A Synthesis of the 2006 Nova Scotia Energy Research and Development Forum Presentations

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The Nova Scotia Department of Energy hosted the second Nova Scotia Energy Research and Development Forum at Saint Francis Xavier University on May 24 and 25, 2006. The event which attracted approximately 200 participants and speakers offered three concurrent sessions with each made up of five separate workshops devoted to different aspects of the session themes. Session one focused on building knowledge about the marine environment; session two dealt with improving our understanding of the province's geoscience; and session three was concerned with sustainable energy. In addition there were two plenary presentations and two luncheon addresses that cut across the session themes by discussing a number of overarching issues.

The Forum was intended to create opportunities for networking, collaboration and sharing technical information covering a range of technical areas related to the further development of Nova Scotia's energy sector. In particular it provided researchers involved in energy research and development, and those who could benefit from the results of that research, with a chance to exchange ideas and consider how research and development (R&D) can help address the energy challenges Nova Scotia faces as well as realize the province's energy potential.

This document provides a high level synthesis of the Forum presentations in order to highlight some of the key messages and conclusions that were presented. It is not intended to be a summary of each of the presentations or a report on the Forum. The majority of the individual presentations are available on the website http://www.energyresearch.ca/ by clicking on the banner "Energy Research and Development Forum 2006". Note that not all presentations are available due to the confidential nature of some of the information and data that they contained.

Opening Plenary Session - *Michael Raymont: EnergyINet – Canada: The Next Energy Superpower*

The opening plenary session set the stage for the Energy R&D Forum by emphasizing Canada's rich energy endowment putting the country in a position to become a global energy superpower. It noted the importance of understanding the elements in the "innovation supply chain", their integration from basic research to ultimate deployment, and the roles of different players (government, universities, NGOs, private sector and capital sources) in fully developing the country's vast array of energy resources.

At a national level EnergyINet's vision is to help Canada become an energy superpower by accelerating the development and deployment of advanced, environmentally-sustainable energy technologies. This can be accomplished by building an integrated energy economy that uses Canada's natural, human, technical and financial resources to their full potential while identifying problems, and implementing solutions. EnergyINet brings together more than 200 international energy, environmental and technical experts to create an integrated 'whole' energy sector that inherently avoids duplication and fragmenting to achieve shared goals.

At a provincial level the goals are similar to those of EnergyINet and will contribute to the attainment of this national vision. By bringing together a cross-section of people from the research community, government, the private sector, students and NGOs the Energy R&D Forum is helping to forge the relationships that will improve the functioning of the "innovation supply chain" in the province and turn opportunities into reality.

Session One–Marine Environment

The five workshops in this session were directed towards improving our knowledge of a number of issues, primarily environmental in nature, that arise from or affect oil and gas activity taking place in the marine environment. Among these are noise and its impacts resulting from seismic activities, improving the baseline knowledge available on various aspects of the marine environment, regulatory and policy research relevant to the Nova Scotia offshore area, wastes and discharges generated by oil and gas operations, and monitoring the environmental affects related to offshore petroleum activities.

The use of seismic to identify subsurface structures with the potential to trap deposits of oil and/or gas is an essential component of petroleum exploration. It has attracted considerable attention by the environmental community, regulators and researchers to better understand its affects on marine mammals, fish and invertebrates. Studies on the effects of marine noise on invertebrate species have been limited and incomplete making it difficult to draw any conclusions about the impacts of this critical issue for Atlantic Canada's large invertebrate-based fishery. Recent work related to snow crab suggested that seismic was not lethal to them and had little or no effect on other parameters studied. With respect to the impact of seismic on fish, electronic fish tagging technology is evolving to enable the study of fish movements in response to such things as seismic surveys which will help in providing more scientifically based data for furthering understanding the impacts.

A consortium of international oil and gas producers is embarking on a three year joint research program valued at in excess of $20 million (US) to characterize sounds emanating from offshore petroleum activities, better understand the propagation of these sounds, measure their impacts and develop mitigation measures. In order to mitigate risks related to seismic in the Canadian offshore areas, the federal government and affected coastal provinces have developed a risk based statement of practice for all seismic surveys conducted in open marine waters using air-gun arrays. Research is also underway to develop alternatives to air guns that will generate the required energy while at the same time minimizing potential impacts. In general the amount of research to understand the impact of seismic on various marine species is greatest for marine mammals with relatively little having been done on invertebrates. Research efforts are increasing to improve this knowledge but in the meantime governments and industry are putting conditions on seismic operations that will limit risks based on current science.

Baseline knowledge related to a broad range of marine life and other biological eco-system components as well as winds, waves, currents, ice (metocean conditions), sound, water and sediment chemistry, etc. is critical to protecting sensitive areas and species, planning mitigative steps and designing offshore exploration programs and production facilities. The baseline knowledge workshop focused on sound, marine mammals, fish resource mapping, wind prediction and corals. It provided an overview of the current state of knowledge, new technologies for measuring and predicting, and emphasized the need for enhanced ocean observation.

Specifically with respect to sound generated from seismic surveys, it was noted that impact forecasting should be part of any offshore survey and for predictive modeling of this nature it requires baseline knowledge of bottom topography, properties of the water column and the response of individual animal species. For marine mammals there is a notable lack of quantitative methods for delineating areas that are sensitive or vulnerable to both natural and anthropogenic stressors such as marine seismic surveys. The use of sensitivity mapping can highlight the potentially negative effects of human activities on marine mammals and provide an understanding of the scope of potential impacts. However the usefulness of this approach needs to be tempered by an understanding of its limitations again resulting from a lack of baseline data related to acoustic conditions, sound propagation and the distribution and abundance of marine mammals in the areas of interest.

More generally obtaining data and generating useful information on the ocean and its various dynamic habitats has always been a technological challenge. New technologies are being developed and used to help understand and address the impact of offshore exploration on the distribution of marine life and the ability to monitor and predict it. The environmental effects of offshore exploration are often species specific, requiring an entirely new solution for predicting and monitoring marine life distribution. Some challenges have been met by using more advanced automated robotic platforms with state-of-the-art sensor technologies. These platforms are able to obtain detailed video images and soil and organism samples needed for detailed studies of ocean corals, reef destruction, and habitat sensitivity.

Wind modeling also plays a key role in predicting ocean changes. Predicting and observing winds remains a problem whereas tracking storm winds and their intensity can be modeled. Currently the SCOOP team (Southeast Universities Research Association Coastal Ocean Observing and Prediction) are working on creating infrastructure for a distributed Integrated Ocean Observing System (IOOS) from Mexico to Newfoundland. This will provide accurate wind, wave and current data that can be used to predict, model and observe trends in wind activity and can also provide accurate models that capture the intensity and timing of storm winds.

In Nova Scotia there is an enormous lack of research on coral reef habitat and the effects of dragging and ice scours on these reefs. The Northeast Channel is assumed to house the largest gorgonian coral reef in the world. Monitoring these habitats is extremely important because present research suggests the reefs off Nova Scotia take more than 20 years to re-colonize after fishing scars left from draggers. In Norway dragging was banned specifically to save the coral reefs; however Canada has not yet advanced this far.

Offshore energy developments, whether oil and gas or other forms of energy, take place within a complex regulatory and policy environment that is intended to strike a balance between the need to protect the ocean environment while at the same time being able to derive economic and social benefits from the use of the oceans' vast resources. The energy regulatory policy research workshop provided an overview of a number of energy-related regulatory and policy experiences and developments relevant to the Nova Scotia offshore region.

The generation of energy from the tides in the Bay of Fundy is not only technically challenging, but presents a number of complex constitutional and jurisdictional issues involving federal and provincial responsibilities and powers, property rights and international agreements. While it is clear that Canada has jurisdiction under the United Nations Convention on the Law of the Sea (UNCLOS), within Canada the regulatory situation is less clear with responsibilities shared with the provinces. Some of the key regulatory and policy issues include environmental impact assessment, effects on the coastal environment, impacts on the fishing industry, nature preservation, tourism, shipping, marine conservation employment and industrial benefits and royalties. Strategic environmental assessments (SEAs) and integrated planning are approaches that could streamline environmental assessments by considering many of these issues at an early stage. More generally, because of the similarities with the regulation of oil and gas offshore Nova Scotia, a joint Offshore Renewable Energy Board is suggested as a model for federal-provincial regulatory coordination and decision making.

An important consideration with any major industrial development such as oil and gas production is the socio-economic impacts it will have on the region or country as a whole. Norway is viewed by many as a model for how to manage these impacts in a manner that provides sustainable long term benefits, and for effectively managing the environmental affects of the petroleum industry.

Norway's national technology strategy is focused on both near term objectives such as increasing exploration success, enhancing recovery and improving operation performance along the entire value chain, but also on the longer term by developing technologies that establish Norway as an international leader in a number of target technology areas with significant export potential. Norway's vision is to have a sustainable petroleum industry for the next 100 years, based on a cooperative approach to knowledge and technology. From an environmental perspective Norway has either left a number of areas closed to exploration or limited activity because of their environmental sensitivity, for example Lofoten and Barents Sea which contain some of the world's richest stocks of fish, seabirds and marine mammals.

Offshore petroleum exploration and production activities inevitably produce waste materials in the form of drill cuttings, produced water and air emissions, all of which contain a range of potential contaminants. There is also the risk of accidental spills of chemicals used during drilling and production operations as well as produced crude oil. The introduction of these materials into the marine environment can have both short and long term impacts that require monitoring, research and appropriate mitigation steps.

Produced water is the largest waste stream by volume resulting from offshore petroleum activities. It is comprised of formation water and injection water containing hydrolysis metals, heavy metals, petroleum hydrocarbons, nutrients, radio-nuclides and treatment chemicals. Norway, with its high levels of production and strict environmental limits, has not documented any sedimentation of hydrocarbons or production chemicals from produced water. However they have experienced transport of radioactive isotopes in the Tampen area of the northern North Sea. Current research in Canada is focused on identifying the environmental impacts of produced water, if any, and acceptable disposal limits that will minimize the cost of treatment or re-injection.

Typically for produced water dispersion models are used to assess the extent and risks of exposure as well as the impacts on marine organisms, but current work suggests that these models may not provide an adequate description. The concentration and composition of discharged produced water contaminants are variable over space and time due to source variations and changes in discharge rates. In addition chemical changes occur within 24 hours of it being mixed with seawater facilitating contaminant partitioning between the surface microlayer, water column and sediments which in turn affects the toxicity of produced water and the impact zone. Based on micro-toxicity analysis, the high volumes of produced water have relatively low acute toxicity, however the effects of low level chronic long-term exposure to marine organisms is relatively unknown and requires further research.

Spills of oil and chemicals represent another risk to the marine environment. The response to spills in Canada places the responsibility for clean-up and the associated costs on the polluter with governments providing a regulatory and oversight role. The federal government, through Environment Canada, is involved in spill-related research to develop, test and demonstrate new detection, containment and clean-up equipment as well as oil spill sorbents, analytical equipment, treating agents and remote sensing equipment. They also provide environmental information and advice, meteorological support during emergencies and legislative enforcement. Due to the extremely large volumes of oily wastes generated from marine pollution incidents, Environment Canada is involved in developing new techniques and strategies for their proper handling, storage, segregation and disposal, and the pre-selection and design of suitable and safe temporary and permanent disposal sites.

All offshore petroleum companies have an interest in monitoring and predicting marine environmental impacts arising from drill wastes, produced water, spills and the use of dispersants as a matter of corporate responsibility and to meet regulatory requirements. Monitoring and analysis of environmental effects over longer periods of time is necessary to determine the extent of impacts from extended exposure, population effects and behavioral changes in species. New technologies are providing increased capabilities to monitor and predict these effects. These include advanced sensors, integrated instrumentation platforms, improved data transmission through higher power and greater bandwidth, more capable and accessible data and information systems, and new visualization tools responsive to client needs. Real time environmental data collection and transmission can be integrated with the remote monitoring and control of operations through such things as voice/data communications and broadband network access providing greater capability to monitor and assess environmental effects.

As noted earlier there has been considerable attention recently on the impact of marine seismic on invertebrates such as snow crab and lobster, marine mammals and fish. A seismic program undertaken by Hunt off the east coast of Cape Breton Island in the Sydney Bight area in 2005 provided an opportunity to study the effects on cod to complement work carried out the previous year on snow crab off Western Cape Breton Island. Past studies indicated damage had occurred to the delicate ear tissues in fish following exposure to air gun discharges, and that the injury showed signs of both increasing and decreasing somewhat over time. An environmental effects monitoring program was designed to determine the threshold at which sub-lethal damage to ear structures of fish occurred. To study the impacts hatchery-raised cod were located in cages at varying distances from the energy source, sound pressures measured and the fish dissected and studied. Reporting on the work is awaiting results from analysis of ear tissues, and when complete will shed further light on the impact of seismic on fish.

Exploration wells drilled offshore are required to undergo an environmental assessment. This had been accomplished through a screening until recent amendments to the Canadian Environmental Assessment (CEA) Act placed exploration wells on the Comprehensive Study List. The question of whether the more time consuming comprehensive study process was warranted for exploratory wells resulted in a study to determine the impacts of exploratory drilling, areas of uncertainty, and gaps in the scientific understanding of the interaction between exploratory drilling and the receiving environment including cumulative effects. The objective was to identify and quantify effects and potential impacts of exploration on the natural environment, quantify their magnitude, estimate the likelihood of occurrence, and indicate the level of certainty surrounding the scientific conclusions reached. The assessment was based on a review of scientific literature and pertinent offshore Canadian EEM data.

The study results indicated that multiple wells drilled at the same location had larger contaminant zones of detection than a single well (several kilometers versus less than 1000 meters); changes in the diversity and abundance of benthic organisms were generally restricted to within 1000 m of drill site(s); drilling discharges had minor effects on fish health; and taint has not been detected for any fish or shellfish species tested with one exception. In addition drilling noise levels were found to be within the range of other marine industrial sources leading to the view that the potential cumulative effects of exploration drilling on the marine environment need to be considered in light of other existing anthropogenic activities. This review was in part responsible for a decision by the federal Minister of the Environment to change the Regulation under the CEA Act.

Session 2- Geoscience

The second session, "*Building Knowledge about Geoscience*", focused on improving the level of understanding about Nova Scotia's offshore petroleum resources by considering what is known about various basins and the petroleum systems that govern the deposition of petroleum resources, the petroleum resource potential, the distribution of reservoirs and important policy issues, particularly data availability and sharing. With the limited amount of exploration success offshore Nova Scotia during the past decade, this knowledge is essential for continued exploration and the discovery of new oil and gas resources.

The experiences of other countries can provide important information and lessons that can be of benefit to Nova Scotia. With that in mind Dr. Jeferson Luis Dias of Brazil's national petroleum company, PETROBRAS, gave the keynote address for the session. He described Brazil's exploration experiences in the offshore beginning with the first discovery of oil in the Campos Basin in 1974 soon followed by other discoveries, albeit modest relative to the country's needs. At the beginning of the 1980s exploration started in the deep water region of the basin resulting in the discovery of seven giant oilfields by 1997. Following a period of restructuring and only a few small discoveries, in 2002 PETROBRAS recentralized and refocused exploration from the mature core of the Campos basin to the northern and southern regions of the basin and to the adjacent basins of Espírito Santo and Santos. As a result, 6.6 billion barrels of oil equivalent were discovered in seventeen (17) new oil and gas fields, mostly in deep and ultra-deep waters and in deeper and older reservoirs than those previously discovered.

Exploration is one of the most costly endeavors for the oil and gas industry, therefore predicting and being able to identify potential reservoirs and sources of hydrocarbon is extremely important. In the Nova Scotia offshore area recent exploration has taken place on three distinct exploration trends: the Jurassic carbonate bank following the 1998 Deep Panuke discovery; shallow water exploration drilling in the Sable sub-basin around the present Sable gas development; and shallow water drilling in Cretaceous and tertiary Turbidite reservoirs within the Scotian Slope targeting large deepwater finds.

The first workshop examined petroleum systems on the Scotian Shelf by discussing the systems giving rise to the Cohasset and Panuke oil discoveries, shelf margin deltas as an exploration play type offshore Nova Scotia, and the formation and evolution of conjugate basins. The Cohasset and Panuke light oil and condensate fields, located on the western margin of the Sable Subbasin, were discovered in 1973 and 1986 respectively. They are among the four relatively small oil discoveries on the otherwise gas prone Scotian Shelf and the only ones that have been commercially developed. The accumulations are structurally and stratigraphically trapped as a result of sands draped over the thick carbonate highs of the Abenaki formation. The oils have low maturity and are derived from source rocks similar to those found in the Newark Basin along the US east coast.

Early Jurassic source rock's geochemistry suggests an upward and lateral migration of the heavier hydrocarbons into distinct compartmentalized reservoirs. This migration often occurs when oils are heated at such depths that the hydrocarbon cracks and becomes gas and other various fractions. Although there hasn't been enough penetration in the early Jurassic source rocks to ensure a significant source of oil, the success in the late Jurassic source rocks (Deep Panuke, Abenaki) give reason to believe one is present.

The Upper Jurassic carbonate bank has had limited exploration along its 650 km. length with only 11 exploration wells and the discovery of one major gas field in addition to the small Cohasset and Panuke oil fields noted previously. During the session information was provided about the Abenaki reef trend, the seismic and geological perspective of the carbonate bank and the problems posed by the high cost of exploratory drilling. High drilling costs have boosted the speed and changed the type of drilling bits being used resulting in rock samples that are often reduced to chalkified-cooked-sheared-small cuttings. This has made the samples less useable and more tedious to look at by geologists. This in turn makes it more difficult for them to map out the geological-structural history of the carbonate bank. Nonetheless some progress is being made by comparing old cuttings with the new ones with the result that evidence from the new cuttings is contradicting past assumptions and generating new knowledge about the bank.

Turbidites are often a key indicator for petroleum reserves because they are a source of rich organic deposits (depocenters). These source sites are buried and then transformed into oil and gas over time by immense temperature and pressure. Finding these source sites or indications of them is thus a key to finding the oil and gas reservoirs. An example of these depocenters is the growth-faulted shelf margin delta complexes which arguably have several of the largest gas accumulations offshore Nova Scotia in spite of these not being recognized explicitly as a play type. Nonetheless they are thought to be excellent exploration targets in their own right and as well useful in identifying deep-water exploration targets. Recognition of the growth-faulted shelf margin play type will improve exploitation strategies in Nova Scotia and provide the framework to identifying new opportunities.

Deep-water drilling has always posed problems, especially in terms of gathering seismic data in the present and the lack of exploration done in the past. More recently there has been deep-water exploratory drilling in the Scotian Basin but still with limited data. To date just six deep-water wells have been drilled with only Annapolis showing any significant hydrocarbons with 30 m of net pay over several zones. While gas was present in all wells drilled in the deepwater, the reservoirs were thin or poor with very fine grained or silt-size sandstone. The hoped for large discovery needed to advance deep-water exploration remains elusive. However only three of the 12 deep-water play types identified have been drilled as yet.

GX Technology has paired up with the Geological Survey of Canada and the oil industry aiming to improve the knowledge of the basin. They have been able to gather data down to 20 km and imaging below salt canopies which will give scientists a more vivid picture of the fundamental geology of the basin. The results, so far, have indicated the presence of more complex petroleum systems than seen in deep-water Gulf of Mexico and West Africa. Currently in Brazil, the deep-water and ultra-deep water successes have been the result of decades of dedicated exploration resulting in many cycles of discoveries, an example to consider in Nova Scotia's offshore.

In general the limited petroleum exploration successes over the past decade underscore the limits of our knowledge of petroleum systems in the basins offshore Nova Scotia as well as those in conjugate margin basins in the Central Atlantic Region, and especially in those with older hydrocarbon discoveries. In order to improve the understanding of the region's basins and petroleum systems an international conference is proposed to be held at Dalhousie University in Halifax during the summer of 2007. The "Central Atlantic Conjugate Margin Conference" will incorporate the results of past hydrocarbon exploration throughout this region with the latest ideas and interpretations on divergent margin basin evolution and petroleum systems. It is intended to enable researchers and industry personnel to share ideas/results and data about these conjugate basins in order to improve understanding about their formation, evolution and petroleum systems. This should lead to elevated hydrocarbon prospectivity, reduced exploration risks and more exploration successes.

The cost of exploration is always very significant, so secrecy and information confidentiality is extremely important to oil companies, however, so is advancing knowledge of geology and petroleum systems. Data collection offshore eastern Canada is especially challenging. Data repositories were proposed in an effort to make information available to the research community, industry and academia. This would allow industry to save money on mapping and exploration costs while advancing knowledge of geological information. These proposed repositories would contain old seismic data and information on old wells, all of which would still be relevant to present exploration and research. This poses a concern with respect to the commercial interests of petroleum and geophysical companies and their right to protect data they have collected, particularly with digital technology and the ability to easily access information. However, with the confidentiality periods set out in legislation, the immediate commercial interests of industry are protected while still allowing the information to be accessed in the future.

The Canadian Nova Scotia Offshore Petroleum Board (CNSOPB) has recognized the need for valuable petroleum data by the regulator, industry, governments, research institutions and the public. The board however, hasn't the personnel or facilities to manage an appropriate system, unless funding from the provincial and federal governments is secured. If the funding is approved, the CNSOPB plans to establish a digital Data Management Centre (DMC) for the offshore Nova Scotia petroleum data within 1-2 years. The Geoscience Data Repository of the Earth Sciences Sector (a division of Natural Resources Canada) is a very good example of what is needed for the Nova Scotia offshore data. This repository is an all digital, on-line and an inexpensive network of databases that makes it easy to access extensive resources of geoscience data. Public/institutional access to data is important because offshore data collection is very expensive ($millions) and data collected in the past is still relevant today. However, since industry is paying for these data it is appropriate to protect its commercial value, maximize the documents' worth and makes the surveyed area more competitive.

Session 3 – Sustainable Energy

Building Knowledge about Sustainable Energy dealt with technical and policy issues impacting the adoption of new renewable and more environmentally sustainable technologies, resource availability in Canada and the Maritimes, and advancements in the sustainable energy industry. The main areas discussed were: clean coal technologies, wind energy, hydrogen energy, tidal energy, solar energy, and geothermal energy and storage. The session covered the implications of these technologies and their future in Nova Scotia as well as the importance of a more sustainable energy future by reducing emissions and costs, and increasing energy supply more efficiently. The role that technological advancements play, the need for more research and public awareness, and a need for up to date detailed resource mapping for tidal, wave, wind and solar energy were also key points brought forth by presenters.

Clean coal technologies enable the gasification and combustion of coal with near zero emissions of acid gases, particulates, air toxins and greenhouse gases, particularly carbon dioxide through its capture and storage. With coal accounting for 66% of the total fossil fuel reserves in Canada and sufficient for over 200 years of supply, clean coal technologies are important to Canada's investment in future energy developments and emission reduction programs. In recognition of the importance of this resource approximately one hundred and twenty Canadian stakeholders from government, industry, academia and the private sector recently developed Canada's Clean Coal Technology Roadmap. The roadmap consists of objectives intended to ensure the continued use of clean coal in Canada, development of time frames, targets for zero emissions and various related information.

Opportunities for retrofitting clean coal technologies into existing coal-fired plants as well as incorporating these technologies into newly constructed plants are being examined. In order for their adoption they clearly need to be efficient and economically feasible. Studies are being done by the Canadian Clean Power Coalition to improve gasification processes, supercritical steam optimization, coal blends, and feasibility of retrofitting or installing new facilities. These studies will lead to the development of a full scale demonstration project to remove greenhouse gas and all other emissions of concern from a coal-fired power plant by 2012 at a competitive cost of power.

In parallel with the pursuit of clean coal technologies, developments in carbon dioxide capture and storage are at the forefront of research in emissions reduction. Currently more than $17.5 million/year has been invested by the federal government of Canada to advance both clean coal and greenhouse gas emission reduction technologies ($6 million/year for clean coal, $11.5 million/year for carbon dioxide capture and storage). There are a number of technologies being pursued for carbon dioxide capture and storage involving primarily enhanced oil and gas recovery, and injection into the subsurface for long term storage. The geological media that provide the space and means for the underground geological storage of CO2 are found in sedimentary basins. Crystalline and metamorphic rocks, such as granite, on continental shields are not suitable for CO_2 storage because they lack the porosity and permeability needed.

Carbon dioxide from a large point source is compressed and transported via pipeline to an injection site (such as a saline aquifer, or subsurface formation), or used for enhanced oil recovery, enhanced coalbed methane recovery and enhanced gas recovery. Currently, Weyburn, Saskatchewan is the world's largest CO2 capture and storage project injecting 5000 tonnes of CO_2 per day transported to the site by pipeline. In the North Sea 1 Mt/year of carbon dioxide has been injected into ten tiers of an 800m deep saline/permeable sand formation since 1996. This project has been monitored using 3-D seismic surveying and gravity monitoring with no evidence of carbon dioxide migrating out of the formation.

In Nova Scotia the potential exists to store CO_2 in sedimentary basins onshore and possibly offshore. Dalhousie University and Nova Scotia Power Inc. have proposed a joint program to develop a broad-based carbon storage strategy utilizing deep coal beds, deep saline aquifers, salt caverns and hydrocarbon reservoirs. A subsequent research program has been proposed involving Dalhousie, NSPI, Stealth Ventures Ltd., EnergyINet, and Schlumberger focusing on CO_2 capture and storage for enhanced coal bed methane recovery (ECBM). The project will determine the feasibility and capacity for CO2 injection and long term storage in the coal seams of northern Nova Scotia to assist CBM recovery while at the same time enabling Nova Scotia Power Inc., to reduce CO_2 emissions. The research would develop the process technology to address the issue of decreasing permeability in coal seams with CO_2 injection and prepare for the implementation of a pilot demonstration project.

There are still many issues to be dealt with such as project boundaries, containment and leakage, costs including transportation, monitoring, permanence and regulatory jurisdiction. Policy issues related to both onshore and offshore carbon storage need to be addressed, particularly as sustainable technologies for mitigating emissions become more vital with growing concerns regarding global warming. Carbon dioxide capture and storage combined with clean coal technologies will be important elements of Canada's energy future that will help to enable sustainable energy resource production and use. They will also be important components of Canada's mitigation options for meeting GHC reductions targeted under the Kyoto Protocol.

On a global basis the use of non-hydro renewable resources for electrical energy generation is expected to grow by a factor of 5 over the next 25 years, but will still represent a very small proportion of the renewable resource potential from biomass, wind, waves, solar, tidal and geothermal sources. Canada is one of the six leading developers of renewable ocean technologies in the world. Wind energy is growing in importance and currently Canada ranks 14th in the world in wind energy generation capacity, but wind regimes and hence the potential contribution of wind energy varies considerably across the country. The energy content of available biomass resources represents 18 to 25% of Canada's annual energy consumption, however only a relatively small amount is actually used. Geothermal energy is used on a small scale primarily for heat pump applications. Both solar and tidal energy have been exploited to a limited extent but have large potential.

Nova Scotia's Minas Passage is currently the site of prospective in-stream tidal energy developments because of the very high power densities in its tidal flows. This site experiences some of the greatest lunar pulls in the world, creating very high and low tides which make it such an ideal location for tidal power production. With proper siting informed by early dialogue with stakeholder groups, in-stream tidal energy promises to be one of the most environmentally benign energy supply options available, with no emissions and minimal aesthetic impact. Economics appear favourable compared to other generation options, and the estimated physical resource of 1,900 or 2,850 MW is substantial relative to current NS installed capacity. . Research is being done on the types of turbines appropriate for this location as well as the impacts of the technology at the site, the affects of noise emissions, electromagnetic fields and vibrations, marine habitat loss, etc. Other important R&D tasks include engineering studies of ice impact and offshore procedures to raise & lower submerged units for inspection, maintenance, and repair. Numerical modeling of turbine array effects on near-field and far-field circulation also is needed.

Similar to Minas Passage, there is potential for near-shore wave power off Sable Island (approximately 1000MW). Mapping the potential for various offshore locations and the amount of energy available is being conducted through the Canadian Renewable Ocean Energy Resource Atlas project. Research efforts are concentrated on energy conversion and conditioning, modeling and forecasting power recovery and output, connecting to the power grid, structural engineering, and reducing the risks and costs.

The solar energy resource base in Atlantic Canada is sufficient for a range of applications including solar electricity in site specific situations, domestic hot water, and active and passive space heating. The resource varies between and within provinces but in general is similar to much of Western Europe. In Nova Scotia there is considerable variation on a seasonable basis and regionally with higher solar radiation in the Annapolis Valley and the Cumberland County area and the least in eastern mainland Nova Scotia. Solar energy deployment program should be an integral part of any sustainable energy strategy especially in new housing and commercial developments. Currently in Bedford, Nova Scotia a solar energy project is underway that incorporates subdivision planning with house orientation to gain the most potential from the sun's energy. However, solar mapping needs to be up-dated and more developmental planning needs to incorporate this resource potential so full advantage can be taken of passive solar radiation.

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Wind is a growing energy industry with the trend toward large rated power turbines in the 100 kW to 5 MW range. Currently research and development is being done in advanced airfoils, super-magnet neodymium generators, low cost manufacturing, smart power electronics, very tall towers, low noise (stealth) and visual impact, energy storage, and small induction based turbines. In Nova Scotia, Atlantic Orient Canada Inc. manufactures small wind turbines and installs them worldwide. They also work with small remote communities to integrate wind-diesel systems to their diesel generator systems. The steadily decreasing cost of producing electricity from wind has many advantages especially to small remote communities implementing this technology. Hydrogenics Corporation and the Prince Edward Island Energy Corporation have plans to implement a wind-hydrogen system in PEI. This will be Canada's first wind-hydrogen village project initiated to demonstrate this technology. It will offer clean and sustainable energy solutions that can be used for many applications.

Underground thermal energy storage involves the use of aquifers, boreholes, and caverns to store thermal energy. .For the past three years, proof of concept studies using concentric treated boreholes has been conducted in Canada. This innovation is the first in the world to use concentric treated boreholes for cold energy storage. The concentric treated borehole design reduces the cost of underground thermal energy storage by up to 50% compared to traditional U-tube design. In Nova Scotia there are studies being conducted in Port Hawkesbury and Alderney Gate. The Alderney Gate Cooling Project is concentrating on direct cooling from the Halifax Harbour.

Other Presentations

In addition to the opening plenary address, the Forum included two general presentations that cut across the subject matter of the individual sessions. The first presentation dealt with the role of "Springboard", a network of 14 Atlantic Canadian universities led by the Association of Atlantic Universities with a mandate to support the commercialization of university research in the region by encouraging the transfer of knowledge and technology to the region's private sector. Springboard's programs include a proof-of-concept fund with an annual $200,000 budget targeting 10 grant awards / year, a patenting and legal fund with a $120,000 budget per year (12 awards / year) and member training to create knowledgeable experts in the region. A number of projects were reviewed in which Springboard has been involved and which span all four Atlantic Provinces and a range of energy related subjects

The second presentation focused on the role and activities of Petroleum Research Atlantic Canada (PRAC) in facilitating and providing funding support for petroleum-related research and development in the region. It pointed to the economic value of petroleum R&D, not only in exploration and production activities, but also in adding value to the resources produced and developing exportable technologies and services. The importance of collaborative R&D was noted, not only for those delivering research but also for those funding it. The presentation also emphasized the critical nature of "market pull" in maximizing the productivity and commercial value of R&D activities by focusing on the needs of those who can adopt the output of thee research activities. PRAC's model for facilitating needs driven research was reviewed as an example of a "market pull" approach.

Conclusion

A follow-up survey of Forum participants indicated that the event achieved its objectives of creating opportunities for networking, collaboration and sharing technical information covering a range of technical areas related to the further development of Nova Scotia's energy sector. It enabled the exchange of ideas and the consideration of how research and development can help address the energy challenges Nova Scotia faces as well as realize the province’s energy potential. There was strong support for future forums of this nature supporting the view that this event was of value to participants, well organized, with speakers who were knowledgeable in their particular fields.