs with absolutely no pollution. Denmark is currently at this level, and is investigating how to increase this amount and still provide a stable grid.

The problem is that eventually we will want wind and solar energy to provide much more than twenty percent of our total energy. The easiest way to balance the intermittency of wind and solar is by providing another energy production method that is variable in output. The most flexible of these is conveniently also a renewable: hydropower. The best known and most established of the alternative energy sources, hydroelectric power provides over half of Canada’s electricity. Hydro power creates energy by converting the flow of water under gravity into electricity. Hydro power can be produced either by constructing a dam that creates an elevated reservoir and thus head, or by installing run-of-river turbines that take advantage of natural drops in elevation. Hydro’s great advantage over the other renewable sources is that it provides a steady supply of energy as the water behind a dam can be let out at a measured rate. Also, a hydroelectric plant can respond almost immediately to fluctuations in power demand by increasing flow over the turbines. Hydro plants can balance the uneven supply from solar and wind installations.

Hydro does have disadvantages. Firstly, dam construction floods large areas of sensitive riverside habitat, and significantly impacts aquatic ecosystems. Reservoirs also affect water flow, as in arid climates evaporation from the reservoir can greatly lower river levels. Dams impede fish movement and the movement of river sediment, and change water temperatures. Hydro energy on a large scale is also limited to certain areas, and many of those areas have already been fully developed. Hydro energy, particularly smaller projects, could still add significant capacity to Canada’s energy mix, but it is not a magic bullet. Thee are also problems with using hydroelectric potential to balance intermittency; the sudden need for energy as solar and wind plants go on and off line can badly disrupt stream flow downstream from a hydroelectric dam as it compensates. Hydro is also limited. We could increase our hydroelectric capacity by using wind power and solar to pump water into currently dry valleys, but the ecological impact of such an action might not be desirable.

If hydroelectricity cannot provide adequate base load to balance renewables, we must look to other technologies. Natural gas, though limited in supply, is the cleanest burning fossil fuel and could be used as a transition fuel as we improve other technologies. We could also capture methane from agribusiness and waste disposal to provide local energy balance. The development of a biomass
industry could also help us to provide clean energy to compliment intermittent sources. In the near term, a larger grid that covers a greater geographic area will be one of the most important elements of a green electrical system. If we can quickly and easily balance shifting demand and intermittent supplies in different regions, we can increase the percentage of supply from sources such as wind, solar, and other emerging intermittent sources such as tidal energy. The size and robustness of Europe’s grid has allowed them to move ahead with wind power at much faster pace than is possible in North America.

Ultimately, improved energy storage media will be needed. Potential technologies include hydrogen production and vastly improved batteries. Such storage media could be used to store energy during peak periods with acceptable losses. However these storage media are not yet technologically feasible; policy to encourage research in this area should be a top priority.

Can nuclear energy provide a base load to support intermittent sources? Probably not: nuclear plants cannot respond quickly to sudden electrical demand. However nuclear energy provides another large scale steady supply of electricity. Nuclear power is attracting the attention of many environmentalists, and has been endorsed by James Lovelock, co-creator of the Gaia theory claiming that the Earth’s ecosystems form one large organism, Geoffrey Ballard, the founder of fuel cell maker Ballard power, and Patrick Moore, a co-founder of Greenpeace. Worldwide 450 nuclear plants produce 16% of the world’s energy (Taylor, 2004). People are attracted to nuclear power because it produces no greenhouse gasses and thus has the potential to mitigate global climate change. However nuclear power has some big disadvantages. Current technologies deplete uranium at a rate that would exhaust supply in an unacceptable time period (Taylor, 2004). In Canada operation of the CANDU reactors has proven to be very expensive. Other countries such as France produce much more affordable nuclear power, but cost is an issue. Some types of nuclear power plant produce weapons grade material as a waste product, creating a security risk. If mismanaged, nuclear power plants can cause very dangerous releases of radiation into the atmosphere, though these accidents have been rare and the industry has maintained a very good safety record.

Nuclear waste poses some very complex disposal problems. Such waste will remain dangerous to human health and the health of ecosystems for tens of thousands of years. We have never managed such a long term problem. Can we leave waste on site at nuclear generating stations, even though they are located near cities and towns, sometimes in seismically active areas? Do we risk transporting the waste to remote locations? Canada is currently grappling with these issues, and is developing a process to store the waste in the rock of the Canadian Shield, allowing access in case we discover a way to destroy the waste. Though nuclear power could help to control global climate change, issues of cost and safe containment of the byproducts of the process must be addressed before we should expand our use of nuclear power.

4.0 Demand Displacement

Canada could easily meet its own energy needs with clean renewable sources as long as a national grid was constructed, but one of our energy goals should be to provide clean energy for export to the United States, where most energy is currently generated by coal. Expanding production is one way to achieve this goal, but it is not always the cheapest alternative; we can also make our economy more energy efficient. It is estimated that we could increase efficiency to cut energy use in half- 5 to 10% improvements over the next 10-20 years (Blok, 2005). As Papmehl will discuss in the next chapter, efficiency might be the best “bridge” between the fossil fuel age and the renewable age. As Amory Lovins (1996) suggests, no renewable generation project is as ecologically sound as not using the power in the first place. By lowering consumption, a utility can offset the cost of developing new
production facilities and transmission grids. Often these "negawatts" (a megawatt of power one no longer requires due to more efficient power use) can be produced at a fraction of the cost of new capacity (Lovins, 1996).

Lovins gives several reasons for creating negawatts. Firstly, many efficient products are now superior to their old counterparts. For example, full spectrum light bulbs give better quality light than older fluorescents. Lovins argues we could save 75% of our energy consumption giving us several decades of breathing room for solving our ecological and social problems (Weizacker, et. al., 1997).

How can there be so much waste in a system designed to maximize profits? Two effects could be at play. Historically, energy has been so cheap that it has been ignored in comparison to the expensive resource of labour. Government has encouraged this behavior by offering cheap electricity to industry and supporting expansion of the generation industry. Homeowners are also not often aware of the magnitude of the savings involved. Technological change occurs much faster than the wear-out time of older production systems and inefficient products. There is also a lag in the spread of information concerning efficient products.

Efficiency is one form of “demand displacement”, in which the need for electricity is reduced. However another way to achieve demand displacement exists; one can use a different method to achieve a goal without using electricity. Such demand displacement is most easily achieved in the provision of heating and cooling. Eleven percent of our electricity production goes to heating (Ayres et al, 2005; Blok, 2005), and heat is not hard to come by in the industrial world. The best known example is cogeneration, in which the waste heat from industrial processes is used to provide heating and hot water to nearby buildings. Almost all industrial processes, including energy generation, give off such heat. The trick is to ensure that a user for the heat is located close by to the generation site. One of the principles of industrial ecology is to plan for the use of waste heat during the construction of industrial facilities.

Another source of “waste” heat is the sun. Passive solar heating involves capturing heat from the sun and releasing it into one’s living space. As South facing walls receive the most light, a passive solar heating system can be as simple as a bank of South facing windows. One can increase this effect by building with materials that have a high heat capacity, such as earth and stone. Stone floors and walls will heat up during the day and then slowly release heat at night; ideal for dry climates with large day and night temperature differences. Larger spaces can be heated by blowing air through tubes on a sunny rooftop or South facing wall. Energy can also be saved by using passive solar lighting. Proper window and skylight placement and the use of mirrored ductwork can bring daylight deep into a building’s interior, reducing the need for electric light. Another passive application of solar power involves solar heating of water. Solar water heaters consist of a solar collector and a storage tank, with a circulatory pump to move water between the two. The sunlight falling upon the collector, which is often composed of black tubes, and then heats the water for use. The water is then pumped to the storage tank.

5.0 Demand Displacement: The Case of Toronto Deep Lakewater Cooling

Micro applications such as the passive solar heating discussed above can seem too minor to bother with, but multiplied by millions of homes such technologies create very large electricity savings. However, demand displacement is not always a microscale enterprise; larger scale projects can provide an excellent opportunity for public private partnerships. Such a project is currently helping to air condition Toronto’s downtown core. Air conditioning is particularly taxing on an electrical grid, as it consumes a great deal of energy and demand for it rises and falls sharply. Even in temperate
climates, our growing collection of electronic devices give off enough heat to increase the requirement for air conditioning. Cooling is thermodynamically more difficult that heating, and currently consumes eighteen percent of US electrical output (Cox, 2006). Technologies that can lower the energy demand of air conditioning could play a central role in demand displacement.

Conventional air conditioners function by exchanging heat from the air to a chilled medium. A compressor, motor, and refrigerant transfers the heat from the chilled medium to the outside air. If it is warmer outside than inside, heat must be moved from a cooler space to a warmer space, a very energy intensive operation.

If a cold body of earth or water is locally available, heat can be transferred directly, eliminating the need for a compressor-based cooling cycle. Water is a particularly good heat sink, and cold water can often be found in deep water bodies. Like most substances, water becomes denser as it cools, but unlike most substances it reaches a maximum density at 3.9 degrees Celsius. As winter arrives cold water on the surfaces of the ocean and lakes cools and sinks through the warmer water below. However in the summer the warm surface layer floats on top of the cooler water below, as it is less dense. A layer of perpetually cold water is created below a certain depth.

Harnessing this cold water to provide cooling or energy generation has long been a subject for theoretical consideration (Lennard, 1995). Many very complicated schemes have been proposed, but one of the simplest applications involves pumping a flow of water to the surface and using it as a heat sink. Water is pumped from the water body and into a heat exchange unit where it comes into contact with a closed cooling loop. The heat exchanger takes the place of the traditional “chiller” or air conditioner.

Energy savings of up to 90% over conventional air conditioning can be achieved by such a system, depending on how the system operates. Electrical demand is displaced in favour of a physical heat sink. The system requires energy to run the pumps and the fans that blow air over the cooling loops. As conventional air conditioning units are no longer needed, the need for ozone harming chemicals such as CFCs is eliminated as well.

There has been some worry about the potential for heat pollution from this technology. Heat pollution can alter marine habitat and have a negative effect on local wildlife. In the ocean, such effects might occur on the local level, but the amount of heat involved is too small to have a large scale effect. Lakes are of course smaller and more sensitive to heat; a study of Lake Ontario estimated that up to 20,000m3/s of water could be withdrawn from the lake and used for cooling without changing the lake’s physical properties (Boyce et al, 1993). For the Great Lakes the maximum draw amount is very large, but this number will be lower for smaller lakes, and must be taken into account when discussing the sustainability of deep water cooling using lake water.

Enwave’s Deep Lake Water Cooling project in Toronto, Ontario, pipes water from five kilometers offshore in Lake Ontario and draws water from a depth of 83 meters to the John Street pumping station. There heat exchangers cool Enwave’s cooling loop which then snakes through downtown Toronto to service client buildings. The lake water, slightly warmed, then goes on to supply Toronto with drinking water; this combination of uses saves resources.

The idea of providing cooling to Toronto using water from lake Ontario had been considered at various times, but the project began in earnest in 2002 (Deverell, 2002; p. 802). As of June 2006, 46 buildings have agreed to join the system, and 27 were already connected (City of Toronto, 2006). At capacity energy savings will be 85 million kWh, for a CO2 reduction of 79,000 tonnes annually.
through demand displacement. The total cooling load will be 3,200,000 square meters; 61% of this capacity has been sold. (City of Toronto, 2006). The project is owned jointly; 57% by the municipal pension fund and 43% by the city of Toronto, and is thus a successful example of a public private partnership that highlights an alternative energy technology.

The Toronto deep water cooling project is a major project with initial expenditures in the 200 million dollar range. (Canadian Press, 2003) Capital costs continue to be incurred as the urban pipeline network expands. The initial capital costs were covered by money from the city and the federal government (Moloney, 2004; p. B02). Toronto Hydro also provided incentives for companies to hook their buildings up to the system in order to overcome the high initial capital cost.

In this case the private public partnership model allowed the project to overcome the high initial costs associated with this technology. Toronto’s success was also supported by the establishment of Enwave as a “middleman”; individual developers didn’t install the infrastructure themselves. Such a model might also prove effective for micro installations of solar and wind power. Deep water cooling has now hit a “critical mass” of sorts with several large projects in the planning phase, including projects in Hawaii and the Persian Gulf.

6.0 Conclusion

Though the decline in fossil fuel reserves and the need to limit carbon emissions will have a negative impact on the resource extraction side of Canada’s economy, it presents a tremendous opportunity as well. Canada is in the position to provide green energy domestically and have a formidable surplus for export to the United States. This surplus will come from several sources; we have ample room for significant wind and solar arrays, and though these are intermittent sources of energy, we are one of the few countries with untapped hydroelectric resources, the perfect energy source for backstopping intermittency. We have a long history of marine technology development, and we have one of the world’s largest coastlines upon which to perfect the harnessing of tidal energy. As the example given above shows, we are also capable of being a world leader in demand displacement, freeing up capacity for export. And though there are questions about the role of nuclear energy, biomass and “clean coal” (coal combined with carbon sequestering), Canada is certainly well positioned to utilize these technologies as well.

The above scenario will very likely unfold of its own accord, and small signs of progress can be seen across the country. The speed of this shift, however, is likely to be unacceptably slow given the urgency of the need to control the impact of climate change. Until tools such as a carbon tax are in place, the shift to renewables will be piecemeal and intermittent. Pricing the costs of global climate change into the energy market could greatly accelerate our progress. Give Canada’s natural advantages and great wealth, the creation of a carbon tax could position us as a leader in alternative energy innovation. The gains from this new economic direction could offset any losses due to a higher cost of doing business. Without such rather bold policy initiatives, an alternative energy economy will develop, but perhaps not at an optimal pace.

This energy future in which a “pantheon” of energy sources provides Canadians with a healthy energy surplus also requires infrastructure investment now if it is to come about. Most importantly, there must be significant infrastructure investment to create an energy grid capable of mass transfer of energy between regions, provinces, and for export. Construction of such a grid creates a natural monopoly, and is capital intensive. It could well require a federal initiative to build such a grid as it is beyond the scale of most private companies, and is thus the largest “sticking point” between Canadians and a secure energy future. It is an imperative, however, if we wish to properly utilize
intermittent renewables from various regions and harness hydroelectric resources located far from population centers. In addition to the construction of a much enlarged national grid, we need to encourage public private partnerships such as the one discussed in this chapter, and loosen regulations preventing innovative generation and demand displacement. Also, energy prices need to reflect environmental concerns, regardless of the level of the regulation of the market. If environmental concerns are seen as externalities, renewable energy will not be able to compete against the economics of environmentally harmful methods of generation.

The above discussions focus on the electricity grid, but does not touch upon a much more difficult problem; transportation. Canada’s vast size, low density settlement patterns, and reliance on trade make transportation reform a great challenge. The answer might well be another form of pantheon that includes fuel efficiency, biofuels, fuel cells, vast expansion of rail and transit, changes to urban design, and local production. This shift, however, requires much deeper changes to our society and in some case requires technologies that are not yet technically feasible or economically viable, and the vested interests in our current transportation system are well entrenched. In many ways electricity production represents “low hanging fruit”, and the shift to a sustainable energy system will likely be complete before we even begin transportation reform. They are not independent, however. The tools we acquire in the shift to a sustainable energy pantheon will be tools needed in the quest to reform transportation.

Delivering clean electricity to an energy hungry population using a diversity of generation techniques will be challenging, but Canada is well positioned to be a world leader in the field. There is no one “magic bullet” technology that can meet our energy demand in a clean and renewable fashion, but the combination of elements from an energy pantheon can provide energy that meets both economic and environmental needs.

7.0 References


Policy options that promote sustainability may often be debatable and controversial. The tools described in Section 1 are useful, application oriented and hard to dispute as their value lies in their applicability and ability to solve hard-core issues. On the other hand, the way towards a sustainable policy environment is not as obvious. There are many possible approaches ranging from strong regulatory intervention all the way through to using the power of the marketplace to promote sustainability. Thus, policy development is controversial as it tries to establish the social context and attempts to open up the dialogue with a wide range of stakeholders.

Authors in this section outline a number of policy options ranging from well accepted and understandable practices to highly innovative and new approaches.

The objective of this section is to create an opportunity for dialogue. The authors have different viewpoints and may not agree on a common approach and may even offer conflicting approaches. However, the authors agree that change is required. This is what makes policy formulation such a difficult task – motivated and sincere individuals may not always agree on a common approach.

Creating a balance, a major objective of any policy, is an extremely complex task and that is what comes out as a strong message from this section.
ABSTRACT

The world’s demand for energy in all forms is rapidly growing and that consumption growth is both fuelling and being fuelled by significant global economic growth. An unintended consequence of this unprecedented demand for more energy is exposing the frailty of the world’s existing energy creation and straining it further.

The provincial government of British Columbia has recently asked the Federal Government in Ottawa to relax their over thirty year long moratorium on any oil and gas exploration related activities on Canada’s West Coast so that the province can begin further exploration and, ultimately, production activities. The investigative information gathered in this paper is applied for an in-depth examination of the most significant issues and their implications for the BC offshore area.

This research paper is about understanding how global energy demand is encroaching upon more of world’s environmentally sensitive areas and what the Canadian province of British Columbia can learn about managing these development pressures.

Keywords: British Columbia, offshore oil and gas reserves, environmentally sensitive ecosystems

A significant recent development in the pursuit of new, economically viable and long-lived fossil fuel reserves has been the growing impact of Oil Sands Development in Northern Alberta. Although not central to the theme of the paper, this point should be kept in mind with respect to the supply-side discussion in the paper, particularly in context of the Canadian political environment.

This timely and well written paper presents an excellent overall discussion of all the relevant issues concerning the continued use and development of fossil fuels reserves: the economic potential, vested stakeholder interests, socio-political factors, environmental risk and regulation, and the role of government. Looking past the obvious economic benefits, the authors present a balanced discussion of the many interlinked and controversial issues within the context of offshore BC oil and oil production. They make a good case in support of maintaining the moratorium that is currently in place, until agreement is reached on many unresolved matters. Unfortunately, this is not likely any time soon, and will delay the development of a potentially significant economic opportunity for the people and government of British Columbia.

Roger Harris
1.0 Introduction

The world’s demand for energy in all forms is rapidly growing and that consumption growth is both fuelling and being fuelled by significant global economic growth. An unintended consequence of this unprecedented demand for more energy is exposing the frailty of and strains on the world’s existing energy creation and consumption systems.

Readily available supplies of non-renewable oil and natural gas fossil fuels are dwindling while finding replacement reserves are becoming more costly in economic terms, political terms and, as the focal point of this paper, in terms of the potential impact on the environment. This situation has shifted the attention of both governments and industries towards other fuel sources such as the world’s abundant coal reserves and, more controversially, nuclear power; however, realistically not near enough towards renewable energy.

The Provincial Government of British Columbia (BC) has recently asked the Federal Government to relax their 30 plus year long moratorium on any oil and gas exploration related activities on Canada’s West Coast so that the province can begin further exploration and, ultimately, production activities. The investigative information gathered in this paper is applied to a more in-depth examination of some significant implications for the BC offshore area.

As with many other industrial development proposals in the world today, there are opponents, often environmentally oriented, in their expressed opposition.

From a supporting perspective, the proponents of development of BC’s offshore oil and gas reserves assert that such a development can be and has been completed elsewhere with manageable environmental and social impact; essentially challenging development opponents to create a stronger or more visible case to warrant stopping further development action.

The polarization of the stakeholders on this issue is potentially a bigger problem than the issue of the removing the moratoriums.

The objective of this paper is not to directly support either viewpoint but rather to take a perspective of leadership and foresight in answering to the average citizen of BC whether there is, in fact,
justification to proceed with development at all, irrespective of whether the moratoriums existed in the first place.

2.0 Global Energy Consumption Trends

Global energy consumption in the common forms of oil, gas, coal, nuclear power and hydroelectric power rose by 4.3% in 2004, with the Asia Pacific region leading that consumption growth with a 2004 increase of 8.9% (BP, 2005; p.2). Global oil consumption alone grew by 3.4% in 2004, the highest rate of increased consumption since 1986. The most significant share of that increase is attributed to China’s 16.6% growth in oil consumption in 2004 (BP, 2005; p.3).

A wide range of activities and needs is driving the demand for more oil and gas production; some of them economic while some more political in nature.

Cumulatively, the effect of this demand has sharply driven up the market price of a barrel of oil to 30-year highs. Some analysts are predicting a continued rise in price as there are currently few signs of a slowdown in global economic activity that would significantly lower demand while the world’s oil production and distribution capacity appears to be close to its current maximum.

Looking at the world’s current and forecasted demand, the question needs to be asked as to whether we believe we can sustain this increasing rate of fossil fuel consumption. There is no simple answer to such a complex question but two points suggest that the answer really is “no”.

One inescapable point is that the earth’s fossil fuel (hydrocarbon) reserves are finite and cannot be replenished. Secondly, there are the unintended environmental consequences on the global economy dependant upon ready access to affordable fossil fuels.

The Consumption Numbers

To help understand the world’s consumption of oil, Table 1 (National Energy Information Center, 2005) presents a breakdown of the largest oil consuming countries and regions in the world. During 2004, the combined consumption of the United States, Europe, Japan and China was 58.9% of the world’s total oil production. Considering the industrialized nature of these countries (with China as an emerging industrial nation), that statistic provides some valuable reference points in terms of where today’s and tomorrow’s consumption problems exist.

The oil consumption patterns in the United States (year 2000) shows that 2/3rds of that oil consumption is associated with transportation and the largest share of that for personal level transportation (Lovins, 2004; p. 35 fig. 6). Two important points emerge from the analysis of this breakdown. The first point is that an obvious target for energy conservation efforts in the United States lies in the transportation sector and, more specifically, in personal transportation. The second (more speculative) point is that this pattern may be more of what can be expected as a global trend in other developing nations as industrial and economic growth and prosperity continues, such as China’s growing demand for new automobiles (World Wide Tax.com, no date).

The International Energy Agency (IEA) predicts the largest proportion of new consumption of oil to be in the transportation sector, both within the 30 member countries of the Organization for Economic Cooperation and Development (OECD) and non-OECD countries (Birol, 2004). Birol’s (2004) data also illustrates how relatively little oil is being used and will be used for the world’s additional power generation needs, a point not widely recognized. The forecast drop in oil used for power
consumption in OECD countries is due to measures such as conversion to natural gas from oil and, mostly in Europe, from the offset of increased use of other renewable energy sources such as wind power. The key message is how significant it will be to better manage transportation-related fuel consumption.

Table 1 - World Oil Demand, 2000 – 2004 (million barrels per day)

<table>
<thead>
<tr>
<th></th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>% Change ’00 to ’04</th>
<th>% Of World Total (2004)</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>19.70</td>
<td>19.65</td>
<td>19.76</td>
<td>20.03</td>
<td>20.87</td>
<td>+5.6%</td>
<td>25.3%</td>
</tr>
<tr>
<td>OECD Europe*</td>
<td>15.17</td>
<td>15.33</td>
<td>15.32</td>
<td>15.50</td>
<td>15.72</td>
<td>+3.5%</td>
<td>19.0%</td>
</tr>
<tr>
<td>Japan</td>
<td>5.61</td>
<td>5.53</td>
<td>5.46</td>
<td>5.58</td>
<td>5.44</td>
<td>‐3.1%</td>
<td>6.6%</td>
</tr>
<tr>
<td>China</td>
<td>4.80</td>
<td>4.92</td>
<td>5.16</td>
<td>5.55</td>
<td>6.63</td>
<td>+27.6%</td>
<td>8.0%</td>
</tr>
<tr>
<td>Other Asia</td>
<td>7.47</td>
<td>7.62</td>
<td>7.78</td>
<td>7.90</td>
<td>8.25</td>
<td>+9.5%</td>
<td>10.0%</td>
</tr>
<tr>
<td>Total World Demand</td>
<td>76.95</td>
<td>78.10</td>
<td>78.44</td>
<td>79.89</td>
<td>82.55</td>
<td>+6.8%</td>
<td></td>
</tr>
</tbody>
</table>

The following sub-section provides additional details about what is and isn’t being done to help manage and reduce future demand for energy and oil.

Understanding the Concept of Consumption vs. Depletion

An important concept supporting the non-sustainability of the world’s current and forecast appetite for oil consumption is the lack of appreciation that today’s rate of daily oil production is actually the same as the world’s rate of depletion of this finite resource. With the world’s oil consumption being at its highest ever, we are also therefore depleting the world’s oil reserves at its highest ever level. Although this concept may seem to be self-evident, this viewpoint does not seem to be wholly recognized when one examines the forecast demand growth for oil. A critical question is - how much future industrial development planning for alternatives in a world of less oil and higher fuel costs is really happening?

What makes this situation more precarious are factors such as reservoir depletion as virtually every oil reservoir being produced from is being depleted by every barrel of oil produced.

Additionally, finding new reserves is also becoming increasingly difficult and economically risky with only modest to small sized new reservoirs being found when compared in size to the world’s past discovered giant oil producing oilfields (OPEC, 2004).

Another limiting factor is the increased cost of the infrastructure necessary for production of these new reservoirs e.g. the costs for the Sakhalin Energy Investment Company offshore oil and gas development project (on the east coast of Russia) has risen from an original estimated cost of ~US$10 billion over the past 10 years to what is now estimated will be over US$20 billion dollars (The

* OECD Europe includes: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, Slovakia, Spain, Sweden, Switzerland, Turkey and the United Kingdom. The other OECD members include: Australia, Canada, Japan, Korea, Mexico, New Zealand and the United States.
Economist, 2005). Similarly, the cost is rising for new oil distribution infrastructure such as new, safer super tankers and more difficult pipeline routes to transport production to market. There are also major political factors such as the war in Iraq and previous bans on business with oil-producing countries like Iran and Libya.

The perceived balancing loop to the cycle of oil demand has been, and continues to be, the belief that reserves will always be replaced, i.e. as more oil is consumed, new exploration and oil discoveries or new technology continues to replace what is being consumed. In reality, this is somewhat paradoxical in that the only thing replaced was the artificial boundary / limit of known reserves – such replacement does not add any more oil in total; it actually decreases the amount of the earth’s total oil reserves available.

Transforming these new discoveries into production capacity must also be done in an investment climate that is increasingly more economically and politically risky, expensive and with an associated environmentally detrimental impact.

The notion that oil production is not a finite resource is also partially due to how that is represented in annual statistical reviews and forecasts that show the world’s Reserves to Production (R/P) Ratio as continuing to be stable and is dramatically better when compared to the R/P ratio of 25 years ago.

An inherent assumption used in the calculation of R/P ratios is that there will be an open market condition where oil-exporting nations will continue to want to export their oil onto the open market that is freely available to be purchased. This assumption seems less valid today given recent examples of actual and threatened supply interruptions, e.g. Russia’s interruption of energy supplies to the Ukraine.

This balance of who has the supply and who has the demand will become an increasingly political issue as demands continue to grow while the world’s rate of depletion increases, something evidenced by the 2005 dispute between the United States and China when the Chinese National Offshore Oil Company attempted to purchase the assets of Unocal, an American owned company (Wu, 2005). It seems likely that such disputes will continue to happen in the future with potentially more grave consequences.

In summary, even though we know that oil and gas reserves are finite and dwindling in nature, worldwide consumption continues to grow. Even a conservative viewpoint suggests that such a consumption trend seems unsustainable and unjustifiable and that, without major supply-side shocks causing unplanned interference, global efforts to achieve greater energy efficiency and to support alternative energy sources and distribution infrastructure should be at a much more advanced state than they seem to exist today.

Looking at the world’s growing demand for all forms of energy, it seems growingly self-evident that this growth in demand is simply unsustainable. A systemic examination of the energy demand cycle would reveal that there are really only a small number of directed factors that can significantly alter this situation – that is decreasing energy demand through:

a. Decreases in economic growth or recession;

b. Increases in energy efficiency, particularly in transportation; and,

c. Increasing utilization of renewable energy sources.
3.0 The Consequences of the Global Oil Demand Cycle

An important concept to help understand oil market relationships comes from understanding the principles associated with the transformation of “proven oil reserves” into “oil production capacity”.

Proven oil reserves or “reserves” are the formal estimates of the amount of producible oil (and gas) believed to exist in a hydrocarbon (oil and gas) bearing reservoir. The most reliable estimates are those that have been created according to the standards of an industry association such as the American Petroleum Institute. Reserves are the theoretical reserve capacity of oil that could eventually be developed into production capacity.

The measurements associated with reserves are considered critical business measures for an oil producing company’s annual Balance Sheet. The total volume of reserves that the company has and the annual (or multi-year) ratio of oil reserves added to a company’s inventory compared to the amount of oil produced in the same timeframe is ideally greater than 100%. These reserves can be from reservoirs that are currently being produced from or from reservoirs known to exist but for which a production development program has not yet been undertaken or completed.

With the cycle time between an initial oil discovery and the first production of commercial volumes from that reservoir can range from 3 years for simple discoveries with existing infrastructure and up to 10 or more years for increasingly difficult and inaccessible developments such as those in offshore deepwater developments.

Production capacity is simply defined here as the amount of oil that, at any moment in time, is capable of being produced and transported into the distribution networks where it can be accessed and be of value to the ultimate end users. Physically transforming reserves into production capacity takes an increasingly greater capital investment (and risk) as the easier to find and produce oil reservoirs have been or are being steadily depleted and new oil discoveries are frequently associated with major technological challenges, political risk or both.

Factors affecting the world’s total production capacity include the aforementioned factors as well as the economics of development, access to oil distribution systems (i.e. pipelines, tankers, etc), government licensing or permitting, natural and industrial accidents and major events such as the second Gulf war in Iraq when essentially all oil production was stopped and it has not yet returned to full capacity in 2005 (Herrick, et. al., 2005).

As the demand for crude oil and crude oil by-products increases and gets closer to available production capacity the interest on investments of all stakeholders involved rises. This steady rise of oil demand and associated rise in prices leads to some profound changes with implications.

Changes

Political tensions in the world are rising amongst consuming nations as they become more aware than ever of the potential ramifications to their respective nations and interests. Further, there is the case of so-called “countries sponsoring terrorism” which are financially benefiting while at the same time they are being denounced by various interest groups and governments.

This systemic weakness has not been perceived as a real problem for much of the past 30 years. It is understood that there is not any one group that can easily manage to break or slow the intensity of these market driven supply and demand cycles. Unfortunately, when the full effects of a shortage
cycle of the kind being experienced in 2005 occurs, everyone becomes more painfully aware of how weak the overall system really is and how difficult and lengthy that real systemic problems are to fix.

**Consequences**

In today’s high oil price environment, there is clearly more motivation from the pressure in the system for ‘something’ to be done. There are changes going on in relation to oil-associated tax policies in various nations, including things such as: some regimes lowering taxes on products to keep net prices for their nations’ consumers lower, higher taxes on oil company profits and lower or maintained levels of taxes for the citizens of oil exporting nations. All of these factors can dramatically affect a nations’ trade balance and GDP growth. For example, Canada is becoming much healthier economically while the USA’s economic situation becomes more difficult as energy exporters gain at the economic expense of energy importers.

Another negative consequence is the lowering of environmental protections and standards and allowing access to previously protected areas. It is certainly true that immense improvements in technology and management as well as corporate self-interest driven behaviours do make some of these developments more likely to be successfully developed without major environmental damage. Unfortunately, it seems the criteria for these decisions is incredibly biased on a relative basis, e.g. the USA’s renewed desire in 2005 to be more self-sufficient was not predicated upon a massive nationwide energy efficiency campaign, it was predicated upon opening up access to previously environmentally protected closed areas.

Net importing countries such as the United States, Japan, China and India are now also increasingly in competition with one another over access to the resources their nations do not possess.

Supply-side shocks such as the oil embargos of the 1970’s are one way the demand cycle can be affected. In this scenario, consumers aren’t voluntarily lowering their demand, their access to supplies are affected by their ability to pay higher market prices. More seriously, in 2005 demand almost reached production capacity, the shortage was more ‘real’ and less arbitrary than it was in the past. As a consequence, every time there is a possible impact on future production, e.g. a new tropical storm forming in the Atlantic, crude oil prices rapidly climb as a defensive position against further market shortages and price spikes, fuelling greater economic instability.

**The Role of Government**

Governments are the only entity that can definitively stop new developments. Other stakeholders can only influence it. That, by itself, does not mean that governments will exert their control effectively.

Many governments in the world are subsidizing the consumption of fossil fuels in an attempt to lessen the burden or impact upon their citizens. There is always an initial benefit or positive feedback to such subsidies and yet such actions are only temporarily beneficial in nature and are often exacerbate the long-term problems by sustaining or even increasing fossil fuel consumption.

There is more interest in alternative energy supplies and energy efficiency during a period of high prices – something that governments in their role as leaders could be much more aggressively supporting and exploiting during times of higher end-user motivation. There are arguments in support of the need for more governments to legislate oil consumption limits, along the lines of the
EU’s directives towards reducing fossil fuel consumption and increasing renewable energy (EU, 2002).

Governments must be able to protect these environmentally sensitive areas. One approach would be to establish (or simply recognize) a more comprehensive value system for a non-development scenario. For example, British Columbia could use a combination of maintained oil and gas pricing and taxation levels, greater investment and capital subsidized infrastructure development in renewable energy and a massive campaign promoting energy efficiency. This seems likely to be able to produce an offsetting economic value at least some significance in relation to the potential economic value of the offshore development.

4.0 Issues Relevant to B.C.’s Offshore Oil and Gas Activity

This section examines some of the specific and unique challenges faced by Canada and the Province of British Columbia regarding the potential development of their west coast offshore oil and gas reserves.

Moratorium Background and Current Status

In 1972 the Canadian Federal government established a policy-based moratorium on further oil and gas exploration and development in the coastal waters on the Canadian West Coast. In 1989 the BC Provincial government established a similar policy-based moratorium on offshore drilling for five years and this provincial moratorium was subsequently extended until 2001 when new development planning discussions began.

During the late 1990’s, a combination of factors led to some renewed interest in potential offshore oil and gas development of this region. The traditional industries of fishing and forestry were faltering and a new analysis of the oil and gas potential in the region was released by the Geological Services Department of the Canadian federal government. The estimated size of the reserves identified the Queen Charlotte Basin in particular as having a potential size over five times greater than the total reserves of the successful Hibernia development on Canada’s East Coast. As of 2005, the wells drilled in these basins have identified some natural gas and crude oil reserves but none were classified as a “commercial” find.

Beginning in 2001, the BC government announced their decision to proceed with enabling the development process for offshore resources and, in 2002, formally requested that the Federal government remove their moratorium and to allow exploration and potential development to continue.

The four basins are: Queen Charlotte Basin; Tofino Basin; Georgia Basin and Winona Basin. Although the moratorium applies to all of these basins, the basin of the most interest is the Queen Charlotte Basin, especially to the people of the Haida First Nations. This section has mixed reference to the entire moratorium area and, sometimes, more specifically only to the Queen Charlotte Basin. However, the issues and information are considered interchangeable unless specifically noted otherwise.

At the time these moratoriums were originally established, the main questions centered on whether or not to proceed with development based upon the technical aspects of how such development could be done without adversely affecting the environment. The concept we now describe as
“sustainable development” was unheard of and certainly not as well understood and supported in the development of offshore oil and gas resources as it is today.

By all accounts, an oil and gas development project proceeding today under a sustainable development management model would have a dramatically less environmental and social impact than similar developments done in the 1970’s era. However, during this same period of time society’s understanding and valuation of the impacts of this development has also evolved. Ostensibly, the understanding gap between development supporters and opponents may even be wider today than at the outset of the original moratoriums’ timeframe.

Additionally, although the views and potential social impacts upon the traditional lifestyles of Canada’s West Coastal First Nations population have always been a consideration, the issue of land claims by First Nations groups to the development areas in question is also more visible today than the timeframe of the original outset of the moratoriums.

The Issues Involved In British Columbia

There are many interrelated and complex issues involved with the process of removing the moratoriums including deeply divided stakeholder views, regulatory jurisdiction issues between the Federal and Provincial governments, First Nations land claims, questions regarding the tradeoffs between environmental and social impact risks and the potential benefits of development and questions about how these issues relate to the Canadian and British Columbian governments’ energy policies.

Brief overviews of the main issues are provided here.

Polarized Stakeholder Viewpoints and Public Opinion

There are two main groups of stakeholders, those supporting development of BC’s offshore oil and gas industry and those opposed. While individual reasons for their relative positioning may be different, this is a highly polarized issue. Many of these stakeholders claim to represent the views and interests of different segments of Canada’s populous yet it is not clear that the average Canadian or British Columbian has any real understanding of the issues and implications involved or if they care to be.

The main stakeholders supporting removal of the development moratorium are:

- BC Provincial government (by virtue of their renewed development plans)
- The Chamber of Commerce’s of many of B.C.’s coastal municipalities
- Oil and gas industry groups

The main stakeholders supporting maintaining the development moratorium are:

- Federal government (by virtue of continuing their moratorium for over 30 years)
- Environmental NGO’s
- First Nations communities
- Tourism industry, particularly eco-tourism interests
- Fishing industry
The Federal Government’s recently released “Report of the Public Panel Review” (Natural Resources Canada, 2004) validates these relative stakeholder positions and how significant the gap is. Although the federal government is maintaining their moratorium position, officially they are reviewing it, not opposing it. A table of the breakdown of the respondents’ views can be found in the report which reports that 75% of the total respondents wanted to keep the moratorium while 23% were opposed to it (Natural Resources Canada, 2004; p. 9, Table 2-1). Public opinion is referenced in that same report as being divided but largely in favour of keeping the moratorium. Individuals living near coastal areas were more in favour of keeping the moratorium. Based upon the questions and the generalities of the viewpoints expressed, individuals more exposed to the risks by virtue of living near a coastline were more concerned about the removal of the moratorium than individuals living in areas who stood to benefit economically without direct environmental impact potential.

**Jurisdiction**

The province of BC is asserting that they have jurisdiction over the development of their provincially owned resources while others assert that at least some areas are in a Federal jurisdiction because of the offshore location, the national implications and potential impact to the federally managed fishing resources. There are also issues associated with the international boundaries associated with the United States at both the south and north ends of the Queen Charlotte Basin in question (Fogarassy, 2003; p. 19-21). Additionally, this area is subject to ongoing discussions with the First Nations groups who claim the entire area as their own.

Under a development scenario where all the major parties are aligned, this question could become essentially a non-issue. Legal challenges seem more likely to be used to stop development rather than start it. In today’s politically charged environment it seems unlikely that a major industry company would proceed with such significant investments if there were major completion risks due to these jurisdictional legal complexities.

**Provincial and Federal Energy Policy Differences**

BC’s energy plan hinges upon having sufficient resources developed to not only meet the current and future needs of British Columbians but to have sufficient and plentiful resources developed to maintain a significant export of these resources (BC Govt, 2002). As a net exporter of oil, gas, coal and electrical energy, it seems that a key question for the average British Columbian or Canadian is: “why does this offshore development need to be done when the energy is not needed within BC or even Canada?” Alternative and renewable energy advocates suggest more investment into tidal, wind and solar options that generate economic benefit and jobs and therefore create energy for consumption or export and do not propagate the further consumption of fossil fuels.

Unlike BC’s energy plan, Canada’s energy policy is not dependant upon the development of BC’s offshore oil and gas industry. Further, Canada has now committed towards meeting the requirements of the Kyoto protocol to reduce greenhouse gas emissions (primarily associated with fossil fuel consumption), while BC is on record as only hesitantly supportive. That federal commitment will mean some tough choices and potential changes for Canadians and our industries from past energy development and consumption practices.

Assuming that in the hierarchy of government from municipal to provincial to federal that there is an associated farther reaching energy policy at the federal level than at the municipal, then it becomes essential that Canada’s federal energy policy provide a clear position on where BC’s offshore oil and gas development fits, or doesn’t, into the national energy policy.
Each government level of energy policy must also provide much more specific direction and commitment towards renewable energy sources in order to make any realistic energy efficiency improvements happen.

This last point is especially critical given the comments of Canada’s Federal Commissioner of the Environment and Sustainable Development in their 2005 Perspective report. To quote: “A recurring theme throughout this year’s Report is that the federal government suffers from a chronic inability to see its own initiatives to completion; it starts out but rarely, if ever, reaches the finish line” (Govt. of Canada, 2005; p. 4) Similar levels of a failure to deliver can be found analyzing the follow through of the BC government to its past commitments to sustainable or renewable energy sources.

**How Much Oil and Gas Is There?**

BC’s four offshore oil and gas basins are know to contain oil and gas but it is not known how much is really there as there have been no recent evaluations of the area for at least 30 years, so the technology and operating experience we have today may present an entirely different picture. Stakeholders chose to use the data interpretation that is most appropriate to their position.

The point here is not to debate these interpretations but rather to draw attention to the implied concept that there is some theoretical crossover point where the potential economic value where the oil and gas development becomes so high that the potential economic value of the environment at risk is acceptable.

In order for that implied concept to really work, it would seem prudent that some reasonably understood and acceptable mechanism be agreed for establishing the value of that environmental risk – something that most certainly does not exist today and seems unlikely to ever be developed with enough refinement for wide acceptance.

The significance and importance of having a strong government position with visible leadership becomes a critical factor in dealing with the rhetoric associated with such statistical comparisons. In contrast, industry stakeholders such as EnCana (a Canadian oil and gas company with lease entitlements in the area) openly state that if permitted to do so by government they will proceed with first steps of renewed exploration activity (Morgon, 2004).

**Environmental and Social Impacts versus Economic Benefits**

Offshore development technology and responsible environmental management have improved dramatically in the past 30 years since the moratorium was originally imposed. Development supporters cite the significant and desired economic impacts derived from other offshore developments in the world, including Eastern Canada and the advances in scientific understandings and responsible environmental management practices.

Development detractors provide contrary economic benefit claims when total life cycle costs are considered. They question whether enough is known to understand the real impacts to the unique and relatively unspoilt environment of the Queen Charlotte Basin in particular as well as other sustainable industries like fishing. This issue is further complicated when one considers the fact that Canada and the Province of British Columbia are already energy self-sufficient exporters and the prime economic benefit would be derived only from energy exports to the United States.
The social questions are equally complex for BC and the municipalities most likely to see some positive economic benefit. Consider the views of a port city like Prince Rupert where they want the development to proceed while others in the province, particularly Coastal First Nations groups, describe broader negative social implications associated with any development.

Scientific literature does support the notion that the Queen Charlottes Basin is very much environmentally significant, having been referred to as “Galapagos of the North” and having one of the richest marine floras in the world (David Suzuki Foundation, no date). Of particular concern are the potential impacts to the world’s only known living glass sponge reefs (Canadian Parks and Wildlife Society, 2004), current proposed as a United Nations’ World Heritage Site (UNESCO).

The economics of any potential development, while sounding lucrative in principle, are actually also suggested as being marginal for the local economy in comparison to a similar sized oil and gas production facility based onshore where development costs are much lower. For example, one estimate is that for an offshore development requiring an investment of $1.3 billion dollars there would be an estimated total of 173 direct jobs during the production phase (Offshore Oil and Gas Research Group, 2004; p. xvii), most of whom would not be local persons.

Going back to the concept of having a comparative value between the potential economic gains versus the potential environmental damage losses, this magnitude of potential economic gain does not represent a very strong argument against all the environmental risks and uncertainties faced if development were to proceed.

What does Science and the Review Panels Say?

Most of the broad questions raised about whether or not the moratorium should be removed center on the scientific and economic aspects of the moratorium removal. From a science perspective, there is a multitude of different ways that the existing information can be used or misused and this report is not intended to clarify all of the possible contradictions. There are, however, some key positions taken that bear consideration, such as the following excerpt from The Report of the Scientific Review Panel (BC Govt., 2002a; p. i), the official panel appointed by the BC Minister of Energy and Mines on the subject of ‘British Columbia Offshore Hydrocarbon Development’:

“Although risks of direct impacts on marine ecosystems may be small, there is a poor understanding of potential long-term cumulative impacts on marine ecosystems of oil or gas spills or discharges from production activities, or of the use of seismic exploration on marine mammals in particular and the ecosystem in general. These potential impacts may be of very low probability but may be catastrophic in the short term and carry serious and possibly irreversible consequences in the long term....”

The Panel for this same report provided four preconditions that should precede any investment or further technical evaluation, even if the moratorium is lifted. A summary of these four preconditions are:

1. Development of an integrated federal-provincial regulatory framework;
2. Negotiation of a Pacific Accord that provides for agreed federal-provincial revenue sharing and other fiscal and management arrangements;
3. Clear delineation of sensitive or vulnerable areas essential to preserve biodiversity and ensure ecosystem integrity;
4. Strengthening and development of scientific and technical capacity to build baseline data and assess the state of the ecosystem.

The most recent scientific “Report of the Expert Panel on Science Issues Related to Oil and Gas Activities, Offshore British Columbia (The Royal Society of Canada, 2004; p. xix) provides two conclusions:

1. “Provided an adequate regulatory regime is put in place, there are no science gaps that need to be filled before lifting the moratoria on oil and gas development”; and,
2. “The present restriction on tanker traffic in transit along the West Coast of North America from entering the coastal zone should be maintained for the time being.”

The first of these two conclusions generated a huge amount of controversy amongst the scientific and environmental communities because of how the conclusion, if taken out of context, could be misused by those groups wanting development to proceed.

The report does provide an extensive collection of what is known and not about the entire region and highlights many key issues needing to be addressed, such as how little is really known about the distribution of most marine species (apart from those of commercial interest) and that makes designation of areas considered to be critical habitat essentially impossible today. This is a highly significant factor related to the slow pace of Canada’s federal government in designating Marine Protected Areas and the objections of environmental organizations that reasonably assert that you cannot protect what you do not yet understand. It is on that basis that they believe no form of development work should proceed.

There are a number of wide-reaching recommendations in the Royal Society report, many of which are appropriately appealing in relation to some of the gaps and different points of view already described earlier. A summary of these recommendations include:

- Establishing an advisory body of stakeholders;
- Completing collection of an extensive list of baseline data relating to species, bathymetric mapping, sea bottom currents, benthic fauna and habitat (fish habitat), surface currents and spill trajectory modeling, wind modeling and seismograph monitoring;
- Conducting chemical and biological monitoring studies – past and proposed drill sites;
- Designating the areas known to contain so-called sponge reefs as a Marine Protected Area as soon as possible, and, with input from stakeholders, proceed with determining which other areas in the Queen Charlotte Basin should be similarly designated;
- Ensuring that all drilling that is ultimately permitted is outside a 20-kilometre exclusion zone from the shore and that no seismic work is done in waters less than 20 metres deep.

First Nations Land Ownership and Social Impact Issues

This issue is closely related to the issue of Environmental and Social Impacts as the main potential development areas in question have been claimed by the First Nations (Drill Bits and Tailings, 2002) and they are not yet covered or governed under any treaty. Both the Federal and Provincial governments identify the significance of First Nations involvement with developing a final solution but the BC Provincial government’s approach is to simultaneously work on resolving these claims while still proceeding.
The official position of the Haida Nation was expressed in a 1985 House of Assembly motion prohibiting any offshore oil and gas activity in their territory.

If the Coastal First Nations continue to withhold support for this development, there are several means of recourse they can use to stop the development until the ownership issues are resolved, such as the previously referenced court challenge. A potential question for the population of British Columbia and Canada is whether or not the broader Canadian society will accept the rights of the Haida Nation and other Coastal First Nations groups to live their traditional lifestyles as being greater than the perceived economic needs and benefits to the greater population of BC and Canada.

This question reflects more of the social and moral side of the issue that will require open dialogue and cooperation between the First Nations and the provincial and federal governments to resolve, something that past experience suggests will take time.

The official gathering of input from the Coastal First Nations groups was reflected in the October 2004 report entitled: Rights, Risks and Respect (Brooks, 2004). The title of the report summarizes the most fundamental point made by the contributing individuals – this traditional area was and is considered theirs to live with and their rights must be respected if there is any prospect of future cooperation.

The First Nations are clearly being recognized as one of the main stakeholders in this process by both the federal and provincial government and that is an important first step towards achieving clarity of what the final criteria for removing the moratorium, if ever, will be.

**Relevancy of Other Development Experience**

Both development supporters and opponents frequently cite benchmarks of comparison with other offshore oil developments around the globe, including Canada’s relatively recent East Coast offshore oil and gas development. There are undoubtedly valuable lessons to be learned, some from positive experiences while the others are negative. At the current time there are selective references being used to support the various positions under discussion.

Unfortunately, based upon the mixed acceptance of previous politically influenced reports and the wide divergence of stakeholder positions, ideally a thorough panel-type review of the broad suite of valuable lessons relevant to BC’s current situation could be conducted in much greater depth than has been done today. Such a comprehensive review should only be conducted after a decision has been made to remove the moratorium in order to form a development plan guide, not as a basis for justifying removal or maintenance of the existing moratorium.

**5.0 Commentary and Conclusions**

Although much of the debate amongst the proponents and opponents is around the science aspects of the merits of removing the moratorium, in reality they seem to be really grappling for sufficient evidence to prove that their viewpoint is right and should be supported by others.

Environmental NGO’s and Coastal First Nations groups are the most outspoken opponents of the moratorium’s removal with related but different reasons. Environmental NGO’s cite the potential irreparable environmental damage and the unknown far-reaching implications of any such disturbances while the Coastal First Nations opposition is driven by a combination of a fear of environmental impact and concerns over disruption to their traditional lifestyles within their
ancestral lands without there being any formal treaty in place with either the BC Provincial or Canadian federal government.

Coastal businesses are divided in their support with businesses such as ecotourism ventures and commercial sport fishing interests being opposed while other commercial businesses such as marine companies and hotels hoping for more development activity.

The BC Government is in favour of removal of the development moratorium and is supported by the majority of the Chamber of Commerce’s of the BC’s Coastal communities who anticipate some local economic benefit to having the moratoriums removed. The oil / energy companies who already have the lease acreages granted to them are in favour of having the moratoriums removed but recognize there are many other significant obstacles to be cleared before they would even consider proceeding.

The BC public is divided in their views but, based upon the formal data gathering done so far, there is more support for keeping the moratoriums in place.

As a supposition question, if an average Canadian understands that there is some environmental sensitivity in the area with some implications for longer-term damage to the ecosystem and Canada’s fishing industry, would they believe there is enough economic benefit to be derived from removing the oil and gas development moratoriums to allow more exploration activity to proceed? At the present time, the answer seems more likely to be ‘no’ than a definitive ‘yes’ for several reasons.

With the main argument for development being economics and the main arguments against development are the risk of environmental damage and the social implications for the Coastal First Nations persons; there seems little basis for finding a commonly accepted solution today. Further, there is no agreed mechanism for assigning an accepted theoretical or actual economic value of protection of the environment or for protecting the traditional lifestyles of the First Nations persons.

An important consideration is the real value associated with the removal of the moratoriums themselves. In reality, these are really only symbolic barriers as both are only enforced by Cabinet orders and neither is enshrined in law. If the moratoriums’ were removed today there would still be no immediately obvious steps to be taken towards development because of the outstanding issues of jurisdiction, First Nations land claims and probable legal challenges from opponents.

Another point emerging through the literature searches for this paper is that the risks of damage to the environment from other activities are already happening without any oil development, e.g. the deterioration of the West Coast’s fishing industry. While preventing any new oil and gas related activity will not help these existing problems, it could worsen the situation faced today. Apart from some limited local economic benefit, the economic case put forward for oil and gas development is not strong.

Another consideration is that the potential developments amount to only a small fraction of the value of the total oil and gas industry to BC’s economy and the West Coast fishing industry that opponents to development fear could be affected. Ironically, the demise of the fishing industry is now one of the drivers for new oil and gas development as an economic replacement for the fishing communities.
Finally, global warming, and its links to widespread and growing use of fossil fuels is another key reason for maintaining the moratorium. In the end, this may well be the limiting determinant for the sustainability of these fuels.

Bearing this perspective in mind, the issue of Canada’s energy-efficiency becomes more significant and relevant. Given the poor energy efficiency of Canada as a whole, environmentalists reasonably assert that a major improvement in Canada’s energy efficiency would not only have an immediate economic benefit for most energy consumers but it would free up more oil and gas for export to the USA without any development of BC’s offshore industry and the potential associated environmental impact.

Defining solutions in systemic terms, the best answers lie in finding the points of strongest leverage to change the current systemic thinking causing these problems. For example:

- How do we recognize the full economic value of a protected ocean and marine environment? Although that may not be easily expressed in jobs growth or budget surplus this year, that doesn’t mean the value isn’t there in both today’s and tomorrow’s value system;
- Recognize that, realistically, only the Canadian federal government is in a position to influence the final outcomes. More importantly, they have the obligation, not just the authority to intervene, to demonstrate leadership by taking a firm position and acting, not just procrastinating on behalf of all Canadians;
- Canada needs a new and realistic energy plan that draws together:
  - Current role as a limited energy exporter;
  - Prioritizes protection of the marine environment above the ‘possible’ benefits of offshore oil and gas development;
  - Establishes aggressive targets for energy and fuel efficiency supported by funding being gained by today’s current high energy prices;
  - Activities linked with Canada’s commitments to the Kyoto Protocol;
  - Defining where and how coal and nuclear energy fit into the plan.

One of the conclusions from both of the main panel reports that does not make sense is why the moratoriums need to be lifted in order to complete the multitude of additional scientific studies and information gathering processes, especially if the panels’ recommend no development be allowed to start until those studies are done.

It therefore seems reasonable to recommend that if no one will fund closing the numerous identified science and information gaps, then either the BC or Federal or both moratoriums should be maintained.

The official position of many oil companies is simply stated that they will go wherever governments will allow them to go and this is specifically true for BC’s offshore areas. As a consequence, the Canadian federal government (in the absence of a strong BC government position) has the ultimate responsibility and accountability to the Canadian public to use their broader and farther-reaching perspective to make the right decisions.
Although the conclusions asserted by the three main federally sponsored reports are considered controversial, the specific recommendations made in all three reports are much more widely accepted and worthy of follow-up if there is any possibility of having any oil and gas development in the future at all.

In parallel, continued studies to close the existing science and information gaps are essential before any development be allowed to commence. Although the main gaps are known today, there is no obvious and immediate source of funding for gathering the extensive amount of information. It is also becoming increasingly important that the Canadian federal government fully implement their commitments towards establishing all of the appropriate Marine Protected Areas at a much quicker pace than is happening today. That effort alone with help to clarify the boundaries of what may be acceptable in the future as well as closing some of the information gaps that exist today.

Based upon the supposition that there are at least two distinct paths to a more widely accepted solution, (one involving development and the other non-development), the following ideas are recommended to the relevant stakeholders for further consideration:

**Development Scenario** – The main principle between this scenario is achieving clarity about all the grey areas of jurisdiction, regulatory structure and environmental / science information gaps that would genuinely allow all the stakeholders to make a more informed decision than can happen today. There are several factors that must be fully clarified to the satisfaction of the main stakeholders involved for any development scenario to progress:

- Establishing a formal steering or oversight body with representation from the main stakeholders involved;
- Establishing a formal agreement with the Coastal First Nations about what is and what is not included in any development activity;
- Establishing a comprehensive program of gathering all the necessary data and studies that have been identified as missing and necessary;
- Ensuring that the development process jurisdictions and other missing regulatory framework information gaps are closed before further exploration activities begin.

**Non-development Scenario** – The main supporting principle behind this scenario is not just to oppose all development but rather to use this non-development scenario as a driver behind a broadly comprehensive program of achieving greater energy efficiency in Canada. Even conservative estimates of the potential improvements in Canada’s energy efficiency create an energy surplus significantly greater than BC’s offshore oil and gas development potential.

Creating such a non-development scenario is undoubtedly easier said than done but there are such tremendous opportunities that exist today that did not exist even a few years ago. Some of the most relevant factors are:

- Canada’s economic position is very strong today;
- Canada is already energy self-sufficient and does not need BC’s offshore oil and gas to maintain that position for many years at the minimum;
Canada is already a significant energy exporter and that position is not fundamentally altered by whether the BC offshore oil and gas is developed or not;

Canada has an overall very poor energy efficiency that will require a combination of both industrial and governmental support to make significant improvements in not only improving energy efficiency but also improving economic competitiveness;

Canada’s performance towards meeting our Kyoto Protocol emissions reductions targets have gotten worse, not better, in the past five years;

BC and Canada’s past commitments towards the creation of additional renewable energy have faltered from a lack of commitment and investment;

At a minimum, it seems absolutely necessary for either level of government to establish much more transparent and achievable targets in terms of the level of renewable energy actually expected to be produced and creating a network of supporting programs from tax credits or infrastructure-creation development to help make that happen.

While this paper has only been able to examine a limited amount of the total information available on this subject, the report author believes that there is an overwhelming trend or pattern of the information available that suggests there is a much stronger and beneficial case for proceeding with the so-called non-development scenario. A development scenario case can be created that may or may not ultimately be considered to be economically viable, the most likely driver of any development. With the information available today, that economic case is not sufficiently strong enough to warrant major investment to gather the necessary missing information without large government investments.

Based upon the apparent wide gap between the viewpoints of development opponents and supporters and the political uncertainty that exists at Canada’s federal government level today, it seems unlikely that there will be any strong and visible demonstration of government leadership that will allow any significant progress will be made on this issue anytime soon. In the absence of such visionary and credible leadership, the most likely scenario will be a modified status quo with continuing political posturing but very little progress on resolving any of the underlying issues needing resolution.

6.0 References


ABSTRACT

This paper studies investment and public policy issues relevant to Alberta's oilsands. It looks at how Albertans want their energy resource endowments managed and compares current business practice with the sustainability issues agreed on by Canada and the international community. Security of Canada’s energy resources and the implications of NAFTA on resource exports to the United States are also examined.

The paper then outlines the economic opportunities and challenges, with emphasis on the petrochemical industry and examines the major threats to the sustainability of the oilsands industry, including impacts on the water, land, boreal forests and air. It visits the Regional Municipality of Wood Buffalo to study the impacts of rapid development on the social life of the community.

The paper proposes a systems approach to identify the key issues and linkages where synergies may be found between the interests of industry and the public. It notes Canada’s capacity strengths in science and technology. Public policy approaches to climate change, including adaptation and mitigation are also discussed. It considers the impact on resource exports and reviews Canada’s framework for environmental policy.

Key Words: Oilsands, public policy, sustainable development, energy, science & technology.

The Alberta Oilsands have become a flashpoint of public concern about the impact of rapid development. This paper outlines the social, economic and environmental impact of the current pace of development in the Oilsands and then goes on to provide recommendations for policy options available for sustainable development of this resource.

The author’s suggestions, while in some regard controversial, open a dialogue that is necessary to more effectively manage the pace of development while balancing social, environmental and economic factors that are critical to the long term health and prosperity of all Albertans, and by extension, all Canadians.

The author argues that the current pace of Oilsands development is not sustainable and that current provincial and federal government policy is not equipped to adequately address the issues that currently confront us all. His suggestions go a very long way toward addressing this issue by applying the principles of sustainable development to manage rapid and intense change.

Joel Nodelman
1.0 Introduction

*Please God, let there be another oil boom. I promise not to piss it all away next time*
(Anon, qtd. in Simons, 2006).

*Tarsands or oilsands?* Ever since Canada's first oil well, Original Discovery Number 1, was drilled in Waterton Lakes National Park in 1878, industrialists and environmentalists have been fighting over the economics, the environmental consequences and the very language of oil. A very popular Alberta bumper sticker petitioned the Almighty to give us just one more boom, swearing next time not to waste it as one might alleviate the discomfort of a drunken binge.

In 1970, a debate was launched over the *Pipeline Guidelines*, which invited proposals for a transmission route for natural gas from the Prudhoe fields in Alaska, south to Alberta. The Arctic Gas pipeline would have been "the greatest construction enterprise ever undertaken" (Canadian Encyclopedia, 2000).

Now a larger debate has evolved. Athabasca's bitumen deposits contain 174 billion barrels of crude oil reserves, currently recoverable. However, by 2010, "oil sands production could consume all the gas delivered by the proposed Mackenzie Valley Pipeline" (Gillmor, 2005). Ominously, petrochemical companies are leaving the province and the country to seek more reliable supplies of feedstock.

Irresponsible exploitation also threatens to destroy Canada's rich environmental heritage. We risk becoming *hewers of wood and drawers of water* – a branch plant, export driven economy, dependent on imported management and technology. Moreover, the Intergovernmental Panel on Climate Change (IPCC) has concluded that anthropogenetic emissions are contributing to global climate change.

Canada is well positioned to assume global leadership in the development of transformative clean energy technologies. Such an opportunity can only be realized with a solid public commitment to energy science and technology and by a robust regulatory regime to ensure that investment in the oilsands serves Canada's public good.
God has granted Albertans that second boom, and the people of Alberta have sent a clear message to government and industry both, that they want and expect the oilsands to be managed sustainably.

2.0 The Issue of Sustainability

_Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs_ (Brundtland, 1987; p.54).

*Our Common Future*, also known as the _Brundtland Report_, was issued by The World Commission on Environment and Development in 1987 in response to an "urgent call" for a "global agenda for change" (Brundtland, 1987; p.11). The Brundtland Report noted enormous disparities between developing and industrial countries, and concluded that present patterns of production in industrialized countries were not sustainable. It called for a holistic strategy that recognized environmental issues at the developmental planning stage – a strategy of sustainable development.

Many present efforts to guard and maintain human progress, to meet human needs, and to realize human ambitions are simply unsustainable - in both the rich and poor nations. They draw too heavily, too quickly, on already overdrawn environmental resource accounts to be affordable far into the future without bankrupting those accounts. They may show profit on the balance sheets of our generation, but our children will inherit the losses (Brundtland, 1987; p.24).

While advanced technologies have allowed industrial production to chase explosive population growth, increasing economic activity depends upon the availability of natural resources. Exhaustion of the resource base will give rise to population movements which may test national boundaries and threaten global peace.

_Most [developing] countries face enormous economic pressures, both international and domestic, to overexploit their environmental resource base_ (Brundtland, 1987; p.22).

Although Canada is among the world's most highly industrialized nations, our huge natural resources base supports the value of our dollar on international markets. Many small countries have cut back environmental initiatives to maintain a positive balance of trade. Environmental decline leads to political tensions, and poses a threat to national security.

_The ability of a government to control its national economy is reduced by growing international economic interactions. For example, foreign trade in commodities makes issues of carrying capacities and resource scarcities an international concern_ (Brundtland, 1987; p.58).

In 1992, the United Nations Conference on Environment and Development, or _Earth Summit_, adopted "a blueprint for action to achieve sustainable development worldwide." Principle 4 of the Rio Declaration on Environment and Development (UNCED, 1992) held that "[in] order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it." The Secretary-General of the Earth Summit was a Canadian public servant Maurice F. Strong.
The General Assembly of the United Nations, in September 2000, adopted the Millennium Declaration, which holds certain values to be fundamental and essential in the conduct of international relations. These include respect for nature and support for principles of sustainable development outlined in Agenda 21 of the Earth Summit. The Millennium Declaration further establishes environmental mainstreaming to integrate environmental policy considerations into economic planning. Principle 4 of the Earth Summit links sustainable development with environmental mainstreaming.

*Environmental mainstreaming is ... a policy principle, placing the environment at par with economic and social aspects of decision-making* (UNDP, 2004; p. 8).

Millennium Development Goal 7, "Ensuring Environmental Sustainability", considers sustainable development to be a cornerstone, upon which all other goals stand. Eradication of extreme poverty and hunger in the world depends on environmental sustainability.

*We must spare no effort to free all of humanity, and above all our children and grandchildren, from the threat of living on a planet irredeemably spoilt by human activities, and whose resources would no longer be sufficient for their needs* (UNHCHR, 2000; para 21).

In 2002, in Johannesburg, the World Summit on Sustainable Development (WSSD), reaffirmed commitment to Agenda 21 and the Rio Declaration. The WSSD Plan of Implementation advocates continuing integration of sustainable goals into UN agencies, programmes and funds (WSSD, 2002; p.2). The United Nations Development Programme (UNDP) and United Nations Environment Programme (UNEP) were established to implement sustainable development policies through United Nations organizations such as the World Bank. The UNDP Emerging Action Plan coordinates global and national efforts in 166 countries to promote the Millennium Development Goals and to facilitate alignment of energy systems with sustainable development.

### 3.0 A word about Energy Security

In 2002, the WEHAB (Water, Energy, Health, Agriculture and Biodiversity) Working Group submitted its *Framework for Action on Energy* to the Earth Summit. It declared that energy services are essential for sustainable development.

*The way in which these services are produced, distributed and used affects the social, economic and environmental dimensions of any development achieved. Although energy itself is not a basic human need, it is critical for the fulfilment of all needs* (WEHAB Working Group, 2002; p.7).

To these three dimensions of sustainable development I would add a fourth – energy security. Without the ability to control the exploitation and development of our own resources, all the rest is meaningless. We have already made significant concessions over Canadian control of oilsands development. It is useful to review the international context in which the oilsands must be managed.

More than 90% of Canada’s energy comes from fossil fuels. Canadian coal has a reserve life of less than 70 years. Natural gas may last nine years. Crude oil has a reserve life of less than seven years. In order to extend reserve life, Canada would need to curb exports. However, between 1982 and 2002, natural gas exports increased by 396%, and crude oil exports increased by 595%. Canada will
not be able to sustainably reduce fossil fuel extraction by conservation alone (Thompson et.al., 2005; p.2).

Energy is security and Canada's future energy supply is critical to the future security of Canada. However, Canada has no energy security strategy. The U.S. National Energy Policy focuses on security of energy supply, and most Canadians believe that Canada is doing too little to control foreign access to our energy resources (Thompson et.al., 2005; p.3). Almost all of our gas and oil exports go to the U.S.

The U.S. is dependent on foreign energy resources at low prices. Lower oil prices are directly linked to reduced inflation, increased real disposable income, and increased gross domestic product. However, the U.S. is vulnerable to supply disruptions, particularly in the Persian Gulf. Such disruptions would "pose a hardship for the U.S. economy" resulting in "substantial economic austerity" (USDC, 1999; p.ES-5). U.S. demand for oil is expected to keep growing because of continued economic growth. Net imports accounted for 58% of domestic consumption in 2005. Dependence on OPEC production is expected to increase, so much so that "the dependence of [U.S.] allies and trading partners on potentially insecure sources of oil might affect their willingness to cooperate with the United states during a supply disruption" (USDC, 1999; p.ES-6).

Fortunately for the U.S., the North American Free Trade Agreement (NAFTA) has secured "unprecedented energy cooperation … [in] developing an integrated and secure North American energy market" (USDC, 1999; p.ES-6). Article 6.05 of NAFTA provides that

1) each country will not impose restrictions on the delivery of energy and basic petrochemical supplies during a supply interruption;
2) any shortfall in supply will be shared equally among U.S. and Canadian markets based on historical percentages;
3) each party will not impose higher export prices than those charged domestically; and
4) there will not be a disruption of the prevailing proportion of energy goods supplied, such as, for example, between crude oil and refined products and among different categories of crude oil and refined products (USDC, 1999; p.ES-4).

NAFTA ties Canadian energy security to that of the U.S. Mexico did not sign the "proportionality" clause. Canada's energy was the primary driving force behind both the Canada – U.S. Free Trade Agreement (FTA) and NAFTA. A U.S. joint congressional report in 1985 called for the U.S. government to obtain guaranteed access to Canada's energy supplies as "a point of national security." Prime Minister Mulroney promised full access to Canada's energy supplies and dismantled the 'vital supply safeguard', which required Canada to maintain a twenty-five year surplus of natural gas. "[The] government of Canada agreed that it no longer has the right 'to refuse to issue a license or revoke or change a license for the exportation to the United States of energy goods" (Barlow, 2005; pp.198-9).

China is heavily invested in the Athabasca Oilsands. In 2005, however, the state-owned Chinese National Offshore Oil Corp. (CNOOC) was forced to withdraw its bid against Chevron for Unocal after Washington congressmen warned the House of Representatives Armed Services Committee that CNOOC was "waging a stealth campaign to lock up the tar sands." The House opposed the takeover on the basis that it would "threaten to impair the national security of the United States." CNOOC cited "'implacable opposition' and 'hostile reaction' from the American congress" as reasons for withdrawing its bid (qtd. in Barlow, 2005; pp.199-200).

The interests of the United States run directly counter to Canada's strategic interest in developing Asian-Pacific markets and building additional pipeline capacity to the West Coast. According to a report prepared for the Canadian International Petroleum Conference by the Alberta Energy Research Institute and the Chinese State Key Laboratory of Heavy Oil Processing – *Asian-Pacific Markets: A New Strategy for Alberta Oil*:

> **China, which currently imports the smallest amount of crude oil, has the most promise in the long-term, with the potential of exporting a value-added product out of Alberta. However, the success of such an export venture will require the cooperation of governments at either end of the exchange, to ensure that regulatory and policy issues do not hamper the development of infrastructure and trade. In addition, long term contracts will need to be secured in both Alberta and Asia, to ensure that the necessary pipelines can be built and as a hedge against risk should the Chinese economy slow** (Laureshen et. al., 2004).

If oilsands trade and development are to be made sustainable, Canada must build an energy security policy within the context of sovereignty restrictions imposed by NAFTA on petrochemicals and energy goods.

### 4.0 Economic Assessment – Petrochemical Feedstock

Alberta's oilsands, located in the Athabasca, Cold Lake and Peace River Regions of Northern Alberta, are among the world's largest hydrocarbon deposits. The petroleum constituent of the oilsands is a viscous crude bitumen. Oil sands layers can be up to 60 metres deep. The Athabasca region contains shallow deposits that can be recovered using surface mining techniques. Other deposits, deeper than 75m, must be recovered using in situ techniques that separate bitumen from the sand and produce it to the surface through wells. In situ techniques are required for 80% of established reserves (CERI, 2004; pp.4-6). In 2003, the industry produced 874 thousand barrels per day of synthetic crude oil (SCO), representing 35% of Canada's total oil production. Canada exported 12 MMb/d of crude oil and petroleum products to the United States (CERI, 2004; pp.5-7).

The oil and gas sector contributed $27.4 billion to Canada’s Gross Domestic Product in 2004. Federal and provincial governments received over $18 billion in royalties, taxes and other payments. Capital expenditures in the oil sands between 2006 and 2015 will total $95 billion. Oil sands production will grow to 3.0 million barrels per day by 2015 (OAG, 2006; para 3.19). An estimated 315 billion barrels of crude bitumen will ultimately be recoverable, including 174 billion barrels recoverable under current economic conditions. Production will increase by about 190 Mb/d per year from 2006 to 2010, involving capital expenditures of about C$8 billion per year. Estimated capital expenditures from 2006 to 2015 total C$125 billion, with a 'logjam' of projects in the 2008 to 2012 period.
However, declining natural gas production combined with projected “business as usual” consumption of natural gas by oil sands operators would lead to resource exhaustion between 2015 and 2030 (ACR, 2004; p.14, 52). According to the Hydrocarbon Depletion Study Group at Uppsala University (Söderbergh et.al., 2006; p.2):

*There is not a large enough supply of natural gas to support a future Canadian oil sands industry with today’s dependence on natural gas. It is possible to use bitumen as fuel and for upgrading, although it seems to be incompatible with Canada’s obligations under the Kyoto treaty. For practical long-term high production, Canada must construct nuclear facilities to generate energy for the in situ projects.*

Oilsands operators are not the only sector dependent on natural gas. Alberta also accounts for half of Canada’s petrochemicals capacity, with $9.5 billion in revenues. It employs 7,773 highly skilled workers with an annual payroll of $526 million. It creates about 20,000 spin-off jobs (Turner et.al., 2005; p.22). Competition with the energy industry has resulted in significantly higher, more volatile prices both for raw natural gas, and synthetic gas liquids (SGL) used as feedstock. SGL consists of paraffinic and olefinic hydrocarbons. Paraffinic hydrocarbons, including ethane, form the basis of Alberta’s petrochemicals industry. Olefins, including ethylene and propylene, are used as feedstock in petrochemicals derivative plants. Current ethane feedstock supply falls short of ethane cracker capacity by about 4,800 m3/d, and new ethylene capacity will be needed within ten years to meet growing demand. Poly-propylene is another high-value olefinic hydrocarbon. North American demand for propylene is growing at three to four percent per annum (NEB, 2006; p.49).

Alberta’s oil sands could provide a secure feedstock for the petrochemical industry. Upgrading and coking processes produce paraffinic and olefinic hydrocarbons. Propylene is available from upgrader-refinery off-gas and ethylene cracker processes. Upgrading and especially coking also produce naphtha, aromatics and vacuum gas oil. However, Alberta lacks the infrastructure to access these intermediary products (NEB, 2006; p.49).

It is estimated that up to 16,000 m3/d of SGL could be entrained in upgrader off-gas, including 9,500 m3/d of ethane. Upgrader and refinery off-gas and ethylene cracker processes could produce about 682,000 tonnes of propylene. Yet future SGL infrastructure development will compete with energy industry requirements. The ethylene and propylene sectors will need a secure, long-term, cost-effective feedstock supply, but the current royalty structure ties heat content requirement costs to natural gas replacement, making recovery of SGL uneconomic (NEB, 2006; p.50).

In the 1970s, government policy required exported natural gas to be stripped of petrochemical feedstock components to support the establishment of a petrochemicals industry in Alberta. The policy was reversed in 1985, giving preferential treatment to raw exports of natural gas. Now ethane is exported to the U.S. petrochemical industry. Ethane shortages have since caused prices to escalate, and in 2003, both the Canadian Chemical Producers’ Association and Industry Canada acknowledged there were insufficient volumes of feedstock available to support major new infrastructure (Turner et.al., 2005; p.22).

Royalty policy also promotes the export of raw gas. Royalties are charged on feedstock constituents extracted in Alberta. However, if exporters do not strip feedstock before export, they pay a lower royalty. In response, Alberta’s Minister of Resource Development announced in December 1999 that the royalty schedule would be changed. The NGL Royalty Advisory Committee identified ethane as a distinct resource and revised the calculation of royalties on natural gas after stripping out ethane. A
new royalty structure was also recommended that would motivate producers to extract ethane in Alberta. Neither change has been implemented (Turner et al., 2005; p.22).

Since 2000, production of natural gas has been banned where oil sands production could be impaired. Assurance has been given to the energy industry that 'frontier' natural gas from the Mackenzie Valley and Arctic would be diverted to oil sands production instead of industrial feedstock. Significant subsidization of oil sands development and preferential royalty terms for oil sands producers (one percent until 2015) further promotes raw natural gas exports over value-added processing (Turner et al., 2005; p.22).

Profits in the petrochemicals industry are highly sensitive to natural gas price fluctuations. In 2007, Celanese Alberta petrochemical plant will close, and its operations will move to Mexico, where natural gas prices are fixed at $4/Mmbtu. In 2005, Methanex announced the closure of its Kitimat, B.C. plant. NOVA Chemicals recorded losses in 2001, 2002 and 2003. This natural reaction to changes in natural gas supply has weakened Canada's domestic industry. In the 41 months starting in June 2000, natural gas prices increased 83%, costing industrial consumers $US 57 billion (Turner et al., 2005; p.22).

5.0 Environmental Assessment – Water, Land, Boreal Forest, Air

The rapid and unconstrained oil sands expansion now before us risks squandering a publicly owned resource and creating a legacy of environmental degradation and long-term environmental liabilities (Woynillowicz et al., 2005; p.vii).

The cumulative environmental impacts of the oil sands are approaching an ecological "tipping point", where change to the environment becomes irreversible (Woynillowicz et al., 2005; p.27).

Surface mining operations involve drainage of muskeg and overburden, dewatering of aquifers and withdrawal of water from the Athabasca River. Freshwater aquifers are affected by the lowering of groundwater to prevent flooding. The decrease in pressure causes depletion of wetlands and reduced discharge into streams and lakes. In steam assisted gravity drainage (SAGD) operations, fresh groundwater is mixed with treated saline groundwater. Desalinization produces significant volumes of acids, hydrocarbon residues and trace metals. Oilsands projects are expected to demand up to 490 million m$^3$ of water per year from the Athabasca River (Woynillowicz et al., 2005; p.35).

Bitumen, sand, silt and fine clay from surface mining operations are mixed with water and stored in tailings ponds. Migration of tailings into the groundwater poses an environmental risk from naphthenic acids found in the bitumen, making them highly toxic to aquatic life and migratory birds. Settlement of tailings can take up to 150 years. Clean-up of tailings ponds represents a potentially major public liability (Woynillowicz et al., 2005; p.31). Discharges must meet Alberta's Surface Water Quality Guidelines. However, the regulations do not cover naphthenic acids. Tailings management criteria were to be developed by the Alberta Energy and Utilities Board (EUB), Alberta Environment and Alberta Sustainable Resource Development in consultation with industry. However, these have not yet been published (Woynillowicz et al., 2005; p.32).

Canada's boreal forests are essential for climate regulation and carbon storage. Yet "[Seismic] lines, roads, power line corridors, and pipelines have the effect of fragmenting the wildlife habitat. Surface mining strips away the boreal forest and wetlands and replaces them with forested hills. Almost 10% of the region will be stripped in the next decade. When companies are finished operations, the land is converted to 'equivalent land capability' which is considered to be similar but not identical to the
way it was. The re-claimed ecosystem will lack bio-diversity and may not be self-sustaining. Rare habitat will be lost forever. The clearing of boreal forest for seismic exploration equals or exceeds the amount removed by the forest industry (Woynillowicz et.al., 2005; p.27).

Air Emissions

**Most Greenhouse gas emissions are not candidates for effective direct technology solutions, and rely heavily on attempts at abatement (ACR, 2004; p.59).**

The Intergovernmental Panel on Climate Change found that emissions of GHGs from human activity is the leading cause of climate change due to global warming. Oil and gas activities emitted 152 million tonnes of greenhouse gases (GHGs) in 2004. Over 28% of the increase in GHGs since 1990 is attributable to oil and gas. GHGs increased 51% from 1990 to 2004, and oilsands emissions are expected to double between 2004 and 2015 (OAG, 2006; para 3.19).

With emissions of more than one billion kilograms of Criteria Air Contaminants (CACs) from industry in 2003, Alberta leads the country in air pollution that affects health. Emissions include nitrogen oxides (NOx), sulphur dioxide (SO2), particulate matter (PM2.5) and volatile organic compounds (VOCs). Computer modelling of pollutant dispersion indicates that concentrations of NOx and SO2 already exceed provincial, national and international guidelines. The Canada Wide Standard level for PM2.5 emissions of 30 micrograms per cubic meter (µg/m³) already exceeds the 15 µg/m³ level shown by epidemiological studies to be harmful to human health. The Alberta Particulate Matter and Ozone Management Framework will require Alberta Environment to implement a management plan in seven communities where concentrations of PM2.5 exceed 20 µg/m³.

VOCs evaporate from tailing ponds and are emitted by burning of fossil fuels. Current VOC emissions exceed 500 tonnes per day, and are predicted to grow to 750 tonnes per day, putting Alberta among the top four provinces and states in North America for VOC emissions. Lakes will also be subjected to acidification. During the period 2000–20, SO2 emissions are expected to rise by 15% in Western Canada, while they decline by 21% in Eastern Canada and 38% in the US (Woynillowicz et.al., 2005; p.52).

Ozone is produced by reactions with nitrogen oxides (NOx) and volatile organic compounds (VOCs). It causes increased hospital admissions for asthma and other acute respiratory diseases. It contributes to reduced lung function and premature mortality (Boyd, 2006; p.7). Fine particulate matter is produced by combustion of fossil fuels. Coarse particulate matter results from diesel exhaust and mining operations. Particulate matter causes increased hospital admissions for cardiovascular and respiratory diseases, and premature mortality from lung cancer and decreased lung functionality. The Ontario Medical Association, estimated that there were 5,800 premature deaths due to air pollution in 2005 in Ontario alone, and that air pollution costs over $9 billion per year (Boyd, 2006; pp.3-4).

### 6.0 Social Assessment - Regional Municipality of Wood Buffalo

*They were right about not having a plan. ... There wasn’t a plan. ... The plan is being developed, but no one could anticipate the phenomenal growth that was taking place. ... And now you’ve had sort of the perfect storm between explosive growth, an economy that's on fire, an increasing population well beyond most economists' wildest imaginations. ... And you add that all up with a labour crunch, and here you go. ... We were prepared for sustainable growth, but not the kind of growth that’s*
Oil sands development has brought phenomenal growth to the Regional Municipality of Wood Buffalo [RMWB]. The annual rate of population growth for the Urban Service Area alone (excluding work camps) will range from 6% to 12% between 2006 and 2010. The current growth rate is 9% (RMWB, 2006; p.13). A normal "boom town" pattern exists when population increases at about 6 percent (RMWB, 2006; p.8). In view of "the negative socioeconomic impacts that have resulted from oil sands industry expansion in the region, ... the RMWB Council [decided that it could not] support any additional approvals for oil sands projects in the region until there is a comprehensive plan in place to ensure responsible development" (RMWB, 2006; p.39).

Uncertainties related to capital project planning are externalized by industry as 'municipal planning risk'. In its application for the Kearl Oil Sands Project, Imperial Oil acknowledged that uncertainties exist with regard to "product market, overall project economics, market conditions for labour and material, conditions resulting from regulatory approvals and government fiscal terms" (RMWB, 2006; p.12). In 2000, the Urban Population Impact Model, prepared by the Regional Issues Working Group (RIWG), and based on population projections that were provided by the energy industry, underestimated the 2004 population by 14% (RMWB, 2006; p.11).

As a direct result, there is currently a shortfall of 3,918 housing units, outstripping the capacity of housing developers to meet demand, and housing starts for 2006 will not exceed 1,700. The homeless population has increased since 2004 from 355 to between 400 and 600. Rental rates are the highest in Canada and the vacancy rate is zero (RMWB, 2006; pp.12-13).

Unplanned growth has overrun municipal infrastructure. The wastewater treatment plant was designed in 1999 for a population of 60,000. The current population of 64,442 has already outgrown it. An upgrade designed for a population of 85,000 may be at capacity when it opens in 2008. Phases 2 and 3 are planned for a capacity of 133,000. Water treatment facilities are over capacity (RMWB, 2006; p.17). The solid waste (landfill) facility is nearing capacity. The capital budget does not include many facilities such as an arena, waterfront park or revitalization of the downtown.

Cost inflation is significant. Dubbed the "Fort McMurray factor", construction premiums in comparison with other municipalities can exceed 100%.

"The quality of life in Fort McMurray is deteriorating." Based on 11 categories of "influences on the goodness and meaning of life," studied by the Federation of Canadian Municipalities, the RMWB has determined that Fort McMurray is deficient in "demographics, affordable housing, civic engagement, community and social infrastructure, education, ... environment, personal and community health, personal financial security, and personal safety (RMWB, 2006; pp.30-32)."

The RMWB is expected to exceed the legislated debt limit. Alberta Municipal Affairs recognizes that exceeding this limit "would indicate major financial stress if not failure (RMWB, 2006; p.29)". Assessment and taxation options available in the Municipal Government Act do not permit a special assessment of oil sands plants at their full value. The RMWB is not able to increase revenues on new oil sands projects before operations begin, but is required to build new infrastructure and provide additional services years in advance.
Unless policy changes force industry and communities to work together to establish the rules of development before permits are issued, one of the key conditions for sustainable development of the oil sands, quality of life for the local residents, will continue to deteriorate.

7.0 Adopting a Systems Approach

A systems approach is essential to maximizing the benefits of energy technologies and effectively managing energy innovation. This approach should be supported by the data and intellectual capacity needed to analyze energy systems (NAP, 2006; p.9).

A systems approach is the best way to identify and exploit synergies among energy resources and investment priorities and to identify technological and regulatory linkages. A systems approach involves identifying key objectives for all stakeholders, in order to strengthen linkages and overcome barriers. The National Advisory Panel on Sustainable Energy, Science and Technology (NAP), in its report to Natural Resources Canada, Powerful Connections – Priorities and Directions in Energy Science and Technology in Canada, identifies a lack of joint priority setting as a major factor limiting commercial success of new technologies (NAP, 2006; p.27).

Canada has significant capacity for transformative energy technology. Federal labs perform a wide array of functions — including standards setting; contracting early-stage research; running S&T funding programs; and providing policy advice to government. The CANMET Energy Technology Centres perform most of the energy S&T in the federal system (NAP, 2006; p.35). Natural linkages occur in science and technology (S&T), between industry investment and public funding.

Key Funding Priorities and Linkages

Technological leadership in the energy sector relies on investment. Failure to maintain investment levels relative to energy production will result in dependency on imported technological innovation. Federal government investment should foster research and innovation capacity and encourage the private sector to commit more resources through public-private partnerships. Provinces own most energy resources and have responsibilities for stewardship and the environment. Provincial investment in energy S&T lags both federal and private commitments. However, additional government funding will have little impact without the active participation of the energy industry (NAP, 2006; p.19).

[We] note that overall private sector R&D spending as a percentage of its energy revenues is only 0.75%, less than one fifth of the Canadian industrial average of 3.8%.... Since over $200 million of these R&D expenditures are by the emerging fuel cell industry, whose revenues are still relatively small, it is evident that the major energy industry sectors spend substantially smaller-than-average percentages of their revenues on energy R&D (NAP, 2006; p.20).

Clear market signals are needed to build private sector participation in S&T. Clear signals decrease risk to industry in deploying existing technologies and developing new technologies to address environmental issues. Private sector funding for research on long-term economic and environmental objectives would be stimulated by regulation.
In large, commodity-based energy industries, governments should consider using regulation or financial incentives to stimulate private sector funding for research to address common, long-term economic and environmental issues (NAP, 2006; p.10).

The Committee on the State of Science & Technology in Canada (CSST) (2006) notes that Canada’s regulatory system has a significant impact on S&T. Intellectual property regulations direct innovation and business framework regulations encourage entrepreneurial activity. However, S&T stakeholders broadly perceive Canada’s regulatory environment to be inhibiting (CSST, 2006; p.19).

The Panel advises that, “the development of a systems research program concerning carbon-based fuels and involving strong partnerships between industry, government and academia is crucial to optimizing the economic and environmental elements of this energy system” (NAP, 2006; p.42). Strong synergies exist in Alberta’s oilsands. A systems approach suggests partnership opportunities in developing platform technologies to improve efficiencies in resource utilization and cut down on greenhouse gases, thereby meeting key economic and environmental objectives.

Multinational corporations must bring major centres of expertise to Canada, and build on the research intensity of the resource sector. New infrastructure technologies can take decades to move through basic research, development, demonstration and commercialization. Retention of a critical mass of highly skilled workers requires long-term commitments to support career transition decisions. Therefore, funding must be delivered over periods longer than the electoral cycle to sustain innovation if key national priorities are to be met (NAP, 2006; p.15).

Market forces should drive industry to invest in the development of new technologies in near-term commodity extraction, feedstock replacement and process refinements. Alberta has recently instituted an offset trading scheme that is still in its infancy. Other than this, there is no market for greenhouse gas permits, as there is in the European Union. Creating a market for negative externalities would motivate industry to invest in clean technologies and to develop a large, technologically advanced Canadian equipment supply sector (NAP, 2006).

**Linkages in Science and Technology**

The main challenge to environmental mainstreaming is finding a strategic nexus and compatibility between development priorities and environmental management objectives where tradeoffs can be addressed pragmatically and capitalize on potential opportunities that benefit both environmental resources and functions and development priorities (UNDP, 2004).

There is considerable correlation in Canada between environmental S&T capabilities and the natural resources sector. In view of the increasing importance of sustainable resource use, and of clean energy in particular, Canada’s global role in environmental S&T relates primarily to the environment–resources nexus (CSST, 2006; p.9).

CSST notes that Canada’s greatest S&T strength is in technological applications related to the oilsands, “where Canada is in a class by itself” (CSST, 2006; p.59). There are strong linkages between environmental S&T capabilities in areas of clean hydrocarbons and energy cogeneration (CSST, 2006; p.9). Even in environmental sciences and ecology, where technologies are considerably weaker, Canada excels in research publication intensity and quality (CSST, 2006; p.12). However, Canada lags
in the area of patenting of petroleum technologies, despite Canada's excellence in chemistry research (CSST, 2006; p.14).

S&T strength is an important indicator of Canada's ability to compete for intellectual and investment capital, and to participate at the leading edge of S&T through global knowledge-sharing networks. Canada enjoys significant advantages in knowledge production. Support for commercialization is exceptionally high, particularly through the NRC's Industrial Research Assistance Program and the Scientific Research and Experimental Development Tax Credit. However, funding of commercial activity by Canadian venture capital providers is surprisingly low, and support from Canada's commercial banks ranks dead last (CSST, 2006; p.18).

8.0 Policy Responses – Mitigation and Adaptation

*Adaptation is the only response available for the impacts that will occur over the next several decades before mitigation measures can have an effect* (Stern, 2006; p.xxii).

Mitigation and adaptation are two fundamental policy responses to climate change. Mitigation involves minimizing emissions and reducing atmospheric concentrations of greenhouse gases (GHGs). Adaptation involves responding to climate change impacts after the fact. Present investments in mitigation will reduce future costs of adapting to the impacts that will inevitably arise from climate change. Failure to mitigate negative human impacts on climate risks profound and perhaps irreversible economic damage later in the century.

Stern (2006) suggests four key areas for adaptation policy: i) high-quality regional climate change information and insurance schemes based on climate risk; ii) land-use planning and performance standards to promote investment in infrastructure that will withstand climate change; iii) long-term strategies for the preservation of natural resources, coastal protection and emergency preparedness; and iv) social services planning for those most vulnerable to climate change.

Mitigation policy involves change, but continuous structural change is part of the dynamic of every successful economy. Nonetheless, structural change will impact Canada's competitive position, and in particular, its export trade in resources. Mitigation policy must promote every opportunity for innovation and development. It must provide clear market signals, allowing for risk management. The cost of a well-organized mitigation policy can be coordinated with other national policies, such as reducing mortality from air pollution, maintaining hydrologic systems, and preserving ecosystem diversity. The opportunity cost of mitigation should also account for the externalized social cost of carbon, which Stern estimates to be in the order of $85 per tonne.

*Strong and early mitigation has a key role to play in limiting the long-run costs of adaptation. Without this, the costs of adaptation will rise dramatically* (Stern, 2006; p.xxvii).

Three essential elements of mitigation policy, according to Stern, involve carbon pricing, funding science and technology, and removing barriers to social change.

**Carbon Pricing**

*Establishing a carbon price, through tax, trading or regulation, is an essential foundation for climate-change policy* (Stern, 2006; p.xviii).
Carbon pricing can be imposed explicitly through taxation or implicitly through regulation. Market pricing of carbon provides a clear economic signal that the social costs of global climate change must be considered in industrial and consumer decisions. In particular, low-carbon alternatives must be included in the long term investment decision matrices of Canada’s large final emitters to reduce the costs of global climate change on current and future generations. Early carbon pricing signals will be critical to prevent Canada being locked into a high-carbon infrastructure.

Policy tools for carbon pricing include taxation and trading schemes. Taxation has the advantage of delivering a steady flow of revenue to the government, while emissions trading schemes allow for greater economic efficiency. Government policy may include a mixture of both.

**Emission cap and tradable permits (ECTP)** are tradable emission permits issued by a government agency to polluters. The system is a form of market-oriented regulation in which the government sets an aggregate cap on emissions. The cap can be lowered by decreasing the number or value of permits issued. Participants can maintain current levels of emissions by purchasing a sufficient number of permits, or reduce costs by reducing emissions (Jaccard et. al., 2004).

The U.S. government’s amendments to its Clean Air Act in 1990 applied ECTP to SO2 emissions from electricity plants with encouraging results in terms of environmental effectiveness and economic efficiency. However, the market for emissions permits could fail if emissions permits are not priced fully to account for the externalized social cost of pollution. Europe set up an emissions trading scheme under which member countries set national limits on emissions and gave allowances to 13,000 factories and power plants to emit a fixed limit of carbon. The resulting carbon market grew to a value of €12 billion in the first half of 2006. Unfortunately, the scheme failed to cut emissions, it failed to make polluters pay, and it failed to induce industry to invest in cleaner technology. Emissions have been flat in Europe largely because the manufacturing sector is in decline. The result has been a surplus of permits on the market, causing their price to fall. Companies, which had been given the allowances free as an inducement, dumped their allotments onto the open market, for a profit of about £800 million. Meanwhile, there has been a boom in coal-fired generation, partly because of high gas prices, and partly because the 2012 time horizon set by Kyoto is too short to allow companies to change investment plans (The Economist, 2006; p. 14).

> To reap the benefits of emissions trading, schemes must provide incentives for a flexible and efficient response. Broadening the scope of trading schemes will tend to lower costs and reduce volatility. Clarity and predictability about the future rules and shape of schemes will help to build confidence in a future carbon price. (Stern, 2006; xviii)

The flexibility of emissions trading would reduce risk for industry by permitting companies to shift capital investment decisions in time to achieve environmental improvements with lower cost. Lack of political acceptance is a drawback, however, given the high visibility of new taxes, according to the C. D. Howe Institute (Jaccard et. al., 2004).

**Taxing carbon** directly could be more politically acceptable. A carbon tax is essentially a "border tax adjustment" as defined in Articles II, 2(a) and III, 2 of the 1947 General Agreement on Tariffs and Trade (GATT). Essentially it would be an excise tax applied to energy goods and services supplied in Canada, similar to a value-added tax. It could be imposed on imported energy goods, or rebated on energy goods supplied outside Canada to relieve significant price disadvantages for domestic producers selling into international markets.
It may be necessary for Canada to proceed on its own with carbon taxes if trade rules raise issues with respect to energy inputs not incorporated in the final product. For example, agriculture is the largest user of fossil fuels. Production processing, packaging, and distribution to global markets all add to the energy intensity of agricultural produce. A carbon tax would provide a useful economic preference signal, causing substitution away from goods transported long distances. However, it could offend one of the essential elements of World Trade Organization agreements carried forward from GATT:

*Article III: National Treatment: requires [each] GATT member ... to treat "like" products of all GATT members as favourably as it treats its own domestic products* (Schrybman, 1997; p.9).

According to previous trade panel rulings, no distinctions may be made between products having the same physical characteristics. Article III ignores environmental impacts associated with production and transportation. The WTO may permit retaliatory trade sanctions or impose substantial financial penalties (Schrybman, 1997; p.3).

*Parties to the International Convention on Climate Change need to make clear their intention to have the provisions of the Convention prevail, in the case of conflict with WTO rules. They can accomplish that goal by declaring that intention as part of any Protocol they may negotiate* (Schrybman, 1997; p.30).

9.0 International Competitiveness and Trade

The impact on location and trade is likely to be more substantial for mitigating countries bordering large trade-partners with more relaxed regimes ... . For example, Canada’s most important trading partner, the United States, has not signed the Kyoto Protocol, raising concerns of a negative competitive impact on Canada’s energy-intensive industry. However, even for open markets such as Canada and the US, ... firms tend to be reluctant to relocate or trade across borders, when they have markets in the home nation. This so-called “home-bias” effect is surprisingly powerful and the consequent necessity for firms to locate within borders to access local markets limits the degree to which they are footloose in their location decisions (Stern, 2006; p.261).

Policies that target greenhouse gas emissions could be disproportionately expensive and self-defeating if they merely result in movement of energy-intensive production to countries that are slower to act on climate change. Countries that have developed comparative advantage in emissions-intensive sectors could be hardest hit by shifts away from those sectors. Without international agreement, countries implementing more active climate change policies could experience reduced output. However, long-term capital investment decisions are also affected by other factor endowments, among which Stern identifies: "the size and quality of the capital stock and workforce, access to technologies and infrastructure, proximity to large consumer markets and trading partners, ... business tax and regulatory environment, agglomeration economies, employment law and sunk capital costs" (Stern, 2006; p.261-262).

Stern found that rich countries in fact have an unexploited comparative advantage in pollution-intensive production, with positive elasticities relative to trade liberalization. "Opening up trade will on average shift polluting production towards richer countries" (Stern, 2006; p.263) as the factor
endowments listed above outweigh tighter environmental restrictions. Alberta's oilsands beg for regulation.

10.0 Canadian Policy – Framework and Administration

The oil and gas sector exemplifies the sustainable development challenge of Canada's energy supply .... The nation's challenge is to reduce greenhouse gas emissions while oil and gas production for export and domestic consumption is expected to increase. The rapid expansion in oil sands development adds to this challenge. ... [Canada] will miss opportunities to tackle this important sector the longer it takes to develop and implement the strategy (OAG, 2006; para 3.58).

CIPEC is a voluntary partnership between the Government of Canada and industry, created in 1975, in part to encourage energy efficiency. It was stalled when the Large Final Emitter System was proposed. As of March 2006, participants had achieved a total reduction of 0.04 million tonnes of emissions (OAG, 2006; para 3.52).

The Carbon Dioxide Capture and Storage Initiative supports emissions research technology and provides financial incentives for programs demonstrating the application of technology that captures and stores carbon dioxide in geological formations. Funding to March 2006 was $25 million. The 2006 target for the project was to reduce emissions by 3.5 million tonnes. Natural Resources Canada has agreements with companies for five demonstration projects. As of March 2006, annual reductions of 0.08 million tonnes had been achieved (OAG, 2006; para 3.53).

The Large Final Emitter System was introduced as part of the 2002 Climate Change Plan for Canada, and continued in the 2005 Project Green plan (Canada, 2005). Commencing in January 2008, it was intended to provide a regulated, market-based, approach to emissions reduction. More than half of Canada's greenhouse gases are emitted by three major industries – oil and gas (18.9%), thermal electricity (17.2%) and mining (16.6%). Originally, the 700 largest industrial emitters were expected to cut emissions by 95 million tonnes. However, the target was reduced to 55 million tonnes in response to concerns from industry over competitiveness. The target was again reduced to 45 million tonnes in 2005, while the baseline, or business-as-usual emissions calculation was revised upward by 6 million tonnes. Investments in the Greenhouse Gas Technology Fund will allow large industrial emitters to be further credited with up to 9 million tonnes. GHG reductions are now expected to be about 65 million tonnes less than originally planned by 2010. To date, no reduction has been achieved (OAG, 2006; para 3.54-5 and para 1.46).

There are presently no federal requirements for industry to reduce emissions whatsoever (OAG, 2006; para 1.73). Furthermore, the compliance objective of international emissions trading is limited by a price cap of $15 per tonne, promised to industry in 2002. Should international credits trade at a price greater than $15, the difference would be made up by the Canadian taxpayer. Liability for not achieving the Large Final Emitter System's emission intensity target could exceed $1 billion (OAG, 2006; para 1.71).

The Offset System still lacks a critical electronic registry to track projects, and no guidance has yet been provided for its use. The Commissioner’s prognosis is not encouraging:

We are unable to conclude whether the [domestic] greenhouse gas emissions trading system as proposed will be effective (OAG, 2006; para 1.87).
Sustainable Development Technology Canada (SDTC) was founded in 2001 with a mandate to fund the development and demonstration of sustainable technologies in Canada. It is governed by the Canada Foundation for Sustainable Development Technology Act. Its board of directors is made up of members from the public, private, and academic sectors. It is sponsored by Natural Resources Canada and Environment Canada, and it is not an agency of the federal government. Its mission is to:

- [Award] funds to develop and demonstrate new sustainable development technologies,
- [Foster and encourage] collaboration and partnering among different organizations to strengthen Canadian capacity to develop and demonstrate sustainable development technologies, [and]
- [Ensure] timely diffusion of these technologies in relevant market sectors (OAG, 2006; para 1.90).

The SDTC has been awarded $550 million primarily to finance climate change technologies. To date, SDTC has funded 74 projects, seven of which have completed development and demonstration activities. Reductions are projected to amount to 12.6 million tonnes of greenhouse gas emissions by 2010, the mid-point of the commitment period. However, SDTC’s reporting to Parliament may be overly optimistic. As yet, ”SDTC has insufficient information to assess and report fully on the degree to which it has achieved its goals” (OAG, 2006; para 1.126).

The Climate Fund is an emissions trading scheme, initiated by Canada in 2005, to purchase between 75 and 115 million tonnes of domestic and international “green” credits per year on the international market, at a cost of $4 to $5 billion. Although Canada will fall short of its Kyoto obligations by 270 million tonnes during the commitment period of 2008 to 2012, the Climate Fund has yet to receive funding for operations (OAG, 2006; para 1.75-7).

> The distinctive features of Canada’s system – for example, its emission intensity target, price cap, and permitted use of offset credits – may limit its ability to link to major trading systems that do not share these features, such as that of the European Union (OAG, 2006; para 1.72).

It is doubtful whether Canada has the capacity to manage any emissions mitigation policy framework effectively. The 2006 Report of the Commissioner of the Environment and Sustainable Development studied several elements of the federal government’s approach to managing for climate change, and made the following observations:

- Canada is not on track to reduce its total greenhouse gas emissions;
- Governance mechanisms for climate change are inadequate;
- Earlier co-ordination mechanisms have been phased out and not replaced;
- Development of accountability tools has been delayed;
- Reporting to Parliament and the public is deficient;
- Performance information systems [are] still being developed; and
- Promised public reports [were] not issued (OAG, 2006; para 1.8-14).

### 11.0 The Carbon Credit Market in Alberta

On March 8, 2007, Bill 3, the Climate Change and Emissions Management Act (CCEMA) and the Specified Gas Emitters Regulation (SGER) came into effect in Alberta. Together, they require about
100 companies that emit 70% of Alberta’s industrial emissions to reduce emissions intensity by 12%, starting July 1, 2007. Facilities that began operations in 2000 or later have up to nine years grace to meet the new requirements. Established operations that began prior to 2000 will have until December 31, 2007. The Minister of the Environment has the discretion to vary the target on a case-by-case basis (Denstedt et. al., 2007).

Options for compliance include:

- operational improvements that reduce emissions (non-regulatory);
- purchased fund credits of $15 per tonne, available for emissions above the 12% target, in a new emissions reduction technology fund;
- offset credits purchased from independently-verified Alberta-based projects voluntarily undertaken since 2002 to reduce emissions;
- performance credits received for emissions decreases beyond the intensity-based target for each year (Denstedt et. al., 2007).

An Emissions Trading Registry was established under the Environmental Protection and Enhancement Act, to allow any person to buy and sell emissions credits. The Registry also sets emissions intensity baselines for emissions, including nitrogen oxides and sulphur dioxides. Compliance will be mandatory for every facility with emissions of 100,000 tonnes annually, including all operators of generating units with a continuous power rating of 25 megawatts or more (Lee-Anderson, 2007). A yearly verification report must be submitted and endorsed by a third party auditor who is a professional engineer or chartered accountant with expertise in both gas emissions and auditing.

In order to be effective, the prescribed Domestic Offset System must meet several criteria. It must be quantifiable. Emissions reductions from a registered offset project must be measurable using recognized methodologies. They must be real. An offset project must identify a specific action that reduces emissions, and doesn’t just move them to another site. Project reductions must represent a surplus to those that would otherwise result from government regulation or other incentive. Reductions must be verifiable by accredited third parties. They must be unique, used only once to create an offset credit. Projects that achieve real reductions or removals of emissions are included in the coverage of Alberta’s offset system, even if they are not included in Canada’s National Inventory for purposes of the Kyoto Protocol. Emissions reductions that meet the other criteria will be eligible for credits where the start of the project is January 1, 2000 or later. The registration period starts on the date of registration and continues for eight years. Projects may be re-registered (Timilsina et. al., 2006).

In April 2005, the Government of Canada made a number of commitments to Large Final Emitters, published in Annex 2 to Moving Forward on Climate Change: A Plan for Honouring our Kyoto Commitment (Project Green). These included the $15 per tonne price cap and an intensity-based approach that limited targets to no more than 15% below projected BAU levels for 2010 (Government of Canada, 2005; p. 40).

On July 16, 2005, Canada issued a Notice of intent to regulate greenhouse gas emissions by Large Final Emitters (NOI), and added greenhouse gases to Schedule I of the Canadian Environmental Protection Act 1999 (CEPA). The (NOI) stipulated maximum use of equivalency agreements with the provinces “to ensure national consistency of the mandatory emission intensity targets.” The federal government’s key objective for equivalency agreements is that sectoral emissions targets be made equivalent among provinces (Whitmore et. al., 2005; p. 1).
Work on equivalency agreements and the regulation under CEPA was to take place in parallel with the provinces. However, the federal government has yet to publish any implementing regulation. Instead, seeking to assert its own jurisdictional authority, Alberta introduced its own 'made-in Alberta' approach to climate change on July 18, 2005 (Alberta Environment, 2006). Section 63 of the CCEMA holds Alberta enactments paramount and section 8 prohibits any interjurisdictional agreement not consistent with Alberta's gas emissions target established by subsection 3(1) (Denstedt et. al., 2006). It was opened for stakeholder input on October 17, 2005 and closed on October 25, 2007 (Environmental Law Centre, 2005).

The Kyoto Protocol became international law on February 16, 2005. As a signatory, Canada committed to an absolute emissions reduction target relative to a 'business-as-usual' baseline. However, economic growth puts upward pressure on the cost of compliance with absolute targets. Intensity targets allow uncertainty reduction because emissions can increase as production increases. Intensity targets are amenable to clean growth policies that enable poor countries to pursue low-emission pathways while increasing economic activity. Intensity targets are not inconsistent with policies to reduce poverty. Another rationale for intensity targets is the political issue of framing. Absolute targets tend to be construed as 'caps' on economic prosperity. Intensity targets remain constant with economic growth, and may serve as a 'performance standard' that 'decouples' economic growth from environmental issues (Herzog et. al., 2006; p. 24).

The essential quality of an environmental target is its effectiveness. The World Resources Institute (WRI) proposes the following four criteria for evaluating the effectiveness of emissions targets:

1. Metric or form – whether the target is absolute- or intensity-based;
2. Stringency – the level of effort or cost required to meet a target;
3. Scope – the basket of emissions covered by a target;
4. Legal character – whether targets are voluntary or legally binding.

In these terms, stringency and legal character are greater determinants of environmental effectiveness than the form of an emissions target (Herzog et. al., 2006; p. 15). However, without adequate context, intensity targets can be "used to depict the status quo as a significant reduction policy" (Herzog et. al., 2006; p. 24). Alberta's long-term objective is a 50% reduction of GHG emissions per unit of GDP below 1990 levels by 2020. However, "if Alberta's economy continues to grow at 4% per year as it did during the 1990's, the 50% intensity target could be met even while the province's emissions rise to 66-83% above the 1990 level" (Whitmore et. al., 2005; p. 2).

Alberta's position is that the right to manage its own natural resources carries the right to set its own emissions (or emissions intensity) targets. At least one former premier of Alberta sees a "constitutional legal conflict" looming over the issue. Peter Lougheed recently told the Canadian Bar Association, "My surmise is that ... national unity will be threatened if the [Supreme Court] upholds federal environmental legislation and it causes major damage to the Alberta oil sands and our economy." (The Globe and Mail, 2007; p. A12).

12.0 Concluding Remarks

Albertans want and expect their energy resources to be managed sustainably. Canada has been prominent in the international initiative to mainstream environmental protections into resource management. We chaired the Earth Summit, and signed the Millennium Declaration, which holds the principles of sustainable development to be fundamental and essential to the conduct of
international relations. Energy security is a pillar of sustainable development, along with environmental, economic and social concerns.

Canada's oilsands are not being managed sustainably. Canada is under enormous international pressure to deregulate oilsands development, which is threatened by looming shortages of natural gas. The petrochemicals industry is threatened by feedstock shortages. Water resources, land, boreal forests and air quality are all under siege. Communities are experiencing unprecedented, uncontrolled growth that is straining municipal infrastructure. We are not on track to meet international commitments under the Kyoto Protocol.

A systems approach is needed to identify key funding priorities and linkages. Strong partnerships must be developed among industry, government and academia to maximize the economic and environmental benefits that can be achieved by investing in sustainable development technologies. Governments must make long-term funding commitments to leverage our immense capacity for scientific research and commercial development of clean technologies. Industry must bring centres of excellence to Canada, and invest in Canadian equipment manufacturing and expertise.

Effective regulation would further the interests of all stakeholders. The cost of adaptation to an environmentally damaged future will be enormous, but failure to implement efficient policies to mitigate the environmental effects of unsustainable oilsands developments would make matters far worse. Carbon pricing by means of direct taxation, creating a market for emissions permits, or by regulation, is essential to climate change policy. International competitiveness and trade would be enhanced by the development and export of clean energy technologies.

Canada’s climate change policy administration is in disarray. We have yet to develop the governance mechanisms and accountability framework needed to make any system of carbon pricing work. A systems approach to identify key linkages and exploit synergies is a necessary first step toward meeting the sustainable development challenge of Canada’s oilsands.

13.0 References


The Application of Program Management Process in the Electricity Market Reform

Gilman Chi Keung Tam

ABSTRACT

Electricity market reform in the last decades has contributed to efficiency gains and technological dynamism. Under intense market competition, organizations operating in a new paradigm would require a different management approach to assist their strategy formulation and implementation. Program management is a process suitable for operating in a turbulence environment. Its ambiguity reduction learning loop and the uncertainty reduction performance loop would help organization focus on identification and realization of program benefits by doing the right projects in a strategic manner (effective use of resources) rather than purely targeting on doing the projects right (efficient use of resources).

This paper introduces the difference between project and program management in context of electricity market reforms. It describes how project and program management contribute to reduction in CO₂ emissions and energy use. It discusses the concept of program management; and the contribution of value management to the process. It also describes program life cycle and the application of such process to organizations in the new paradigm. For those utility spin-off organizations, issues such as cultural change; change in roles and responsibilities; as well as change in stakeholder expectations and impacts are discussed. Program and project strategy formulation needs to consider funding requirements. The Equator Principles, concern about social and environmental risks assessment and mitigation, is important for those organizations seeking project financing.

Keywords: Program Management, Project Management, Value Management, Project Finance, Electricity Market Reform.

This paper assesses the role of project management, program management and the potential for Equator Principles and value management in the Electricity market reform.

It makes a strong case for the role of program management in a new management paradigm required to operate in the post reform operating environment. The author demonstrates the structure of the integrated program management cycle model and its relationship to value management and project management. The paper also described links with cultural change, related changes in roles and responsibilities, and stakeholder expectations and impacts.

On balance, this paper is highly relevant to strategic management in the post reform electricity sector. The presentation can be extrapolated easily to other sectors of the operating environment and has a contribution to make in terms of strategic processes in support of sustainable development.

Jim Dunn
1.0 Introduction

The world trend in the electricity market reform can be traced back to the late 1970s in the United States of America (US). In 1978, Public Utility Regulatory Policies Act (PURPA) was adopted in the US requesting utility companies to purchase electricity from independent and small power producers. Following to PURPA, Chile has enacted a law to allow large end-users to buy and negotiate electricity price freely to their selected power suppliers. The England and Wales electricity market pool was formed in 1990. This market mechanism has allowed determination of the dispatch of generators and the wholesale electricity price in order to increase competition amongst power generation companies. In the subsequent years, several other OECD (Organization for Economic Cooperation and Development) countries have followed the footsteps (IEA, 2001, p.106).

Similar to many other utility companies under electricity market reform, the Ontario Hydro in the Province of Ontario in Canada split the vertically integrated, government-owned monopoly into generation and transmission components in April 1999. Hydro One Inc. (Hydro One) was given ownership of the transmission grid and Ontario Power Generation Inc. (OPG) was given ownership of the generation assets (Trebilcock and Hrab, 2005, p.124-125). In UK, the vertically integrated state-owned monopoly provider, Central Electricity Generating Board (CEGB), was disintegrated into several generation companies and a transmission company. In Australia, the state of Victoria has split their generation assets into five separate entities and consolidates their distribution facilities before privatization (Trebilcock and Hrab, 2005, p.130-131).

According to the International Energy Agency (IEA), pool performance under electricity market reform critically depends on the horizontal and vertical structure of the market (IEA, 2001, p.108). A number of generating companies of similar size is necessary to induce competitive bidding behavior in the market. Vertical integration of generating facilities and transmission & distribution assets may hinder competition, as a transmission & distribution network operator may have an incentive to favor its own generation assets. It is one of the reasons why the generating function is becoming an independent organization due to the market reform initiatives.

Electricity market reform, whether privatizing the utilities or otherwise such as Hydro One or OPG, is widely expected to introduce economic benefits in the existing infrastructure through efficiency gains. In addition, the market reform would also introduce technological dynamism in the generation activities in particular. More independent power producers utilizing efficient generating facilities in the market for competition in power generation coupled with advanced information and communication technology for metering and measuring equipments have facilitated the separation
of utility electricity generation from transmission and distribution in the industry. With the backdrop of efficiency gain and technological dynamism, a number of spin-offs from the utility companies have taken place in the last decade.

**Figure 1: Simplified Market Structure Showing Intense Competition at Power Generation, Transmission & Distribution Levels**
With background understanding on the reasoning for electricity market reform, it becomes clear that vertically integrated utility company is likely to disintegrate their facilities and split into independent generation company and transmission & distribution network operators. Under the new operating regime, spin-off organizations shall perform not only to the satisfaction of internal stakeholders but also to most of the external stakeholders. A new management paradigm may be required to assist them to face severe competitions under the new operating environment.

The generation company and the transmission & distribution companies established after the market reform are de facto program-based organizations. The newly established generation company, for instance, has to maintain its routine power generation (operations) and develop new generating facilities to meet future demand (projects). The concept of program management process can be used to help those spin-off entities to compete with others in the new market environment. It also contributes to reduction of CO₂ emissions and energy use through effective and efficient use of resources for utility operations in the reformed market. Figure 1 outlines a simplified market structure showing intense competition after market opening at power generation, transmission and distribution levels.

To appreciate the process of program management and its applications to those organizations under restructuring, it is important to have an understanding of the definitions of “Project” and “Program Management” as well as “Program” and “Program Management”. The Association for Project Management (APM) in the U.K. and the Project Management Institute (PMI) in the United States have in their body of knowledge defined the respective meaning of such terms. Definitions provided by PMI are given in the section below. Following to discussion of Why Project and Program Management and their Definitions, the Concept of Program Management including contribution of Value Management to program management process and the program life cycle will be introduced.

In the section of Program Management in the New Paradigm, the benefits, significance and the applications of the process to those spin-off organizations are described. Other Related Issues such as the cultural change; the stakeholders’ expectations and impacts; and the change in roles and responsibilities operating in the new paradigm that may affect the program performance will be addressed. Another factor that may affect program performance involves the issues of sustainability in financing project(s) for a program of choice. As sustainable development becomes a critical issue in formulating program and project strategies, it is beneficial for those organizations seeking project financing in particular to follow Equator Principles in their programs. Equator Principles as recognized by major international project financiers with respect to sustainability issues in project financing are discussed.

2.0 Why Project and Program Management

The 1992 Earth Summit in Rio de Janerio, Brazil recognised that the world is confronted with a perpetuation of disparities between and within nations, a worsening of poverty, hunger, ill health and illiteracy, and the continuing deterioration of the ecosystems on which we depend for our well-being (UNCED, 1992). The Agenda 21 calls for global partnership including governments, business and industry for sustainable development. Canada is among the first signatory countries of Kyoto Protocol which entered into force on 16 February 2005. As of September 2006, 166 states and economic regions including Canada have deposited instruments of ratification, accession, approval or acceptance (UNFCCC, 2006). The Protocol brings in a total cut in greenhouse gas (GHG) emissions of at least 5% from 1990 levels in the commitment period of 2008 to 2012.
In the past 15 years, international agencies and national governments have been cooperating in collecting information about GHG emissions and energy use. The information obtained is used to compare country performance with respect to their Kyoto Protocol requirements. Canada has been working towards limiting the growth of CO$_2$ emissions and Total Primary Energy Supply (TPES) since 1990. According to IEA, for the period 1990 to 2003, the percentage increase in CO$_2$ emissions is 28.6% and increase in TPES is 24.6% while GDP growth is 43.2% and population growth is 14.2%. During the same period, the World average increase is 20.5% (CO$_2$), 22.7% (TPES), 39.9% (GDP) and 19.5% (Population) respectively (IEA, 2005). The Canadian figures are not very impressive in terms of CO$_2$ emissions and energy use. The per capita CO$_2$ emissions and TPES figures are even worse. In 2010, Canada’s Energy Outlook published in 2006, growing energy demand and a changing energy production mix lead to growth in GHG emissions from 758 megatonnes (Mt) in 2004 to 828Mt in 2010 and 897Mt in 2020. Natural Resources Canada predicts that the 2020 figure is 265Mt above Canada’s Kyoto Protocol target (563Mt) which is 6% below 1990 levels (NRC, 2006).

In Canada, about 85% of total GHG emissions are associated with energy consumption, production and distribution. Of that, 60% is due to end-use consumption of fossil fuels and the remaining 40% is from energy production and distribution (NRC, 2006). In other words, utility companies in the electricity supply industry play a crucial role in reducing energy use and GHG emissions in particular. Electricity market reform provides Canadian society an opportunity to improve energy efficiency through structural change. However, without support from appropriate management system, utility companies do not gain synergistic benefits from the reformed market. To cope with new operating paradigm, utility company must put in place a new form of management system that can help the organization to achieve higher corporate performance both from financial and sustainability measures.

Central to reduction in GHG emissions and energy use; and minimization of waste is effective and efficient use of resources. Tools and methodologies are required to help business and industry to meet ever demanding rules and regulations towards environmental sustainability. The inherent nature of project management is efficient use of resources to arrive at deliverables within scope, cost, time and meet the predetermined quality requirement. Program management process concerns about effective use of resources. It directs resources to the right place for efficient implementation. Together, the processes help to reduce CO$_2$ emissions and energy use through effective and efficient use of resources in the reformed market and effectively contribute to meet Kyoto Protocol target. Electricity market reform targets on efficiency gain through restructuring of operating regime. It also would like to bring in wide range of renewable and non-renewable technology to achieve sustainable generation. Project and program management processes are capable to enhance organizational capabilities in delivering right projects efficiently.

3.0 Definitions

Reference has been made to the “Project” and “Project Management” definitions provided by the APM in its APM Body of Knowledge 5th Edition (APMBOK) and the PMI in its A Guide to the Project Management Body of Knowledge – Third Edition (PMBOK Guide) which has been adopted as an American National Standard (ANSI/PMI 99-001-2004). PMI has also defined “Program” and “Program Management” in their newly published The Standard for Program Management (Program Standard). Understanding the difference between project and project management as well as program and program management would help those spin-off organizations to understand the concept of program management and appreciate the significance and benefits of adopting such processes in the reformed market. For the purpose of this paper, definitions provided by PMI are given below.
**Project and Project Management**

According to the PMBOK Guide, “Project” is defined as “A temporary endeavor undertaken to create a unique product, service, or result” and “Project Management” is defined as “The application of knowledge, skills, tools, and techniques, to project activities to meet the project requirements” (PMI, 2004).

The application and integration of project management process of initiating, planning, executing, monitoring and controlling, and closing form the basic structure for project management. The PMBOK Guide (PMI, 2004, p.8) describes the management of a project include: (1) identifying requirements; (2) establishing clear and achievable objectives; (3) balancing the competing demands for quality, scope, time and cost; and (4) adapting the specifications, plan, and approach to the different concerns and expectations of the various stakeholders.

**Program and Program Management**

In 2006, PMI published another set of standard to supplement those areas that the PMBOK Guide concentrating on single project does not cover. The Program Standard is used to assist practitioners in directing and administering programs. It defines the “Program” as “A group of related projects managed in a coordinated way to obtain benefits and control not available from managing them individually. Programs may include elements of related work (e.g., ongoing operations) outside the scope of the discrete projects in a program.” It also defines “Program Management” as “The centralized coordinated management of a program to achieve the program’s strategic benefits and objectives” (PMI, 2006).

The Program Standard has pointed out that program management focuses on those project interdependencies within an organization and determines the optimal pacing for the program. This enables appropriate planning, scheduling, executing, monitoring, and controlling of the projects within the program. In essence, factors such as strategic benefits, coordinated planning, shared resources, interdependencies, and optimized pacing contribute to determining whether multiple projects should be managed as a program (PMI, 2006, p.5).

**4.0 The Concept of Program Management**

Before the Program Standard was published in 2006, there were a number of pioneers who suggested the scope, definitions, applications and benefits of program and program management for practitioners. Of particular interest to those generation companies and transmission & distribution network operators operating in the reformed market is that a “program” is “a collection of change actions (projects and operational activities) purposefully grouped together to realize strategic and/or tactical benefits” (Murray-Webster and Thiry, 2000; Thiry, 2004a). Program management as described by Thiry is mainly a purposeful strategic decision management process, grounded in change and aimed at the effectiveness of solutions. It can include both projects and non-project actions. It is a management process that addresses both decision making and decision implementation (Thiry, 2004a).

The scale of a program can be large or small which depends on situation. Some programs may be of relatively short timeframe (e.g. renewal of all 33kV overhead lines which are more than 20 years old), while others, such as program on cultural change, may take many years. Taking OPG targets on supplying less polluted electricity to the Province of Ontario, for instance, it considers phasing out all fossil fuel power stations in their system in the earliest practical timeframe. This OPG replacement
program is huge. Finding suitable alternative clean energy sources to replace existing 8578MW (OPG, 2006) coal and oil fired generating capacity is a time consuming process.

Project management focuses on delivering results and benefits of clear objective(s) within the constraints of scope, time, cost and quality. It is based on a performance paradigm (Thiry, 2002) embedded in an “uncertainty-reduction” process (Winch et al., 1998). The program management is different from the project management in the sense that it focuses on delivering strategic benefits to the organization through the program setup. In delivering strategic benefits through strategic decision making and change actions, the management has to deal with internal and external stakeholders with different agenda. It creates ambiguity and requires an “ambiguity-reduction” process such as the “learning loop” to nurture an effective means to strategic decision making. Thiry et al. have advocated Value Management (VM) based on learning loop approach to address the strategic decision making and continue to retain the project performance loop approach to implement change actions within the program paradigm (Thiry, 2004a). In essence, project management concerns about efficiency (do the project right) and program management concerns about effectiveness (do the right project).

In a complex business environment, such as utility companies undergoing restructuring in a new market environment, a program management paradigm has to integrate both the ambiguity reduction learning loop and the uncertainty reduction project performance loop to form an effective framework capable to meet challenges arising from emerging situations. Figure 2 shows the process of program management in terms of learning-based value loop and performance-based project loop.

Under OPG fossil fuel replacement program, management has to identify realistic situation of the system and find out possible solutions to achieve the outcomes. It is an ambiguity reduction learning process which makes sense of the air polluting situation and identify clear objectives and best alternative amongst possible solutions. However, there are emergent situations that may affect OPG to achieve its objectives. For example, OPG was requested by the Provincial Government of Ontario to close down all its coal and oil fired power stations by 2009. Nevertheless, as the Independent Electricity System Operator (IESO) revised its projected supply capacity and future demand requirements by as much as 2500 – 3000MW, the situation has changed. OPG is now requested not to close all its coal fired generation by 2009 (OME, 2006). This is an emergent input to OPG’s program. Program management process is iterative in nature. It urges management to get in touch with emergent situations and adopt appropriate actions thereof. This iterative process will be further discussed in the section Program Life Cycle below.

When appropriate decisions are made under the learning loop, OPG enters into uncertainty reduction performance process to plan, execute and control its projects such that project deliverables achieved will deliver strategic benefits to the organization. It is a linear process with a mentality of do more with less.

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1 Value Management is a management approach for maximizing the overall performance of an organization. It is based on the principles of adding measurable value, focusing on objectives and concentrating on function to enhance innovation. The European Commission (EC) recognized the power of Value Management in delivering competitive advantage to its users. EC has developed a European Standard BS-EN 12973:2000 to capture the essence of VM and provide a framework for its applications.
Figure 2: The Integrated Program Management Cycle Model

Source: Michel Thiry (2002).

How Value Management Contributes to Program Management Process

Figure 2 clearly shows that Program Management process composes of two elements which are Value Management (Learning Loop) and Project Management (Performance Loop). The process of project management has been widely recognized as an effective means to deliver outputs. The program team is responsible for identifying appropriate change actions (projects) which are to be carried out by the project team. The program team may utilize Value Management as provided in the European Standard BS-EN 12973:2000 to identify beneficial changes.

The Value Management Standard recognizes that VM is distinct from most other management systems and uniquely brings together four key principles. They are (a) a management style based on value; (b) positive human dynamics; (c) consideration of external and internal environment; and (d) effective use of methods and tools (Chiswick, 2000). These four key principles set the rhythm that links the program and/or organizational strategic decisions to change actions.

The VM process emphasizes (a) sensemaking to understand the situation and come to a shared agreement about the critical success factors and key performance indicators; (b) ideation for generation of innovative alternatives; (c) elaboration for viable option(s) through the evaluation of alternatives on achievability and contribution to the expected benefits; (d) choice of the best option(s) with reference to prioritizing the critical success factors; and (e) mastery of benefits based on a formative evaluation and control process which focuses on the improvement of value (Thiry, 2004b). The process is iterative and requires adjustment on outcomes and decisions should emergent input to the process occur.
The Program Life Cycle

The program life cycle can be divided into five phases. They are: Formulation; Organization; Deployment; Appraisal; and Dissolution phase. Unlike project life cycle which is linear in nature, program life cycle is iterative and operating in a cyclical manner. Program is often ongoing or in a longer term than the duration of a single project. As some projects within a program may have been completed and turned into operation phase or new project within a program may be started before the earlier project(s) completed. Figure 3 shows the program life cycle which demonstrates the five phases from benefits formulation at the strategy level to organization at program level; deployment at projects level; appraisal at operations level and dissolution of program when the strategic benefits derived from such program no longer exist.

At every phase of the program life cycle discussed below, the VM process shall always be referred to because emergent inputs occurred from time to time are likely to affect the strategic benefits identified. For example, OPG’s fossil fuel replacement program is affected by IESO’s latest system assessment report (emergent input from external stakeholder). In addition, support from senior management is always important. Without full commitment from the management, whether financial resources or otherwise, the targeted strategic benefits will not be realized. Furthermore, program stakeholders, whether internal or external, need to be monitored at all time. It is because they can either help (influence positively) or hinder (influence negatively) those predetermined program outcomes. Utility companies shall establish communication strategy to engage the stakeholders, manage their expectations, and improve their acceptance to predetermined outcomes (PMI, 2006, p.12). For instance, reactivating Pickering nuclear generating facilities already removed from service in the Province of Ontario must have to seek views and opinions from various stakeholders, including environmental pressure groups, in order to understand and protect their interests affected by the program.

At Formulation phase, it is required to determine if a program shall be established with reference to synergistic factors such as strategic benefits, coordinated planning, shared resources, projects interdependencies, and optimized pacing etc. Program benefits identified shall be aligned to organizational mission and objectives. Moreover, the internal and external stakeholders’ expectations and needs are identified at this stage. It is at this phase that the level of ambiguity is high. Careful identification and analysis of emerging situations can reduce risks that may affect program performance at a later stage. It is very important at this stage to recognize effective solutions and appropriate strategic benefits through the correct change actions (do the right project) rather than efficiently conducting changes.

Once the strategic decision to establish a program is made, an Organization phase is going to select and prioritize projects and other actions required to deliver benefits. Based on the program requirements agreed, program team and program structure are being established. In this phase, a strategic plan which includes the program organization structure; communication channels; efficient use and prioritization of resources; and pacing of the program is required. Furthermore, selection of actions shall take into account not only the resources availability; project interdependencies and prioritization, but also the pacing of the program to spread out in such a way that program stability period (shown in Figure 3) would help to minimize benefits fluctuation during the program period.

The Deployment phase refers to the actual implementation of projects and other related actions as well as the management of their interdependencies within a program. Program manager needs to manage stakeholders’ expectations while s/he is continuously assessing the program environment and evaluating the program contributions to the organization. Furthermore, program manager shall
act as project sponsor and buffer to control senior management’s direct influence to projects. The program manager is responsible for resources allocation and re-allocation upon regular assessment on project benefits and re-alignment of projects priorities. The evaluation of program shall be “formative” in nature (improvement perspective) with reference to emergent inputs rather than “summative” (assessment perspective) type of control against set parameters or benchmarks (Guba & Lincoln, 2001).

Figure 3: The Program Life Cycle

![Diagram of Program Life Cycle]

Source: Michel Thiry (2002).

The Appraisal phase grants the program an opportunity to gain an overview of its significance in existence. This process is actually a learning and improvement feedback loop on the program using formative evaluation approach. It needs to outline the program team performance and effectiveness of the program on, inter alia, (a) the achievement of expected benefits; (b) the responsiveness on changing business environment; (c) the overall contributions against critical success factors of the organization; and (d) the effective use of resources. The appraisal to be carried out ideally in the program stability period\(^2\) shall inform the senior management whether they should retain the original program as planned; make necessary re-alignment; or even cease operations.

Dissolution phase is the ending phase of a program. It happens when the synergistic factors for the program no longer exists. Those uncompleted works within the program shall either be completed within a specified period of time or assigned to other program subject to re-formulation of program strategy of that program. All the updated documentation together with post program review shall be fed back to the organization and be used as reference material in the future.

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\(^2\) Program stability period normally exists when positive or beneficial impacts are flowing into the organization.
The five phases discussed above (formulation, organization, deployment, appraisal and dissolution) help utility companies to deliver strategic outcomes. In formulating a program of reducing GHG emissions rate, for instance, a spin-off generation company may consider the synergy of strategic benefits, coordinated planning, shared resources, projects interdependencies and project pacing, etc among various projects within a program. The possible projects may include shutdown of coal fired power stations; retrofit of desulphurization plants; investment in renewable energy technology; and planting of trees, etc. The goal of a program is to gain benefits that may not be available if projects are to be carried out individually.

5.0 Program Management in the New Paradigm

The program management process focuses on delivering effective solution and value to organization and can be seen as part of the strategic decision making process. It links strategic decision making to change actions. Its framework includes both a learning loop in response to emergent and turbulence situations; and a performance loop for the purpose of implementing change actions with identified strategy.

There are two characteristics that lead program management process be suitable for the implementation of corporate strategy. They are (a) the iterative nature of the process, which enables a regular review and assessment on the benefits, evaluation of emergent inputs and pacing of the process upon necessity; and (b) the emphasis on the interdependencies of change actions, which ensures strategic alignment and delivery of strategic benefits (Thiry, 2004a). This program management paradigm can help the top management of the spin-off organization to go through the ambiguity reduction process under a turbulence situation by sensemaking, ideation and elaboration to identify correct choice of action(s) through iteration. With a correct outcome identified from the previous process, the output or result of uncertainty reduction process through planning, execution and control will be in line with the needs of the stakeholders and/or the organization. The program management paradigm shall make contributions not only in directing action changes (including projects and operations) but also in the formulation of strategy for changes.

For those spin-off organizations operating in a complex environment, its long-term developments and ongoing operations has to be subject to both ambiguity and uncertainty. In an emerging situation of stringent environmental regulations to combat climate change, for instance, generation companies have to optimize their benefits of whether they should (a) install flue gas desulphurization plants to reduce SOx; (b) reduce coal-fired generation and shift part loads to other generating facilities using renewable energy; or even (c) procure emission credits from the market and retain full generation by coal.

The ambiguity reduction under the learning-based value loop consider strategic benefits as a whole for the possibility of either constructing flue gas desulphurization facilities in order to maintain full generation by coal or reducing/replacing such coal-fired generations by other possible generating plants using renewable energy. Uncertainty reduction under the performance-based project loop needs to minimize the unexpected outcomes where it is impossible to attach probabilities of risk to them. Unexpected political turmoil in the host country would create problems for projects and operations. The uncertainty reduction process urges the management to plan and make clear the works to be done in advance. Hence, program management has to take care of strategic perspective, organizational effectiveness and a learning approach which is suitable for dealing with emergent situations.
Taking OPG as another example, the Provincial Government of Ontario has entered a Market Power Mitigation Agreement (MPMA) with OPG in order to discourage OPG from using its dominant position in generation to exercise market power (Trebilcock and Hrab, 2005, p.125). To handle this situation, OPG has no alternative but to find ways to maintain its competitiveness. The OPG strategy alternatives may include but not limited to the following options: (a) selling of the right assets to newcomers for the sake of compliance to MPMA; (b) develop a right mix of renewable and non-renewable power generation facilities for market development and environmental compliance; and (c) improve projects and operations efficiency for better operating results.

As can be seen from OPG case above, it requires some kind of management process which helps OPG in achieving benefits (through operations) and building capability (through a suitable mix of projects). Program management process focuses on delivering optimized benefits and results to program and eventually to organization. It would help utility company under restructuring to identify strategic benefits and build capability to improve competitiveness.

6.0 Other Related Issues

Before electricity market reform, utility companies have long been operating in a less competitive environment. The long established shareholders centered utility operations has a deep rooted organizational culture. To enhance competition in the new operating environment, spin-off organizations shall have to make a change in the culture; adjust their roles and responsibilities; and manage the stakeholders’ expectations and impacts. In addition, organizations nowadays have to face ever demanding environmental constraints and be socially responsible. Projects over USD 10 million seeking project financing shall have to comply with the Equator Principles as stipulated by most of the major international financiers. Without adjustment on those aforementioned factors, the performance of the program management process may have been affected.

The Cultural Change

The market reform shall have brought in benefits in terms of efficiency gains and market dynamism. However, it is inevitable to have turbulence on organizational culture. The change in culture may be a consequence of change in skill sets, knowledge base, attitudes, values, organizational structure, management information system and working methodologies, etc. in association with people of the organization.

The utility companies under restructuring have been in operations for many years. They have built up a strong culture and sub-culture from their day-to-day activities. It is therefore that implementation of cultural change in a newly reformed organization shall never be an easy task. The understanding of the nature of resistance to change will definitely help to assist the changes.

Turner (1999) suggested that employees’ inherent resistance to change may be due to (a) a change of formal and informal working relationships; (b) a change in the nature of work which requires learning of new knowledge and/or skill; (c) the loss of job; or (d) the loss of control or autonomy over their areas of work responsibilities. In addition, conflict is likely to occur when people (a) are not consulted when implementing a change action; (b) do not understand or agree with the change actions made and the benefits that they may bring along; (c) have different perceptions over the changes needed; or (d) are fed up with ineffective constant change actions, etc.

A well organized plan shall alleviate the anxiety of employees under the market reform process. The plan shall include employee participation and representation in implementing the changes; and a
training and development scheme which incorporate cultural elements to help employees to bridge the difference. Effective communications between top management and staff at all levels are central to a successful change management and establishment of new culture in the transformed organization.

The Change in Roles and Responsibilities

Most power generation companies and transmission & distribution network operators before the market reform were part of the vertically integrated and virtually monopolized utility power supply companies. Majority of utility companies have placed their roles and responsibilities simply on generation of electricity and transmission & distribution of the same to their direct customers through their own networks.

In a transformed power generation company, for instance, it is operating as an independent entity. It generates electricity and sells it to the grid. The generator has no shareholding relationship with network operator and is free to compete with other independent power producers.

The reform has rationalized the market structure, which introduces competition and improves operation efficiency. The roles and responsibilities of the new entity are clear. Subject to commercial viability and resources allocations, the reformed organization is responsible for (a) continuation of efficient operations on existing generation facilities and to a high degree of reliabilities and safety standards; (b) development of new plants and/or replacement of old power generation facilities using renewable and non-renewable energy resources to meet future demand; (c) exploration of other business opportunities; and (d) comply with statutory environmental regulations and social responsibilities. The new entity, being an independent power producer, shall have to compete with other new players. Its roles and responsibilities are, therefore, of no difference to their competitors.

The Stakeholder Expectations and Impacts

Electricity market reform will bring in new rules and regulations that create opportunities and challenges to stakeholders. Different stakeholders have different expectations and agenda about the changes. For instance, external stakeholders, such as the governments, consumers and environmental pressure groups, would expect that the spin-off organization could (a) maintain a high degree of stability in electricity generation; (b) bring in low electricity price; (c) continue to make appropriate investments to meet future demand in the region; (d) introduce green electricity to meet demand of various consumers; (e) compete with other new power producers on a level playing field; (f) contribute to alleviate GHG emission problems; and (g) play a leading role in corporate social responsibility issues. Internally, the employees would expect that employer could continue to provide job security which is, at least, equivalent to that before the restructuring; the shareholders would expect that the new setup could maintain a high level of financial returns; and the top management would target on setting up a more efficient organization for better performance. The stakeholder expectation list is growing and by no means exhaustive.

As mentioned earlier, program stakeholders may influence positively or negatively on targeted outcomes. They will act in according to the program impacts on them. Not every stakeholder benefits from the market restructuring, such as customers in the Province of Ontario, who due to prior low tariff policy, had paid a much higher electricity tariffs at the early days of market opening. It is, therefore, that engaging the impacted stakeholders at the early stage of program development and enhancing their communication channels that would likely to reduce their negative influence and improve their acceptance on the program of choice.
The Equator Principles in Project Financing

Program and project strategy formulation nowadays has no alternative but to incorporate social and environmental risk assessments into their plans. For those capital intensive and/or commercially viable projects seeking project financing, most international project finance institutions would request borrowers to follow the Equator Principles (Freshfields Bruckhaus Deringer, 2005) which have been adopted since June 2003 with a focus on determining, assessing and managing social and environmental risks in project financing. Understanding of such principles would help senior management to seek funding and to formulate appropriate program and project strategies in their organization.

According to “The Equator Principles”: A financial industry benchmark for determining, assessing and managing social & environmental risk in project financing (EPFI, 2006), Equator Principles Financial Institutions (EPIs) apply the principles to all new project financings globally with total project capital costs of USD 10 million or more, and across all industry sectors, in order to ensure that all projects financed by EPFI are developed in a manner that is socially responsible and reflect sound environmental practices. Although the participation of EPFI is voluntary, however, the principles have effectively been taken as standards in the project finance industry.

Appendix 1 outlines an abstract of the Equator Principles. EPIs will only provide loans to projects that conform to Principles 1 through 9 of the list. It is therefore important for organizations seeking project financing be prepared to answer questions about social and environmental issues in relation to their programs and projects. Details of the Equator Principles can be found in the EPFI publication mentioned above.

7.0 Conclusion

Canada in the past 15 years has been working towards limiting the growth of CO₂ emissions and energy use. The Canada’s Energy Outlook: The Reference Case 2006 published by Natural Resources Canada reveals that there is a risk of not achieving Kyoto Protocol target in the commitment period (2008 – 2012) and a significant part of GHG emissions is due to energy production and distribution. Power generation, transmission & distribution companies in the electricity supply industry play a crucial role in delivering environmental sustainability. Electricity market reform grounded in market competition to induce efficiency gain and technological dynamism. To reap the benefits of restructuring, organizations operating in a new paradigm shall require adopting a different management approach for strategy formulation and implementation. Project and program management processes are suitable for transformed organizations operating in a competitive environment to deliver right projects efficiently.

Project management focuses on delivering results and benefits of clear objective(s) within the constraints of scope, time, cost and quality, program management is a process suitable for operating in a turbulence environment. The ambiguity reduction learning loop and the uncertainty reduction performance loop would help the senior management to run through the iterative process of sensemaking; ideation; elaboration; choice of actions; planning; execution; and control, etc. The process is responsive to emergent situations and is therefore useful for strategy formulation.

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3 Project finance is a method of financing in which the lender considers mainly on the cash inflow of the project. The revenue is used for repayment of loan on a pre-determined schedule. This form of financing is commonly used in capital intensive project such as power station development.
Program management focuses on realization of program benefits by doing the right projects in a strategic manner (effective use of resources) rather than purely targeting on doing the projects right (efficient use of resources) as in a project management paradigm.

The concept of program management covering the contributions of VM to the process was discussed. The program life cycle which include the formulation; organization; deployment; appraisal; and dissolution phases is operating in a cyclical manner. Program will be dissolved when the program benefits are no longer in existence. The benefits, significance and the applications of program management process to those spin-off organizations in the reformed electricity market were analyzed.

In view of the fact that utility companies have long been operating in a less competitive environment before market opening, it is necessary to address the changes in culture; roles and responsibilities; as well as expectations and impacts from the perspectives of external and internal stakeholders. Recent developments in international project finance have urged organizations to follow Equator Principles in determining, assessing and managing social and environmental risks in financing their projects. Hence, Equator Principles is an important consideration in formulating program and project strategies. The above mentioned related factors will contribute to the success of program management process operating in the reformed market environment.

8.0 References


Appendix 1: The Equator Principles

Principle 1: Review and Categorization
EPFI to review and categorize potential impacts and risks of the project in accordance with the environmental and social screening criteria of the International Finance Corporation (IFC).

Principle 2: Social and Environmental Assessment
For projects of significant impacts as identified by EPFI, the borrower has to conduct social and environmental assessments and to propose mitigation and management measures relevant and appropriate to the nature and scale of the proposed project.

Principle 3: Applicable Social and Environmental Standards
For projects located in non-OECD countries or in OECD countries not designated as High-Income under the definition of World Bank Development Indicators Database, the assessment shall refer to the then applicable IFC Performance Standards and Industry Specific EHS Guidelines. It is acceptable for projects in High-Income OECD countries in compliance with local or national laws as substitution to IFC requirements.

Principle 4: Action Plan and Management System
The borrower has to prepare an Action Plan to describe and prioritize the actions needed to implement mitigation measures, corrective actions and monitoring measures on the assessed impacts and risks; also to establish a Social and Environmental Management System to ensure such actions comply with the applicable laws and regulations of the host country and IFC Performance Standards and EHS Guidelines.

Principle 5: Consultation and Disclosure
The project affected community has to be consulted in a structured and culturally appropriate manner. The borrower has to take account of and document the process and results of the consultation. For projects with adverse social or environmental impacts, disclosure should occur early in the assessment process.

Principle 6: Grievance Mechanism
The borrower has to establish a grievance mechanism as part of its management system. This will allow the borrower to receive and facilitate resolution of concerns and grievances about the project’s social and environmental performance raised by individuals or groups from among project affected communities.

Principle 7: Independent Review
An independent social or environmental expert not directly associated with the borrower will review the assessment, action plan and consultation process documentation in order to assist EPFI on due diligence and assessment of Equator Principles compliance.

Principle 8: Covenants
For projects of significant impacts as identified by EPFI, the borrower will covenant in financing documentation its compliance of: (a) all relevant host country social and environmental laws, regulations and permits; (b) action plan during the construction and operation of the project; (c) providing reports in a format and frequency acceptable to EPFI; and (d) decommissioning of facilities, where applicable and appropriate.

Principle 9: Independent Monitoring and Reporting
To ensure ongoing monitoring and reporting over the life of the loan, EPFI, on those projects of significant impacts, will require appointment of an independent social and/or environmental expert or require that the borrower retain qualified and experienced external expert to verify its monitoring information and share the same with EPFI.

Principle 10: EPFI Reporting
Each EPFI adopting the Equator Principles commits to report publicly at least annually about its Equator Principles implementation processes and experience, taking into account appropriate confidentiality considerations.
Critical Factors in Development of a Sustainable Energy System

Darin Tucker

ABSTRACT

Many reports today indicate that governments, regulators, industry and individual energy consumers acknowledge the world needs to progress toward a sustainable energy system if we expect to maintain a healthy global economy, while eradicating poverty and improving the quality of life for people in developing nations. However, for energy companies to move toward development of sustainable energy sources and new technologies, they must be able to generate acceptable investment returns and create a competitive advantage as a result. This article examines the critical factors influencing or impeding the development and deployment of a future sustainable energy system. The solutions for a successful transition to a sustainable energy future are diverse, although very much intertwined. They consist of energy conservation and greater efficiency, reducing greenhouse gas emissions, greater international cooperation and developing new government policy to promote energy investment and technological innovation in all areas of energy supply and use, including renewable energy sources. Although energy companies have a large role to play in the implementation of these solutions, it will take the combined efforts of all energy stakeholders worldwide, working together toward market-driven solutions, to ensure our future demands are met by an ample supply of sustainable and affordable energy.

Keywords: alternative, renewable, sustainable, technology, policy

As the world’s population grows and as developing nations continue to improve and expand their economies, creating a sustainable world energy supply is becoming ever more important. Sustainability demands not only new and innovative technologies; it also requires ever-increasing efficiency in our production and use of traditional energy sources. In the end, the holistic application of a broad range of more efficient traditional, emerging and renewable energy sources applied in their appropriate niches will provide a path toward sustainability. To compound matters, much of the evolving technology is still very developmental and will not be ready in the short-to-medium term. Thus, the path toward sustainability must also incorporate a fundamental understanding of pragmatic and achievable options for the short, medium and long term.

The author provides an excellent summary of the technological and policy considerations that must be addressed in order to arrive at a sustainable energy mix. The paper outlines the thinking of energy experts who must confront these issues on a daily basis, in the “real world”. This paper provides a good foundation for understanding the complexities of sustainable energy supply and how these issues may be addressed to clear a path toward sustainable development.

Joel Nodelman
Critical Factors in Development of a Sustainable Energy System

Darin Tucker

1.0 Introduction

We are living in exciting times. A global phenomenon is on the horizon - a worldwide transition to greater diversification of primary energy sources. The end-point of this transition will be a much more sustainable platform of clean, low- or no-carbon, energy. This phenomenon is currently in its infancy stage, but within the next one to two generations, the shift to a cleaner and much more diverse energy mix will be well advanced as a result of a pending break point in the economics of the world’s current energy supply and demand balance. Although the transformation from a world dominated today by non-renewable, environmentally degrading fossil fuels, to a world of clean energy will bring its share of challenges and relative short-term discomfort, the long-term rewards will significantly benefit society, business and our natural environment.

Not unlike other cyclical events, such as economic cycles, the world also experiences energy cycles. According to Tertzakian (2006), throughout history the world has experienced cyclical periods in time when energy demand has reached a feverish state causing volatile tension and a tremendous build-up of pressure on energy supply chains. These events have always been followed by a break point and a period of re-balancing that result in innovative uses of existing fuels, deployment of radical new technologies and a transition to alternative, or substitute energy sources. This sequence of events represents the energy cycle.

Since the start of the industrial age, the world has seen five cyclical events or transitions to “alternative” or substitute energy sources: wood to coal, coal to whale oil, whale oil to crude oil, crude oil to natural gas and finally, natural gas to nuclear energy (Tertzakian, 2006). In each case, there has been a break point followed by a dramatic change in primary energy sources and the way energy is used. Tertzkian (2006) provides convincing evidence that the world today is on the verge of another break point in the energy cycle.

The escalation in the volatility of energy markets and the sustained high price of oil since about 2002, coupled with insatiable demand growth from both the United States and developing countries such as India and China, are strong indicators that we are well advanced into the pressure build-up stage of the energy cycle that immediately precedes a break point. Compounding the pressure on today’s supply chains to meet demand, and fuelling sustained high energy prices, are a multitude of external forces including, geopolitical, economical, environmental, and social. Additionally, there are factors such as government policy constraints and consumer behaviours; not to mention the extreme costs and geographical challenges of accessing large volumes of new supply.
Numerous reports indicate that governments, regulators, industry and individual energy consumers acknowledge that the world needs to progress toward sustainable energy systems if we expect to maintain a healthy global economy, while eradicating poverty and improving the quality of life for people in the developing nations of our world. Population growth and gross domestic product (GDP) are the two primary drivers behind the world’s economy. The main ingredient necessary to support GDP growth is abundant and affordable energy. Therefore, future economic prosperity is tied directly to the world’s future energy platform and its sustainability. Building on this, it is highly probable the majority of global energy stakeholders would agree that if a truly sustainable worldwide economy is achievable, we should all strive together to accomplish such. In order to achieve this lofty goal, it will be imperative for the world to transition to a future that is ultimately powered by a sustainable energy system.

However, for the energy industry of today to voluntarily move toward development of sustainable energy sources and deployment of new technologies, they must have reasonable assurance they can achieve suitable investment returns and the potential for competitive advantage as a result. The ability of industry to achieve these results will be dependent on a wide variety of factors and future actions taken by governments, regulators, investors, individual energy consumers and business itself.

The objective of this article is to identify and examine the critical factors influencing or impeding the development and deployment of a future sustainable energy system. The following topics are reviewed and discussed: global energy supply and demand, security of future supply, technological innovation, climate change, investment challenges and government policy. Also discussed are the viewpoints and actions being taken today by two of the world’s leading energy companies to position themselves to meet current and future market demand for alternative energy in a profitable and competitive manner.

The critical factors selected for discussion in this article stem from previous research conducted by the World Energy Council (WEC). As the global voice for the energy industry, the WEC’s mission is “to promote the sustainable supply and use of energy for the greatest benefit of all” (WEC, 2006). In the WEC’s 2005 annual statement “Delivering Sustainability: Challenges and Opportunities for the Energy Industry,” eight focus areas were identified as key to delivering energy sustainability in the future. The WEC (2005) concludes in their statement “energy systems which meet the criteria of sustainability are achievable in a matter of decades, if vigorous action is taken in the following areas.”

1. Energy diversity and energy efficiency
2. Energy infrastructure investment and cost-reflective prices
3. Market-sensitive interventions
4. Supply reliability
5. Regional integration of energy systems
6. Market-based climate change responses
7. Technological innovation and development
8. Public understanding and trust

The critical factors discussed in this article are congruent with these key focus areas. However, the conclusions are tailored toward opportunities and challenges for energy businesses during the transition to a sustainable energy future, given their need to generate acceptable investment returns and create long-term competitive advantage.
2.0 Global Energy Supply and Demand

The topic of energy supply and demand and its future direction is currently at the forefront of futurist, financial, political and social debate (Lauzon et al, 2006). Moreover, this debate is now occurring on a global scale. The primary issues fuelling the debate are security of future energy supply and the growing concern over environmental impacts, specifically climate change, resulting from today’s predominant use of fossil fuels as our main source of supply. According to Gadonneix (2006), 80% of the world’s energy supply today is generated from fossil fuels, namely oil, natural gas and coal. Crude oil makes up the largest percentage of these three. The world currently consumes about 86 million barrels of oil per day (bpd). This equates to 60,000 barrels a minute, or 1,000 barrels per second (Tertzakian, 2006).

In recent years, worldwide demand for energy has increased dramatically. A large amount of this demand growth has been realized in the United States, but more alarming as of late has been the recent surge in energy consumption in the Asia Pacific region, specifically the developing nations of India and China. According to the International Energy Agency (IEA), China’s oil consumption alone has gone up by 1.6 million bpd over the last two years and is projected to increase by 7% a year over the next 15 years (Lauzon et al, 2006). This compares to forecasted average annual oil demand growth of 1.4% worldwide over the same period. Furthermore, according to Lauzon et al (2006), Asian economies led by China, are predicted to overtake the United States as the world’s largest energy consuming region over the next two and a half decades. This will inevitably place an unprecedented strain on future energy supply chains.

The following is a synopsis of an energy outlook to 2030 compiled in 2005 by ExxonMobil Corp. (EMC), one of the largest independent energy suppliers in the world today. EMC’s 2005 Energy Outlook incorporates the viewpoints of the IEA and the U.S. Department of Energy as well as other economic and energy experts from around the world (EMC, 2005). Future energy demand forecasts are based primarily on economic drivers such as GDP and population trends. However, the following outlook also considers aspects such as energy efficiency improvements, current and future consumption patterns, competition between fuels (e.g., potential for fuel switching) and the challenges associated with maintaining availability of supply (EMC, 2005).

The world’s population as of 2000 was about six billion people. This is expected to increase to eight billion by 2030. From 2000 to 2050, the human population is projected to grow to about 9 billion – 50% in 50 years (Gadonneix, 2006). Only about one-fifth of the world’s population today lives in developed nations, or Organization for Economic Cooperation and Development (OECD) countries. Eighty percent or 4.2 billion people live in developing nations, or non-OECD countries. Of these countries, more than half of the world’s population live in the Asia Pacific region alone. As a result, this region will have a substantial impact on energy demand growth in future years as they progress their economies and attempt to eradicate poverty. Of the two billion in population growth expected between 2000 and 2030, 1.8 billion (over 90%) will be in the developing world (EMC, 2005).

Economic output is also a primary measure of energy demand. In 2000, the world’s economic output was valued at $31.5 trillion. OECD nations, which only account for 20% of the global population, account for more than 80% of the world’s economic output as measured by GDP. Worldwide economic output is forecasted to double in size by 2030 to approximately $71 trillion (EMC, 2005). However, the fastest growth is expected to take place in developing countries. Accelerating economic expansion in the Asian region, predominantly in the nations of China and India, coupled with rapid population growth, will result in this region becoming the world’s largest energy consumer in the next 25 years (Lauzon et al, 2006).
According to EMC (2005), worldwide energy demand is projected to increase by 1.6% per year on average from about 205 million barrels per day of oil equivalent (MBDOE) in 2000 to 335 MBDOE in 2030 – more than a 50% increase overall. Of this increase, energy demand growth in OECD countries is projected to be relatively small. Non-OECD demand, driven primarily by the developing Asia Pacific nations of India, China, Indonesia and Malaysia, will provide more than two-thirds of the world’s growth in energy use by 2030 - far surpassing that of OECD nations (EMC, 2005).

Although EMC’s 2005 outlook data indicates that worldwide average annual growth in oil, natural gas, and coal consumption will remain strong at 1.4% for oil and 1.8% for both gas and coal, the most notable growth is that of wind and solar. Growth in these two renewable energy sources is forecasted to average about 11% per year. However, even with this strong projected growth, the contribution of solar and wind to the world’s total energy mix in 2030 will still only account for about 1% of overall energy use (EMC, 2005).

On the supply side, EMC (2005) estimates that global conventional oil reserves total 3.2 trillion barrels, and when combined with non-conventional resources such as oil sands; the total reaches just over four trillion barrels. The largest known oil reserves remaining in the world are located in the Middle East region where it is estimated that one trillion barrels of conventional oil remain to be tapped. In comparison, Canada’s vast oil sands in north-eastern Alberta, which are recognized by the U.S. Department of Energy as containing the second largest reserves of crude oil in the world, are currently estimated to contain approximately 200 billion barrels of producible oil (Tertzakian, 2006).

3.0 Security of Future Supply

It is well publicized today that energy is first and foremost on the minds of the world’s citizens, especially North Americans. Their concerns are driven by the recent high costs of gasoline and electricity as well as threats of supply disruption due to major geopolitical tensions (Worthington, 2006). Additionally, energy markets today are more concerned than ever, as reflected by the high-energy prices of late, with the recent conflict that’s been taking place in the Middle East and the concentration of oil supply that exists in such a vulnerable region (Tertzakian, 2006).

According to Fatih Birol (2005), Chief Economist with the IEA, the substantial share of the world’s remaining hydrocarbon reserves, which are located in the Middle East and North African (MENA) nations, contain considerable potential for meeting the world’s energy needs over the next few decades. However, there are a number of factors that may impede future production growth and much needed global supply from this region.

Aside from the well-publicized geopolitical tensions between MENA countries and major oil importing nations, and the significant uncertainties these tensions create with respect to security of supply, a predicted shortcoming in investment capital required to develop incremental production will also have profound implications on future supply volumes for consuming countries (Birol, 2005). Birol (2005) further indicates that according to the IEA, significantly more fossil fuel reserves will need to be proven in the MENA region between 2005 and 2030 in order to avoid production peaking out before the end of the period, thus stretching the need for investment capital even further. Birol (2005) concludes that financing the necessary capital investments in non-OECD countries to meet future energy supply requirements will be one of the largest challenges the energy industry will face in the coming years.
Major oil and gas consuming nations, including most OECD countries and south Asia (China and India), are currently positioned to become ever more reliant on MENA imports (Birol, 2005). According to (Tertzakian, 2006), centralizing oil dependency on one region in the world is a circumstance defined by financial investment firms as a “concentration of risk.” Energy markets today have noted this concentration of risk and have translated it into price volatility. Concentration of risk in politically unstable regions also tends to show up in return-on-investment targets that independent energy producers require in order to justify operations in these countries (Tertzakian, 2006).

Finally, it is inevitable that oil and gas production will become concentrated in fewer and fewer countries over time as reserves are depleted. This not only adds to the vulnerability of a disruption to consuming nations, but it also creates a further risk that those countries will attempt to use their dominant market share to inflate prices at some point in the future (Birol, 2005).

To summarize, as a result of the ever tightening global supply and demand balance, oil-consuming countries (net importers) must formulate policies and develop measures focused on reducing the risk of supply chain disruptions and escalating prices, as well as mitigating their consequences (Birol, 2005). Further, Birol (2005) concludes that, “Reducing dependence on oil and gas through diversification of fuels and their geographic sources and more efficient use of energy must be central to long-term [government] policies aimed at enhancing energy security.”

4.0 Technological Innovation

The recent increase in the world’s energy consumption has fuelled tremendous global economic and technological growth. However, this robust growth has simultaneously propelled the world into a pending crisis where energy demand is on the verge of outstripping supply. While technology has advanced the world’s economy and increased its reliance on fossil fuels, many global energy leaders are also touting technology as the world’s salvation to its energy dilemma (Ritch, 2006). This includes President George W. Bush, who declared in an April 2005 speech promoting his Energy Plan “Technology is this nation’s ticket to greater energy independence” (Tertzakian, 2006).

Although there is little doubt that advancements in technology over the long-term will greatly facilitate the coming transformation to a sustainable energy world, according to Tertzakian (2006), there are many technological barriers that will have to be overcome before a complete replacement, or substitution, for fossil fuel energy will be found. In support of this, almost all energy supply forecasts, whether from government, industry, or independent energy associations, indicate that a complete phasing out of fossil fuels in the next few decades is highly unlikely, primarily due to the lack of obvious substitutes for fossil fuels and the lack of infrastructure to support the distribution and use of new, or alternative fuel sources.

Many of the same reports indicate that short term solutions for bridging the energy transformation gap, such as a greater emphasis on energy conservation and efficiency, developing cleaner forms of fossil fuel energy (e.g., clean coal technology and biofuels), advancing greenhouse gas (GHG) emissions reduction technology and even expanding the use of nuclear power will be a priority during the initial stages of the upcoming energy transition period.

A fundamental impediment to development of a substitute energy system for fossil fuels is the oil and gas supply chain infrastructure that exists today (Tertzakian, 2006). This large-scale interconnected worldwide web was designed for energy production from traditional fuels including coal, oil, natural gas, hydro-power and even, as of late, uranium. New technology fuels, such as
hydrogen, and renewable power sources such as solar and wind, require not only many more years of technological advancement to improve performance and competitiveness, but also an incredible amount of capital investment in new infrastructure before they could compete as a substitute for fossil fuels. Thus, it will be many years still before these energy sources replace fossil fuels on a large scale.

Nuclear fusion is viewed by some as a potential longer-term replacement for today's energy platform, but the technology itself is still largely unproven, and even after it is commercially available, there will likely still be a long public adoption period before it makes a material contribution to the world's energy mix (Tertzakian, 2006). As a result, Tertzakian (2006) argues there are no “magic technology bullets” in the offering to replace fossil fuels any time soon and, therefore,...”we must be determined to make all...existing [energy] supply chains more efficient, while also making them cleaner and learning how to lower our demand for them.”

Therefore, although large investments in technological advancement toward renewable energies, alternative fuels such as hydrogen and biofuels, clean coal technology and even nuclear power are crucial over the longer-term, there is also a need for short- to medium-term investments in energy conservation and efficiency and mitigation of GHG emissions (i.e., CO₂ reduction) from burning of fossil fuels.

To this end, a study was recently completed by the IEA to demonstrate that by employing existing technologies in addition to those currently under development; the world could be diverted onto a much more sustainable energy path (IEA, 2006). In this study, the IEA provides scenarios that show how CO₂ emissions can be returned to their current levels by 2050, while also reducing demand for oil at the same time. In an effort to lower oil demand, the IEA study looked at technology changes aimed at generating substantial energy efficiency gains in the transport, industry, and building sectors, as well as the increased use of biofuels for road transportation. In addition, the study also examined significantly decarbonising the electricity generation industry by shifting the power-generation mix towards nuclear power, renewables, natural gas and coal using carbon capture and storage (CCS) technology (IEA, 2006).

The IEA study found that it is particularly urgent to commercialize advanced coal-fired power plants with CCS. If government and the private sector were to work together to achieve this objective, coal can continue to play a major role in the world's energy mix to 2050 at least (IEA, 2006). This will significantly reduce the costs of shifting to a more sustainable energy future in the near term, especially for developing nations, where energy demand growth will be unprecedented over the next couple of decades and coal is available in abundance.

The study determined that at least ten full-scale integrated coal-fired power plants with CCS technology are needed by 2015 for demonstration. These plants are projected to cost between US$500 million and US$1 billion each. The IEA concluded that in order for these projects to be successful, it is imperative that governments strengthen their commitment to CCS development and deployment and work in close conjunction with the private sector, in addition to involving developing nations with large coal reserves such as China in the process.

5.0 Climate Change

According to the WEC (2004), “climate change is a major environmental issue, despite remaining uncertainties about the scale of the phenomenon and the costs of abatement of emissions or of adaptation to the consequences.” As previously stated, most of the growth in energy demand over
the next few decades will still need to be met with fossil fuels, and according to many reports including, Jeroen van der Veer, Shell’s Chief Executive, “managing the CO₂ emissions from using more fossil fuels is the biggest challenge” (Shell, 2006).

Furthermore, the IEA (2006) states that currently “the world is not on course for a sustainable energy future.” Indeed, if the world’s future is in line with present trends as outlined in the IEA’s World Energy Outlook, 2005 Reference Scenario (IEA, 2006), oil demand and associated CO₂ emissions are projected to continue to grow rapidly over the next 25 years. The IEA (2006) report further indicates that when this outlook is extended beyond 2030, it appears that these disturbing trends are likely to become much worse.

Although the effects and future risks of climate change are becoming more apparent as time goes on, concentrations of CO₂ continue to increase at an alarming rate in the earth’s atmosphere. However, there is a growing consensus that CO₂ concentrations must be stabilized and significantly reduced below current levels over the next few decades if the world is to avoid economically and environmentally disastrous conditions such as rising sea levels leading to flooded coastal areas, increased loss of arable land due to desertification and more unpredictable storm events, which will pose significant threats to real estate, human life, and energy infrastructure itself.

Therefore, according to Stephens (2006), achieving the magnitude of emissions reductions required for atmospheric CO₂ stabilization to occur within a few decades seems increasingly unlikely without the use of CCS technologies. Interest and investment in CCS technologies has grown substantially over the last decade, and in particular in the past year, due to the recent escalation in oil and gas prices.

Stephens (2006) goes on to add that even if CCS is implemented on a wide-scale basis in the future, it alone will not solve the climate change dilemma. However, as society gradually shifts from today’s fossil fuel driven economy to a low-carbon alternative energy system, CCS technologies have great potential to reduce the world’s CO₂ emissions, thus allowing hydrocarbon fuels, including the possible increased use of coal, to successfully bridge the transition to a sustainable energy future.

Many reports now indicate that clean coal technology will have to play a much more important role in our future energy mix if we are to meet the predicted surge in energy demand growth from developing nations (Jaccard, 2006). However, coal emits more CO₂ per unit of energy than any other type of fossil fuel. As such, deployment of CCS will have to accompany the advancement of clean coal technology if we need to rely on sustained use of coal in a carbon-constrained future (Stephens, 2006).

As stated, Stephens (2006) indicates that CCS technology should not be considered as the only solution necessary to resolve our GHG problems. In order to enable a successful transition to a sustainable energy economy, CCS must be deployed in unison with a portfolio of other energy technology changes including: increased use of renewable energy sources; a shift to low-carbon-emitting or no-carbon-emitting fuels; reductions in other non-CO₂ greenhouse gases; enhancement of biological uptake of CO₂; and, very likely an increased use of nuclear power generation (Stephens, 2006).

However, the use of CCS technology with all oil, gas, coal and biomass fuel supply systems should be prioritized for the near future. If this technology is adopted soon, it will go a long way toward turning existing hydrocarbon supply alternatives into suitable transition options (Gieelen and Unander, 2005). Furthermore, according to the World Business Council for Sustainable Development
(WBCSD) (2006), the use of CCS technology will form a crucial bridge to development of new energy systems.

On a relatively small-scale basis, CO₂ has been captured and transported through pipelines and injected into underground geologic reservoirs for decades (Stephans, 2006). In these instances, the technology has been used for enhanced oil recovery (EOR) in oil wells with declining production. This has been practiced in west Texas for some time, but more recently CCS for EOR has also been deployed in the North Sea, Canada and Algeria.

Stephens (2006) concludes that advancing CCS technologies for use on a worldwide scale will first require increased investment in large-scale demonstration projects as well as regulatory support for private investment and early deployment. Stephens (2006) goes on to say that further advancement of CCS technology is no longer limited by technical feasibility or past safety concerns and the risk of leakage during underground storage, but rather by the lack of clear government regulations providing much needed incentives for investment.

6.0 Investment Challenges

As the world progresses toward substantial increases in energy demand over the next few decades with concurrent difficulty in accessing supply, one of the primary challenges for energy players will be how they prepare for and manage uncertainty. A large portion of the uncertainty they will encounter will consist of the amount of stability, or lack thereof, in the investment environment. According to Mattes (2006) “Unless governments and industry can build trust, work more closely together, and ensure the sanctity of markets, investment will be discouraged and the supply of cheap, clean, sustainable forms of energy will lag behind demand.”

According to Bray (2006), in the most recent world investment outlook completed in late 2005, the IEA forecasted a need for $17 trillion in global energy investment through to 2030. This equates to an annual average of around $0.55 trillion, assuming the approximately two billion people without electricity today remains the same. Obviously, still greater investment will be required if access to electricity for those currently in need is created. In comparison, capital raising efforts in the energy sector in 2003 were around $230 billion (Bray, 2006). This figure will have to increase by more than double per annum over the coming decades to meet the IEA’s forecast.

According to the WEC (2002), “more often than not, the financial requirements of energy projects are a bigger challenge than accessing the technology and know-how.” As such, the amount of investment required over the coming decades to ensure security of future energy supply must be closely monitored (Mattes, 2006). To this end, as with most other solutions currently being debated to help bridge the energy transformation gap, the large capital investments required for infrastructure expansion, delivery systems and new technology development, will not happen without long-term, transparent and well defined legislation first being developed so that industry can build business plans and run their economic models based on clear assumptions and quantifiable variables.

7.0 Government Policy

So far, the importance of developing a sustainable energy system on a global scale in the future has been identified as crucial for many reasons including the development of a sustainable worldwide economy and for the betterment of society and the environment as a whole. The importance of technology development to help us reach these goals and the large capital investment required to
fuel technological advancement have also been discussed and highlighted as instrumental in reaching the end goal.

However, by far the most critical success factor needed to support the enormous investment required in the energy industry over the next several decades is transparent, globally integrated government energy policy along with national and international regulatory reform. It is imperative that governments take expedient action to create a stable policy environment that promotes low- and no-carbon energy supply options and reduced environmental impact. As indicated by Andre Caille (2005), Chairman of the WEC, “the challenges facing the energy sector and those who depend on energy require forward-thinking, investment friendly government policies and incisive action by the energy industry – globally, regionally and locally.”

Although marked improvements to government policy are greatly needed to facilitate and expedite action by the world’s energy leaders, simultaneously, the importance cannot be understated that policy changes must allow for unencumbered operation of energy markets. According to Lauzon et al (2006), although government legislation is important for protecting environmentally sustainable growth, it must allow market fundamentals to work independently.

Energy policy advancements could help to foster sustainable energy development in many ways and in some cases it will be mandatory to success. As an example, government incentives for GHG emitters must be internationally coordinated to ensure fair and equal treatment, especially for hydrocarbon intensive industries. Without this, the IEA (2006) indicates the risk remains that industry may move their facilities to more lightly regulated regimes - thereby impeding the potential to reach much needed global GHG reduction targets.

As a result of the need for increased reliance on energy supply over the next few decades from non-OECD countries, Birol (2005) strongly recommends that consuming countries must start identifying policies and measures targeted at reducing the risk of supply disruptions and sustained higher prices. As well, the governments of these consuming nations must also give serious consideration to long-term policies that promote further diversification of their indigenous energy supplies as a means of reducing their vulnerability to supply disruptions while at the same time addressing environmental concerns (Birol, 2005).

According to Hatano (2006), one of the main barriers for renewable energy options in today’s markets is the common perception that they generate poor economics when compared to fossil fuels. This may be true in many cases, but it results from the use of traditional pricing structures that do not incorporate social and environmental costs, or other intangible externalities associated with energy production and use (Hatano, 2006). Much has been written in the literature about the challenges and benefits of accounting for social and environmental costs, but until government policy mandates that total life cycle costs be accounted for in all energy projects, the economics of environmentally non-sustainable projects will in most cases out-weigh those of more environmentally benign alternatives. As concluded by Hatano (2006), “to ensure sustainable energy development in the long-term, greater emphasis on full life-cycle costs is required.”

Impartial and transparent energy regulation on a national and international scale is also needed as a cornerstone for attracting the large private capital required to finance future exploitation of new energy reserves as well as development of infrastructure and energy delivery systems. As energy markets become more integrated worldwide, energy regulators have to become more aware of the new challenges facing industry players such as long-term planning and systems operation, trans-border infrastructure development, dispute resolution mechanisms and harmonization measures
(WEC, 2002). Regulatory institutions are the only bodies that can breakdown and remove these barriers to future energy development, thus facilitating and expediting much needed capital investment.

International authorities also need to start considering policy requirements and regulations for expediting and streamlining the diffusion of new technologies across multi-national borders. According to the WEC (2002), the opening up of worldwide energy markets, combined with their regional integration and global trade will accelerate the diffusion of new technologies, especially in developing nations. The WEC (2002) goes on to state that developing countries need this...“to address the goals of commercial energy access, the quality and continuity of energy supplies and the environmental acceptability of energy production, distribution and use.” Along with the future need for improved sharing of new technological developments, there is also the associated issue of protecting intellectual property rights where governmental institutions must also play a significant role.

In an interview of energy executives conducted by Korn/Ferry International (Lauzon et al, 2006) under commission to the WEC, government legislation was considered to be an important tool in protecting the environment; ensuring sustainable development and influencing efficient energy use, but only if it remains grounded in reality. Although the executives interviewed concurred that emissions reductions and the development of alternative fuels are key priorities, they also agreed that hydrocarbons will continue to play a dominant role in the energy supply mix for some time to come, and legislation that impedes investment in this area by promoting incentives for renewable energy, will lead to ever increasing price volatility in traditional energy markets. This predicament will not help to stabilize the investment environment required to support expanded fossil fuel production, which will continue to supply the lion’s share (approximately 90%) of the world’s energy demand for at least the next 20-30 years (Lauzon et al, 2006).

The global executive panel were also in unanimous agreement that it will be the end-users, or energy consumers, most of who are voters, that will influence the form of future legislation (Lauzon et al, 2006). Consumer lobbying of government legislative change will, for the most part, be driven by future energy prices. However, to-date, consumers have been relatively accepting of recent fuel price increases – that is, demand has not been noticeably curbed by escalating price. A more rapid transition from high priced fossil fuels to alternative energy sources including renewable energy solutions could have been expected in recent times. But, much to the misfortune of many fuel cell technology firms, car manufacturer’s hybrid-sales projections and wind power suppliers, this has not happened (Lauzon et al, 2006).

The question remaining is – for how long will society tolerate sustained high energy prices before they lobby for legislative changes? One energy executive indicated that consumers will continue to accept price increases, and will be reluctant to change their behaviour, until high energy prices start affecting their overall purchasing power (Lauzon et al, 2006). The executive panel agreed that renewable energy strategies should be pursued to offset a potential price spike that could not be sustained over the medium- to long-term by consumers. Although most of the executives agreed that their corporations should invest more in alternative fuel sources, they also believe that more should be done to educate consumers about the benefits of conservation and efficient energy use. Finally, the panel concurred that today’s supply and demand balance is very narrow, which provides further justification for a sharpened government focus on renewable and sustainable energy policy. (Lauzon et al, 2006).
According to Birol (2005), the uncertainty that exists today in the outlook for global energy markets has almost never been greater. He goes on to say, however, that one thing is certain; the rate of growth in primary energy consumption, and the mix in fuels of choice in the future will depend on what action governments ultimately decide to take to curb fossil fuel demand and associated GHG emissions and on developments in energy technology.

In summary, the policies of energy producing and consuming countries will change over time in response to each other, to market developments and to shifts in market power (Birol, 2005). According to (Birol, 2005), there is a strong case to be made right now for “improving market transparency, for more effective mechanisms for exchanging information between oil producers and consumers, and for more profound dialogue between them.” The key message delivered by both the IEA (Birol, 2005) and the WEC (Gadonneix, 2006) is that governments and industry players alike need to take action. Solutions have been identified and discussed – it is now time to act.

8.0 Market Demand for Alternative Energy – Case Studies

There are many companies both large and small that recognize the growing market niche for alternative energy supply today. They also have realized the competitive advantage to be gained through early exploitation of renewable energy sources and low-carbon technologies. However, as stated earlier, large amounts of capital are required to develop and deploy new technologies and alternative fuel sources and not all companies have the capacity to do this. Two companies that do are BP and the Royal Dutch Shell Group. Both are world leaders in alternative energy development.

**British Petroleum (BP)**

Lord John Browne, CEO of BP, believes the purpose of business is to be a part of society and to satisfy society’s needs (Browne, 2006). BP (2006) indicates that society and the world currently demand solutions to two urgent challenges: security of energy supply and the environmental impact of energy use. They go on to state that these issues in conjunction with advances in technology and the strong likelihood that carbon will soon be assigned a market price have convinced them that markets for cleaner energy will emerge before long (BP, 2006).

In preparation, BP launched a new line-of-business (LOB) in November 2005 called BP Alternative Energy, which plans to invest $8 billion over 10 years in low carbon alternative power. BP intends to lead the market in generating power from the sun, wind, hydrogen and natural gas - in short they are intent on exploring new ways to live without oil (BP, 2006). Over the next decade, starting in 2006, BP plans to grow their alternative energy LOB five to ten times over, which they project will reduce GHG emissions by 24 million tonnes by 2015 and generate a profitable, high growth, global LOB for the company.

BP is already one of the world’s top solar power companies. Their solar business became profitable in 2004 after 30 years of growth. In 2005, BP manufactured and installed 100 MW of solar power worldwide and they are now focused on increasing that capacity to 300 MW by 2008 (BP, 2006).

Wind is one of the most rapidly expanding sources of low-carbon power in the world - about 20% per year over the last five years (BP, 2006). BP estimates that if 10% of the world’s power were derived from wind, it would reduce CO₂ emissions by one billion tonnes a year. Therefore, wind power has the potential to make a notable contribution toward controlling climate change. BP Alternative Energy intends to penetrate the wind power business on a large scale growing their existing wind
business from 30 MW in 2005 to 450 MW by 2008 (BP, 2006). By 2015, they plan to be a major player in wind power.

In 2005, BP Alternative Energy accelerated their plans to generate power from hydrogen. Their plans are to extract hydrogen from coal, oil or natural gas to generate electricity while capturing the majority of the CO₂ and injecting it underground for enhanced oil recovery (BP, 2006). BP estimates that if only 5% of the world’s new electricity capacity required by 2030 was generated from hydrogen; it would decrease CO₂ emissions by over 500 million tonnes a year. This would be equivalent to removing more than 100 million cars from the world’s roads and highways.

BP is already well positioned to expand on its existing base of natural gas-fired power generation capacity. BP currently produces enough gas-powered electricity to supply 10 million homes. Natural gas is the lowest CO₂ emitting hydrocarbon. As such, gas is viewed by many, including BP, as the ‘bridge’ to the low-carbon economy of the future. Gas will play a critical role in making an early and substantial contribution to stabilizing GHG emissions. Within the next three years, BP Alternative Energy plans to advance development and initiate construction of new gas-fired co-generation facilities totalling more than 700 MW in power output (BP, 2006).

BP is also conducting research toward a new generation of advanced biofuels. These new biofuels are projected to have a much greater potential for reducing emissions and improving performance over conventional biofuels. BP believes that improved biofuel technology is required if these fuels are to make a major contribution to the transport fuel mix of the future (BP, 2006).

Indicators suggest that BP is well on track toward creating a profitable and sustainable alternative energy business. Tony Hayward, Chief Executive of Exploration and Production at BP (Hayward, 2006), indicated that BP believes…”sustainability means enduring as a business and creating shareholder value into the long term.” Mr. Hayward went on to say in his concluding remarks that “Our sustainability as businesses will in large part depend on the contribution that we make to the world’s sustainability.”

Further, Lord John Browne of BP previously stated during a speech in 2002 at Stanford University on the topic of reinventing the energy business…“leadership is what people expect from big companies...[they] expect a company like BP to offer answers and not excuses.” He went on to conclude that reinventing the energy business to address the long-term needs of the world and its people... “is the route to creating a sustainable, profitable business” (BP, 2002).

Clearly, BP is taking action to position itself at the leading edge of the transition to a sustainable energy system. In May 2006, BP announced “Over the next three years, BP Alternative Energy plans to increase the sales of solar products threefold, start construction of two of the world’s first industrial-scale hydrogen power plants, build new gas-fired power co-generation capacity and develop a significant wind power business. We believe that solar, wind, hydrogen power and gas-fired power technologies have reached the tipping point and [BP] can create a profitable, high-growth, global business in the course of the next decade” (BP, 2006).

**Royal Dutch Shell Group (Shell)**

In February 2006, Shell’s CEO, Jeroen van der Veer, announced that the company was revamping its alternative energy strategy in order to focus on four promising technologies – biofuel and hydrogen for transport, and wind and thin-film solar for electricity (Shell, 2006). Shell (2006) indicates they plan to turn one of these technologies into a substantive future business. As of early 2006, Shell’s
investment in alternative energies totalled more than US$1 billion since 1997. This has positioned them as one of the world’s leading organizations in the alternative energy sector.

Shell is already the world’s largest marketer of biofuels, as well as a leading developer of biofuel technologies. Despite their market position, Shell is actively planning to grow their presence as the largest marketer and distributor of biofuels by partnering with Iogen of Canada to produce cellulose ethanol from plant waste (Shell, 2006). The biofuel produced from the logen process can be burned in today’s internal combustion car engines, while reducing CO₂ lifecycle emissions by 90% compared with conventional fossil fuels.

Shell also announced in early 2006 that they were opening two new hydrogen filling stations in the United States in their effort to demonstrate the long-term viability of a hydrogen economy (Shell, 2006). They opened their first hydrogen filling station in Washington DC in 2004 and as of late 2006 they have installed hydrogen filling stations in five countries. It is estimated by the IEA that hydrogen will be fuelling up to 700 million vehicles by 2050 (Shell, 2006). However, long before then, Shell’s intention is to make hydrogen fuel pumps just as common as gas and diesel are today (Shell, 2006).

Wind is well recognized as one of the most promising sources of renewable energy in the world today. In the United States, Shell is already one of the largest wind energy developers. Shell plans to increase their wind energy capacity from 350 MW in 2006 to 500 MW in 2007 (Shell, 2006). Shell is also making progress with the development of a 1,000 MW offshore wind farm in the United Kingdom, which will provide about 25% of London’s electricity once completed. As of 2006, this project is one of the world’s largest planned wind farms.

Shell is also very active in solar energy. In early 2006, Shell committed to divest of their crystalline silicon solar business and move straight into next generation CIS (copper indium diselenide) ‘thin-film’ technologies. Shell is convinced that CIS technology will be able to achieve cost competitiveness with retail electricity on a faster timescale than silicon (Shell, 2006). In February 2006, Shell signed a Memorandum of Understanding with Saint-Gobain, one of the world’s leading producers of glass and other building materials, to investigate further development opportunities for next generation CIS technology.

Shell Renewables was established in 1997 and forms one of their five core businesses. Today, Shell has the broadest alternative energy portfolio of any major energy company in the world (Shell, 2006). They claim to be the...“first petrochemicals company to significantly commit to a new energy future” (Shell, 2006). This commitment consisted of US$1 billion in spending from 1997 through 2005 on alternative energy research and development. The company has been serving the energy needs of society and business for over a century and according to Shell, “[they] fully intend to be a leading player in energy a hundred years from now” (Shell, 2006).

Shell is convinced that concerns over climate change, coupled with the need for secure energy supply in the future, mean that today’s fossil fuel based energy chain must become progressively decarbonised as we move forward in the 21st century. In the words of their Chief Executive, Jeroen van der Veer, “I see the potential to develop ways of using fossil fuels so that increasingly the CO₂ produced is captured, stored or used productively...If we can make that work, both technically and financially, we would be on the way to something really big and exciting.” Shell further indicates that they believe renewables will become an important part of the energy mix of the future and they...“intend to create a significant business in this sector, making the most of the opportunities which this trend will bring” (Shell, 2006).
9.0 Concluding Remarks

There are many reports that indicate the world is not running out of oil anytime soon, but there is a general consensus rapidly forming that we are running out of large reservoirs of easily accessible, low cost oil. According to EMC’s 2005 energy outlook, there are over four trillion barrels remaining in the world. However, a large majority of these reserves are either technically challenging to access (e.g., deep sea waters), contained within politically unstable regions (e.g., MENA), or very costly to produce (e.g., Canada’s oil sands). As such, it is very important that we keep all supply options open for the foreseeable future and that we work diligently towards developing new technologies and new energy sources.

Compounding the future challenges of finding and proving additional fossil fuel supply, global energy demand is simultaneously entering an unprecedented growth stage. In addition to forecasted growth in demand from OECD nations, consumption in non-OECD countries like India and China is going to pose a serious hurdle for energy suppliers to meet in the coming years. Not only is China’s economy growing at a supercritical speed, but also China and India are both highly dependent on oil to feed their economic growth. Indeed, they have the highest oil dependency factors of all nations in the world (Tertzakian, 2006).

Basic economics indicate that in a world of high demand growth, combined with significant supply constraints, the result is going to be high prices. As such, all evidence suggests that sustained high energy prices and price volatility are going to become the norm, rather than not. However, it is important to note that the future will hold relatively short periods of economic downturn, which will temporarily deflate energy prices. During these periods, it will appear to many that the energy crunch is over and the looming break point in the energy cycle has been averted. But, according to Tertzakian (2006), these periods of compressed economics will be short-lived and energy prices will remain very sensitive to any increase in pressure on the supply-demand balance. Worldwide spare capacity of oil is extremely thin, with no foreseeable opportunity for change, thus any world event such as a disastrous hurricane or political turmoil between energy exporting countries and consuming nations will quickly override depressed economics and energy prices will immediately spike back up to historical highs.

As a result, changes in our energy supply and use are on the not-to-distant horizon. According to Tertzakian (2006), the elevated and increasingly volatile energy prices of today are a sure sign of looming change ahead. Tertzakian (2006) further indicates that the world is... “on the cusp of a break point that will change the way governments, corporations, and individuals exploit and consume primary energy resources, especially crude oil.”

As global energy demand continues to grow almost virtually unimpeded, and proven reserves of new fossil fuel supply become more difficult and expensive to replace, the markets will react, and price will continue to escalate. Add to this scenario, unstable geopolitical relations in major hydrocarbon supply regions, a lack of government policy to manage long-term energy challenges, a projected shortfall in required investment capital plus social and environmental concerns, such as the threat of climate change, and it becomes much more evident that an energy pressure bubble is forming.

Tertzakian (2006) sums up the current global energy dilemma by saying “As the pressure builds, we will soon wake up to the realization that the age of cheap, clean, easy-to-obtain energy is rapidly coming to an end.” He goes on to suggest that if further calamities occur in the future, either natural or political, the pressure points on the energy bubble will be significantly exacerbated, bringing us to the tipping point for oil – or what he terms the “break point.”
Tertzakian (2006) uses historical evidence from past transitional periods in the energy cycle, or break points in primary energy supply, to predict the next energy transition. However, he notes that break points should not necessarily be viewed negatively. Although painful choices have to be made when a break point is approaching, Tertzakian (2006) indicates, “wholesale change [in energy platforms] has historically improved our social conditions and created great opportunities for wealth and economic growth.” He points out that in the transitional era after a break point... “lifestyles change, businesses are born, and fortunes are made.”

Change notoriously brings opportunity for business – indeed many have made their fortunes in the past during times of radical change - John D. Rockefeller and Bill Gates are good examples, amongst others. As alluded to earlier, the energy businesses of the future that prove to be the most effective at managing change and uncertainty will most likely determine the winners from the losers.

The solutions to the world’s pending energy problem are diverse, although very much intertwined. Among many things, they consist of energy conservation and greater efficiency, reducing GHG emissions, greater international cooperation and developing new government policy to promote energy investment and technological innovations in all areas of energy management including renewable energy supply. As indicated by Gadonneix (2006), the world is facing a new situation; the days when we could live off our past investments and supply our needs with relatively cheap energy, are over. Gadonneix (2006) concludes, “An age of energy shortage, of precious energy, and of enormous investment in energy awaits us.”

While energy industry leaders like Shell and BP have already started positioning themselves for longer-term competitive advantage in the new world of sustainable energy, there will also be plenty of business opportunity for large and small alike during and immediately following the next energy break point. In the words of Tertzakian (2006), although economies of scale are important in energy development, it will not only be energy giants that will thrive in the new energy economy, many fortunes will be made by smaller players who become early adopters and recognize that opportunities abound in a rapidly changing new game.

According to Tertzakian (2006), the first two decades of this century will become known in history as the dawn of a new energy era. This era will consist of a concentrated focus on energy conservation, efficiency and development of cleaner fuels for bridging the gap to a sustainable energy future. Although this will create opportunities, there will also be plenty of challenges, and it will take the combined efforts of all energy stakeholders worldwide, working together toward market-driven solutions, to ensure our future demands are met by an ample supply of sustainable and affordable energy.

10.0 References


   http://www.bp.com/home.do?categoryId=1


ABSTRACT

Renewable energy technologies are the solutions of the future. However, climate change, global warming, rising energy prices and demand are urgent problems of the present. Without dependable, cost-effective and widely-available GHG-free technologies, how are we to solve these energy issues in the near term?

Energy conservation is being heralded a viable transitional energy solution, a bridge between the carbon and renewable age. The benefits are many: it can be done immediately with existing technologies, it buys time and it works. Efficiency efficient technologies, coupled with wise management practices, can help to preserve the existing fossil fuel resource for future generations, enable a company meet its Kyoto targets and save it money, until full scale adoption of renewable energy becomes feasible.

This paper examines what is being done to increase energy efficiency and conservation in Canadian organizations of varying sizes in the industrial, institutional and commercial (IC&I) sectors. What technological innovations are they using and what management practices are they applying? How are measures like energy retrofits, equipment upgrades, waste management practices, on site co-generation, process integration and re-design, fleet and logistics management, energy measurement and energy awareness initiatives helping these organizations to reduce emissions, save money and increase productivity? How are these projects funded and what ancillary co-benefits are these organizations gaining from their conservation efforts? Finally, what can they teach other organizations?

Key words: conservation, incentives, management, innovation, integration and efficiency

Energy conservation is the first thing that comes to mind when all other variables are fixed and there is pressure to lower energy costs. As often said, a unit of energy saved, is a unit of energy generated.

Yet conservation does not get as much attention as other solutions that are long-term measures and require a significant amount of investment. Conservation can be applied immediately and its benefits can be felt right away.

This chapter discusses some cases of Canadian organizations that have adopted energy conservation and outlines their financial and environmental successes.

The author argues, with the help of these case studies, that conservation helps reduce emissions and has a cost advantage over construction of new power generation units to meet increasing demand. The author suggests that without addressing demand side consumption, there is little hope of solving energy challenges in the future.

Anshuman Khare
1.0 What’s Good About Fossil Fuel?

The disadvantages of fossil fuels read as a litany of liabilities: they are polluting, costly and finite. All aspects of fossil fuel—exploration, extraction, refining, transportation and combustion—have environmental, economic and social impacts. Adding to the liability list is the fact that the oil and gas industries receive subsidies of approximately $1.4 billion per year from the federal government (Taylor et al. 2005). This has kept oil and gas prices artificially low for many years and consumers unaware of the true cost of energy. It is hardly surprising that Canadians are among the highest per capita consumers of fossil fuel and producers of greenhouse gas emissions.

Today, we are advised to cut down on fossil fuel use for two main reasons: one is global warming, believed to be caused by emissions from burning fossil fuel; the other is the alleged dwindling global oil and gas supply, which has caused fossil fuel prices to rise.

While Canada has enjoyed vast oil and gas reserves in the past, it is not immune to the supply threat. The warnings come not only from zealous environmentalists, but the oil and gas industry itself. For example, in early 2005, EnCan’a’s then Executive Vice-President of Corporate Development, Brian Ferguson, was quoted in The Globe and Mail, in an article by Richard Bloom (2005), as saying that at current rates of production, Canadian natural gas reserves would last less than ten years and that conventional fields were at their ‘tipping point.’

For Ontario the forecast is particularly troubling. According to a Report of the Electricity and Conservation Supply Task Force (2004), power demand is expected to rise from 24,000 megawatts as of 2004 to more than 30,000 megawatts by 2020 owing to increases in population and industrial activity. At the same time, about half the province’s generating capacity is in decline: a number of gas powered and wind powered projects have been put on hold, all nuclear plants will reach the end of their planned operating lives before 2020 and will need to be replaced, refurbished or retired, and many of the province’s substantial coal-fired generating assets, which account for 26% generating capacity, are slated to be shut down.

In response, the Ontario government announced plans in early 2006 to build additional capacity to its existing nuclear reactors and possibly build more reactors. This has raised alarm among environmentalists, some politicians and local residents. While non-GHG emitting and potentially infinite, nuclear power comes with a high price tag, lengthy time lines to build and a history of technical problems. Nuclear energy also presents significant public health and safety issues: how to dispose of nuclear waste safely and protect against radioactive leaks, accidents or terrorist attacks.
Advocates of clean energy suggest moving exclusively to alternatives like solar and wind, which ostensibly offer unlimited, clean and emission-free power. But these are not without technical, commercial and even environmental limitations. Many renewables are characterized as intermittent, of low energy density and inconvenient location or requiring dedicated facilities for energy concentration, storage and transmission, which can have significant environmental and human impacts (Jaccard, 2005).

Nor are alternatives without controversy, as some of the negative publicity around wind farms can attest. With their tendency to be noisy, deadly to birds and aesthetically unappealing, wind farms tend to suffer from the ‘not in my backyard syndrome’ or NIMBY syndrome. One example currently receiving wide press coverage involves Senator Ted Kennedy (a self-professed supporter of alternative energy) who is leading a protest against a proposed wind farm wind farm in Nantucket Sound, Massachusetts, that could provide three quarters of the Cape and Islands’ energy needs. While Kennedy maintains his opposition is based on environmental and navigational concerns, others allege that Kennedy, who has ocean-front property in the area, does not want an unsightly and noisy power plant near his home.

It appears we are still far away from getting large-scale renewables off the ground; however, using fossil fuels as we have in the past will not solve our climate change or supply problems. What is the answer? To many the solution lies in a third way—energy conservation—which, ironically, includes the fossil fuels.

For all their shortcomings fossil fuels have distinct advantages over present-day renewables: they are proven, reliable and less expensive than many alternative power sources. Furthermore, the technological advancements of the 20th and 21st centuries enable fossil fuels to be used more efficiently, cost-effectively and with fewer emissions. These technologies can be used to complement existing renewable technologies, non-fossil sources of energy and/or combined with astute energy management practices for further energy savings.

Just how effective are existing energy efficiency and conservation technologies? The World Energy Assessment estimates that industrialized countries could achieve cost-effective energy gains of 25-35% over the next twenty years from energy efficiency technologies and practices. Joseph Romm (1999) suggests that companies can reduce energy use by around 50%. In the residential and commercial sectors alone, Paul Hawken (1997) submits that energy savings of up to 90% can be achieved by using technology astutely.

These are disparate numbers, to be sure, but the question is perhaps best addressed by examining real world examples. The following seven case studies are a representative sample of what is being done in the Canadian organizations within the industrial, commercial and institutional (IC&I) sectors that have voluntarily undertaken energy conservation initiatives within their facilities. I include both small to mid-sized (SME) and large organizations.

One of the key motivators driving organizations to invest in energy efficiency is cost. Rising energy prices make it imperative that energy be strategically managed, regardless of sector. But as the following examples will show, the benefits of energy efficiency and conservation are not restricted to diminished fuel consumption, reduced emissions and saved money. Energy efficiency can be a catalyst to improved overall organizational performance and productivity gains. These will be described and discussed with the case study presentations.
Before proceeding, a few words about the federal government’s key initiative towards energy conservation are in order. In 1998, the federal liberals established, through Natural Resources Canada (NRCan) the Office of Energy Efficiency (OEE). The OEE’s mandate was to promote energy conservation and efficiency within the residential, commercial, industrial, institutional and transportation sectors. Since that time, the OEE has functioned as a resource, offering information, financial assistance, publications, training and tools for eligible organizations that wished to undertake projects. Approximately 1,000 Canadian organization have participated in these programs including the following four case studies that I will present here: Hbc, Famz Foods, Maple Leaf Foods and London Health Science Centre. The energy conservation initiatives described in the Gerdau Ameristeel Corporation, Interface Flooring Systems (Canada) Inc. and The Beer Store case studies were undertaken without government funding assistance.

Finally, since several of the following case studies have many initiatives in common, I will avoid repetition by concentrating on the areas of energy conservation that are unique or innovative to that particular organization. These cases have been prepared using corporate data and interviews with senior officials.

Famz Foods

Famz Foods operates 10 Swiss Chalet restaurants and two Harvey’s fast food establishments in southwestern Ontario. In the late 1990’s, utilities had become the company’s fastest rising operating cost, as it had for the rest of the food industry. Offsetting these costs through shutting down equipment or raising food prices was not an option; therefore, the restaurant chain needed to find alternate forms of conversion. A chance citing of an NRCan Energy Innovators Initiative in a hospitality magazine by the company’s vice-president in 1999 prompted the food chain to apply for funding and take action.

Prior to joining NRCan, the Famz’ energy intensity was below industry average (7.01 GJ/m² compared to 9.80 GJ/m²), and the company had implemented a number of energy conservation initiatives of its own, albeit in an ad hoc fashion and without any measuring or tracking mechanisms. By 2000, one year after joining EII, Famz had a formal action plan and began implementing a pilot retrofit to one of its London Swiss Chalet restaurants, consisting of upgrades to lighting, refrigeration, controls and heating, ventilation and air conditioning (HVAC). To develop and implement the plan, Famz worked with an energy consultant, a strategy that helped the company avoid costly mistakes as well as develop appropriate procedures, guidelines and tracking systems around its energy management. In addition, working with an expert made Famz eligible for insurance coverage in case it failed to realize the expected savings from the program.

Famz achieved its targeted energy savings on the first project and has since undertaken similar retrofits at a few more of its restaurants, and each establishment has undergone a complete lighting retrofit. Energy consumption has been reduced by 5 to 10% across all restaurants, and the return on investment (ROI) has been positive despite the fact that utility costs (hydro and gas) continue to rise

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1 This section draws on information and data from the Energy Innovators Case Study (NRCan, 2003) and interview with the Vice-President, Famz Foods Ltd.

2 The Energy Innovator’s Initiative (now called the EnerGuide for Existing Buildings) is an NRCan Office of Energy Efficiency initiative to assist commercial and institutional buildings in becoming more energy efficient. See http://oee.nrcan.gc.ca/commercial/existing.cfm.
across the industry. Since 2000, Famz’ utility costs have risen by 60% compared with the industry average of 100%.

When purchasing new equipment, life cycle costs are factored in: management weighs higher up-front costs to investing in energy efficient machinery against the longer-term payoffs. For instance, Famz replaced its deep fryers with high efficiency gas fryers, which cost more than twice the price of conventional deep fryers but have a lifetime guarantee, a 2-3 year payback period, use less gas to stay hot and require fewer service calls. Another example was the purchase two new rooftop HVAC units for a Swiss Chalet in London, which cost $3,500 more than the standard unit but generate enough energy savings to capture those costs within 6.7 years and come with 20-year life expectancy.

Apart from investing in technology and equipment, Famz has undertaken training and awareness initiatives with its employees. A mix of workshops, written communications posted on bulletin boards, newsletters and incentives are used to deliver the message that energy conservation is a shared responsibility. It is as crucial to the company’s competitiveness and broader duty as a good corporate citizen as it is every individual’s responsibility to lessen his/her environmental footprint. Employees are also taught about the shared benefits to be had through energy conservation and how examples from the commercial/retail sector can be translated to the home. For instance, running only half the lighting at a Swiss Chalet dining lounge on a bright day can also lower the room temperature by a few degrees, putting less stress on the air conditioning system and saving electricity costs. The same principle can be applied in a household with similar benefits achieved.

The company’s training and awareness efforts appear to have sparked a shift in employee attitudes towards energy. Energy conservation is now factored into the daily routines and start-up checklists. Staff are also seeing the bigger picture and suggesting practical, common-sense ideas of their own for further reducing energy. Some of small-scale initiatives and innovations include:

- Turning off unnecessary lighting on bright days.
- Changing an incandescent light bulb from 40 or 60 watts to 30 watts or removing a fixture altogether if not really needed.
- Installing timers on lights and air exhaust fans in staff washrooms.
- Replacing small side-stand refrigerators, where servers kept cream, milk and butter (so that they can quickly stock tables at the Swiss Chalet restaurants) with thermal units that go in the main freezer overnight, then stay cold at the side stand during the day. This saves $2,790 in electricity costs per year.

Famz sees the August 2003 Blackout as a turning point in changing customer attitudes towards energy conservation. Prior to the Blackout, Famz’ efforts to reduce unnecessary lighting on bright days were met with mixed responses from customers. Many would ask whether the restaurant was closed or going out of business. Today, as a result of increased government and media awareness campaigns post-Blackout, many of the large retailers such as Costco, The Beer Store and A&P shut down unnecessary lighting. Famz continues this practice as well and reports that customers now commend the company for its conservation efforts.

Famz’ challenge is to keep rising energy prices at bay while continuing to serve food at competitive prices. In keeping with this objective, Famz continues to examine new and innovative energy technologies. Currently, the restaurant chain is testing cyclone fans at its St. Thomas Swiss Chalet restaurant. The fans, which use very little hydro, can reduce the load on the restaurant’s rooftop HVAC unit from the 12 tons to 7, thereby reducing energy intensity, costs and emissions. The fans also
maintain comfortable temperature levels inside the restaurant, keeping cooler air at ground level during hot weather, and bringing warm air from the ceiling down to floor level during cold weather.

With all of the preceding energy saving initiatives, Famz has reached its energy reduction target of 5.61 GJ/m² (gigajoules per square meter).³

**Hudsons Bay Company (Hbc)**

Established in 1670, Hbc (Hudsons Bay Company) is Canada’s oldest diversified general merchandise retailer, operating more than 500 stores across the country, including The Bay, Zellers, Home Outfitters, Designer Depot and Fields. The Hbc energy saving story starts in 1999, when the then-head of facility management for the Zellers division stores pointed out to senior management that the company could avoid substantial costs by improving its energy efficiency.

What started as a modest pilot retrofit project the same year has become as of 2006 a company wide strategy, enabling the retailer to avoid an average of 10 per cent of energy costs over the period 2000-2005 and reduce emissions intensity by 13%. The energy conservation mandate has also resulted in ancillary benefits: better temperature controls and air quality, improved staff morale, retention and productivity and increased customer satisfaction and loyalty.

As of 2006, the majority of Hbc stores have been retrofitted, and building automation systems (BAS) are planned for all stores by 2007.⁵ Energy consumption is measured and analyzed at the end of each month. The top 10 energy consumers are put on a remedial plan.

Individual stores are directed to reduce energy use by 30 per cent through simple activities such as turning off lights, adjusting store temperatures and adjusting other electrical equipment. In stores that are BAS-equipped, these adjustments are made remotely; in all other stores, a colour alert program through the Intranet advises stores to power down.

New buildings are built according to high energy efficiency standards, meeting or exceeding Commercial Building Incentive Program (CBIP) standards. At one existing building, design changes were made, incorporating skylights to take better advantage of natural light and light dimming systems for analysis purposes.

Further efforts to integrate energy conservation are made through the supply chain and fleet management. The company purchases climate neutral carpeting from Interface Inc.,⁶ designates 40 percent of its appliance business to consist of Energy Star products and has increased its use of rail

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³ 1 Gigajoule = 277.8 kWh.

⁴ The information and data cited in this section are taken from Hbc’s Corporate Social Responsibility Report (Hbc, 2005), Energy Innovator’s Case Study (NRCan, 2003a) and interview with Senior Manager, Energy, Environment, Hudsons Bay Company.

⁵ BAS is a web-based technology which monitors and reports on daily energy consumption, enabling the company to monitor and track its energy performance.

⁶ Interface Inc. is a U.S. carpeting and flooring manufacturer known for its sustainability practices. Its climate neutral carpeting is produced without any net GHG emissions. In 2005, Hbc’s carpet purchases resulted in 77 tons of GHG emission credits. A more detailed discussion on climate neutral carpeting can be found in the book, *Natural Capitalism* (Hawken et al.; pp. 140-1).
transport for shipment of goods to 75 million kilometers annually (70% of its totally transport kilometers from 2002-2005). All of Hbc’s 18-wheeler trucks that once drove the Toronto/Montreal route have been taken out of service and replaced by rail.

There are, however, times truck transport is the only option. While energy efficiency is a consideration here, it is not always easy to achieve. For example, the company had to make a tradeoff between energy efficiency and emissions reductions when it required all newly manufactured trucks as of 2003 to have gas re-circulation engines. While these engines produce fewer airborne particulate emissions, they are also less fuel-efficient. Hbc attempts to recover these lost efficiencies elsewhere within the truck fleet: ensuring that all equipment is properly maintained, finding the most efficient truck routes with global positioning technology (GPS), reducing transportation distances by maximizing regional distribution systems and local suppliers, using tandem trailers (where permissible)—one truck pulling two trailers—during the warmer months (April to November) and reducing idling time.

The company’s Queen Street Bay Store and head office tower in Toronto is using a cooling technology called deep lake water cooling (DLWC), supplied by Enwave Energy Corporation. The system draws cold water from the bottom of Lake Ontario (where the temperature remains a constant 4 degrees C year round) through three intake pipes located 5 kilometers offshore at a depth of 83 meters. The water is first treated at the Toronto Island Filtration Plant and then sent through a cross-harbour rock tunnel to the John Street Pumping Station (JSPS). There an energy transfer between the ice-cold lake water and the Enwave chilled water supply loop takes place, via a system of 36 stainless steel, plate and frame heat exchangers. Once the energy transfer is complete, the lake water proceeds to its final destination as part of the City’s potable water system, while the Enwave system is used to cool a separate, self-contained water supply loop that is connected to the air conditioning of 27 Toronto buildings, including the Air Canada Centre, the TD Centre, Metro Convention Centre and several high rise office towers in the financial core. Because the system uses the coldness from the lake water, as opposed to the water itself, there is no wastewater or thermal discharge into the lake.7

The energy savings and environmental benefits of the system are numerous. Concerning Hbc specifically, the downtown office tower has been able to shut down all of its high energy consuming chillers (refrigeration/mechanical air conditioning systems), reducing electricity usage (and associated expenses) by 90% and freeing up more than 61 megawatts of power from Ontario’s electrical grid. Water consumption is reduced by 22 million liters (5 million gallons) per year because the rooftop cooling tower unit is no longer needed, and 79,000 tons of carbon dioxide emissions as well as ozone depleting refrigerants like CFCs have been eliminated.

How did Hbc achieve such a comprehensive and integrated energy conservation strategy within such a short time? Getting the buy-end from both senior management as well as the rest of the staff was key. To do this, the energy manager appealed to each group’s main concerns and how energy conservation could address them. With senior management, the emphasis was on the business benefits (cost savings, enhanced image and improved efficiencies), with the environmental benefits presented as secondary; with the staff, the opposite approach was used, emphasizing the environmental benefits over the financial. The reason? As the energy manager pointed out, staff members are not directly affected by the company’s financial situation in the same way that senior management are (they

7 Not all deep lake water cooling systems operate without discharging back into the lake. A similar system used to cool buildings at Cornell University and a nearby high school in Ithaca, New York, pumps warmed water into the shallower parts of Cayuga Lake, raising concerns about the effect on aquatic life (Smith, 2004).
receive their paycheck regardless). However, they are affected by pollution, climate change and power supply shortages.

Following the initial buy-in, energy awareness was first diffused among the store managers at each of the 24 districts through a series of road shows. Since then, a series of culture building and knowledge sharing initiatives have been developed: monthly employee newsletters, offering energy saving tips both at home at work, a report called Protecting Our Future to all regional, district and store managers, financial incentives offered to district store associates who achieve the highest year-over-year improvement on energy efficiency and monthly quizzes that associates can complete to win Hbc points. Externally, the company communicates the benefits of energy conservation to customers through signs posted at store entrances, flyer ads and partnering with utility distributors.

London Health Sciences Centre

London’s (Ontario) hospitals have a strategic partnership that was formed in 2000 between the city’s two primary health care institutions, London Health Sciences Centre (LHSC) and St. Joseph’s Health Care, London (SJHC), to integrate medical services and share resources. The Centre consists of seven sites, employs 16,000 people and occupies over six and a half million square feet of space.

Conscious of rising energy costs and concerned about the effect that their emissions (namely carbon dioxide, nitrogen oxide and sulfur oxide) were having on the environment, the hospitals started to ramp up their energy efficiency efforts in the mid 1990s. As a rule, hospitals are high consumers of energy, ranking second next to food-service facilities; they are also estimated to waste as much as 30% of the energy they use. Thus, even a small percentage reduction in energy consumption and waste can lead to significant savings in an industry with tight margins (Greer, 2005).

Nearly all of the seven hospital sites received energy retrofits over a ten-year period (1996–2006), and new projects have since been initiated. The London hospitals are a compelling case study on what can be achieved when internal sources of capital funding are unavailable. After investigating a number of options, the hospitals opted to enter into performance contract agreements with an energy service company (ESCO), of which both Johnson Controls and Honeywell have been involved. For certain projects, the hospitals received additional funding from local utilities and NRCan.

Over this ten year period, the majority of energy efficiency projects consisted of standard retrofits: lighting upgrades, variable speed drives placed on pumps and fans, installation of zone dampers and heat recovery systems, replacement of boilers and chillers with more efficient ones, upgrades to the

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8 Information and data cited in this section are taken from the Energy Innovators Case Study (NRCan, no date) and St. Joseph’s Health Care, Parkwood Hospital and Honeywell (2005) brochure.

9 In an energy performance contract, the initial cost of the project is absorbed by the ESCO, who is later paid back by the organization from the guaranteed savings realized by the project. Once the project costs are paid in full, the savings belong to the organization, who may then decide how to re-allocate the money. In LHSC’s case, savings are directed towards paying off outstanding and/or future project costs.

10 Variable speed drives are electronic controls, which permit motors to operate more efficiently at partial loads. For example, a variable speed drive on air handling fans can program the fans to operate at a higher speed when the rooms they are conditioning are full of people, then run at a slower speed and the end of the day when the rooms are empty, thus consuming less energy.
Building Automation System (BAS) for control and monitoring purposes, improvements to the building envelope, thermal pool covers and water management strategies.

The majority of the energy upgrades were implemented at each of the two hospitals in three phases. St. Joseph’s campus was first, implementing all three phases over the period 1996 to 2001. The total project cost was $1.8M with guaranteed yearly savings of $300K and a guaranteed payback of six years. Actual average annual savings have turned out to be slightly higher at $340K. As a result, St. Joseph’s hospitals avoid the release of 1,385 tons of greenhouse emissions (CO2, NOx and SOx) and save 148,081 gigajoules (GJ) of energy each year.

Subsequently, Parkwood Hospital (part of St. Joseph’s Health Care), completed a series of similar retrofits and upgrades to its facility in early 2006. The project cost $1.17M and is expected to generate savings of $170K per year with a 6.9 year payback and reduce CO2 emissions by 692 tons. Primary funding for this project came from a twelve month ESCO contract, and secondary funding of $3,800 was provided by Union Gas, the local gas supplier, and an additional $79,000 in financial incentives came from NRCan’s Office of Energy Efficiency.

In 2001, Victoria Hospital, LHSC began the first phase of its three-phase ESCO arrangement. The total project cost was $2.7 million. In addition to ESCO funding, the hospital obtained a $288,000 grant from NRCan’s Energy Innovator’s Initiative. The resulting annual savings are $739K on average with a six-year payback period, and an avoidance of 6,400 tons of greenhouse gas emissions and 60,354 GJ of energy each year.

In 2003, as part of the second phase, the majority of retrofits done at Victoria Hospital were replicated at LHSC University Hospital. The project cost was $3.1 million, and yields annual savings of $687K on average with a payback period of five years. Each year, 4,394 tons of greenhouse gas emissions are avoided as well as 46,106 GJ of energy.

Figure 1: The energy in the pressure previously absorbed by the pressure-reducing valve now powers the turbine. High pressure enters the turbine, drives the generator and exhausts at a much lower pressure, suitable for process heating and cooling.

Note: Courtesy London Health Sciences Centre/St. Joseph’s Health Care London.
The third and perhaps most technologically innovative phase of LHSC’s energy upgrades is the new steam backpressure turbine at Victoria Hospital. In 1986, Victoria Hospital built an energy-from-waste (EFW) power plant on site. The plant used household garbage as a fuel source to generate steam for boilers that were used to operate large condensing turbines that produced electricity. That facility was dismantled in 1999, but the power plant continued to operate as a co-generation based plant using a gas fired jet engine turbine system. However, with the original system being designed to produce steam at 650 pounds per square inch or psi (higher than needed for the facility today), the steam pressure needed to be reduced to around 200 psi before being distributed for process heating and cooling.

To achieve this, Victoria Hospital added a steam-fired backpressure turbine. In addition to reducing the steam pressure (without the need for pressure-reducing valves and their associated cost and maintenance), the new turbine captures an additional 2MW of free energy, raising the plant’s generating capacity from 5MW to 7MW. With this extra capacity, the Victoria Hospital is now able to generate nearly 100% of its own power, self-sustain its winter demand and sell excess energy to nearby Parkwood Hospital. The extra capacity also provides a hedge against fluctuating energy costs (although astute purchasing strategies have enabled the hospital to lock in at favourable prices) and ensures better emergency preparedness should it face a blackout. This final phase of LHSC’s performance contract cost $2.5 million and is expected to generate savings of $411,799 per year with 6.1 year payback period, and eliminates 260 tons of greenhouse gas emissions annually.

The Beer Store\textsuperscript{11}

The Beer Store is Ontario’s main beer distribution and sales channel. A private company, owned and operated by Labatt, Molson & Sleeman, the Beer Store (TBS) is renowned for its industry-funded deposit return system, which it has been running since 1927, the year it was established. Under this system, The Beer Store takes back 100% of the packaging in which its products are sold, including bottles, bottle caps, aluminium cans, plastic can rings and carry-out bags. While originally established for economic reasons, this system today is environmentally significant in that it diverts large amounts of waste from the municipal landfill, reflecting the overall approach that TBS takes called “eco-effectiveness.” Eco-effectiveness focuses more on recovering and reusing waste in another product or delivery of another service than in eliminating it. This approach also has implications for energy conservation and it is from this perspective that we shall discuss it.

TBS’s truck fleet collects empty cans and bottles as well as secondary packaging from all Ontario collection points when making deliveries. Empty refillable bottles are shipped to respective brewers for washing and refilling between 12 and 15 times. Non-refillable containers and packaging are sent to a recycling facility in Brampton, Ontario where recyclable material is processed and shipped to various recycling markets.

Non-refillable clear and brown glass is sold to Owens Illinois, a U.S. glass and plastics producer, to be re-manufactured into new bottles, many of which become beer bottles again. Aluminium is sold to Anheuser-Busch Recycling Corp., where it is melted and re-manufactured into more aluminium cans and other sheet metal products. Scrap cartons are sent to paper mills for re-manufacturing of packaging cartons and other paper fibre-based products. The steel cans, caps and spent kegs are sent back to the steel industry for re-smelting into new steel products.

\textsuperscript{11} The information and data in cited in this section is taken from the Responsible Stewardship Report of The Beer Store (2005) and information provided to the author by the organization.
By TBS’s own estimates, this cradle-to-cradle approach diverted 91.5% of all its beer containers in 2005, and reused and recycled 433,776 tons of packaging, an amount equal to 53% of all the packaging currently collected through the municipal curbside programs by weight. While the implications on waste management are obvious, the impact on energy conservation is equally compelling. In the same year, the retailer avoided the release of 161,133 tons of greenhouse gas emissions and saved more than 2.5 million GJ of energy, worth about $31 million in crude oil costs, attributable to the company’s practice of reusing and recycling its containers.

How does such a waste recovery system mitigate energy inputs and emissions? The answer lies in the difference in energy needed to manufacture goods from scratch and that needed to recycle existing materials. A report by ICF Consulting (2005), commissioned by Environment Canada and Natural Resources Canada, examines the life cycle GHG impacts of waste management of specific materials in the Canadian residential and industrial, commercial and institutional (IC&I) streams. The study compares energy inputs and GHG emissions from both virgin and secondary (recycled) inputs. While the impacts are variable across sectors, they can significantly high with certain products such as paper, steel, plastics and aluminium, which require more energy to produce from primary inputs than they do from secondary inputs. Recycling these materials can yield energy savings of several tons of CO₂ per ton of product recycled because of the lower amounts of energy required to manufacture recycled inputs. In the case of aluminium, for example, recycling can require up to 95% less energy than virgin aluminium.

The Report (ICF Consulting, 2005), duly notes that some manufactured products use low levels of energy (less than 0.5 GJ/ton) to produce goods from primary feedstock; thus, the energy savings and GHG reductions from recycling would be small. Because the majority of TBS’s packaging comes from materials that require high amounts of energy to produce initially, the energy and emissions savings through reuse and recycling are considerable.

While the key benefits of the deposit return system are in waste management and energy reduction, there are also some economic and business benefits. The system saves municipal taxpayers approximately $30 million per year by keeping beer packaging out of the waste stream, creates jobs and induces customers to return to the retail outlets with their deposit money, where they tend to purchase more beer. In addition, the reusing of one beer bottle (costing 15 cents each) 12 to 15 times results in a per-trip cost per bottle of slightly more than one cent. This type of production efficiency is an economic necessity in an environment when nearly 50 per cent of the product is taxed.

The deposit return system was the standard means of dealing with soft drink containers in Ontario until the 1970’s when the industry switched to non-refillable containers (Papmehl, 2003). With the environmental problems caused by non-refillable and non recyclable containers are becoming increasingly apparent, many are suggesting that this system be resurrected by other beverage retailers, particularly by the Liquor Board of Ontario (LCBO). In September 2006, Ontario’s Premier, Dalton McGuinty, announced that his government would implement a deposit return program for all alcohol products sold by the LCBO. As of February 2007, more than 350 million alcohol containers now carry a deposit and are returnable to all Ontario Beer Stores.

It is hard to predict whether comparable waste diversion and energy conservation could be achieved through this model in a different commercial setting. One key reason for TBS’s success with deposit return is that the infrastructure to support it has been in place nearly eighty years. Another reason has to do with the uniformity of its containers—the participating brewers use standard sized bottles, which makes the cycle easier to manage. There are many unknown variables in creating an
infrastructure from scratch to accommodate containers of varying sizes, shapes and colours. Nevertheless, The Beer Store reveals how a once archaic system, conceived in a different era for different purposes, can be highly relevant and innovative in the context of the environmental issues of today.

Finally, while TBS derives most of its energy savings through the deposit return system, energy savings are also achieved through standard conservation measures such as efficient lighting, heat transfer systems, temperature controls, building envelope, sound fleet management practices (such as reduced idling times of trucks at delivery stops) and natural gas cogeneration at many of the breweries.

**Gerdau Ameristeel Corporation**

Another way in which waste management can influence energy conservation is by converting waste into fuel, known as energy from waste (EFW). One EFW technology that has gained prominence in recent years is the capture and flaring of methane gas from landfill sites to offset natural gas use. The landfill gas (LFG) represents a readily available source of fuel that would otherwise lie dormant, and the act of turning that LFG into fuel alleviates some of the adverse environmental and social impacts associated with the landfill itself such as gas migration, foul odours, potential for explosion and toxins seeping into groundwater.

In 1995, the Regional Municipality of Waterloo installed a system to extract and flare off methane gas produced by the decomposing waste at a landfill site in nearby Cambridge, Ontario. One year later, the Region formed a partnership with Gerdau Ameristeel Corporation, a recycler of post-consumer and industrial scrap metal (then operating under the name Gerdau Courtice Steel) to use previously flared landfill gas to offset natural gas consumption at its adjacent mill site.

In 1996, the Region drilled 44 vertical gas-collection wells into the landfill and installed a system to extract, remove moisture and flare off the methane gas that was being produced by the decomposing waste, primarily from the landfill’s perimeter. The Region also increased the amount of material used to cover the landfill to ensure efficient capture of the LFG.

Gerdau expanded the collection facility to 62 wells in 1998, and installed a comprehensive system to extract and pressurize the LFG, then deliver it via a 200-millimeter (8-inch) diameter pipeline directly from the landfill site to the reheating furnace at the steel plant. The furnace was modified to run entirely on landfill gas, supplemented by natural gas when higher energy inputs are needed.

In terms of costs, the Region installed and funded the well field and collection/flare system and owns 95 per cent of the collection facility. Gerdau funded the utilization system, which the Region operates, without any government assistance. The original capital cost to Gerdau was $900,000.

With modifications completed by September 1999, Gerdau started using the methane gas as energy for its reheat furnace facility. The original installation was commissioned to deliver approximately 1,000 cubic feet per minute. However, when subsequent studies showed that there was more gas in the landfill than previously expected, Gerdau invested another $1 million in 2004 to increase the flow rates. The system can now deliver more than 1,800 cubic feet per minute (CFM) with a target average

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12 The information and data cited in this section are based on information supplied to the author by the organization.
of 1,400 to 1,450 CFM. On a yearly basis this amounts to approximately 374 million cubic feet (or 10.41 million cubic metres) of LFG flowing from the landfill to the steel plant.

Today, between 30 to 35% of Gerdau’s energy input for the reheating furnace comes from LFG, and the plant avoids approximately 118,000 tons of CO$_2$e emissions per year.\(^{13}\) The company reports significant cost savings as well, but does not disclose the amounts as they are proprietary.

Gerdau’s agreement with the Regional Municipality will extend for twenty years from the time it first started utilizing the LFG in 1999. Although the Cambridge landfill officially closed at the end of 2003, the waste deposited there will continue to generate methane through anaerobic (where oxygen and moisture are absent) decomposition until about 2019. After that time, the methane production is expected to drop to the point where it will no longer be economically feasible to pipe it to the mill. Gerdau will go off line and the Region will flare off the remaining gas.

**Maple Leaf Foods\(^{14}\)**

Maple Leaf Foods is a Canadian food processing company, operating over 100 plants across Canada, the U.S. and Europe. Being in an energy-intensive industry, the company’s energy costs have been running high, at over $100 million per year. Faced with the prospect that these costs will go even higher, the company established an energy council in 2001 and began a company-wide energy management strategy.

In the same year, the company set an annual energy reduction goal of 3%. Over a five-year period (2001-2006), Maple Leaf has met this target consistently, while saving more than $15 million. No data is available on emissions reductions since the company is not currently tracking this.

The company attributes much of its energy-saving success to its efforts in developing awareness and culture-building initiatives around energy conservation. Maple Leaf is a study in how to engage employees, leverage, capture and share their knowledge on energy conservation in a company where employees are spread over a large geographical area.

Some words about the company’s corporate structure will help to explain how Maple Leaf accomplishes this. The company is divided into six independent operating companies (IOCs), each of which contains a number of individual plants. Each IOC has its own energy champion who reports to the corporate energy champion.\(^{15}\) At the plant level, the energy champion is typically the plant manager, although he or she may delegate that function to the maintenance manager of chief engineer.

Energy teams, consisting of employees from different areas of the plant, are a key resource to developing and implementing energy saving ideas. The teams work closely with the engineers, so that ideas may be evaluated and implemented quickly. Each energy champion is involved in creating,\(^{13}\) CO$_2$e stands for CO$_2$ equivalent. Other GHG emissions are weighted by a factor that represents their global warming potential expressed in equivalent CO$_2$ units and included in the CO$_2$ total.

\(^{14}\) The information and data cited in this section was collected through an interview with the Energy Coordinator, Corporate at Maple Leaf Foods.

\(^{15}\) Fairly new terms in the corporate lexicon, energy champions and energy leaders are individuals within the organization who can rally both executives and staff in achieving company-wide awareness and implementation.
implementing and managing energy savings projects that take place under his or her IOC and reporting them to the corporate energy champion. The energy coordinator, who also reports to the corporate energy champion, collects all project data, new information, ideas and suggestions from the plants and tailors that information to the needs of a broader company audience by putting this information on a shared drive, so that one plant can learn from another.

With many energy projects taking place across the company, Maple Leaf has a formidable challenge in managing the new energy saving information that comes from the plants and sharing it with other plants. A dedicated Intranet portal disseminates energy knowledge and ideas across the company. The portal can be accessed by all employees and contains a range of information and topics: data on every single energy project undertaken (including how it was done, the challenges it faced and whether it succeeded), what is expected of an energy champion, incentives, initiatives and training programs. The portal also contains a comprehensive technical library, from which employees can access information on matters such as boilers, cogeneration, compressors, pumps, steam systems and lighting systems. With information in one place, the need for time-consuming ‘google’ searches is eliminated.

The training and information materials that staff receive and collect at workshops and conferences (CD-ROMS, PowerPoint presentations and handouts) are also posted on the portal for the benefit of other employees. The portal’s home page displays the Thumb Rule of the Week, an energy conservation message or tip, to help them work energy efficiency into the daily routine. Energy managers from across the company’s Canadian plants can also share information among themselves and interact across a dedicated energy managers’ portal.

Recognizing that its employees can be a fertile source of knowledge and innovation, Maple Leaf has invested in training its staff on how to spot energy savings opportunities. The company has used a number of NRCan workshops such as “Spot the Energy Savings Opportunities” and “Dollars to Sense” as well as technical seminars delivered by outside consultants.

Energy awareness is also incorporated into the everyday culture through activities such as Energy Day (celebrated every September 26 across the company) and plant-level activities such as barbeques, energy contests, rewards and prizes for employees that come up with the best energy suggestions.

**Interface Flooring Systems (Canada) Inc.**

In keeping with its corporate wide sustainability mission, Interface, a U.S. owned manufacturer of carpeting and flooring, has been integrating energy efficiency into its operations at every opportunity. Since 1995, the company’s Belleville, Ontario plant has reduced GHG emissions (mostly CO₂) by 64%, saved $14 million, decreased electricity per square yard from 3.2 kWh to 1.16 kWh and reduced natural gas from 0.6 cubic metres to 0.18. Today the plant’s per unit energy consumption is 72% below 1995 levels.

To achieve these results, all standard energy saving measures (upgrades to lighting, improved HVAC, extensive use of waste heat recovery, improved compressed air and motor systems and creating the

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16 The information and data provided in this section were based on information supplied to the author by the company and an interview with the Director of Technology and Environment, InterfaceFLOR Commercial.
culture) were implemented. But it is in the integration of the processes themselves that the plant has found the most significant energy conservation opportunities.

In the manufacturing sector, the design of a process can have a positive or negative effect on productivity, resource consumption and waste. However, as the plant discovered, a poorly designed, wasteful process can be re-designed, at little or no capital cost, to improve both energy and business performance. What is required are common sense, creativity and an eye for opportunities.

A flagship example occurred with the carpet printing process line. The original process was labour- and energy-intensive and contained many waste-inducing pieces of equipment and steps: the use of a dye printer, using steam to affix the dye to the fabric, spraying a high-pressure power water to wash away the gum that held the dye, vacuuming out most of the water from the fabric and heating the fabric in a gas-fired oven to remove the rest of the water. This process created 550,000 litres of wastewater per month, in addition to waste in energy and materials.

In 1997 this process line was redesigned to incorporate a computerized tufting machine so that the design could be embroidered onto the carpet at the beginning of the carpet making process. In addition to using a fraction of the energy as the previous process, the new process eliminated a number of waste-intensive steps (including all of the wastewater), reduced the number of off-quality (defective) carpets and freed additional space within the plant.

However, further benefits accrued to the business. With the design now permanently affixed to the carpet fibre, as opposed to the surface, it is no longer prone to fading through everyday use, making it a higher-quality product. With less labour and fewer resources required, the carpet is now sold at a lower cost, making it a more competitive product. In addition, by selling off the old equipment (printing machine, boiler, steamer and dryer), the company received more money than what it paid to redesign the process line. No capital expenditures were required to fund these new efficiencies.

To find energy conservation opportunities such as the preceding, the plant examines its processes thoroughly to find what can be eliminated. Sometimes the removal of a single piece of equipment will improve energy performance and reveal unexpected ancillary benefits. For example, the steering mechanisms that were used to prevent carpets from wandering off line were prone to frequent malfunctions, machine downtime, lost productivity and created a lot of off-quality. By replacing these steering mechanisms with a procedure change (making sure that carpet feeders were properly aligned at each maintenance check), carpets no longer wander off line and energy-wasting machinery is no longer necessary.

The plant found another way to eliminate the unnecessary when it calculated the amount of ideal heat needed for some of its processes versus the amount of heat it was actually using. When it discovered it was using more than necessary, the plant weeded out excess heat from each of its process and, in so doing, reduced BTU per unit of production by more than 70%, again without any capital expenditures.17

This ‘lean’ approach to process integration reflects the company’s belief that extensive machinery and equipment tend to deal with the symptoms rather than the root cause of manufacturing inefficiencies. The plant takes a similar approach to monitoring and tracking energy use, eschewing elaborate software systems in favour of staff being responsible for checking monitors, meters and trend charts

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17 BTU – British Thermal Unit – the quantity of heat needed to raise the temperature of one pound of water (about 1 U.S. pint) one degree F.
on a regular basis. It is up to each individual within his/her sphere or influence to help the company achieve its objective of decreasing energy use on a per unit basis. That, according to the company, is better achieved by brainpower than software power.

The Interface corporate culture is one where employees are expected to contribute their brainpower by coming forward with ideas and suggestions on how to save energy. However, to create this culture, Interface has invested in employee training and engagement around sustainability in general and energy conservation in particular. Staff members are taught how to be energy efficient both at home, believing that this attitude will spill over into the workplace, where it is needed. To this end, the company has numerous incentive programs: subsidized home energy audit programs, caulking, installing low flow shower heads, insulation, ensuring the building envelope is sound, advice on lighting configurations, interest-free loans for bicycle purchases and a carpooling program. In turn, employees are well versed in energy issues, including energy generation, climate change and the impacts of greenhouse gas emissions on the atmosphere.

2.0 Analysis and Conclusion

Through the preceding case studies, we have seen a variety of ways and means through which Canadian organizations approach energy conservation within their facilities and operations, the challenges they face and how they overcome these challenges. While the technologies and management practices used vary according to the size, nature and resources of the organization, the two main objectives of reduced emissions and reduced costs were achieved.

But these are not the only benefits. In many instances, the case study organizations simultaneously achieved significant other ancillary business gains, again in as many and varied forms: savings through fewer service, maintenance, repair and replacement costs on energy efficient equipment, improved indoor air quality resulting in a more comfortable, motivated and productive staff, lower employee turnover and less absenteeism, better customer satisfaction and loyalty, improved emergency preparedness, less resource and materials waste, enhanced image, better use of human capital, improved knowledge management and information sharing capabilities, and being able to transfer innovative thinking and practices on energy management to other areas of the business. In addition, by undertaking energy conservation projects, organizations often find new opportunities to spot energy savings.

What has made these organizations successful energy conservers? It is a combination of several factors. Fundamentally, a solid commitment and buy-in at all levels as well as a culture in which energy conservation extends throughout the value and supply chains. Companies that manage energy successfully also tend to be resourceful and forward thinking, from applying creativity and out-of-the-box thinking to problem-solving to uncovering funding opportunities to being able to implement quickly. Frequently, such organizations will have an energy champion who can effectively bring disparate factions of the organization (such as engineering and financial) towards a common goal of reducing energy consumption. Another component is energy awareness, as the preceding case studies have demonstrated. Why is awareness so crucial? Romm (1999) gives a succinct answer to this, quoting Jim Obendorfer, facilities manager at Perkin-Elmer, a manufacturer of analytical instruments: “If people don’t think you care about it [energy], they won’t do anything about it. Workers have no idea what energy costs.” Finally, working with energy experts who understand the needs and goals of the organization can go a long way in helping the firm design and implement an energy conservation plan, select appropriate strategies and products and avoid costly mistakes.
These success stories, as well as those of the high-ranking global companies (such as DuPont, 3M, Compaq, Toyota, Interface, Shell and Xerox), lend support to the position that significant energy use and emissions can be reduced through the technologies available today. But is it working in the broader scenario; that is, is it helping Canada to meet or exceed its Kyoto targets and preserve its existing resources for the future?

The answer is no, not because of any defect in the energy conservation practices themselves, but because the efforts of energy conservers are being overwhelmed by increases in energy intensity elsewhere. While the NRCan programs have proven their effectiveness in helping individual organizations achieve energy efficiency goals, they have been sharply criticized by sustainability experts and proponents as falling far short of the mark in helping Canada to do the same. The NRCan programs reflect the federal government’s current policy approach to climate change, which is voluntary rather than compulsory, consisting largely of information and subsidies as opposed to direct government action.

Since the federal government enacted its Climate Change Plan in 1990 GHG emissions have increased by 24% in Canada, while increasing by only 13% in the United States (Heaps, 2005; pp. 15-17). Jaccard et al. (2006), in a study commissioned by the C.D. Howe Institute, assess the future effectiveness of this approach if it were to continue over a 35-year period (2005-2040). Estimates are that not only would GHG emissions continue to grow, but at great expense, costing approximately $80 billion, with much of the money being spent outside of Canada.

If voluntary approaches have done little to solve the climate change problem so far, they are unlikely to quell the consequences of an anticipated growth in population coupled with an increased demand for energy consuming electronics, gadgets and small appliances over the next 20 years. There are those who argue that energy conserving technologies and strategies make the problem even worse, pointing to the unintended ‘rebound effect,’ in which energy-efficient technologies and devices encourage greater consumption. Paradoxically, the very thing (innovation) that drives solutions to energy problems also has a role in creating them.

The efforts made to conserve energy on the supply side will not solve our energy challenges if nothing is done to stem excessive consumption on the demand side. This is an area of energy policy that has yet to be addressed, but will need to be if energy conservation is to work to the benefit of the nation. From the purely technical side, energy conservation is a viable and cost effective present day option that can accommodate our present day and short-term future energy needs. However, it can only accomplish this if complemented by policy that discourages waste and inefficiency. Similarly, in any discussion on energy policy, conservation should be a vital part of the discourse.

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4.0 References & Bibliography


The Case for a Carbon Management Standard: Implications for Energy Technological Change and International Relations

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ABSTRACT

Achieving deep reductions in greenhouse gas emissions over the long-term will require profound technological changes in the energy sector, changes that will not occur without substantial policy intervention. However, emission reduction presents special challenges for environmental policy-making. In particular, emissions abatement is a global problem that faces the enormous difficulties associated with negotiating and enforcing international agreements. With the Kyoto Protocol demonstrating how difficult it is to allocate and enforce national emission caps, some policy analysts have focused on the formulation of policy instruments to drive technological change that can be implemented at the level of a single, national government and from there grow into coordinated international action. In this vein, we propose a market-oriented regulation built around the concept of producer responsibility. We call this instrument a carbon management standard. It requires no international agreement on greenhouse gas emissions and it would develop initially through unilateral or multi-lateral initiatives, with trade pressure as the eventual mechanism for achieving broader participation.

Keywords: climate policy, market-oriented regulation, international agreements.

The authors of this chapter argue that it is time to consider an alternative to the Kyoto approach of setting short run, “top-down” targets. Policy analysts have increasingly acknowledged the inadequacies of negotiating a series of short-run solutions to what is inherently a long-run problem: each step leaves uncertainty about subsequent agreements, emissions reductions are unlikely to be achieved efficiently, and serious compromises are necessary to arrive at an international consensus. Many now see domestic or more local initiatives, such as the Regional Greenhouse Gas Initiative in the U.S., as a more promising path.

The authors further contend, though, that neither conventional command and control policy nor newer market-based policies like carbon cap-and-trade programs are likely to succeed, even at more local levels. They propose a new policy called a carbon management standard, which would make those who extract or import fossil fuels responsible for carbon emissions from those fossil fuels. The authors make an interesting case for this new policy approach based on effectiveness, cost efficiency, and political and administrative feasibility.
1.0 Greenhouse Gases, Climate Change and Long-Term Abatement Targets

There is increasing concern that carbon dioxide (CO₂) emissions from fossil fuel combustion are accumulating in the atmosphere and, along with other greenhouse gases (GHGs) from various activities, increasing the atmosphere’s natural greenhouse effect such that the earth’s climate could change significantly over this century. Many scientists suspect that rising atmospheric concentrations of GHGs will increase the earth’s temperature and affect climate in difficult-to-predict ways, perhaps increasing the frequency of extreme weather events. A general warming may also melt part of the polar icecaps, causing sea level rise that threatens vulnerable, low lying countries (IPCC, 2001a).

Much of the national and international focus on climate change mitigation to date has been on short-term goals, as articulated in the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC). In this, industrialized countries and countries formerly part of or under influence of the Soviet Union committed to specific GHG targets for 2010, equating to 5.2% below 1990 emission levels for the signatory countries.

More recently, focus has shifted towards a long-term approach. Although no long-term climate stabilization goal or emissions trajectory has been adopted internationally, the UNFCCC provides some guidance as to the form of an appropriate long-term goal: “to achieve the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system” (United Nations, 1992). Proposed goals for CO₂ stabilization range between concentrations of 450 parts per million (ppm) and 650 ppm, based on differing interpretations of “dangerous” human interference with the climate system (IPCC, 2001a). Stabilizing CO₂ concentrations in this range will require deep emission reductions from baseline projections. Several countries and regions have adopted their own ambitious targets for long-term emission reduction, while lobbying and negotiating for others to follow.

Achieving deep reductions in GHG emissions over the long-term will require profound technological changes in the energy sector representing a dramatic shift from our current path, but this will not occur without substantial policy intervention. However, reducing GHG emissions presents special challenges for environmental policy-making. There is a great deal of uncertainty about the costs and benefits of emission reduction, with the potential for high costs. Actions that contribute to GHG
emissions are disconnected in time and space from their consequences. Because climate change is a global problem, emissions abatement faces the enormous difficulties associated with negotiating and enforcing international agreements.

Existing policy instruments may not be adequate for meeting these challenges. In particular, some policy analysts have focused on policies that can be implemented at the level of a single, national government and then grow into a system of coordinated international action on climate change. The need for such an approach is evidenced by the failure of the Kyoto Protocol to address significant GHG reduction beyond 2010 and to include the major GHG emitting countries such as the US, China and India. In this chapter, we propose a new policy approach.

We address the policy challenge in more detail in Section 2 and suggest a series of evaluative criteria for climate policy. In Section 3 we analyse conventional policies for addressing environmental externalities. In Sections 4 and 5 we discuss market-oriented regulations – emissions cap and tradable permits and artificial niche market regulation – designed to improve upon the performance of the standard policy options. We explain in Section 6 why even these policy innovations are not adequate to addressing the challenges of global climate policy. Section 7 provides a detailed description of the carbon management standard, our alternative proposal for market-orientated regulation. We evaluate this new approach against the established policy evaluative criteria in Section 8. In Section 9 we present results from simulating a carbon management standard in the CIMS energy-economy model. We offer our conclusions in Section 10.

2.0 The Policy Challenge

The link between our actions as consumers and the resulting GHG emissions is not readily apparent to most people. Furthermore, the degree to which emissions place ecosystems and people at risk is highly uncertain, and likely to remain so. Policy makers wanting to reduce GHG emissions find themselves in the unenviable position of possibly imposing significant near-term costs on consumers and businesses for hazy and poorly understood benefits in the future, benefits mostly realized by future generations on the other side of the planet. Climate change is a global problem that ultimately can only be solved with global efforts; however, there are enormous difficulties in negotiating most global accords, and uncertainty about the magnitude and location of costs and benefits entails potentially huge equity impacts between countries.

Our current economic structures, businesses, houses, and transportation infrastructure have evolved in a world in which CO2 emissions can be freely emitted to the atmosphere. Implementing policies to dramatically reduce GHG emissions over the next several decades will require significant changes that will impose real transition costs. Some sectors and regions will be affected more than others. While governments may attempt to compensate those most negatively affected, it is not realistic to expect no economic costs during the transition to a low GHG economy. The possibility of high costs does not imply that we should do little to reduce emissions; however it does reinforce the need to design policies that are cost-effective.

GHG emissions abatement also presents unique challenges when it comes to cost-effectiveness. First, it is extremely costly to convert to alternative capital stocks of equipment, buildings and infrastructure more rapidly than the “natural rate of capital stock turnover” – the rate at which equipment stocks would normally require retirement and replacement. Second, new, higher cost technologies face the conundrum of needing market dissemination today in order to lower their costs in future, but needing lower costs today in order to achieve market dissemination. Third, new technologies are inherently riskier, and perceived that way by businesses and consumers, again
requiring market penetration and greater use to reduce perceived and real risk. Fourth, to the extent that technologies require longer payback periods to show a profit, even though they may be more profitable over their expected lifespan, businesses and consumers will be reluctant to adopt them.

Policies to achieve deep, long-term reductions in GHG emissions will inevitably require difficult trade-offs in which there are winners and losers. To assist in navigating the obstacles to effective climate policy design, it is helpful to turn to a series of evaluative criteria. Four criteria commonly applied by policy analysts are:

- environmental effectiveness;
- administrative feasibility;
- economic efficiency; and
- political feasibility.

In order to be environmentally effective, climate policy should hinder the development and dissemination of new technologies that emit GHGs and should drive the long-run development and dissemination of low GHG emitting technologies. The desired technological change can be accomplished through actions that reduce energy use, switch to lower or non-emitting energy forms, and capture and permanently store GHGs in order to prevent their release to the atmosphere.

At the same time, to fulfill the criteria of economic efficiency, policy design must address the special challenges to cost-effectiveness described above. It must provide strong long-run signals that motivate businesses and consumers to innovate and adopt new zero-emission technologies at the time of capital stock turnover. But it must not shock the economic system with a dramatic increase in energy prices in a short time period, which can lead to premature obsolescence of what was otherwise productive capital equipment.

Political feasibility indicates the extent to which a policy has “attributes that enable the negotiation of an acceptable balance among clearly defined interests.” This criterion is sometimes referred to as negotiability or equity in that it highlights the reasons why some policies may score well against the first three criteria and yet politicians who want to implement them dare not (Hahn et al., 1992). As we discuss below, GHG taxes provide an example of a policy that has great difficulty achieving political feasibility even though it performs well in terms of environmental effectiveness, administrative feasibility and economic efficiency.

The generic policy design and evaluation criteria described above are appropriate for policies applied at the level of a single national government or a lower level of government. With climate change, however, there is the additional issue of making sure that what a country does domestically is consistent with, or contributes to, the development of international commitments and coordinated, least-cost international action. This is important for the success of international climate policy, and also helps to protect an individual country from suffering a substantial loss of competitive position with unregulated trading partners if it acts before other countries. In the following three sections, we refer to the generic policy evaluation criteria in presenting and evaluating existing policy options for addressing environmental externalities. We return to the issue of compatibility with international climate policy as we explore the need for further innovation in policy design.

3.0 Conventional Policy Options: Regulation, Taxes, Subsidies and Information Provision

Command-and-control regulations (sometimes called prescriptive regulations) mandate specific emission levels, energy efficiency standards, or other technology characteristics, with non-
compliance incurring stringent financial or legal penalties. This approach dominated environmental policy in the 1970s and is still prevalent today. Economists have criticized regulations because they can be economically inefficient where they require identical equipment choices or managerial practices by participants whose costs of compliance differ considerably (Hausman et al., 1982; Newell et al., 2003). Regulations usually provide no incentive for companies to innovate beyond the legal requirement (Millman et al., 1989; Parry, 2003). However, regulations may be justified where information or search costs are particularly high, and research has found that application of regulations can even lead to net benefits to society in certain situations (Moxnes, 2004).

Unlike regulations, financial disincentives – emissions taxes, charges, levies, fines and other financial penalties – are assumed to promote economic efficiency if they are set to reflect incremental environmental damages and provide a consistent price signal throughout the economy. Each business or consumer pays charges based on the amount of emissions they cause, but they are not prohibited from activities that release GHGs. In this way, the policy is sensitive to the diversity of industry pollution reduction costs and consumer preferences. The total cost to society of achieving an aggregate environmental improvement is minimized if each plant or household pursues its self-interest in reducing pollution only to the point where additional reductions cost more than paying the tax.\(^1\) Furthermore, this policy provides a continuous impetus for pollution-reducing innovations, since even the smallest levels of pollution incur the tax. In terms of political feasibility, however, financial disincentives present a challenge, which explains perhaps why the approach has not been widely used. In requiring either tax payment or an action to reduce emissions, this policy is often portrayed as an instrument of intrusive and coercive government, associated with the suspicion that the charges reflect government revenue needs rather than a legitimate attempt to correct prices to reflect environmental harms and risks.

An alternative way of fostering actions that reduce GHG emissions is to offer financial incentives or subsidies in the form of rebates, grants, low-interest loans, tax credits, insurance guarantees, publicly funded infrastructure and public R&D. Subsidy programs have figured prominently in energy policy for decades – examples include government funding of R&D for nuclear power, support for oil and gas exploration and extraction, the demand side management programs of electric utilities in the 1980s and 1990s, and government policies for GHG abatement in the 1990s. Government largesse is obviously popular with recipients, so this policy appears to score well in terms of political feasibility. In practice, however, the use of financial incentives faces substantial constraints. First, the policy requires funds that governments mostly acquire through unpopular taxes, and scarce public resources are diverted from other programs. Second, it is inherently difficult to design subsidy programs to exclude free-riders – participants who qualify for the subsidy even though they would have undertaken the action anyway. When free-rider effects are calculated, subsidy programs tend to be an expensive and relatively ineffective means of reaching an environmental goal (Joskow et al., 1992; Loughran et al., 2004). Third, increases in consumption of an energy service can occur when a subsidy reduces the cost of obtaining that service – a phenomenon known as the rebound effect (Greening et al., 2000). Fourth, many types of subsidy programs are costly to administer, requiring adjudication of applications, monitoring of performance and hindsight evaluations. Finally, a subsidy approach generally places government in the position of choosing specific technologies to support, rather than allowing these decisions to be made according to market forces.

Voluntary actions by firms and consumers might be stimulated by information programs such as labelling, moral suasion, and voluntary agreements that allow individual companies and consumers to determine their own level of effort for environmental protection, and cast government in the role

\(^1\) Economists call this the equi-marginal principle.
of information provider, facilitator, role model, or award giver. Voluntary programs for GHG reduction and energy efficiency have formed a major part of past policy efforts, with programs directed at public outreach, industry energy efficiency, and information provision to consumers and businesses. However, while the growth of government voluntary programs has been dramatic and participants offer much anecdotal evidence of voluntary actions to improve the environment, the effectiveness of such programs is difficult to determine (IPCC, 2001b; Harrison, 1999). Recent empirical reviews of voluntary programs suggest that their environmental effectiveness is questionable and their economic efficiency is low (OECD, 2003; Khanna, 2001; Carraro et al., 1999).

Each of the conventional policies for addressing environmental externalities described thus far receives a strongly negative assessment in terms of at least one of our policy evaluative criteria. Command-and-control regulations and financial incentives perform poorly against economic efficiency, financial disincentives perform poorly against political feasibility, and voluntary and information programs perform poorly against environmental effectiveness and economic efficiency. Policy instruments cannot necessarily be expected to perform perfectly against all evaluative criteria; however, recent policy innovations have attempted to improve upon the performance of the standard instruments by combining regulation at the aggregate level with individual market flexibility. This type of policy is sometimes referred to as a “market-oriented regulation” or a “quantity-based market instrument.” We describe two key variations on this theme here: emissions cap and tradable permits and artificial niche market regulation.

4.0 Market-Oriented Regulations: Emissions Cap and Tradable Permits

In 1968, J. Dales first showed how the allocation of tradable property rights to pollute could minimize the costs of pollution reduction. To apply this principle to GHG emission reduction, government sets a maximum level for emissions, then allocates tradable emission permits to all emitters covered by the program so that the total allowed by the permits equals the emissions cap – hence the term emissions cap and tradable permits (ECTP). Usually the permits decrease in number or value over time, gradually lowering the aggregate emissions cap. The ECTP is a form of regulation in that the aggregate emissions cap cannot be exceeded, participation is compulsory, and penalties for non-compliance are substantial. Unlike traditional command-and-control regulation, however, the ECTP has similarities to environmental taxes in that it allows participants to determine what actions if any they take to reduce emissions and whether, as a consequence, they buy or sell in the emissions permit market. This means that the policy should be economically efficient as long as each participant only acts to reduce emissions where this costs less than the permit trading price.

Starting with M. Weitzman in 1974, economists have generated a large literature debating the relative merits and most appropriate applications of ECTP and financial disincentives – what is sometimes called the “quantities versus prices” debate (Kemp, 1997). In theory, both approaches should cost about the same to achieve a given level of emission reduction, but ECTP provides greater certainty about the emissions outcome. Environmental taxes, on the other hand, provide greater certainty about maximum cost (no one pays more than the tax) – a salient feature given the scientific and economic uncertainties surrounding climate change. We are not certain of the environmental harm associated with GHG emissions or of the cost of abatement, and there are those who argue we should avoid higher cost actions until we learn more.

The most noteworthy application of ECTP began with an amendment to the US Clean Air Act in 1990, which has inspired a growing number of policy experiments in the US and elsewhere. Sulphur emissions from specified electricity generation plants were subject to ECTP in exceedingly stringent five-year phases starting in 1995. The policy produced substantial reductions in emissions with costs
that were estimated to be 50% lower than would have been incurred by a command-and-control approach (Ellerman et al., 2000).

Depending on the number of participants and their level of experience with market trading instruments, application of the ECTP faces hurdles in terms of administrative feasibility. Also, in terms of political feasibility, the allocation of permits involves a delicate balancing of interests; auctioning all permits would concentrate costs on heavy emitters whereas awarding all permits according to base-year emissions (grandfathering) could have the opposite effect, even generating considerable wealth for heavy emitters if they have the lowest incremental abatement costs or can partly manipulate the market for permits. The greatest challenge for ECTP is where the cost of emission reduction is uncertain but possibly very high in the near term. Governments are reluctant to set stringent emissions caps in case these cause high costs to the economy (perhaps especially during the typical four to five year political mandate). In a compromise proposal, suggested initially in the mid-1970s by M. Weitzman, M. Roberts and M. Spence, the government would offer to sell an unlimited number of permits at a fixed price (Weitzman, 1974; Roberts et al., 1976). This guarantees a ceiling (safety valve) for the ECTP cost, but accordingly reduces confidence in achieving the environmental outcome.

Adding a permit price ceiling to the ECTP effectively converts it into a hybrid price-quantity policy. Because of the cost, benefit and timing uncertainties associated with emissions abatement, and the resulting political feasibility challenges for implementing effective policy, the ECTP with permit price ceiling has lately attracted a great deal of research interest for the design of GHG abatement policy (McKibbin et al., 1997; Jacoby et al., 2004; Pizer, 1999; Nordhaus et al., 2003). Analysts assess where the cap should be set (upstream on the carbon content of fuels production or downstream on end-use carbon emissions), the level at which the price ceiling should be set initially (to reduce cost anxieties and limit premature retirement of capital stock), whether the price ceiling should be scheduled to increase over time (to provide the appropriate long-term signals for innovation and new capital investment), and how the policy could work as part of an international permit trading system.

The ECTP with a scheduled declining emissions cap – and rising emission permit price ceiling in the case of a price-quantity hybrid – has attractive features. It minimizes the risk of short-term economic disruption while providing a long-term signal to stimulate R&D and dissemination of new technologies; this should help with political feasibility and economic efficiency. Also, its permit trading flexibility provides a uniform price signal throughout the economy, depending on how widely the policy is applied, which should improve the prospects for economic efficiency.

5.0 Market-Oriented Regulations: Artificial Niche Market Regulation

The ECTP controls emissions, but the principles of market-oriented regulation have also been applied to regulating market outcomes at a technology or energy level. The purpose is to establish artificial niche markets for critical new types of technologies or forms of energy that might not otherwise gain a foothold in the economy, a foothold that helps launch the typical cycle of initial product diffusion, production cost reductions through learning and economies-of-scale, initial consumer feedback and product improvement. Once new technologies have reached this market-recognition stage, policy makers should find it easier to intensify environmental taxes or ECTP because businesses and consumers would have available alternatives to their conventional high-emission technologies. Noteworthy applications of niche market regulations involve the energy sources for electricity generation and the emission levels for automobiles (Jaccard et al., 2002; Jaccard, 2005a).
The renewable portfolio standard (RPS) emerged in the 1990s as an instrument to force greater generation of electricity from renewables. Electricity providers (or consumers in some jurisdictions) are required to ensure that a minimum percentage of electricity in their portfolio is generated by renewables. Each provider must comply or take advantage of flexibility provisions that allow for purchasing of credits from those whose renewables generation exceeds the minimum requirement; non-compliance results in exclusion from the market or substantial penalties. Thus, the RPS forces an aggregate market outcome, but supports economic efficiency by encouraging only those with the lowest generation costs to provide electricity from renewables to the market. In recent years, the RPS has been adopted by Australia, almost twenty states in the US and several countries in Europe, and is under development in many other jurisdictions.

The vehicle emission standard (VES) is another form of niche market regulation that requires automobile manufacturers to guarantee a minimum percentage of vehicle sales in one or more categories according to emission levels. Historically, manufacturers claimed that low- or zero-emission vehicles would be too expensive to build and, in any case, would not satisfy consumer demands for acceleration, horsepower, range and safety. Then, in 1990, the California Air Resources Board, a quasi-judicial environmental regulatory agency under state legislation, established a VES that set deadlines in future time periods for minimum percentage sales of vehicles in low- and zero-emission categories, creating artificial niche markets for these new technologies. Vehicle manufacturers are allowed to work together so that the total California fleet meets the standard even if individual manufacturers fall short.

The California VES seems to have played a pivotal role in the development of new options for vehicle power platforms, including gasoline-electric, battery electric and fuel-cell systems (Kemp, 2003). The California legislation has been adopted by twelve other states in the US, with provisions in New York, Massachusetts, Vermont and Maine to adjust automatically their standard to any changes made in California (together with California, these account for about 20% of the US automobile market). It has also had a significant effect on technology developments in Europe and Japan, although no other country has yet matched the policy.

These recent experiences with the renewable portfolio standard and the vehicle emission standard illustrate the possible strengths of market-oriented regulation that focuses on creating artificial niche markets for types of technologies or forms of energy (Jaccard et.al., 2002; Jackson, 2001). First, the policy sends a regulatory signal that pushes manufacturers to innovate and commercialize low-emission technologies without significantly impacting vehicle or energy prices. In order to meet their minimum sales requirements, producers will either capture higher revenue from those consumers willing to pay more for low-emission technologies, or subsidize these technologies from their sales of conventional electricity (RPS) or conventional vehicles (VES). Because the niche market for the low-emission technology is initially small, any cross-subsidy has a minimal effect on the price of these conventional products. By allowing technological change to occur at a pace that matches the natural rate of capital stock turnover, a carefully designed policy can avoid huge economic costs from premature capital stock retirement or retrofit.

Second, by forcing innovation and commercialization efforts, the policy provides policy makers with critical information about the future production costs and consumer acceptance of low-emission technologies, which can inform subsequent decisions about the timing and ambition of energy-environment targets. In terms of equity, the cost of acquiring this information is appropriately borne by the purchasers of conventional vehicles who cause the externality impacts and risks in the first place, instead of by general taxpayers, some of whom might not own or use personal vehicles.
Third, the market niche policy incorporates the other positive features of the ECTP policy. Market-share requirements can be scheduled to rise gradually over time, signalling the long-term objective to industry and consumers without short-term disruption to productive capital stocks. Trading between participants reduces the cost of compliance. The penalty for non-compliance can be set to perform like the cost ceiling that transforms the ECTP into a hybrid price-quantity policy, which reduces the risk to policy makers.

The major critique of regulating artificial niche markets is that this approach could be economically inefficient in that by stipulating specific energy or technological outcomes, the regulator may overlook lower cost ways of achieving the environmental target. The renewable portfolio standard may cause unnecessarily high costs if it turns out that zero-emission fossil fuels, nuclear or some combination of these can achieve low impact and low risk electricity production at much lower costs than renewables. A policy that targets emissions instead of the energy form, as with the California vehicle standard, reduces this risk within a sector, but fails to address the potential for dramatically different emission reduction costs in different sectors. Moreover, because it focuses on an environmental target in one sector of what is an integrated energy system, the vehicle emission standard could have perverse effects in encouraging low-emission vehicles that use electricity or hydrogen generated by a technology or energy form that causes higher net global or local impacts.

Regulated niche markets score well in terms of political feasibility, so it is no accident that they are rapidly increasing in popularity among policy makers. The policy approach does pose economic efficiency risks, however, so it must be applied cautiously. Artificial niche market regulation should be implemented in concert with an overarching policy, such as an economy-wide ECTP, which will be necessary to provide a unitary economic signal across the economy that will consolidate the technological advances into wide-scale diffusion of low impact and low risk technologies and energy forms.

6.0 Lessons for Policy Design

The preceding assessment of policy options has demonstrated that deep GHG emission reductions require a broad-based regulatory constraint or financial penalty that places a value on the atmosphere. The policy should, however, incur only small costs initially, allowing time for technological transformation and also for potential adjustments as more information becomes available about the costs and benefits of GHG abatement. A successful policy will be as broad-based as possible to minimize total costs to society of a given environmental achievement. Policies that focus on preventing emissions are likely to be superior to policies that force a particular technology, a particular level of aggregate energy efficiency, or a particular form of energy.

A potentially attractive policy portfolio might rely considerably on market-oriented regulations – specifically on an economy-wide emissions cap and tradable permits approach supplemented by a few key niche market regulations that strategically target areas where profound technological change has great potential but faces high transitional costs. An economy-wide ECTP with a scheduled declining emissions cap and rising emission permit price ceiling would reduce emissions cost-effectively, minimizing the risk of short-term economic disruption while providing a long-term signal to stimulate R&D and the dissemination of new technologies.

Nordhaus and Danish noted in their 2003 (p. 25) analysis of the potential design of a mandatory GHG reduction program for the US that: “The process for this distribution [of allowances or permits]...is likely to be the most difficult and potentially contentious issue in designing a cap-and-trade program.” While the allocation debate may be a challenging but manageable aspect of domestic
ECTP design, this issue plagues international ECTP systems – as exemplified by the trials and tribulations of the Kyoto Protocol.  

In the Kyoto Protocol, emissions from the regulated Annex I countries were capped overall at 5.2% of 1990 levels in 2010, with permits allocated as a result of intensive negotiations. In this case, permits are called assigned amounts or emissions quotas and they determine the national caps under the Protocol. International emissions trading is allowed between the Annex I Parties, and project-based flexibility mechanisms provide opportunities to gain credit for emissions mitigation projects both inside (Joint Implementation) and outside (Clean Development Mechanism) the regulated group.

The allocation of emissions rights under the Kyoto Protocol used a base year of 1990 when setting targets in the year 1997 for a compliance year of 2010. W. Nordhaus (2005; p. 10) explains the perils of Kyoto’s arbitrary baseline and finds: “it is inconceivable that the United States [who withdrew from the treaty in 2001] would agree to the enormous resource transfers to Russia and other countries that are envisioned by the Kyoto Protocol.” The profound problems associated with the establishment of quantity limits under constantly changing conditions are among the reasons Nordhaus recommends a shift to price-type control mechanisms, such as internationally harmonized carbon taxes, for future climate change policy.

7.0 An Alternative Proposal for Market-Oriented Regulation

The challenges to implementing broad-based compulsory policy to address GHG emissions have motivated us to formulate an alternative proposal for market-oriented regulation. We call this instrument a carbon management standard and it is built around an essential concept of producer responsibility – that our productive sector must be regulated to sell us products and services that are benign before, when and after we use them.

The carbon management standard we propose would require the fossil fuel industry to take responsibility for the fate of a growing percentage of the carbon it extracts from the earth’s crust – ensuring that this carbon is not released to the atmosphere. The obligation would be implemented at a modest level as quickly as possible and gradually raised according to a schedule announced up-front that would ultimately result in deep emission reductions over a period of decades. Firm penalties would be associated with non-compliance. A carbon management standard may require some adjustment over time as new information becomes available about the benefits and costs of

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2 While we critique various aspects of the Kyoto Protocol in this document, this is with the intent to provide suggestions for a more effective agreement moving forward in the post-Kyoto phase of international negotiations on GHG emissions. We recognize that the first cut at an international agreement on climate change will inevitably be flawed when viewed from a single dimension such as economic efficiency or equity.

3 It appears that the emissions trading system of the European Union – functioning within the broader framework of the Kyoto Protocol – may be able to overcome these difficulties. The members of the European Union are linked geographically and by a supranational union consisting of a single market, a common currency and shared policies. This degree of existing cooperation improves their chance of success in negotiations around emissions abatement.

4 These ideas are also associated with the terms “life cycle management” and “cradle-to-grave” responsibility as part of shifting environmental protection responsibility, even for consumer goods, to firms.
alternative energy options, alternative rates of GHG emission abatement, and alternative policy designs. However, great effort should be made to minimize such adjustment as this could undermine the incentive for participants to take the scheduled requirements seriously enough to commit major investments in a timely fashion.

When implemented by a national government, the standard would apply to fossil fuel producers, and would likely be imposed at oil and gas field bulk collection and shipment points and coal mine mouths. Importers would also be covered if trading partners did not yet have an equivalent policy in place. Likewise, fossil fuel exporters could be partially exempted initially if unilateral application of the carbon management standard would lead to unnecessary hardship for the domestic industry. Government would collect certificates from firms that must match their aggregate obligation under the standard. These certificates would demonstrate that carbon has been prevented from entering the atmosphere. Firms regulated by the carbon management standard would trade certificates amongst themselves in an established market. At the end of each year, each producer and importer of fossil fuels would be required to remit certificates to government in accordance with its overall obligation to produce zero emission fuels. The system could allow firms to bank certificates acquired in one period for use in a future period. Firms could also be allowed to borrow certificates from future time periods for use in the present, although this is a matter for future debate.

There are similarities between a carbon management standard and an upstream ECTP in that both policy instruments regulate fossil fuel producers and importers, and in both cases trading is allowed to promote economic efficiency. However, the carbon management standard is unique in that it sets an obligation for a growing fraction of carbon to be managed such that it does not enter the atmosphere, whereas a conventional upstream ECTP sets a cap on the overall amount of carbon that can be sold by fossil fuel producers and importers. Rather than allocating permits to emitters in accordance with the cap, under a carbon management standard government collects certificates from firms.

An interesting issue is the nature and magnitude of the penalty for a fossil fuel producing company if it fails to obtain enough carbon management certificates in a given year. Government could decide that, as with some types of environmental regulations, failure would trigger legal action. However, the more likely scenario is that the carbon management standard would be associated with progressively stiffer financial penalties for each unit of the gap between the certificates that a company holds and its obligation in a given year. If government is worried, however, about the ability of firms to make investments that meet some of the earlier obligations, it could set a maximum financial risk by agreeing to offer an unlimited number of certificates at a ceiling price in early years. This would be comparable to the approach with the environmental cap and tradable permit policy of providing unlimited emission permits at a given price – the so-called safety valve. The need for a safety valve approach is reduced if certificate banking and borrowing are permitted.

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5 Within a reasonable time period, importers of electricity, biofuels such as ethanol, and hydrogen should also be covered by the carbon management standard if fossil fuels are consumed in the production of these energy forms.

6 Borrowing of permits/certificates is contentious and requires a credible institutional arrangement to ensure future permit/certificate deficits are not forgiven by the regulator. However, borrowing is likely to significantly lower costs of compliance.
Figure 1 shows the basic design features of the proposed carbon management standard. The system could allow non-covered sources to sell project-based certificates directly to regulated firms. For example, electricity generators could undertake carbon capture and storage projects, obtain certificates and sell them to the upstream fossil fuel industry. This flexibility would encourage carbon capture and storage projects throughout the economy, as well as projects to reduce fugitive emissions from oil and gas wells, reduce methane emissions from coal mines, the agricultural sector, and from natural gas pipelines upstream of oil refineries. Projects would need to be certified through government or third-party audits, and certificates could be marketed through a central emissions exchange or exchanged bilaterally. All carbon contained in fossil fuels would be covered and the standard could also eventually apply to emissions of HFC, SF₆, and PFC on the basis of their global warming potential relative to CO₂.

The design of specific components, including the nature and magnitude of penalties for non-compliance, certificate banking and borrowing, and policy compliance monitoring, is critical if the carbon management standard is to function effectively and efficiently. While this chapter does not address these issues in detail, significant experience with the design of various types of market-oriented regulations is available to draw upon through the emissions trading system of the European
Union, the SO₂ trading provisions under the US Clean Air Act, the California RECLAIM program for NOₓ and SO₂ emissions, the phase-out of lead from gasoline, and many other programs.

8.0 Assessment of the Carbon Management Standard

A series of policy criteria were introduced in Section 2, against which we can evaluate the carbon management standard. In terms of economic efficiency, the gradual increase in stringency provides a strong signal for innovation and adoption of new technologies at the margin without incurring the high costs associated with prematurely forcing the retirement of existing capital stocks (Jaccard et al., 2007). Trading in certificates also reduces the cost of emission reduction, and a safety valve would set a maximum financial risk for regulated firms. Further efficiency improvements could be achieved by allowing firms to bank and borrow certificates.

By framing the policy in terms of the responsibility of the fossil fuel industry to manage a substance released upon consumption of its products – a substance (carbon) that has been linked to dangerous climate change impacts – political acceptability is increased over other compulsory approaches. The carbon management standard shifts the language from removing a “right to pollute” to enforcing an “obligation to manage dangerous substances,” which is potentially more saleable to industry, politicians and the public. More importantly, by using an obligation/certificate approach rather than the conventional cap/permit approach, a national government avoids politically and economically complex negotiations over initial permit allocation. And because the fossil fuel industry represents a relatively small number of entities with great experience in coordinated action and government relations, the carbon management standard should perform well in terms of administrative feasibility.

Environmental advocates may criticize our proposed policy approach on the basis of environmental effectiveness because it does not establish an absolute limit on emissions. It is important to bear in mind, however, that any instrument which attempts to provide some protection from abatement cost uncertainty by setting a maximum cost must compromise in terms of the certainty of its emissions outcome. Neither an emissions tax, nor an ECTP with safety valve can guarantee a particular level of emissions abatement. Furthermore, as the percentage requirements for carbon management increase to higher and higher levels, the distinction between the proposed standard and an instrument that specifies an absolute target becomes less germane. Indeed, if the final target in the scheduled increase of the carbon management standard is set to reach 100% of all carbon extracted from the earth, then the policy would be equivalent to an absolute cap requiring emissions to fall to zero. Thus, the carbon management standard can be set to replicate the effect of an absolute emissions cap.

The carbon management standard has features that make it compatible with different scenarios of international response to climate change. From the perspective of an individual country acting unilaterally, partial exemptions for fossil fuel exporters would limit impacts on the international competitiveness of its energy sector. In the case of coordinated action, the approach would allow the international community to sidestep negotiations associated with the initial setting of national emission caps – negotiations that have brought the ECTP system of the Kyoto Protocol to a virtual standstill. Indeed, the key advantage the carbon management standard is that it requires no international agreement on GHG emissions.

Victor (2004) argues (in the context of an international emissions trading system for carbon) that because of the difficulties associated with reaching comprehensive global agreements we should instead pursue a “bottom-up” approach where individual countries take action first, becoming
interconnected over time. He uses the development of the World Trade Organization from a series of bilateral agreements to illustrate how a sophisticated international regime can be built in this way. The carbon management standard would develop initially through unilateral or multi-lateral initiatives, with trade pressure as the eventual mechanism for achieving broader participation. Implementation by major producer-consumers of fossil fuel products like the US and major consumers like Europe – a “clean energy pact” – would put pressure on countries exporting fossil fuels to these regions, since their exports would be subject to the standard. Trade sanctions could eventually be used to establish conformity. An internationally applied carbon management standard would present a powerful impetus for shared innovation, joint investments, technology transfers and even political cooperation among participating countries.

At Kyoto, industrialized countries were unable to convince key developing countries, such as China and India, to agree to any quota on their total GHG emissions. Pizer (2005) explains that the Kyoto approach, with its absolute emissions limits, would inevitably limit the development prospects for such countries and instead makes the case for intensity-based emissions limits (emissions per dollar of real GDP). He states that: “intensity targets simultaneously remove the concern that industrialized countries are attempting to lock in their economic advantage through absolute emissions limits and use a metric that tends to favor developing-country performance” (Pizer, 2005; p. 7). Because the carbon management standard we propose is based on percentage requirements rather than absolute targets it provides similar advantages in terms of opening the door to negotiations with developing countries. Furthermore, because the carbon management standard is applied to fossil fuel production as opposed to consumption, implementation at the international level need not directly impact developing countries or their prospects for growth. Pressure would instead be placed on OECD countries and the coal exporting countries.

9.0 Simulating the Impact of a Carbon Management Standard in an Energy-Economy Model

We simulated the implications of a carbon management standard in Canada in our energy-economy model. The model we use, called CIMS, is a hybrid energy-economy model in that it is technologically explicit but also behaviourally realistic, as we explain in more detail below.

Over the 15 years since 1990, GHG emissions have grown by almost 30% in Canada, and appear to be on a trajectory for continued rapid increase resulting from growth in population, economic output, and fossil fuel production. In the absence of compulsory policies for GHG emission reduction (financial penalties, regulatory requirements or some combination), Canada will likely be producing energy-related emissions of 1,000 to 1,500 Megatonnes CO₂ equivalent per year by 2050, perhaps double the emissions produced today. Achieving deep reductions is an enormous challenge in the context of such rapid emissions growth.

Our simulation of the carbon management standard in Canada was carried out with a goal to reduce GHG emissions in 2050 by 60% from the 2010 baseline, which is equivalent to a 76% reduction from the forecasted emissions in 2050. This target is in-line with announced commitments by federal political parties inside and outside of government. A recommended policy package was formulated for Canada, built around a gradually tightening carbon management standard as described in Table 1. In our simulation, fossil fuel importers were covered by the standard, whereas exporters were exempt. Therefore, the simulation represents a scenario in which Canada acts before some other countries and has to protect its fossil fuel industry. Banking and borrowing of certificates was not permitted. The policy package also included a zero emission vehicle standard, residential and
commercial building codes for new buildings, and appliance and energy efficiency standards to phase out less efficient equipment.\(^7\)

**Table 1: Aggregate requirement for fossil fuel producers and importers under the carbon management standard**

<table>
<thead>
<tr>
<th>Percentage of carbon not allowed to enter the atmosphere</th>
<th>2011</th>
<th>2016</th>
<th>2021</th>
<th>2026</th>
<th>2031</th>
<th>2036</th>
<th>2041</th>
<th>2046</th>
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<tr>
<td></td>
<td>6%</td>
<td>11%</td>
<td>17%</td>
<td>25%</td>
<td>34%</td>
<td>43%</td>
<td>52%</td>
<td>56%</td>
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**Note:** The percentage requirement applies for a five year period starting in the first year listed.

The CIMS model was used to simulate the effect of the recommended policy package out to the year 2050 relative to a baseline scenario where GHG emissions are not constrained by policy. CIMS has a detailed database that includes most of the technologies in Canada that use energy and emit GHG emissions. It simulates the manner in which consumers and businesses choose between different technologies using behavioural parameters estimated from real-world evidence. CIMS is an integrated model in that energy supply and demand interact to reach an equilibrium of energy prices and quantities. It also incorporates macroeconomic feedbacks that adjust the demands for products and services as their prices change, and simulates the trade in energy and other products between Canada and other countries (Jaccard et. al., 2003; Bataille et. al., 2006).

Simulation using CIMS showed that the policy package would likely reduce domestic GHG emissions in 2050 by 58% from the forecasted 2010 baseline and by 75% from the 2050 baseline.\(^8\) We found that the target established was challenging, especially in light of forecasted growth in Canada’s oil sands and given that some long-lived capital stocks acquired prior to implementation of the carbon management standard did not reach the end of their expected lifetimes by 2050. The certificate trading price or marginal cost of emission reduction associated with the carbon management standard over time was estimated in CIMS and used to set a recommended financial penalty for non-compliance, as shown in **Table 2**.\(^9\) This could also be interpreted as a safety valve to protect firms in case costs are higher than expected.

\(^7\) More information on the baseline forecast used in this analysis, an explanation of the development of the policy package tested, and details of the policy instruments themselves can be found in (MKJA, 2006).

\(^8\) These percentage reduction are based on the categories of GHG emissions modeled in CIMS. The results are inclusive of energy-related emissions, and process emissions (linked to production levels rather than technology type or fuel consumption) from industry have been included wherever possible. Other sources of anthropogenic emissions (solvent or other product use, livestock, waste management, land use changes, etc.) are not included.

\(^9\) The financial penalties shown in **Table 2** do not increase with the gap between certificates held and a company’s obligation, as suggested in section 7, but represent a flat rate set slightly above the simulated certificate trading price.
Table 2: Possible penalty for non-compliance/safety valve for the carbon management standard

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<th>2011</th>
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<th>2021</th>
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<td>130</td>
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</table>

Note: The penalty / safety valve applies for a five year period starting in the first year listed.

The deep GHG emission reduction achieved under the simulation was associated with technological change across the economy. Key actions are listed below and their impact over time displayed in Figure 2 in terms of a wedge diagram, as popularized by Pacala et.al. (2004):

- Reduced emissions from electricity generation through carbon capture and storage, hydroelectric generation, nuclear generation, and the large scale use of emerging renewables such as wind turbines;\(^\text{10}\)
- Carbon capture and storage in the upstream oil and gas, chemical products, and iron and steel industries;
- End-use and energy supply efficiency;
- Fuel switching between fossil fuels and from refined petroleum products into hydrogen and electricity in the industrial, residential, commercial and transportation sectors; and
- Output changes associated with the macroeconomic feedbacks in CIMS.

Figure 2: Wedge diagram showing emission reductions by action to 2050

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\(^{10}\) In terms of achieving deep emission reductions, the relative costs of these pathways are similar, and the choice amongst them may be more political than economic. Fuel switching from coal to natural gas is also an emission reduction option, but is not useful for deep reductions because natural gas still has half the emissions of coal when burned, and is required for reductions in other sectors.
In the early simulation periods following implementation of the carbon management standard and other targeted policies, output changes and end-use and energy supply energy efficiency improvements accounted for the most significant portion of emission reductions. With the passage of time, output changes diminished in significance while end-use efficiency, fuel switching, carbon capture and storage in the upstream oil and gas and industry, and low-GHG electricity production using hydropower and gasified coal with carbon capture and storage increased in importance. Large scale penetration of non-hydropower renewables in electricity generation, and the use of hydrogen for transportation and heating – primarily made from coal in polygeneration plants with sequestered emissions – were also seen in the later simulation periods.

Given the gradual introduction of the carbon management standard and other policies, Canadian trade competitiveness was not significantly affected in our simulation. Overall, the economy was relatively immune to long run effects caused by the constraint on GHG emissions. Demand for most traded sectors fell less than a few percent.

Energy prices will rise in a carbon constrained future; however, these changes are expected to be manageable. Jaccard (2005b) presents evidence that electricity, hydrogen and synthetic fuels can be produced with zero emissions (and low impacts and risks to land and water) at energy production costs 25–50% higher. Since the cost of the commodity typically represents less than half of its final price, after transmission, distribution and taxes have been added, even a 50% increase in the commodity cost would only result in a 25% increase in the final price seen by residential and most commercial consumers. This is within the range of oil and natural gas price increases in the period 2000–2005.

10.0 Conclusions

Shifting our global energy system onto an emissions trajectory that will eventually stabilize atmospheric concentrations of CO₂ at levels believed to avoid dangerous climate interference will require profound technological changes over the better part of the next century. The challenges to implementing national emissions caps to address climate change have motivated us to formulate an alternative proposal for market-oriented regulation. We call this instrument a carbon management standard and it is built around the concept of producer responsibility. The standard would require the fossil fuel industry to take responsibility for the fate of a growing percentage of the carbon it extracts from the earth’s crust – ensuring that this carbon is not released to the atmosphere. Firms would trade certificates amongst themselves in an established market and the system could allow non-covered sources to sell project-based certificates directly to regulated firms.

We believe the carbon management standard will perform well against the generic evaluative criteria used by policy analysts and has features that make it compatible with the development of an international response to climate change. The approach would allow the international community to sidestep negotiations associated with the initial setting of national emission caps – negotiations that have been detrimental to the Kyoto Protocol. Indeed, the key advantage of the carbon management standard is that it requires no international agreement on GHG emissions. An international application would develop initially through unilateral or multi-lateral initiatives, with trade pressure as the eventual mechanism for achieving broader participation. Because the standard we propose is based on percentage requirements rather than absolute targets it provides advantages in terms of opening the door to negotiations with developing countries. Furthermore, implementation need not directly impact developing countries or their prospects for growth because the carbon management standard is applied to fossil fuel production as opposed to consumption.
We simulated a carbon management standard in the CIMS energy-economy model as part of a policy package designed to achieve deep emission reductions in Canada by 2050. The standard we tested applied to fossil fuel importers but exempted exporters. As such it is representative of a scenario in which Canada acts before some other countries and has to protect its fossil fuel industry. The carbon management standard, along with a few selected technology-specific instruments, was simulated to reduce domestic GHG emissions in 2050 by 58% from the forecasted 2010 baseline and by 75% from the 2050 baseline. Although marginal costs under the standard reached substantial levels in our simulation, Canadian trade competitiveness was not significantly affected.

11.0 Acknowledgements

We would like to thank the Natural Sciences and Engineering Research Council of Canada (NSERC) and Natural Resources Canada for their funding assistance. We also wish to acknowledge the contributions of Bryn Sadownik and Jotham Peters to this work.

12.0 References


This short section brings together the discussions in the previous two sections through discussions of a very pressing sustainable energy topic in Alberta – remediation.

The energy sector has a large footprint in Alberta which is a huge challenge in achieving sustainability. These papers tackle the issues straight on. Clearly it is complex because we are seeking to balance diversity of needs. The issues presented here are real and are not going to disappear in the near future as the development of the energy sector in general and the oilsands, in particular, continues.

The authors here bring to the fore issues and challenges that would otherwise get ignored till they became symptoms of a bigger problem.
ABSTRACT

One of the challenges Alberta, Canada faces with oil and gas development is a significant environmental reclamation and remediation inventory. Unfunded (orphaned) or poorly funded contaminated sites often have significant clean up costs appended. While Alberta legislative impetus has attempted to assess liability to current operators in the Oil and Gas industry, more work needs to be done. This chapter will attempt to catalogue the environmental liability associated with conventional oil and gas assets, since they will be the first fossil fuel sector to face depletion. Lessons learned here can be applied to the oilsands, coal, enhanced recovery projects and coal bed methane. It will address whether sufficient economic, social and regulatory pressure is present to ensure the sites are cleaned up. Where a deficit exists, the chapter will discuss alternatives of societal, financial, regulatory and risk based approaches that can be applied to the myriad of sites requiring cleanup.

Key words: Reclamation, remediation, liability assessment, risk management

Energy production fuels the growth of Alberta. The rich natural resources have been exploited and mined for over a century. The author states that conventional oil and gas industry will be the first to face depletion of the natural resource. The approach taken here towards remediation and reclamation of the land used to extract conventional oil and gas will be important in future reclamation work done for other types of natural resources.

The author highlights many challenges to assiduous reclamation of well sites, returning the land to the natural environment of the local flora and fauna. He points out the liabilities to stakeholders (all Albertans) of abandoned and shoddily signed-off well sites. The author calls for the awakening in public consciousness of the environmental and economic liability faced by the government and all Albertans in this respect.
1.0 Preamble

Alberta, Canada has enjoyed the benefits of oil and gas extraction for almost 100 years. There is a downside to this, however, and that is the residual remediation deficit.

One of the largest challenges to the regulators is the repeated disposition of assets and conventional oil and gas fields and related facilities. As fields deplete, larger firms dispose of them to companies willing to extract the last of the resource. The establishment of income trusts is in direct response to exploiting mature fields to the benefit of the trust holders. However, these sites require diligence so that their reclamation and remediation does not become a liability to the government.

While coal was the first fossil fuel to be exploited on a commercial scale, conventional oil and gas will the first fossil fuel sector in Alberta to be exploited and in the midterm future, depleted. The challenge for all stakeholders is to ensure the residual liability is cleaned up in a timely manner, and remains the responsibility of the group that caused the contamination and gained the largest economic benefit from exploiting the resource. The end-of-sector life issues of underfunded conventional oil and gas sites will be the first faced by Alberta, and therefore the lessons learned can be applied against all sectors of the industry.

When the last conventional oil and gas is depleted and there is no economic value left in these resources there are three fundamental goals that need to have been achieved. They are:

- that the last contaminated site is remediated;
- the last bare site is reclaimed with no residual risk to any environmental receptor, and,
- the land is restored to its original level of productivity.

This work focuses on the first fossil fuel source to be depleted; therefore we hope it will provide lessons for other sectors of energy extraction, such as coal, heavy oil, steam assisted gravity drainage SAGD, tar sands mining, and coal bed methane. The systemic and regulatory challenges are immense.
The paper will focus on leases under the Province of Alberta’s jurisdiction, not Federal Lands. It will focus on the immediate issues of contamination, cleanup and reclamation.

2.0 Challenges

Challenges that face all stakeholders are listed below and will be discussed in some detail in the sections that follow:

1. The growing gap between the number of abandoned wells and those remediated and reclaimed; leading to a buildup of uncertified wells;

2. Upstream oil and gas facilities are generally geographically diverse. Assets are dispersed. Mobilization and demobilization of resources to affect any action on small leases have little economic efficiency;

3. Treatment or landfill technologies are not well developed for dispersed contaminated sites;

4. Reserves are declining and there are less resources left to clean up the leases. Also, technical resources are diverted elsewhere;

5. The declining reserves are dispersed over hundreds of companies. Some conventionally private and public companies continue to look for growth, and reinvestment. Other company structures are income trusts or companies structured solely for extracting cash flow; therefore investment or long term capital commitment to cleaning up sites may not be there;

6. In most cases, the land is leased, either from the Crown (provincial government, on public lands) or private land owners;

7. While some cleanups are relatively easy to do, many of the residual sites are more challenging;

8. Technical challenges: landfill versus in-situ remediation technologies. Economic technologies meeting the peculiar needs of small, dispersed sites where infrastructure is not present are not plentiful;

9. The number of abandoned wells failing the audit, indicating technical challenges or lack of professional capabilities to reclaim well sites effectively;

10. Changes in ownership of oil and gas assets are making it a challenge to ensure the liability sticks to the original progenitor of the remediation problem;

11. Public perception: because the problem is so dispersed, there is not as much public pressure to address the associated issues; and

12. Reclamation challenges.

Challenge 1: Increased inventory of abandoned wells

In 2006, there were 173,695 active wells, 85,879 reclaimed wells, 34,879 abandoned wells and 48,8257 inactive wells. With approximately 35000 wells to be currently reclaimed, at an average cost of $25000/well, there is an economic cost of $875,000,000 just to clean up the currently available wellsite inventory (Jede, 2006). On the negative side of the ledger, if one assumes each well is 100 metres by 100 metres (1 hectare) then 35000 hectares that could be used in another productive capacity are currently non-productive. That does not include the roads leading to these sites or
related facilities such as dedicated oilfield waste management facilities, batteries, gas plants and other midstream activities.

Alberta Environment (2006) in its State of the Environment Report outlined the issue. The challenge is shown in Figure 1.

This indicator shows the change in the number of oil and gas wells that have been abandoned and reclaimed each year from 1963 to 2005.

“Abandoned wells are those that have been permanently dismantled as prescribed by the Alberta Energy and Utilities Board regulations (EUB, 2003) and left in a safe and secure condition. Reclaimed wells are those that have met the reclamation standards (Alberta Environment, 1995) and received a reclamation certificate from Alberta Environment or Alberta Sustainable Resource Development, or were exempted from certification” (Alberta Environment, 2006).

Figure 1: Cumulative Number of Drilled, Abandoned and Reclaimed Oil and Gas Wells, 1963-2006

The trend indicates that reclamation certification is progressing slower than abandonment.

“There were 37,680 uncertified wells remaining at the end of 2006. Approximately 28% (10,706) uncertified wells were abandoned between 1963 and 1996. On average, over the last 10 years, approximately 14,468 wells were drilled per year, 3,580 were abandoned and 1,640 certified. This indicates that over the last 10 years, the certification rate has been approximately 45% of the abandonment rate” (Alberta Environment, 2006).

The build up of uncertified wells is of paramount importance. It is a tangible measure of an accruing liability that is not going away. Reclamation and abandonment rates should be similar to prevent
future liabilities associated with a buildup of uncertified wells (Alberta Environment, 2006). An abandoned well needs to be reclaimed as soon as the well cannot be used any further.

Drilling is not slowing down. According to CAODC (2006), the number of wells has risen steadily, and the total metrage has increased significantly. **Table 1** (CAODC, 2006) presents the trend. More wells are continually being added to the inventory.

**Table 1: Alberta Drilling Statistics**

<table>
<thead>
<tr>
<th>YEAR</th>
<th>OIL</th>
<th>GAS</th>
<th>DRY</th>
<th>SVR.</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of wells 2001</td>
<td>4689</td>
<td>11,177</td>
<td>1759</td>
<td>308</td>
<td>17,933</td>
</tr>
<tr>
<td>total metres</td>
<td>5,713,392</td>
<td>10,893,625</td>
<td>2,101,842</td>
<td>337,601</td>
<td>19,046,460</td>
</tr>
<tr>
<td>Number of wells 2002</td>
<td>3,832</td>
<td>9,073</td>
<td>1,289</td>
<td>265</td>
<td>14,459</td>
</tr>
<tr>
<td>total metres</td>
<td>4,532,351</td>
<td>8,987,361</td>
<td>1606469</td>
<td>308,259</td>
<td>15,434,440</td>
</tr>
<tr>
<td>Number of wells 2003</td>
<td>4,473</td>
<td>13,944</td>
<td>1,233</td>
<td>201</td>
<td>19,851</td>
</tr>
<tr>
<td>total metres</td>
<td>5,374,320</td>
<td>13,351,526</td>
<td>1,517,763</td>
<td>234,922</td>
<td>20,478,531</td>
</tr>
<tr>
<td>Number of wells 2004</td>
<td>4,427</td>
<td>15,645</td>
<td>1,266</td>
<td>255</td>
<td>21,593</td>
</tr>
<tr>
<td>total metres</td>
<td>5,366,801</td>
<td>15,781,169</td>
<td>1,550,078</td>
<td>303,224</td>
<td>23,001,272</td>
</tr>
<tr>
<td>Number of wells 2005</td>
<td>4,822</td>
<td>15,359</td>
<td>1,414</td>
<td>330</td>
<td>21,925</td>
</tr>
<tr>
<td>total metres</td>
<td>6,178,299</td>
<td>16,429,386</td>
<td>1,706,458</td>
<td>355,420</td>
<td>24,669,563</td>
</tr>
<tr>
<td>Number of wells 2006</td>
<td>5599</td>
<td>15289</td>
<td>1072</td>
<td>167</td>
<td>22127</td>
</tr>
<tr>
<td>total metres</td>
<td>7,392,584</td>
<td>17,825,913</td>
<td>1,291,822</td>
<td>198,310</td>
<td>26,708,629</td>
</tr>
</tbody>
</table>

**NOTE:** These figures are for Western Canada only.

**Challenge 2: Geographical dispersal**

**Figures 2 and 3** (Jede, 2006) show the distribution of the wells through the province. Running the entire width and length of the Western Canada Sedimentary Basin, 178000 wells are spread over the province. They extend from Zama in the extreme Northwest corner of the province to Manyberries in the southeast. The challenge, then, is applying the appropriate technology cost-effectively. Many cleanup technologies developed around the world are designed to address issues at large, centrally-located, complexes, but make little economic sense on such dispersed sites. It also means that local expertise capable of managing such technologies is stretched.

**Challenge 3: Technology challenges**

Most industrial cleanup technologies have been built for large, centrally located, industrial sites. The economies of scale are lost when applied to thousands of sites hundreds of kilometers apart.

The costs for mobilization of complex technologies to small sites are, in proportion, quite high. In addition, by the time reclamation or remediation begins on an abandoned well, the site is not
serviced with power or by other utilities and access might be limited or non-existent. Any technology will have to be self sufficient, and stand-alone.

In addition, weathered, long-chain hydrocarbon and salt contaminated soils comprise the dominant volumes of materials disposed in cleanups and recorded by the Energy and Utilities Board (EUB 2000; EUB, 2001: and EUB, 2002)). Salt and long-chain hydrocarbon contaminated soils are not easy to treat, particularly in relatively small amounts and dispersed through the soil matrix. The default position for the oil and gas industry has been landfilling.. Technically, the design of these landfills are much better now, under the scrutiny of the EUB and Alberta Environment, than in the past. And while it allows the land covered by the wellsite to be brought back to a productive use, it is still a form of long term storage. The environmental liability has not been mitigated.

Figure 2: Abandoned Wells in Alberta
Challenge 4: Reserves are declining and there is less resources left to affect clean up

Using the Canadian Association of Petroleum Producers’ (CAPP), moderate case scenario, conventional oil production will decline from just under 1,500,000 barrels per day in 1999 to 600,000 barrels per day in 2015 (CAPP, 2004). Investment in the last 10 years (1995-2004) in the oil industry has been $120 billion (Alberta Energy, 2006), with levels of investment continuing but focusing on oil sands. However, the proportionate and real dollars will probably drop on the conventional side eventually, and so it is incumbent to clean up these sites now while investment is stable, and before investment declines (see Table 1).

Challenge 5: The declining reserves are dispersed over hundreds of companies

There are about 150 member companies in CAPP (2006), involved in the upstream oil and natural gas industry. An additional 450 upstream oil and gas companies belong to the Small Explorers and
Producers Association of Canada (SEPAC, 2006). While many companies are devoted to further exploration and committed to the continued development of the Western Sedimentary Basin, others are not. Some companies have developed a thoughtful risk-based approach to clean up. Other companies do not have the expertise in house; still others do not even know where to turn.

However, CAPP in its recent publication, Stewardship Benchmarking Guide (CAPP, 2006a), has defined benchmarks for at least measuring the progress made in reclamation. They have demanded data from their members including mandatory registration on active operated wells, inactive operative wells, and reclamation certification. This initiative will significantly assist in monitoring progress on reclamation.

Some companies are taking a pro-active stance. Petro-Canada Oil & Gas (PCOG) has instituted a risk-based inactive-well management system (RIMS). Rather than waiting for a low (poor) license liability rating (LMR), PCOG developed a risk assessment matrix based on vintage, casing integrity, years of inactivity, environmental issues, accessibility, cathodic protection, Surface Casing Vent Flows (SCVF) and the presence of sour gases. This allows a conscious focus on those sites of highest risk (Petek, 2006).

**Challenge 6: Land ownership**

One of the biggest challenges facing all stakeholders is that the land on which conventional oil and gas activities frequently occur is leased by the oil company, not owned. The land is either owned privately, or by the Crown. For the landowner, the consequence of a site that has not been cleaned up is serious, as the site is of no productive use to the landowner until it is reclaimed. Our experience is some of them have not been able to gain financing from financial institutions because of the residual contamination caused by others. While Alberta Environment has attempted to address this issue (Alberta Environment, 2001), all parties, particularly financial institutions do not completely comprehend their liability risk. Even though the liability may lie with the originator, or current oil and gas licensee, the consequences often lie with the landowner. For the Crown on public lands, the issue is more the diversion of resources to manage these sites from more constructive regulatory tasks. At its extreme, the Crown is left with the residual liability.

**Challenge 7: Residual sites are becoming more complex to clean up**

With new drilling and containment techniques and stricter environmental controls, new facilities should be cleaner than older ones. But some of the older facilities left are the most difficult to clean up. While most sites are relatively easy to handle, others are not. Hydrophobic soils, widely distributed salt contamination, and or widely dispersed hydrocarbon contamination, horizontally and vertically are not uncommon.

This is of particular concern to regulators and landowners, because of the concern of these stakeholders being left with the residual liability.

More rigour is being applied. The Upstream Oil and Gas Reclamation Program changed on October 1, 2003 to include contamination assessment and remediation as a requirement for obtaining a reclamation certificate. The program changes also provide for reclamation applications to be certified throughout the year following a desktop review (Alberta Environment, 2006).
Challenge 8: Technical and professional challenges

There are approximately 400 companies providing remediation services. A large majority of these companies are small and highly specialized. Furthermore, a labour shortage in key technical fields constrains development of remediation technology and its implementation. There is also a need to have technology that addresses the surface fragmented sites (dispersed sites), and the increasing urban development interacting with the oil and gas industry (Jede, 2006). The new technologies have to be mobile, cost-effective, robust, and self-sufficient. These technologies also have to be robust enough to withstand climactic extremes.

Alberta Environment and others are working with others to reduce cross-media transfer, such as contaminants released from soil to water or air. This initiative will demand more rigorous technologies to complete the work. Alberta Environment has recently released new, clearer, remediation levels (Tier 1, Tier 2) which provides consistency and rigour.

von Hauff et al. (2006), addressed Alberta Environment’s push toward a more consistent contaminated sites management system, in terms of: redefining levels of concern; reviewing Tier 1 and Tier 2 levels; incorporating stratified remediation; and developing risk management approaches. Sawatsky et al. (2006) state one can now mix Tier 1 and Tier 2 levels based on site use and media differences on a particular site. More rigorous delineation of the contamination is now needed as well as protection for cross-media transfer. Both Tier 1 and Tier 2 levels can be applied in the application to Alberta Environment for remediation certificates. Remediation certificates are now being brought forward, specifically to the area cleaned up only, not the entire site. While these are not applied to upstream oil and gas sites yet, the trend is positive; it means Alberta Environment has a more formal sign-off on remediation. Initially the remediation program will be voluntary (Howat et al., 2006). Remediation certificates can not be applied to Exposure Control (site specific risk assessment) may not be applied to remediation certificates.

Exposure control (site specific risk assessment) may not be applied to Remediation Certificates. Sawatsky et al. (2006) state one can now mix tier 1 and tier 2 levels based on site use, media differences on a particular site. The focus is pollution prevention and not polluting up to guidelines. More rigorous delineation of the contamination is now needed.

These changes are based on the last 30 years of experience in site cleanup and allow the professional more adaptability, with the consequent increase in adaptability to reach a successful, scientifically valid, clean up of a site.

Challenge 9: Failing audits

In 2003, remediation requirements were added to the reclamation certificate program. The company that owns the well or pipeline applies to either Alberta Environment or Alberta Sustainable Resource Development for a reclamation certificate. Each application must include an assessment to determine if contamination is present and a report detailing how contaminants were cleaned and surface issues were addressed. If all standards are met, Alberta Environment issues the company a reclamation certificate (Alberta Environment, 2006a).

Table 2 (Alberta Environment, 2007; pp. 1) below shows the challenges facing the professions associated with the certification of contaminated sites. In 2006 and 2007, only 58.3% of the sites passed this audit process. This is a critical challenge for, while Alberta Environment field offices audit
sites randomly in Alberta, the responsibility for these sites increasingly lies with the professional providing the sign off.

**Table 2: Field Audits on Certified Sites, Alberta Environment (AENV) and Alberta Sustainable Resource Development (ASRD)**

“The field audit performance measure indicates the percentage of certified sites audited by Alberta Environment that have met Alberta Environment’s reclamation and remediation requirements. A portion of upstream oil and gas sites that receive a reclamation certificate under the new reclamation program will be randomly audited. This performance measure provides assurance that certified sites are meeting Alberta Environment’s remediation requirements and reclamation criteria” (Alberta Environment, 2007).

<table>
<thead>
<tr>
<th></th>
<th>Total Audits Held</th>
<th>Certificates Upheld</th>
<th>Results Not Available</th>
<th>Sites Under Investigation</th>
<th>Certificates Cancelled</th>
<th>Percentage Passed</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SURFACE AUDITS</strong>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AENV***</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>2003-5</td>
<td>38</td>
<td>34</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>89.5%</td>
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<tr>
<td>2005-6</td>
<td>96</td>
<td>89</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>92.7%</td>
</tr>
<tr>
<td>2006-7</td>
<td>88</td>
<td>80</td>
<td>6</td>
<td>0</td>
<td>2</td>
<td>90.9%</td>
</tr>
<tr>
<td>ASRD***</td>
<td></td>
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<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>2003-5</td>
<td>86</td>
<td>75</td>
<td>0</td>
<td>0</td>
<td>11</td>
<td>87.2%</td>
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<tr>
<td>2005-6</td>
<td>188</td>
<td>187</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>99.5%</td>
</tr>
<tr>
<td>2006-7</td>
<td>279</td>
<td>250</td>
<td>28</td>
<td>0</td>
<td>1</td>
<td>89.6%</td>
</tr>
<tr>
<td><strong>CONTAMINATION AUDITS</strong>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AENV***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2003-5</td>
<td>23</td>
<td>20</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>87.0%</td>
</tr>
<tr>
<td>2005-6</td>
<td>43</td>
<td>32</td>
<td>11</td>
<td>0</td>
<td>0</td>
<td>74.4%</td>
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<tr>
<td>2006-7</td>
<td>48</td>
<td>28</td>
<td>20</td>
<td>0</td>
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<td>58.3%</td>
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</tr>
<tr>
<td>2003-5</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100.0%</td>
</tr>
<tr>
<td>2005-6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>2006-7</td>
<td>25</td>
<td>0</td>
<td>25</td>
<td>0</td>
<td>0</td>
<td>0.0%</td>
</tr>
</tbody>
</table>

[*]: The number of audited sites in determined by the number of certificates issued in the previous financial year.

[**]: Alberta Environment

[***]: Alberta Sustainable Resource Development
Alberta Environment and the rest of the stakeholders are attempting to increase the proficiency of those signing off on sites. Practitioners now must be a member of a professional organization, have a minimum five years experience in reclamation or remediation, know the legislation, be able to manipulate information sources, excel in report preparation, and know and apply standards for reclamation protocols, survey and mapping, and consultation (Howat et.al., 2006; Alberta Environment, 2004). By working with the professional organizations, censure and discipline can be applied to the individual should consistent poor performance arise. As well, professional development requirements demanded by these organizations to maintain one’s membership will keep the practitioner current on new techniques.

**Challenge 10: Distribution of liability**

Since the early 1990’s, Alberta has been working to better define the liability associated with contaminated sites. The Alberta Environmental Protection and Enhancement Act (EPEA) established joint and several (jointly distributed) liability. This ensures that any party responsible for the contamination must be responsible for their share.

This first attempt at a liability management program has been supplemented by recent additions. Bill 29 has amended EPEA to now define allocated liability or partitioned liability, instead of joint and several. Alberta Environment focuses on the owner of the substance (s. 1(ss)(ii)) or his successors (s. 1(ss)(iii)). The licensee of the upstream oil and gas site is generally deemed to be the owner of the substance, and the consequent contamination (Alberta Environment, 2001).

Alberta’s Upstream Oil and Gas Reclamation and Remediation Program is meant to ensure that land used for oil and gas development is restored to a productive state. Several departments are involved in this program including Alberta Environment, Alberta Sustained Resources Development and Alberta Energy and Utilities Board. The program requires all upstream oil and gas sites on private and public land to be reclaimed when a site is no longer productive. Alberta Environment is responsible for the reclamation of private land and Alberta Sustainable Resource Development is responsible for public land. Alberta Environment oversees the development of guidelines and documentation used to administer these parallel programs (Alberta Environment, 2006). Alberta Energy and Utilities Board is responsible for the safe abandonment of surface and below ground activities (EUB, 2003).

Under Alberta Energy Utilities Board (EUB) rules, the current licensee is responsible for the residual contamination of previous licensees.

The License Liability Rating Program (LLR), administered by the Alberta Energy Utilities Board (EUB), is designed to encourage reclamation soon after well abandonment. Industry helped define the baseline liability values. EUB Directive 001 and Directive 006 provide the basis for the liability assessment. They use the well equivalent number as a basis for calculation. As an example, a small battery site is assigned an equivalent of 5 wells at the rate of $10,000 per well.

LLR compares deemed assets versus deemed liability, where assets are based on profit/ cubic metre of oil of annual production over three years. Liability is modified by the present salvage value. Where liabilities exceed assets, a security must be deposited with the EUB.

Site specific assessments are given under both EUB waste management regulations, and oil and gas conservation regulations. Values can be assessed by the formulae presented, or self declared assessments (Site-Specific Liability Assessments) can be used to define the liability. That liability is
then assessed against the producing assets to define what deposit must be left with the EUB to cover unprotected liabilities.

The Orphan Well Program, funded by the oil and gas industry and administered by the Orphan Well Association, is designed to reclaim wells formerly owned by companies that are no longer in business. The Orphan Fund is a self-insurance program to address, in part, defunct liability. Discussions continue between the Orphan Well Association and Alberta Environment on the application of the Orphan Well Fund. As an example stakeholders argue that sites closed to 1962 are exempt from the Orphan Well Fund, as these sites were considered closed to the standard of the day. If there are continued problems, these revert directly to the Crown (Alberta Government) for cleanup. The Orphan Well Association is also resisting assuming responsibility for sites on which the reclamation certificates is issued up until October 2003, which would leave the Crown liable as well.

The Orphan Well Association had the Oil and Gas Conservation Act modified in 2000 to accrue liability against the current working interest partners (those who partake in gross costs and gross revenues), as opposed to the royalty interest partners, who collect revenues on a net basis. This means there is no liability against the previous owners. The current license holder is the duty holder. Some might argue that this is inconsistent with polluter pay principal.

The efforts by various government departments and agencies to address remediation challenges has accelerated since 2000. It is timely to now assess the effectiveness of these programmes.

One concern is the lack of a contaminated sites registry for the upstream oil and gas industry. While issues can be inferred by referring to databases on underground storage tanks and spills, requesting incident records through the Freedom of Information and Protection of Privacy Act (FOIP), and reviewing Environmental Law Centre databases, there is no central registry of contaminated sites (Alberta Environment, 2004a). Any transfer of these assets, whether to a landowner, purchasing oil company or the Crown must be done with a ‘buyer beware’ attitude.

**Challenge 11: Lack of Public Concern**

Broad public concern has been addressed for more large-scale environmental issues and has not addressed this widely dispersed reclamation deficit. While surface rights groups have expressed there concern, other non-governmental organizations (NGO’s) have been relatively silent.

The drivers will probably be landowners, banks and representatives of the Crown, who do not want to be saddled with residual liability. Landowners often receive a lease payment from oil and gas companies for their activities on privately owned land. Upon suspension of an oil and gas activity on their land, landowners sometimes get short shift with reduced lease payments, so there is little incentive for abandonment. CAPP’s stewardship benchmarking initiative and Alberta Environment’s State of the Environment reports will help all stakeholders keep the reclamation and remediation issue in focus.

Professional organizations will also be looking for increased diligence and procedures. Their members, with the new remediation strategy under the reclamation certificate process, and the reliance on the professional stamp for risk management assurance, are taking more of the responsibility and risk on themselves.
Challenge 12: Reclamation Challenges

A paragraph from Alberta Land Conservation and Reclamation Council (ALCRC, 1993; pp. 2) summarizes some of the disparate challenges reclamation of wellsites:

“Gravel removal, compactions, adverse topography, winter conditions during drilling, older wellsites, and loss of topsoil or poor distribution of topsoil were identified as problems in surface reclamation which increased costs.

There appear to be more problems in reclaiming older wellsites, especially those drilled prior to 1978 when there was no requirement for topsoil conservation. Lack of topsoil and organic matter was often cited as a problem.

Various parts of the province have unique reclamation situations to deal with. For example, government and industry representative indicated there were deeper wells and therefore larger sump volumes to handle in the northwestern portion of the province. Muskeg sites were also mentioned as being potential problems, particularly in northern Alberta. Accessibility to wellsites could also greatly increase surface reclamation costs (both in hauling costs and in costs of reclaiming long access roads).

In the east-central and southeastern areas, vegetation establishment is difficult because of sandy soils, dry weather conditions, and high erosion potential. In the foothills, area, topography, rocks, forests and long access roads are all situations that pose problems during reclamation.”

While surfeits of topsoil are found near rapidly developing urban centres, wells in the hinterland are often short of the right type of topsoil or organic matter for well cleanup. The challenge does indeed come with facilities drilled before 1978, or where successive development has hidden or dispersed topsoil piles. The challenge is that reclamation should try to mirror what was there before, so importing the wrong type of topsoil is a disservice.

Another challenge is to bring the land to a high level of agricultural productivity in the white (privately held land) zone for efficient cropping and a level of ecological productivity in the (publicly held land) green zone. Debates continue on end land use, such as whether to bring a site to a level of ecological integrity for instance, or to be better exploited by a forestry operation.

If the site is contaminated, the problems listed by ALCRC are exacerbated. If large volumes of materials are removed, they must be replaced, often taken from a newly disturbed borrow (material extraction), causing a domino effect in reclamation needs. If the site has been reclaimed previously, the site may not even have road access.

3.0 Conclusion & Recommendations

With the work of industry and government stakeholders, the reclamation and remediation deficit for the upstream oil and gas industry is at least measurable. We know the current deficit of unreclaimed wells, and these are being measured by Alberta Environment annually. There were 34,825 uncertified wells remaining at the end of 2005 and over the last 10 years, the certification rate has been approximately 55% of the abandonment rate. At an average cost of $25000 per well, there is an
economic cost of $875,000,000 just to clean up the currently available uncertified wells site inventory. This deficit grows annually.

The liability management programs and orphan fund programs in place at least reduce the residual environmental liability to the Crown. New Tier 1, Tier 2 and Risk Management Standards put the onus on the professional to make prudent and scientifically sound decisions.

The backlog of sites must be cleaned up before investment in conventional oil and gas recedes. While all stakeholders need to provide input, some ideas follow to stimulate further discussion.

1. CAPP and SEPAC should continue to provide services and encouragement to their members on the need for reclamation and remediation, and the liabilities they are accruing. There is enlightened self-interest in this if their member companies can get liabilities off their books. CAPP’s stewardship initiative should become a mandatory policy for its members.

2. The current programmes should be measured for their effectiveness. Alberta Environment’s State of the Environment report should always include a reclamation deficit section. EUB should re-institute summarizing waste manifest data. The Orphan Well Association should summarize their activities annually. CAPP and SEPAC should provide annual reclamation stewardship reports.

3. Financial institutions in Alberta still do not consistently understand the liability risk their clients and the institutions themselves face. All stakeholders should work with these institutions both formally and informally to take the pressure off the landowners and allow financial lending to proceed where appropriate. Government Remediation Certificates help, and perhaps a formal educational program geared toward landowners and financial institutions, led by government should be established.

4. New technologies have to be mobile, cost-effective, robust and self-sufficient. They have to be robust enough to withstand climatic extremes and cross-media transfer of constituents should be actively discouraged. Regulatory agencies should be encouraged to facilitate trials in new technologies, allowing them to field test their equipment before imposing final license conditions. Organizations like Petroleum Technology Alliance Canada (PTAC), Environmental Services Association of Canada (ESAA) and Alberta Economic Development should develop forums to showcase new technologies and get them in front of the oil and gas industry.

5. All upstream oil and gas companies should have a mandatory risk-based inactive-well management system (RIMS). When a company institutes such a system, there should be a financial reward, including a better licence liability rating.

6. Professional Organizations in Alberta should continue to work on policy, discipline, training, professional development and procedures to ensure the right professional people are remediating the site. The goal should be at least 95% acceptable sites under Alberta Environment’s reclamation and remediation audit programme.

7. A contaminated site registry should be built and administered for the upstream oil and gas industry.
8. While the License Liability Rating (LLR) program and the Orphan Fund program go a long way in reducing the financial liability to the Crown, and consequently to the people of Alberta, perhaps more direct fiscal instruments could be used on those companies that do not remediate their sites. For instance an increasing ladder of levies could be applied for each site that is not addressed after three years abandonment. Alternatively, a reclamation bond for every lease site should be instituted before the surface lease is granted. Finally, Directors or signing officers should be held liable for sites not addressed after 6 years.

9. Remembering that the goal is to remediate the last contaminated site when the last conventional oil and gas is depleted, the following measurable deliverables can be considered:

- 95% acceptance rate on remediation audits;
- by 2010, the number of remediated and reclaimed sites equal the number of abandoned wells that year; and
- by 2015, the deficit of abandoned sites have been addressed and are remediated and reclaimed.

4.0 Acknowledgements

Many thanks go to the staff at the Alberta Energy Library and the Environmental Law Centre. Thanks to all my peers in Alberta Economic Development, Alberta Energy, Alberta Environment, Alberta Energy and Utilities Board, Small Explorers and Producers Association of Canada (SEPAC), Canadian Association of Petroleum Producers (CAPP) and the oil and gas sector who guided me to information and who continue to work hard toward a sustainable environment.

5.0 References


ABSTRACT

Remediation of contaminated sites must occur to ensure that potential negative impacts do not occur to humans, plants, animals, and the environment. From a strategic perspective, remediation of contaminated soil supports the goal of sustainable development; however, not all forms of remediation have the same positive economic, social, and environmental impacts.

This paper presents a methodology to assess the impact of remediation technologies using Alberta oilsands as an example. It is believed that with further research and analysis, this simple tool can be turned into a comprehensive assessment and comparison tool.

Using a set of sustainability criteria, this paper assesses twelve soil remediation technologies used for hydrocarbon contamination in Alberta. The sustainability criteria used for evaluating the negative impacts are annoyance, air quality, water, soil, legacy, and resources. While conservation, economic and social aspects are evaluated to assess the positive impacts. Since different remedial technologies vary in their sustainability, they were ranked from the smallest to greatest negative impact.

Keywords: remediation, sustainable remediation, sustainable development

The description and assessment of soil remediation technologies serves not only as an informative document that summarises remediation options for the casually interested, but also as a valuable reference to assist stakeholders select a preferred technique, based on efficacy, costs, time/duration and environmental impacts.

The paper’s scoring and ranking of remediation options provides the reader with the capacity to make informed and reasoned decisions about alternative clean-up measures.

Paul D. Hunt
Methodology for Assessing Sustainable Soil Remediation Technologies

Lisa Dechaine

1.0 Sustainable Remediation

Sustainable remediation can be defined as remediation that employs technologies that would meet the needs of the organization and stakeholders and whose negative impacts do not exceed the benefits of the project (CLARINET, 2002a). It is a derivative of the sustainable development concept that was first introduced in the Bruntland Report of the World Commission on Environment and Development (1987). Sustainable Development is “development that meets the needs of the present generations to meet their own needs.” (p.51) Sustainable remediation like sustainable development must balance the economical, environmental and social aspects.

According to the World Bank Group (2002), social aspects look at the issues that impact people directly and either help or hinder the process of improving the quality of life. Economic aspects look at the system that determines how the limited resources are distributed and used. Environmental aspects look at renewable and non-renewable resources that make up our surroundings and help us to sustain and better our lives.

Contaminated Land Rehabilitation Network for Environmental Technologies (CLARINET) research suggests the best cost-reducing strategy for remediation is to reduce the volume of soil requiring treatment and increase the amount of materials that can be recycled or reused. Biological techniques are considered to be the “most sustainable”. In situ remediation technologies are preferred over ex situ since there tends to be less impact. The least desirable option from a sustainability perspective is excavation and off-site disposal because of transportation and related problems.

Sustainable remediation technologies can help in addressing differences in points of view between stakeholders. It can be useful for promoting the broader impacts of what might be seen as “greener” solutions. It can help a local authority or company demonstrate sustainability. Another benefit is that more sustainable technologies may in fact be the most cost effective given that they attempt to maximize resource utilization.

2.0 Background

Energy is needed to power our economy and produce goods and services but we could get by with far less fossil fuel. Our current measures of progress are based primarily on economic growth statistics, which is misleading because the message it sends is the more energy we burn, the better off we are. These conventional measures also ignore other costs associated with energy consumption.
depletion, soil contamination, air and water pollution, illness costs, damage to marine and terrestrial wildlife, land-use conflicts, and the effects of global climate change all remain invisible in our conventional economic accounts (Colman et al., 2006).

Soil contamination can occur from leaking fuel tanks and a variety of industrial and commercial activities. Remediation of contaminated sites must occur. From a strategic perspective, remediation of contaminated soil supports the goal of sustainable development by conserving land, preventing the spread of pollution and reducing the pressure for development on greenfield sites (CLARINET, 2002a). However, not all forms of remediation have the same positive economic, social, and environmental impacts.

The most utilized form of soil remediation consists of excavating, hauling, and disposing soil at an approved landfill. This method has been seen as a reliable way of remediating a site within a well defined time period while avoiding future liabilities. However, many Alberta landfills are nearing their capacities and placing contaminated soil in them could be viewed as wasting valuable space, costly, and a potential threat of legal liability.

Technologies to remediate contaminated soil fall into two categories: in situ and ex situ. In situ treatments remediate contaminated soil without removing the material from the ground. Ex situ involves the removal of contaminated soil for treatment. The conventional in situ remediation technologies that are used for petroleum hydrocarbon contamination are natural attenuation and surface capping/encapsulation. Other less popular technologies are biodegradation, bioventing, and soil vapor extraction. The most common ex situ for the same type of contamination is excavation and landfill disposal. Other less popular technologies are solid phase biological treatment, slurry phase biological treatment, soil washing, and low temperature thermal desorption (Industry Canada, 2005).

Remedial options are constrained by cost, land requirements, time required for remediation, regulatory requirements, and available effective techniques. The cost for disposing contaminated soil at approved landfills is increasing which will directly increase ex situ remediation costs. Companies will need to evaluate other forms of remediation technologies. More progressive and transparent companies and contractors are going to look at sustainable technologies where the negative impacts of remediation do not exceed the benefits of the project. In other words sustainable technologies will take into consideration the economic, social and environmental impacts.

According to Ecomark Ltd., a consulting firm in Edmonton Alberta, companies are beginning to look for remediation technologies that are more sustainable (personal communication). Specifically, technologies meeting organizational and stakeholders needs while the negative impacts do not exceed the benefits of the project (CLARINET 2002a). A review by CLARINET (CLARINET, 2002b), concludes that “there are no generally agreed means of carrying out sustainability appraisal for remediation projects even though there is great interest in Europe in promoting sustainable remediation” (p. 16).

3.0 Sustainable Management of Contaminated Land

CLARINET was formed by European Union members to find effective ways of dealing with contaminated land in response to a long history of industrial activities, limited quantities of land available for development, and a proactive approach to sustainable management of contaminated land.

CLARINET (2002a) has presented the concept of “risk based land management” (RBLM) as a framework for sustainable management of contaminated land. RBLM tries to integrate environmental, economic
and social issues. The three main elements of RBLM are “fitness for use”, “protection of the environment” and “long-term care” (p. 11-12).

Fitness for use is the relationship between site usage and the risk management required to limit risks for that specific usage. Protection of the environment takes into account all impacts associated with the contaminated site because of sustainable development principles and to demonstrate appropriate use of resources and value for money. Long-term care is to ensure that monitoring and control are implemented to ensure the solution is effective and land usage is restricted in accordance.

4.0 Methodology

This paper attempts to develop a methodology to assess the impact of remediation technologies using Alberta oilsands as an example. It is believed that with further research and analysis, this simple tool can be turned into a comprehensive assessment and comparison tool.

In this paper twelve soil remediation technologies used for hydrocarbon contamination in Alberta are assessed using sustainability criteria. The sustainability criteria used for evaluating the negative impacts are annoyance, air quality, water, soil, legacy, and resources. Conservation, economic and social aspects are evaluated to assess the positive impacts. Since different remedial technologies vary in their sustainability, they were ranked from the smallest to greatest negative impact.

4.1 Remediation Technologies

A key element that differentiates remediation technologies from a sustainability perspective is whether the technology is ex situ or in situ and the type or process used for the remediation. This section concludes with identifying the twelve remediation technologies that will be used in this assessment.

4.1.1 Ex situ

Ex situ is very common because the site is remediated quickly, liability is limited, operational experience is available, process optimization and final results can be easily controlled, and site geological conditions are irrelevant. The disadvantages are: Working labor and surrounding environment are likely to be exposed to higher concentrations of contaminants; it is not easily applicable to contaminants located deep in the ground: it is difficult to use when existing infrastructure is complex or requires special precautions, it can have extensive negative influences on a natural environment; it can be costly because larger volumes of soil often need to be treated since it is difficult to limit the volumes of soil to be removed due to time constraints, and there is the potential for many negative side effects.

4.1.2 In situ

In situ techniques are generally more suitable when contaminants are located under or around existing infrastructure (buildings, parking lots, roads, etc.), contaminants are located deep in the ground, when groundwater and soil both need to be treated, large volumes of contamination, the contamination is situated in coarse types of soil, time required for treatment is not important, and minimal site disturbance is required.

In situ technologies help to reduce concerns associated with “not in my back yard,” remove the risk of accidental spillage during transport, costs for excavation, transport, and landfilling.
or off-site treatment are reduced or avoided, and working labor and environment are exposed
to less contamination than ex situ.

Some of the disadvantages are the longer duration required for remediation, greater
knowledge of the geology may be required, process containment, optimization and control is
more difficult than ex situ approached, techniques can be limited by the accessibility of
contamination, greater concern for residual liability and concern with completeness is greater.

4.1.3 Remediation Categories

Remediation technologies are classified into five categories based on the process acting on the
hydrocarbon contaminant. These are:

1. Removal: a process that physically removes the contaminant or contaminated
medium from the site without the need for separation from the soil.
2. Separation: a process that removes the contaminant from the soil.
3. Destruction: a process that chemically or biologically destroys or neutralizes the
contaminant to produce less toxic compounds.
4. Containment: a process that impedes or immobilizes the surface and subsurface
migration of the contaminant.
5. Extraction: a process that extracts contaminants from the soil and stores it in another
medium.

Removal, separation, destruction, and extraction are processes that reduce or remove the
contaminant. Containment technologies, on the other hand, control the migration of a
contaminant to sensitive receptors without reducing or removing the contaminant.

A number of the technologies have been adapted from general commercial uses in other
industrial sectors. These are considered "conventional" technologies. The term "innovative"
refers to technologies that have been developed specifically for the site remediation industry.
Emerging technologies are considered new techniques which are not yet recognized as full
scale treatment technology (EC, 2002a).

4.1.4 Sustainability Assessment

Remediation technologies are many and varied. In this paper twelve different soil remediation
technologies will be assessed for sustainability. The traditional in situ soil remediation
technologies will include are soil vapor extraction, soil flushing, and bioventing. Ex situ
technologies will include landfarming, cold-mix asphalt, vitrification, low temperature thermal
desorption, biopiles, bioslurry/bioreactors, and soil washing. The remaining two in situ
technologies which are considered to be more ecological are natural attenuation and
phytoremediation.

4.2 Sustainability Criteria

There are many criteria that could be used in assessing each remediation technology that it was
difficult to narrow them down. Bardos et.al. (2002) provide the basis for the nine criteria to be used in
this sustainability analysis. They developed a sample matrix for evaluating all the possible
sustainability issues for five remediation approaches. Their project consultants developed a set of
initial surmises based on an evaluation of different stakeholder perspectives. These criteria led to the
development of the following key questions used in evaluating each remediation technology. The first six criteria evaluate a technology from a negative aspect. The last three look at the more positive aspects. Table 1 presents these nine criteria with the answers to the questions used to evaluate the impact of each technology. The discussions in Section 5.0 of this paper are based on answers to questions listed in this table against each criteria.

**Table 1: Key Questions**

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annoyance</td>
<td>Is noise generated during the remediation?</td>
</tr>
<tr>
<td></td>
<td>Is dust generated during the remediation?</td>
</tr>
<tr>
<td></td>
<td>Are any odors generated during the remediation?</td>
</tr>
<tr>
<td></td>
<td>Is there a significant increase in traffic as a result of the remediation?</td>
</tr>
<tr>
<td></td>
<td>Does the remediation cause visual intrusiveness?</td>
</tr>
<tr>
<td>Air Quality</td>
<td>Are there emissions of volatile organic compounds (VOC) associated with this remediation technology?</td>
</tr>
<tr>
<td></td>
<td>Is particulate matter (PM) generated during the remediation?</td>
</tr>
<tr>
<td></td>
<td>Does the remediation generate CO₂ emissions?</td>
</tr>
<tr>
<td>Water</td>
<td>Are there any emissions to groundwater?</td>
</tr>
<tr>
<td></td>
<td>Are there any emissions to surface water?</td>
</tr>
<tr>
<td>Soil</td>
<td>Does this remediation disturb the ground?</td>
</tr>
<tr>
<td></td>
<td>Does this remediation create a change in ground function?</td>
</tr>
<tr>
<td></td>
<td>After the remediation, will contaminants remain on-site?</td>
</tr>
<tr>
<td>Legacy</td>
<td>Will there be a requirement for off-site disposal?</td>
</tr>
<tr>
<td></td>
<td>Is there any waste generated?</td>
</tr>
<tr>
<td></td>
<td>Is there a long-term impact on the site?</td>
</tr>
<tr>
<td></td>
<td>Does the remediation offer a temporary solution?</td>
</tr>
<tr>
<td>Resources</td>
<td>Will fuel be required for this remediation?</td>
</tr>
<tr>
<td></td>
<td>Will significant amounts of electricity be required for this remediation?</td>
</tr>
<tr>
<td></td>
<td>Will water be required for this remediation?</td>
</tr>
<tr>
<td>Conservation</td>
<td>Will the remediation technique attract wildlife?</td>
</tr>
<tr>
<td></td>
<td>Does the technique use biodegradation?</td>
</tr>
<tr>
<td></td>
<td>Does this remediation minimize human and environmental exposures?</td>
</tr>
<tr>
<td></td>
<td>Is there any recycling or reuse of materials?</td>
</tr>
<tr>
<td>Economic</td>
<td>Will the remediation create minimal disturbance to commercial site operations?</td>
</tr>
<tr>
<td></td>
<td>Does this remediation have low capital costs?</td>
</tr>
<tr>
<td></td>
<td>Does this remediation have low operational costs?</td>
</tr>
<tr>
<td>Social</td>
<td>How is the technology accepted by the community?</td>
</tr>
<tr>
<td></td>
<td>Score: Low = 1; Medium=2; High=3;</td>
</tr>
<tr>
<td></td>
<td>Is technology accepted by the regulators?</td>
</tr>
<tr>
<td></td>
<td>Score: Low = 1; Medium=2; High=3</td>
</tr>
</tbody>
</table>

For all of the criteria except social, a score of 1 was given to each question that received a “yes” answer and the scores for each criterion were averaged. For instance, landfilling requires the excavation and transportation of contaminated soil from the site to the landfill. This process generates dust, noise, odors, and traffic. The excavation is also visually intrusive. Based on this information, all five questions in annoyance were answered with a “yes” which equates to a score of 100%. The scores for the social criteria ranged from 1 to 3 depending on how acceptable the remediation technique is to the community and regulators.

**4.3 Assumptions**

In order to carry out the analysis the following assumptions were made:
• Technical, feasibility, suitability, risk management and project driver requirements associated with remediation techniques were not evaluated in the sustainability analysis; It is assumed that these are addressed prior to completing the sustainability assessment;
• The remediation technologies evaluated are applicable for hydrocarbon contamination;
• Environmental assessments and monitoring programs will not be included in the sustainability analysis;
• Source of contamination has been removed; and
• The remediation will occur on-site.

5.0 Assessing the Impact of Soil Remediation Technologies

5.1 Soil Vapor Extraction

Soil vapor extraction (SVE) is an innovative, in situ, separation process where hydrocarbon vapors can be removed from the soil through extraction wells. As soil vapors are removed, hydrocarbons present in the other phases in the soil transfer to the vapor phase. This process is primarily a physical process but an increase supply of oxygen in the subsurface has been observed to enhance the biodegradation of the hydrocarbons in the soil (CPPI, 1991). Remediation takes an average of 1 to 3 years. This technology can treat large volumes of soil at a reasonable cost of US $405-$1485 per cubic meter (FRTR, 2002a).

Vertical and horizontal wells are installed in specified locations within the areas of contamination to ensure adequate vapor flow through the significant zones of contamination while minimizing vapor flow through other non-contaminated zones. A vacuum blower is applied through the wells to induce air flow through the soil matrix. Some of the volatiles, semi-volatiles and organic contaminants evaporate and/or biodegrade while others are carried to the screened extraction wells. The induced air flow draws contaminated vapors from the extraction wells through plastic piping to the surface to a vapor treatment process, such as activated carbon and then released to the atmosphere (US EPA, 1996a).

Applying the questions in Table 1, we conclude that the average of the positive impacts was 61%. The overall negative average was 40%. To conclude, the positive impacts are greater than the negative impacts for soil vapor extraction.

5.2 Soil Flushing

Soil flushing refers to an in situ, separation process where the zone of contamination is flooded with water or water additive mixture in order to dissolve the contaminants which are brought to the surface for treatment through extraction wells. Injection and extraction wells are drilled into the zone of contamination and can be installed vertically or horizontally. A flushing solution, consisting of water and additives to enhance contaminant solubility, is pumped into the injection wells. The solution passes through the soil picking up the contaminants along its way to the extraction wells. The solution is collected by the extraction wells and treated by a wastewater treatment system where the contaminants are disposed and the treated water can be reused in the process (US EPA, 1996b). Soil flushing is expected to achieve cleanup within 1-3 years of operation. The cost of soil flushing is US$30-$325 per cubic meter (FRTR, 2002b).

Applying the questions in Table 1, we conclude that the average of the positive impacts was 50%. The negative had an overall average of 46%. To conclude, the positive impacts are slightly higher than the negative impacts.
5.3 Bioventing

Bioventing is a form of in situ biodegradation in which oxygen in the form of air is delivered to contaminated soils through a system of extraction and injection wells. Air is injected into the contaminated soil at a specific rate to stimulate natural biodegradation and enhance bacteria activity. This constant supply of fresh air allows the micro-organisms to degrade contaminants and minimize the volatilized contaminants entering into the atmosphere. The microorganisms are naturally occurring in the soil and biodegrade organic contaminants that are adsorbed to soils. Cost is US $79-$928 per cubic meter which is considered cost-competitive (FRTR, 2002c). It may take several months to years to remediate a site.

The average of the positive impacts was 72%. On the negative side the overall average was 18%. To conclude (using the Table 1 criteria), the positive impacts are significantly higher than the negative impacts.

5.4 Landfarming

Landfarming is a proven technology and has been practiced worldwide for over 100 years (Khan et.al., 2004). And is simple to design and implement. It is the process by which affected soils are removed and spread over an area to enhance naturally occurring processes. These natural processes include volatilization, aeration, biodegradation, and photoysis (Weston, 1988) and may take several months to years to remediate. The cost of landfarming is less than US $100 per cubic meter (FRTR, 2002d).

Landfarming involves the spreading of excavated contaminated soils in a thin layer on a liner and stimulating microbial activity within the soils through aeration. Minerals, nutrients and moisture may be added to the soil to enhance the microbial activity. Soil is tilled regularly to maintain the availability of oxygen to allow for biodegradation of the soil. Microbial activity results in the in the degradation of adsorbed petroleum product constituents through microbial respiration (Khan et.al., 2004).

Applying the questions in Table 1, we conclude that the average of the positive impacts was 83%. On the negative side the overall average was 76%. The positive impacts are higher than the negative but the negative average is still very high.

5.5 Cold Mix Asphalting

Recycling contaminated soils containing certain types and quantities of contaminants into an asphalt paving material has many years been considered a feasible and preferred alternative to disposing in a landfill for. Cold-mix asphalt batching recycles contaminated soil and reduces contaminant mobility. It is an ex situ technique that involves a mix of separation and destruction processes. Treatment time is short. Recycling contaminated soil can reduce paving costs by as much as 40% (Mouch, 1999).

Contaminated soil is excavated and transported to the asphalt plant. The soils will be loaded into a hopper in a controlled manner for conveyance to a mixing chamber where they will be wetted or treated with anti-dust agents to prevent dust emissions. An asphalt emulsion, delivered from a tanker truck, will be applied to the soils using rotating blades inside an enclosed device known as a pugmill. The temperature of the emulsion is generally 100°F to 120°F. Gravel will be added to the soil emulsion mix inside the pugmill to further stabilize the asphalt paving material. The material then will be removed from the pugmill, stockpiled, and covered for curing which lasts from 48 to 72 hours. Curing is a hardening or solidifying process that binds contaminants to the asphalt and prevents contaminant evaporation and leaching. After curing, the material can be used as subgrade for use in roadways or
parking facilities. It is covered with 1-2 inches of asphalt cover for durability and to limit the infiltration of water. If at any time contaminated soil is stockpiled, piles must be covered. In eight years of leachability testing, no contaminant leaching from batched asphalt has been detected (US AFCEE, 1999). Cost is US $45-$75/metric ton (US EPA, 1999).

The average of the positive impacts was 53%. On the negative side overall average was 56%. The positive impacts are just slightly higher than the negative.

5.6 Vitrification

Vitrification is considered an innovative remediation technology because it immobilizes contaminants by melting soil in a solid block of glass-like material and can be done in place or above ground. It can be either ex situ or in situ. The latter method is explained herein. In situ technique avoids the expense of digging up soil or trucking it to a landfill for disposal. The solidified material is permanent and can be left in place. It is highly resistant to leaching and stronger than concrete (US EPA, 2001a). Treatment is immediate and cost varies from US $50-$330 per cubic meter (FRTR, 2002e).

Vitrification uses electric power to create the heat needed to melt soil. Four graphite electrodes are inserted in the polluted area. An electric current is passed between the electrodes, melting the soil between them. As the soil melts, the electrodes sink further into the ground causing deeper soil to melt. The heat may cause some chemicals to be destroyed and others to evaporate. A hood covering the heated area is used to collect the chemicals which are sent to a treatment system for cleaning. When the power is turned off, the melted soil cools and hardens turning into a solid block of glass-like material. The electrodes become part of the block. When vitrified, the original volume of soil shrinks. This causes the ground surface in the area to sink slightly. To level it, the sunken area is filled with clean soil appropriate to the surroundings. (US EPA, 2001a).

The average of the positive impacts was 33%. On the negative side overall average was 34%. The negative impacts are 1% higher than the positive impacts. In general the averages are low.

5.7 Low Temperature Thermal Desorption

Low temperature thermal desorption (LTTD) is an innovative ex situ separation technology. The process physically separates volatile organic contaminants from soils. This process incorporates sound environmental practices which are consistent with the objectives of the Environment Canada’s (EC) Greening Government and the Office of Environmental Stewardship (EC, 2002b). The cost varies from US $44-$252 per cubic meter (FRTR, 2002f).

Contaminated soil is excavated and transported to the on-site thermal desorption unit. Soil is loaded into a feed hopper and then directed to a conveyor. The conveyor leads into a closed chamber or dryer where the soil is heated ($95 \degree C – 315 \degree C$) to volatilize the hydrocarbons. The vaporized hydrocarbons and dust particulates in the gases are collected and directed to a gas treatment system such as an activated carbon adsorption unit.

The average of the positive impacts was 31%. On the negative side overall average of 54%.

5.8 Biopiles

Biopiles are an ex situ, destructive and innovative technique. Contaminated soil is excavated and heaped into piles. Biopiles require large areas of land but less than a landfarm. Aerobic microbial
activity is stimulated within the soils through aeration, moisture and soil amendments. Air is forced by injection or extraction through slotted piping placed throughout the pile. Biopiles are closed systems allowing vapor emissions to be controlled (US EPA, 2002). Treatment time varies from 6 months to 2 years. Cost varies from US $130-$260 per metric ton (FRTR, 2002g).

Contaminated soil is mixed with soil amendments and transported to a designated area that is impermeable to prevent leaching into the groundwater. Soil is then piled into heaps and moisture is added to stimulate microbial activity. Treatment piles are covered with an impermeable liner to prevent runoff, evaporation, and volatilization and to reduce heat loss and promote passive thermal warming. Aerobic microbial activity is stimulated by extracting air through slotted or perforated piping placed at the base of the pile. Leachate is collected, treated and disposed. Vapor emissions will require treatment (US EPA, 2002).

The average of the positive impacts was 72%. On the negative side the overall average of 74%.

5.9 Bioreactor

Bioreactors are an innovative, ex situ, destructive remediation technology. The principal emphasis is in stimulating biological degradation rate by choosing optimum temperature, degree of aeration and other factors. A bioreactor requires a large area but less than the area required by a landfarm. Cost is US $130-$200/ cubic meter (FRTR, 2002h). Treatment time can vary from less than a month to greater than six months (Khan et al., 2004).

Excavated contaminated soil is processed to remove larger particles and then placed in a reactor and mixed with water and nutrients to a pre-determined concentration of 10% to 30% by weight. The slurry is agitated and aerated to keep the solids in suspension and to maintain aerobic conditions. The addition of water to soils to create a slurry phase enhances soil mixing and contaminant and nutrient mass transfer. The water acts as a lubricant for mixing and as a solvent to dissolve contaminants and nutrients and to suspend bacteria within the reactor. Mixing inside the reactor is maintained at optimal levels for indigenous microbial life to biodegrade the hydrocarbon contaminants. Gaseous emissions from the reactor are collected. When biodegradation is complete the slurry is dewatered. Cleaned soils are disposed. Process water is collected and the fluids are either recycled or treated for disposal (US EPA, 2002).

The average of the positive impacts was 42%. On the negative side the overall average of 64%.

5.10 Soil Washing

Soil washing is an innovative, ex situ, separation remediation process. Treatment time can take from weeks to months. Average cost including excavation is US $70-$187 per cubic meter (FRTR, 2002i). Hydrocarbon contaminants bind to fine soil particles such as clay and silt. Soil washing separates fine particles from sand and gravel in water-based systems based on particle size. Wash water may be augmented with a basic leaching agent, surfactant, or chelating agent or by adjustment of pH to help remove contaminants. Soils and wash water are mixed ex situ in a tank or other treatment unit. The wash water and various soil fractions are usually separated by means of gravity settling. This reduces the volume of contaminated soil that has to be treated.

Since this technology is portable, it can be used to remediate the soil at the site. Contaminated soil is prepared for treatment by excavating and screening it to remove large objects and debris. Screened soil is placed in a scrubber along with water and sometimes detergents. This mixture passes through
sieves, mixing blades and water sprays. This separates the silt and clay from larger-grained soil and considered to be clean soil (US EPA, 2001b).

Some of the hydrocarbon contaminants may dissolve or be suspended in the wash water which is sent to a treatment plant then reused or discharged. The silt and clay is analyzed to assess the contaminant levels present. Depending on the results, the soil will either be clean and returned to the site or still be contaminated and require further cleanup. Sand and gravel will settle in the scrubber and will also need to be analyzed for the presence of contaminants and if clean can be returned to the site. If contamination exists, it will require further cleanup (US EPA, 2001b).

The average of the positive impacts was 42%. On the negative side overall average of 64%.

5.11 Monitoring Natural Attenuation

Monitored Natural Attenuation (MNA) is considered an in situ, conventional, destructive technique. It represents the ability of soil and groundwater to self-remediate. In fact natural attenuation occurs at most polluted sites. In fact MNA works at all polluted sites and works in four ways:

♦ Some microbes that live in the soil and groundwater use contaminants as a nutrient source for food. This process converts contaminants into harmless byproducts;
♦ When contaminants stick to soil, it keeps them from polluting groundwater and leaving the site;
♦ As contaminates migrates though the soil and groundwater they are diluted; and
♦ Some contaminates can evaporate within the soil. If these gases escape to the air, they are destroyed by sunlight. (US EPA, 2001c).

Natural attenuation includes a variety of physical, chemical, and biological processes that, under favorable conditions, result in reducing the concentration of the mass, toxicity, mobility, volume, and/or concentration of contaminants in soil and/or groundwater. The only activity is ongoing monitoring to evaluate the effectiveness of the remediation. This method is considered the least expensive of remediation costs. However, it may take years to decades for a site to be cleaned.

The average of the positive impacts was 61%. On the negative side the overall average of 4%. The positive impacts are significantly higher than the positive impacts.

5.12 Phytoremediation

An emerging in situ technology that takes advantage of natural plant processes is referred to as phytoremediation. Selected plants remove harmful contaminants from the ground when their roots take in water and nutrients from polluted soil. Tree roots grow deeper than smaller plants, so they are used to reach pollution deeper in the ground. Once inside the plant, chemicals can do any of the following:

• Store in the roots, stems, or leaves;
• Change into less harmful chemicals within the plant; and
• Change into gases that are released into the air as the plant transpires (breathes) (US EPA, 2001d)

Phytoremediation can occur even if the chemicals are not taken into the plant by the roots. For example, chemicals can stick to plant roots or they can be changed into less harmful chemicals by bugs or microbes that live near plant roots. Afterwards, for safety reasons plants are harvested or recycled if
the plants can be reused. Usually, trees are left to grow and are not harvested (US EPA, 2001d). The process of cleaning up the site may take many years. Costs can range from US $147-$2322 per cubic meter (FRTR, 2002j).

The average of the positive impacts was 89%. On the negative side the results overall average of 35%.

6.0 Comparison of Remediation Methods

In this section all the remediation technologies will be compared to each other by analyzing the scores for each sustainability indicator. Then the technologies will be ranked by the smallest negative effect. This section will conclude with a ranking of the positive and negative averages for each technology.

6.1 Annoyance

The two ecological remediation technologies had the smallest scores, followed by the in situ technologies. All the ex situ technologies had the highest score for annoyance and consequently the greatest negative affect, due to excavation and removal activities. The scores and ranks are summarized in Table 2.

<table>
<thead>
<tr>
<th>Remediation Method</th>
<th>Score</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitored Natural Attenuation</td>
<td>0%</td>
<td>1</td>
</tr>
<tr>
<td>Phytoremediation</td>
<td>0%</td>
<td>1</td>
</tr>
<tr>
<td>Vitrification</td>
<td>20%</td>
<td>2</td>
</tr>
<tr>
<td>Soil Vapor Extraction</td>
<td>40%</td>
<td>3</td>
</tr>
<tr>
<td>Soil Flushing</td>
<td>40%</td>
<td>3</td>
</tr>
<tr>
<td>Bioventing</td>
<td>40%</td>
<td>3</td>
</tr>
<tr>
<td>Landfarming</td>
<td>100%</td>
<td>4</td>
</tr>
<tr>
<td>Cold Mix Asphalt</td>
<td>100%</td>
<td>4</td>
</tr>
<tr>
<td>Low Temperature Thermal Desorption</td>
<td>100%</td>
<td>4</td>
</tr>
<tr>
<td>Biopiles</td>
<td>100%</td>
<td>4</td>
</tr>
<tr>
<td>Bioreactor</td>
<td>100%</td>
<td>4</td>
</tr>
<tr>
<td>Soil Washing</td>
<td>100%</td>
<td>4</td>
</tr>
</tbody>
</table>

6.2 Air Quality

Monitored natural attenuation and bioventing had the least impact on air quality. This was followed by three technologies that treat hydrocarbon vapors prior to releasing to the atmosphere. Phytoremediation was third only because it was assumed there are Particulate Matter and CO2 emissions when planting trees and sowing seeds for plants. The positive air quality benefits are not reflected in the score due to the approach taken in this assessment. All ex situ technologies created a significant negative impact on air quality. The scores and ranks are summarized in Table 3.

<table>
<thead>
<tr>
<th>Remediation Method</th>
<th>Score</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitored Natural Attenuation</td>
<td>0%</td>
<td>1</td>
</tr>
<tr>
<td>Bioventing</td>
<td>0%</td>
<td>1</td>
</tr>
<tr>
<td>Soil Vapor Extraction</td>
<td>33%</td>
<td>2</td>
</tr>
<tr>
<td>Soil Flushing</td>
<td>33%</td>
<td>2</td>
</tr>
<tr>
<td>Vitrification</td>
<td>33%</td>
<td>2</td>
</tr>
<tr>
<td>Phytoremediation</td>
<td>67%</td>
<td>3</td>
</tr>
<tr>
<td>Landfarming</td>
<td>100%</td>
<td>4</td>
</tr>
</tbody>
</table>
6.3 Water

The results only divided the technologies into two ranks; no impact or impact. Only three of the twelve remediation technologies had an impact. These are landfarming, soil vapor extraction, and soil flushing. The scores and ranks are summarized in Table 4.

Table 4: Water

<table>
<thead>
<tr>
<th>Remediation Method</th>
<th>Score</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioventing</td>
<td>0%</td>
<td>1</td>
</tr>
<tr>
<td>Monitored Natural Attenuation</td>
<td>0%</td>
<td>1</td>
</tr>
<tr>
<td>Phytoremediation</td>
<td>0%</td>
<td>1</td>
</tr>
<tr>
<td>Cold Mix Asphalting</td>
<td>0%</td>
<td>1</td>
</tr>
<tr>
<td>Vitrification</td>
<td>0%</td>
<td>1</td>
</tr>
<tr>
<td>Low Temperature Thermal Desorption</td>
<td>0%</td>
<td>1</td>
</tr>
<tr>
<td>Biopiles</td>
<td>0%</td>
<td>1</td>
</tr>
<tr>
<td>Bioreactor</td>
<td>0%</td>
<td>1</td>
</tr>
<tr>
<td>Soil Washing</td>
<td>0%</td>
<td>1</td>
</tr>
<tr>
<td>Landfarming</td>
<td>50%</td>
<td>2</td>
</tr>
<tr>
<td>Soil Vapor Extraction</td>
<td>50%</td>
<td>2</td>
</tr>
<tr>
<td>Soil Flushing</td>
<td>50%</td>
<td>2</td>
</tr>
</tbody>
</table>

6.4 Soil

The results in this category provide three rankings. The two ecological methods had the least impact. The three technologies that have a negative impact are biopiles, landfarming, and vitrification. All the other technologies were in the middle. The scores and ranks are summarized in Table 5.

Table 5: Soil

<table>
<thead>
<tr>
<th>Remediation Method</th>
<th>Score</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitored Natural Attenuation</td>
<td>0%</td>
<td>1</td>
</tr>
<tr>
<td>Phytoremediation</td>
<td>0%</td>
<td>1</td>
</tr>
<tr>
<td>Soil Vapor Extraction</td>
<td>33%</td>
<td>2</td>
</tr>
<tr>
<td>Soil Flushing</td>
<td>33%</td>
<td>2</td>
</tr>
<tr>
<td>Bioventing</td>
<td>33%</td>
<td>2</td>
</tr>
<tr>
<td>Cold Mix Asphalting</td>
<td>33%</td>
<td>2</td>
</tr>
<tr>
<td>Low Temperature Thermal Desorption</td>
<td>33%</td>
<td>2</td>
</tr>
<tr>
<td>Bioreactor</td>
<td>33%</td>
<td>2</td>
</tr>
<tr>
<td>Soil Washing</td>
<td>33%</td>
<td>2</td>
</tr>
<tr>
<td>Biopiles</td>
<td>67%</td>
<td>3</td>
</tr>
<tr>
<td>Landfarming</td>
<td>67%</td>
<td>3</td>
</tr>
<tr>
<td>Vitrification</td>
<td>67%</td>
<td>3</td>
</tr>
</tbody>
</table>
6.5 Legacy

Bioventing and cold mix asphalting had the least impact. Monitored natural attenuation and low temperature thermal desorption had the second least impact. Biopiles, landfarming and phytoremediation had a significant negative impact. The scores and ranks are summarized in Table 6.

<table>
<thead>
<tr>
<th>Remediation Method</th>
<th>Score</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioventing</td>
<td>0%</td>
<td>1</td>
</tr>
<tr>
<td>Cold Mix Asphalting</td>
<td>0%</td>
<td>1</td>
</tr>
<tr>
<td>Monitored Natural Attenuation</td>
<td>25%</td>
<td>2</td>
</tr>
<tr>
<td>Low Temperature Thermal Desorption</td>
<td>25%</td>
<td>2</td>
</tr>
<tr>
<td>Soil Washing</td>
<td>50%</td>
<td>3</td>
</tr>
<tr>
<td>Soil Vapor Extraction</td>
<td>50%</td>
<td>3</td>
</tr>
<tr>
<td>Vitrification</td>
<td>50%</td>
<td>3</td>
</tr>
<tr>
<td>Soil Flushing</td>
<td>50%</td>
<td>3</td>
</tr>
<tr>
<td>Bioreactor</td>
<td>50%</td>
<td>3</td>
</tr>
<tr>
<td>Biopiles</td>
<td>75%</td>
<td>4</td>
</tr>
<tr>
<td>Landfarming</td>
<td>75%</td>
<td>4</td>
</tr>
<tr>
<td>Phytoremediation</td>
<td>75%</td>
<td>4</td>
</tr>
</tbody>
</table>

6.6 Resources

This indicator was assessed from a qualitative perspective. Actual data, if it existed, could completely change the results. Monitored natural attenuation required the least amount of resources. The remediation technologies having a second place ranking were soil vapor extraction, bioventing, and vitrification. The remaining technologies were ranked third or fourth. The scores and ranks are summarized in Table 7.

<table>
<thead>
<tr>
<th>Remediation Method</th>
<th>Score</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitored Natural Attenuation</td>
<td>0%</td>
<td>1</td>
</tr>
<tr>
<td>Soil Vapor Extraction</td>
<td>33%</td>
<td>2</td>
</tr>
<tr>
<td>Bioventing</td>
<td>33%</td>
<td>2</td>
</tr>
<tr>
<td>Vitrification</td>
<td>33%</td>
<td>2</td>
</tr>
<tr>
<td>Phytoremediation</td>
<td>67%</td>
<td>3</td>
</tr>
<tr>
<td>Landfarming</td>
<td>67%</td>
<td>3</td>
</tr>
<tr>
<td>Soil Flushing</td>
<td>67%</td>
<td>3</td>
</tr>
<tr>
<td>Low Temperature Thermal Desorption</td>
<td>67%</td>
<td>3</td>
</tr>
<tr>
<td>Biopiles</td>
<td>100%</td>
<td>4</td>
</tr>
<tr>
<td>Bioreactor</td>
<td>100%</td>
<td>4</td>
</tr>
<tr>
<td>Soil Washing</td>
<td>100%</td>
<td>4</td>
</tr>
<tr>
<td>Cold Mix Asphalting</td>
<td>100%</td>
<td>4</td>
</tr>
</tbody>
</table>

6.7 Conservation

This is the first of the positive impact indicators which means the ranking process has to be reversed. The remediation technology the will have the greatest positive impact is phytoremediation. The eleven remaining methods all have a positive impact but fall in either the second or third rank. The scores and ranks are summarized in Table 8.
Table 8: Conservation

<table>
<thead>
<tr>
<th>Remediation Method</th>
<th>Score</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phytoremediation</td>
<td>100%</td>
<td>1</td>
</tr>
<tr>
<td>Soil Vapor Extraction</td>
<td>50%</td>
<td>2</td>
</tr>
<tr>
<td>Soil Flushing</td>
<td>50%</td>
<td>2</td>
</tr>
<tr>
<td>Bioventing</td>
<td>50%</td>
<td>2</td>
</tr>
<tr>
<td>Landfarming</td>
<td>50%</td>
<td>2</td>
</tr>
<tr>
<td>Monitored Natural Attenuation</td>
<td>50%</td>
<td>2</td>
</tr>
<tr>
<td>Biopiles</td>
<td>50%</td>
<td>2</td>
</tr>
<tr>
<td>Low Temperature Thermal Desorption</td>
<td>25%</td>
<td>3</td>
</tr>
<tr>
<td>Bioreactor</td>
<td>25%</td>
<td>3</td>
</tr>
<tr>
<td>Soil Washing</td>
<td>25%</td>
<td>3</td>
</tr>
<tr>
<td>Vitrification</td>
<td>25%</td>
<td>3</td>
</tr>
<tr>
<td>Cold Mix Asphalting</td>
<td>25%</td>
<td>3</td>
</tr>
</tbody>
</table>

6.8 Economic

Four remediation methods have a positive impact. These are monitored natural attenuation, phytoremediation, bioventing, and landfarming. The scores and ranks for the remaining technologies are summarized in Table 9.

Table 9: Economic

<table>
<thead>
<tr>
<th>Remediation Method</th>
<th>Score</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitored Natural Attenuation</td>
<td>100%</td>
<td>1</td>
</tr>
<tr>
<td>Phytoremediation</td>
<td>100%</td>
<td>1</td>
</tr>
<tr>
<td>Bioventing</td>
<td>100%</td>
<td>1</td>
</tr>
<tr>
<td>Landfarming</td>
<td>100%</td>
<td>1</td>
</tr>
<tr>
<td>Cold Mix Asphalting</td>
<td>67%</td>
<td>2</td>
</tr>
<tr>
<td>Biopiles</td>
<td>67%</td>
<td>2</td>
</tr>
<tr>
<td>Soil Vapor Extraction</td>
<td>67%</td>
<td>2</td>
</tr>
<tr>
<td>Soil Flushing</td>
<td>33%</td>
<td>3</td>
</tr>
<tr>
<td>Vitrification</td>
<td>33%</td>
<td>3</td>
</tr>
<tr>
<td>Low Temperature Thermal Desorption</td>
<td>0%</td>
<td>4</td>
</tr>
<tr>
<td>Bioreactor</td>
<td>0%</td>
<td>4</td>
</tr>
<tr>
<td>Soil Washing</td>
<td>0%</td>
<td>4</td>
</tr>
</tbody>
</table>

6.9 Social

The remediation technologies that more acceptable to the community and regulators are landfarming, Biopiles, bioreactors, and soil washing. The ones that received the least acceptance are monitored natural attenuation and vitrification. The scores and ranks for the remaining technologies are summarized in Table 10.

Table 10: Social

<table>
<thead>
<tr>
<th>Remediation Method</th>
<th>Score</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landfarming</td>
<td>100%</td>
<td>1</td>
</tr>
<tr>
<td>Biopiles</td>
<td>100%</td>
<td>1</td>
</tr>
<tr>
<td>Bioreactor</td>
<td>100%</td>
<td>1</td>
</tr>
<tr>
<td>Soil Washing</td>
<td>100%</td>
<td>1</td>
</tr>
<tr>
<td>Soil Vapor Extraction</td>
<td>67%</td>
<td>2</td>
</tr>
<tr>
<td>Soil Flushing</td>
<td>67%</td>
<td>2</td>
</tr>
<tr>
<td>Bioventing</td>
<td>67%</td>
<td>2</td>
</tr>
<tr>
<td>Phytoremediation</td>
<td>67%</td>
<td>2</td>
</tr>
<tr>
<td>Cold Mix Asphalting</td>
<td>67%</td>
<td>2</td>
</tr>
<tr>
<td>Remediation Method</td>
<td>Score</td>
<td>Rank</td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>-------</td>
<td>------</td>
</tr>
<tr>
<td>Low Temperature Thermal Desorption</td>
<td>67%</td>
<td>2</td>
</tr>
<tr>
<td>Monitored Natural Attenuation</td>
<td>33%</td>
<td>3</td>
</tr>
<tr>
<td>Vitrification</td>
<td>33%</td>
<td>3</td>
</tr>
</tbody>
</table>

### 7.0 Positive / Negative Averages

As demonstrated in the previous sections, one remediation may create some negative aspects and also have high scores on the positive side. It is very difficult to assess them by only using indicators.

If the remediation technologies are assessed from the least negative impact then monitored natural attenuation is first followed by bioventing then vitrification and phytoremediation is fourth. Refer to Table 11 for the remaining rankings.

<table>
<thead>
<tr>
<th>Table 11: Least Negative Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remediation Method</td>
</tr>
<tr>
<td>---------------------------------</td>
</tr>
<tr>
<td>Monitored Natural Attenuation</td>
</tr>
<tr>
<td>Bioventing</td>
</tr>
<tr>
<td>Vitrification</td>
</tr>
<tr>
<td>Phytoremediation</td>
</tr>
<tr>
<td>Soil Vapor Extraction</td>
</tr>
<tr>
<td>Soil Flushing</td>
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<tr>
<td>Low Temperature Thermal Desorption</td>
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<tr>
<td>Cold Mix Asphalting</td>
</tr>
<tr>
<td>Bioreactor</td>
</tr>
<tr>
<td>Soil Washing</td>
</tr>
<tr>
<td>Biopiles</td>
</tr>
<tr>
<td>Landfarming</td>
</tr>
</tbody>
</table>

There is a one caveat attached to these rankings and that is to consider the average positive impact along with negative. Even if the negative impact has a low percentage, it may still be greater than the positive impacts and this needs to be taken into consideration.

### 8.0 Potential Areas for Improvement

In the past many companies would undertake site remediation without ever letting the nearby community know about it. One day the corner gas station is operating the next there is a big gaping hole where it once stood. Communication is one area where improvement is required because it can help increase community and regulator support which in turn improves its sustainability. One example is to place signage at the site and explain what is occurring, for how long, and who to contact for additional details. If the project is using “green power” then this is a great opportunity to also share this with the community. This can enhance a company’s reputation, “green” image, external validation, and sustainable operations. In 1999, the Conference Board, a worldwide business research network, asked consumers what matters the most when forming an impression of a company. Most said reputation—it was the number one response. Almost half said they had done business with a company in the preceding 12 months or supported it in some other way if they considered it socially responsible. Half said they had boycotted a company’s products in the same period or had urged others to do so when they didn’t agree with its actions or policies (ITRC, 2006).

Another way to improve the sustainability rating for a remediation method is to create green spaces on the site after remediation or in a nearby development. A green space enhances surrounding land, improves quality of life, and enhances property values.
Improvements that can be made in the three in situ technologies, soil vapor extraction, bioventing, and soil flushing, are reducing the noise and visual impact of site equipment and using more energy efficient equipment which could assist in reducing electrical consumption as well as operational costs.

The key improvement that is required with monitored natural attenuation is to gain increased support from the community and regulators. One way to approach this is to combine it with risk based land management (RBLM). RBLM tries to integrate environmental, economic and social issues. The three main elements of RBLM are “fitness for use”, “protection of the environment” and “long-term care” (CLARINET, 2002b p.11-12). Alberta Environment has guidance material on their website for risk management. The Policy for Management of Risks at Contaminated Sites in Alberta and Risk Management Guidelines for Petroleum Storage Tank Sites can be found at the Alberta Government website (http://www.gov.ab.ca/env/).

Phytoremediation is an emerging technology which means there are still some questions associated with it. The areas for improvement are in understanding more about the positive and negative sustainability aspects of this technique which will require further research.

Ex situ remediation methods require significant resources and generate VOC, PM, and CO₂ emissions. One way to reduce these impacts is to combine ex-situ with some in situ methods. Reducing the volume of soil requiring ex situ treatment methods will reduce the amount of resources and air emissions.

9.0 Methodology Assessment

Pros

According to CLARINET (2002a), “there are no generally agreed means of carrying out sustainability appraisal for remediation projects even though there is great interest in Europe in promoting sustainable remediation” (p. 16). There were many indicators that could have been used in this assessment but the paper prepared by Bardos et.al. (2002) provided guidance into what stakeholders value when a remediation occurs. Nine diverse indicators were used and twelve technologies were reviewed which made for a comprehensive assessment.

This methodology could be modified to include site specific data for a site. Then a sustainability assessment could be undertaken to re-rank the remediation technologies based on site specific information.

Additional remediation technologies could be evaluated using this methodology provided the required information is available.

Cons

If a different method along with different indicators were used in a sustainability assessment of remediation technologies the results could possibly be different.

Since this sustainability was a general assessment it didn’t take into consideration site specific issues or use actual data. Assessing remediation methods from a sustainability perspective is new which means that the actual data required has never been collected.
Limitations

This assessment was based on the interpretation of the information uncovered during the research portion for this paper. If different sources for the remediation technologies are used, then the results of the assessment could be different.

This paper was a general qualitative assessment and the findings may no be relevant in all situations or locations.

10.0 Conclusion

The methodology developed for this paper is simple and can be used to assess other remediation technologies. But like any methodology, if different sustainability criteria or quantitative data are used, the results will be different. If this were to occur, then identifying sustainable remediation technologies will continue to be a challenge because there will be no standards for comparison. Standards would help to identify the type of data that is required which would allow assessments to become verifiable and defensible.

Based on the rankings of the sustainability assessment, monitored natural attenuation, bioventing, vitrification, and phytoremediation have the least negative impacts. Ranking these technologies by negative aspects comes with one word of caution. For some of the technologies, the negative averages may be greater than the positive which means this inequality needs to be taken into consideration.

It can be concluded that the negative impacts associated with in situ and ecological remediation technologies are much less than ex situ. This is important for companies looking for sustainable remediation technologies. It is also important for the remediation industry because this can be beneficial for supporting the continued use of these methods, improving existing methods to become more sustainable, and developing new technologies.

Out of all the technologies assessed, the one that had the least amount of information was phytoremediation. It is considered an emerging technology which means there are still some questions associated with it. More information on the positive and negative sustainability aspects of this technique is required.

11.0 References


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