Government of Canada
Policy Research Initiative

Gouvernement du Canada
Projet de recherche sur les politiques

The Science-Policy Interface

Water and Climate Change, and the Energy-Water Nexus

March 2008

PRI Project
Engaging US Think-Tanks

In collaboration with

Woodrow Wilson International Center for Scholars
Canada Institute

Canada

About this Report

The PRI contributes to the Government of Canada's medium-term policy planning by conducting cross-cutting research projects, and by harnessing knowledge and expertise from within the federal government and from universities and research organizations. However, conclusions and proposals contained in PRI reports do not necessarily represent the views of the Government of Canada or participating departments and agencies.

The Canada Institute of the Woodrow Wilson Center

The Canada Institute of the Woodrow Wilson International Center for Scholars seeks to promote a free flow of ideas and policy options for deepening understanding, communication, and cooperation between the United States and Canada by engaging policymakers and members of the scholarly, business, and not-for-profit communities in creative dialogue. The Canada Institute's programming and publications – both in the United States and in Canada – seek to generate discussion and increase awareness of the bilateral relationship on a broad scope of issues including energy and environmental policy, trade and economic issues, and border security and the shared defense relationship. In addition to raising the profile of Canada in the United States, the Canada Institute encourages a full discussion of the bilateral relationship in the policy dialogue by organizing programs throughout Canada that include US perspectives on key bilateral issues.

Established by an Act of Congress in 1968, the Woodrow Wilson Center is the United States' preeminent policy forum. Under the auspices of the Smithsonian Institution, the Center brings together the world's leading scholars, business leaders, and policymakers in a nonpartisan atmosphere of study and discourse. Created as a "living memorial" to President Woodrow Wilson, the only American president to hold a Ph.D., it unites his passion for government and academics. Located in the heart of Washington, D.C., the Woodrow Wilson Center is host to nearly 800 meetings and lectures each year. In addition, the Center maintains an active campaign of outreach through books, newsletters, the award-winning Wilson Quarterly magazine, and the globally syndicated dialogue radio and television programs.

This publication is available electronically on the PRI web site at the following address:

<www.policyresearch.gc.ca>

Print copies of this publication are available upon request. Please contact:

Policy Research Initiative
56 Sparks Street, First Floor
Ottawa, ON K1P 5A9

Tel: 613-947-1956
Fax: 613-995-6006
E-mail: <questions@prs-srp.gc.ca>

PH4-43/2008E-PDF
ISBN 978-0-662-48074-7

Table of Contents

The Science-Policy Interface

Water and Climate Change, and the Energy-Water Nexus

Introduction

In Canada, policy research and the science-policy interface occur inside government, at universities, or to a lesser extent, in think-tanks and lobby groups. In the US, think-tanks play a much larger role in both research and influencing the public policy agenda, although government and universities are also important contributors.

While linkages already exist between Canadian and US governments, Canadian and US academics, and Canadian and US think-tanks, the links between Canadian universities and US think-tanks are – at best – weak. Thus, there is potential gain to be had in improving those links. For example, links could be fostered between individual researchers, between institutions, or along topical lines. Among these possibilities, a topical approach to strengthening these ties is likely to be the most useful for developing strong, long-lasting linkages.

Several themes have been suggested for piloting an initiative to strengthen such links. One such theme is freshwater. Several aspects of freshwater give rise to policy issues, many of which are common to both Canada and the US.

On June 15, 2007, the Government of Canada's Policy Research Initiative (PRI) organized a planning meeting to identify freshwater topics that could be pursued. The participants decided to examine areas of collaboration on "Water and Climate Change" and "The Energy-Water Nexus," and how different systems of governance, different needs, and different political drivers have influenced current science and policies in Canada and the US.

On October 2, 2007, the Woodrow Wilson International Center for Scholars hosted a meeting in Washington, D.C., to explore possible areas and means of improving Canada-US policy research links in freshwater policy in the context of "Water and Climate Change" and the "Energy-Water Nexus" (see Appendix 1 for the meeting agenda).

The roundtable meeting was organized by the PRI and chaired by Dr. Howard Alper and Dr. Heather Munroe-Blum. An equal number of Canadian and American experts in freshwater science and policy participated, observed by senior Government of Canada officials from Environment Canada, Natural Resources Canada and Foreign Affairs and International Trade Canada (see Appendix 2 for a full participant list).

The content of this paper reflects the presentations and discussions that occurred on October 2, beginning with a review of "Water and Climate Change," followed by "The Energy-Water Nexus." The paper also includes a synthesis of the policy "pushes" and science "needs" identified by the participants, and closes with a short discussion of conclusions and next steps. A link to background materials is provided at the end of the text. This material, which was prepared by participants, will provide additional information on many of the subjects discussed in the document.

Water and Climate Change

There is a general consensus that the earth's temperature is rising due to increased levels of greenhouse gases. Impacts resulting from a changing climate will have important consequences for water, including:

- A change in the seasonality of flow, marked by higher flows in the winter, particularly in areas where water is stored as ice and snow;
- Increased evapo-transpiration resulting from higher temperatures, which may be responsible for lower total annual flows; and
- More-frequent, high-intensity precipitation events that can change drainage patterns and produce flash floods that could have safety implications, not only in terms of physical hazards, but also for water quality.[1]

Climate-related impacts on the hydrologic cycle can have serious implications for water availability, because they can often pose serious storage challenges. There are four types of water storage – reservoirs, groundwater, soil moisture, and snow and ice. Increased temperatures will cause premature melting of snow and ice, and will increase evapo-transpiration that will remove moisture from the soil, reduce surface-water levels, and have implications for groundwater recharge. The latter will also be limited by the high, fast-flowing runoff that is associated with extreme rainfall. Changes in the timing of flows will also present storage-related challenges. For example, short supplies in the summer will coincide with periods of high usage. Managing our stores will thus be a critical issue in the face of climate change in order to ensure a sufficient supply of water. Planners will need robust tools and innovative strategies to cope.

Although our current scientific understanding can provide us with a fundamental sense of the types of impacts we can expect, there is a tremendous amount of uncertainty associated with climate change. It is critical that we incorporate this uncertainty into our modelling tools and our decision-making processes.

Current modelling relies heavily on the historical record to inform outputs. This approach is no longer appropriate. Not only is climate change introducing the potential for large surprises, there is also a need to consider naturally occurring events that the scientific community is only recently beginning to understand and appreciate, such as the El Nino Southern Oscillation (ENSO), the Pacific Decadal Oscillation (PDO) and the Atlantic Multi-decadal Oscillation (AMO). All of these phenomena are associated with potentially significant departures from normal conditions and need to be regarded jointly, *not* in isolation. A new paradigm in modelling is therefore required – one that shifts away from stationary models and acknowledges both the potential for deep uncertainty and the links between climate and the hydrologic cycle.

New approaches are needed in other domains as well. Existing legal frameworks in Canada and the US treat surface water and groundwater separately, which limits our

---

[1] Increased sedimentation resulting from high runoff can introduce sediment-bound pollutants into surface waters, and incidences of waterborne diseases peaking following high-intensity rain.

ability to plan for the resource. From a scientific perspective, however, our understanding of the connections between surface and groundwater is increasing, providing a good opportunity to create science-based policy. By considering surface and groundwater jointly, we can make more-informed decisions regarding supply and storage and we can also develop conjunctive-use strategies. For example, some areas (such as dry climates) are more suited to using groundwater supplies, whereas others would benefit more from using surface water. With storage becoming an increasingly important issue in the face of climate change, it is important to understand all of the options, including whether groundwater recovery is feasible. Such decisions are difficult to make without having a complete picture of the resource.

Management challenges in this regard are perhaps greater in Canada, where different agencies are often responsible for surface and groundwater. Furthermore, Canada has a more limited data capacity than the US, due to reductions in the scale of water measurement programs, particularly with respect to groundwater. Although the legal framework poses a management challenge, the combination of dispersed management and sparse information can also make it very difficult to plan.

Another important consideration in water-use planning that will be relevant in adapting to climate change is how much water will be required to meet in-stream flow needs. Scientific research is needed both in terms of defining what in-stream flow needs are, and establishing a methodology for qualifying the amount of water that is required to meet such needs on a case-by-case basis. There is a consensus that such information is essential for establishing a baseline for allocation – a baseline that will not compromise the ecological integrity of a given freshwater system. In the US, there is a policy push to advance scientific work in this area in response to the *Endangered Species Act*. A parallel need to establishing in-stream flow requirements is the need to determine the non-market economic benefits of a healthy ecosystem.

We must also make changes to our planning approaches. In general, sewage and water infrastructure in North America is old and in worsening condition. Maintenance and updating costs are growing. When planning for the future, current design assumptions need to be revised. Given the 75-100 year lifespan of new systems, it is critical that our systems be designed to withstand a wide range of scenarios beyond those that are traditionally planned for (such as a 25 or 100 year flood). The large-scale surprises that could be experienced in a changing climate, such as frequent and intense precipitation events, can exceed the capacity of urban infrastructure, exposing limitations in terms of treatment capacity and structural integrity. Furthermore, a shift from centralized facilities towards a decentralized system of smaller facilities may be a more feasible option in the future for containing any failures that do occur.

Site-specific planning will also be important, tailoring systems to local conditions. To achieve this new planning paradigm, revisions will need to occur at the academic level. For example, engineering associations could consider integrating “green” technology education into their accreditation processes. More generally, we need to take a multidisciplinary approach when educating engineers, scientists and planners to gain an appreciation and understanding for the many factors that are involved in designing robust systems.

From a policy perspective, there is a sense that "no-regret" strategies can be employed in moving forwards. The desired policy directions need to be promptly identified, based on our current knowledge but allowing for adjustments and changes as our scientific understanding of climate change and its impacts increases. A number of short-term and long-term strategies relating to water efficiency are being pursued and could be further developed without compromising deliberation on the broader policy. For example, demand management encompasses a number of tools and strategies that can reduce the amount of water we use, and will be a critical element of climate-change adaptation.

An important element of demand-management is the use of efficient technologies. Water-efficient technologies can have a large impact, both at the household level and for larger-scale users. The agricultural sector, for example, is a major user of water, although the sector uses 30 percent less water than it did only 25 years ago, due to innovative technologies. Improved irrigation-conveyance technologies, and instruments that monitor soil moisture, are among the technologies that allow for the increased re-use and recycling of water with respect to irrigation, and increased efficiencies in the sector as a whole. Although we have made many advances in efficient use of irrigation water, we need more innovation to identify and prevent significant losses of treated water throughout distribution networks in the urban environment. It should be noted, however, that efficiency improvements in water infrastructure have finite gains: with continued population growth and development, additional policy and planning solutions are needed to cope with limited water supplies.

Using economic instruments to influence industrial and societal behaviour is another option for managing the demand on water. Economic price signals place a monetary value on water, which may affect how people use the resource. With respect to agriculture, market-based water prices are critical to rationalizing the choice of crop; however, economic decision-making in this regard is distorted by current irrigation practices and agricultural subsidies. In the urban setting, we need further research to determine at what price households are willing to make changes – affordability of water is seldom an issue in many North American homes. Behavioural change could be encouraged without financial incentives by using effective communication strategies and programs. History shows that societies can adapt if needed.

"Soft path methodology" is an example of a long-term approach to reducing our demands on water. Such approaches involve large-scale changes to water infrastructure and governance, while being mindful of ecological limits and the importance of public involvement. Soft-path approaches incorporate a number of tools and strategies to promote the sustainable use of water. Research in water soft paths has illustrated that it is easy to achieve 50 percent savings at the local, watershed and provincial levels. However, we need more data to understand the full potential of the soft-path process.

To cope with a changing climate, both Americans and Canadians need to rethink how we integrate our scientific understanding of water resources into the decision-making process and our governance structures. We also need to maximize the robustness of our decision-making tools and planning approaches in the face of deep uncertainty. No-regret strategies that are founded on demand management will need to be pursued, and adaptive management principles will need to be adopted, to facilitate the efficient integration of new science into policy.

The Energy-Water Nexus

The use of energy and water are closely related. Energy is required to treat, pump and distribute water, and water is used in the energy sector for cooling, extraction and other processes specific to the energy source. Although there are many interdependencies in these resources, we will discuss the two sectors separately.

The Use of Energy in the Water Sector

The water sector requires significant amounts of energy. As the demand for water grows in urban areas, more energy is needed to transport and treat the water, particularly if new water sources are required. When dense urban areas exceed the capacity of existing water supplies, planners are often forced to rely on additional water sources that are far away and of poorer quality. Energy is needed to pump this water from greater distances or from deeper aquifers, and to treat the water to the desired quality. Coastal communities also have the option of desalinizing water to meet the demand, but this alternative is both energy-intensive and costly.

With warmer temperatures, severe precipitation events are expected to occur more frequently, requiring additional pumping to manage the excess water. Increasing energy prices and the growing demand for energy will lead to tradeoffs whereby expensive repairs and upgrades to the water infrastructure will often be sacrificed to cover energy costs, leaving the system more vulnerable to failure. Energy-management solutions for water utilities are therefore being explored. For example, pumping water at off hours (as opposed to peak hours) could reduce energy costs in some areas, and moving towards decentralized systems will mitigate energy costs by containing failures related to excess water.

Over the years, irrigation costs have risen steadily in line with rising energy prices. In response, the agricultural sector has found innovative ways to cope. For example, solar energy can be used to power water pumps and pivots, and technologies and practices that increase water efficiency, such as low-pressure applicators and drip irrigation, are also energy efficient. To date, technology has the potential to yield approximately 20 percent efficiency gains in irrigation. Another option that has yet to be fully explored is rain-fed agriculture. Assessing the rain-fed potential of different crops is an area of research that should be pursued in the context of rising irrigation costs.

The close link between energy and water resources could have serious consequences in the event of long-term and widespread power failures or other threats to traditional power supplies. To ensure that our crucial water supplies are not compromised by such events, redundancy and resiliency are needed from a water-security perspective to sustain a minimum supply of water. Establishing agreements with neighbouring jurisdictions to acquire energy and water during emergency situations may prove to be a sound approach, given that decisions will often need to be made very quickly. Although renewable energy sources may have the potential to treat and distribute water in emergency scenarios, there is still some uncertainty as to the reliability of such sources. As discussed, the agricultural sector has successfully used technology for solar powered pivots for irrigation. Conversely, the use of wind power for desalinization has been explored but it is unclear if enough energy will be generated. More research is needed in this area, particularly in regards to the potential of renewable energy in municipal supplies.

Reducing the amount of water we use will in turn reduce energy use and thus maximize efficiency, thereby facilitating management of energy costs in the water sector. Attaching a monetary value to the amount of water used will certainly help manage energy costs and could encourage conservation.

However, the majority of municipalities in North America are not recuperating the basic operation and maintenance costs of water infrastructure through economic pricing, let alone charging for the water itself. In fact, the US has the lowest rates for water in the OECD. Expensive technologies such as desalinization, which are being adopted or seriously considered in many coastal communities, may be further distorting the rational pricing of water. Without a cost-benefit analysis on the economics of desalinization, a realistic application of market price signals for water use may be difficult to envision. Many researchers and policy-makers feel that pricing will lead to sustainability not only for domestic and urban uses but for industrial uses as well.

The issue of subsidies in the agricultural sectors is particularly contentious. Those in support of removing subsidies and pricing the use of water believe that markets will run efficiently without policy interference: they cite examples from New Zealand. Those opposed to the removal of subsidies fear that full pricing of water and in turn energy will increase the cost of food.

Another strategy for managing water use and energy costs is to take a place-based approach. Many experts agree that managing at the watershed level is desirable. In general, our activities are limited by the supply and quality of water within a given watershed and thus any attempts to manage the resource should occur at that scale. Protecting land within a watershed can have positive effects on water supply and quality. For example, increasing forested land cover by 10 percent can reduce treatment costs by up to 20 percent, which saves energy. Protecting land is an effective tool for source water protection and can have many benefits for the communities within a watershed. In the US, purchases of land trusts by private donors doubled from 2000 to 2005. Perhaps a similar opportunity exists for developing a ‘water trust’ program.

Place-based management approaches are typically more attractive to many stakeholders because local citizens and industries have a vested interest in the area surrounding them – it is therefore easier to engage people at this level. Such approaches require distributive governance and resources with multiple stakeholder engagement – the foundation for which is being set in many Canadian provinces. Such watershed-based governance systems can be tasked with developing long-term watershed plans in co-operation with local stakeholder groups that recommend how water resources are to be protected and improved as land uses change.

In terms of defining the scale at which to manage, there is no right size to work with: it is often best to take a nested approach, where the different needs of the watershed are determined and then the appropriate jurisdictions are identified to address the needs. Flexibility and adaptability are required with respect to governance, since each watershed will have unique issues that may require the involvement of different players.

The many approaches that have already been used in North America present a tremendous opportunity to share best practices and demonstrate sustainability.

Water Use in the Energy Sector

The energy sector is an intense user and consumer[2] of water. For example, thermal power generation is the largest user of water in Canada and one of the two largest in the United States. Beyond the generation of electricity, large amounts of water are needed for hydro power; oil and gas extraction and production; refining and processing various energy sources; and transportation. This heavy use of water could affect both water quantity and quality, especially in areas of intensive use.

Water efficiency has improved in the energy sector by more than 66 percent over the past 50 years, but with energy use increasing seven-fold over this period, water use in the sector is increasing. Furthermore, the areas of highest growth and highest energy demands often have the least amount of water, and as water shortages increase, supply issues will become critical. In the US, 36 states are predicting water shortages in the next decade, suggesting that solutions need to be found now.

Water-efficient technology and innovation will continue to be essential in the energy sector. Many opportunities for improvements with technology and alternative water sources are being explored. For example, air cooling can be used as an alternative to water cooling in thermal power generation, although its benefits are limited to cooler climates – this method is not efficient in warmer climates, where water shortages are most severe. Investing in technology will not only benefit the environment, but the bottom line – which is an important driver for industry. In some cases, a relatively small investment in existing technologies could lead to considerable savings.

One industry that is in urgent need of innovation is the oil sands. In Canada, water use discussions in the energy sector are largely focused on oil production in Alberta, which is second only to Saudi Arabia in oil reserves. Oil-sand production reached one million barrels a day in 2005, and is expected to double by 2015.

Extracting bitumen from the oil sands is very water-intensive. On average, 2 to 2.5 barrels of water are needed to produce 1 barrel of oil, and most of the water that is withdrawn to extract the oil is too toxic to be returned. Only 10 percent of the water that is removed from the Athabasca River is returned. Such large withdrawals are decreasing the flow of the Athabasca River and many of the tributaries that feed the Mackenzie River. The changing climate is also contributing to decreasing these rivers' flow. This reduced flow is particularly problematic in winter, when there is not enough water available for oil production if the province's in-stream flow guidelines are to be met. Water will be the limiting factor for this industry unless more efficiencies are found and implemented. This will be a huge innovation challenge and opportunity for Canada.

Another rapidly growing energy sector that is gaining a lot of attention is biofuels. The use of ethanol is gaining political favour because it is perceived to be an environmentally friendly alternative to fossil fuels. However, there are still a number of environmental

---

[2] Water is considered to be consumed when it is not returned to the source after it is used. Large users of water are not necessarily large consumers of water.

concerns associated with this industry, including the negative impacts it will have on aquatic ecosystems. For example, the majority of corn production in the US occurs in existing agricultural areas that have some of the highest nutrient and pesticide levels in the country. As corn production increases, water quality problems will only worsen, both locally and downstream. Furthermore, marginal agricultural land may be brought into production to accommodate the growing demand for corn. To achieve adequate yields from these areas, above average amounts of water, fertilizer and pesticides may be required, thereby putting additional stress on ecosystems.[3]

In addition, new ethanol plants are proposed in areas that have declining aquifers, thus causing additional strain in water-stressed environments. With corn production expected to grow to 93 million acres in the next few years, there is a potential for serious water quality impacts and water shortages. The gains that are linked with biofuel renewable technologies may not be enough in terms of minimizing the environmental effects associated with our energy use. In the short to medium term, it may be more beneficial to invest in reducing the impacts of non-renewable energy supplies, rather than rushing into renewable technologies for which the true environmental gains and costs are not completely recognized.

Another area of research that is relevant to the energy-water nexus is the impact of carbon reduction strategies on water. Because of the strong interdependence of water and energy resources, it is thought that carbon reduction strategies, such as a cap and trade system, may lead to more efficient water use. Carbon sequestration, whereby carbon dioxide is pumped into deep aquifers, has unknown implications for water. If this practice is to increase, we must determine the potential impacts for drinking water and groundwater dynamics in general.

General Discussion

Following the organized discussions on water and climate change and the energy-water nexus, the participants were asked to identify the policy and science needs that they felt to be the most pressing. From this query, there was significant convergence on the following themes:

- Data and Modelling
- Water-Related Research for the Energy Sector
- Watershed Management
- Policy and Programs to Increase Water Efficiency
- In-stream Flow Requirements and Ecosystem Needs

The following sections discuss the identified needs surrounding these topics separately, although it should be noted that there are several science and policy links between them.

Data and Modelling

There appear to be several needs with respect to data. First, there is a consensus that existing measurement and monitoring programs are insufficient. More capacity is needed to collect data that will improve our understanding of hydrologic systems and how our

---

[3] It should be noted that there are other types of biofuels and sources of ethanol that are not discussed here, which will have varying environmental benefits, impacts, and concerns.

water resources are being used. However, although more data and trend assessments will help to inform better management decisions, we will need to resolve issues that arise from inconsistencies. In many cases, data from shared watersheds do not match up at political borders, making it difficult to understand what is going on. Neighbouring jurisdictions will need to work together to ensure that their respective measurement programs are complementary.

We also need to share data and information relating to water needs with municipalities and other local stakeholders, and effectively communicate to policy-makers. Furthermore, we need to link empirical data to forecasting models to compare model outputs with what is happening on the ground. Better data will inevitably help improve hydrologic models. However, other upgrades are needed. Linking hydrologic and climate models could be very beneficial and informative, specifically for predicting potential climate related impacts on water supply. Mainstreaming climate issues in general seems to be preferred from both a modelling and planning perspective.

Water Related Research on the Energy Sector

There are two specific issues relating to water and energy that urgently need research: the impact of corn-based biofuels on water quality and supplies, and water use in bitumen extraction.

First, given the rapid growth of the biofuel industry, it is essential that the full implications of increased corn production be understood in terms of the effects on water quality and aquatic ecosystems. Corn production is expected to expand rapidly, which would increase non-point-source pollution in areas that are already heavily contaminated with nutrients and pesticides. Additional concerns, which could be exacerbated in a changing climate, stem from the energy and water requirements of ethanol plants and their placement in locations that have depleting groundwater supplies. If biofuels are found to have an unacceptable impact on the environment, there is an opportunity to influence renewable energy policies before additional damage is done.

Oil production in Alberta is thriving, but the rapid growth of the oil sands industry could be limited by water if innovative solutions are not found. As discussed, bitumen extraction is water-intensive and the region is experiencing serious water availability concerns. There is a need for research and development in this area: efforts and resources should be focused on finding water efficient technologies and alternatives so that Canada can benefit sustainably from this valuable resource.

More generally, research is needed to find innovative technology throughout the energy sector; to improve our understanding of the links between energy consumption and water; and to determine how efficiencies applied to one resource can influence the other.

Watershed Management

There are many examples of place-based approaches to managing water resources and consensus that the watershed is the appropriate scale at which to address water issues. Policy work is needed, however, to address issues relating to shared watersheds and the integration and engagement of different watershed users. Watersheds that are located in more than one jurisdiction can have unique management challenges. We need to establish frameworks to integrate the various laws and regulations that come into play in a shared watershed, so that legislation does not prevent different parties from reaching common goals.

Rethinking how to resolve transboundary disputes at all levels may be beneficial as well. Formal arrangements such as the 1909 Boundary Waters Treaty and the International Joint Commission provide some mechanisms for addressing transboundary issues between Canada and the US, but such issues can also be addressed through coordination or negotiation directly between the two federal governments. There is, however, a trend to devolve decision-making to lower levels of governments – a trend currently reflected in numerous regional, state and provincial bodies. Connections and coordination among the various levels needs to be kept in mind, especially as complexities and disputes increase if and when the impacts of climate change begin to affect water quality and supply in transboundary basins. Each partner can best contribute to that aspect that can most effectively address the issue at hand, while avoiding cross-purposes and stovepipes.

Work is also needed in communicating the importance of the watersheds to stakeholders and decision-makers who are affecting water resources. Integrating planners and land-use planning tools into watershed management frameworks will be particularly important, as will the empowerment of municipalities and local stakeholders in general, through the provision of relevant data, information and best practices.

Policy and Programs to Increase Water Efficiency

The implementation of new and existing policy interventions that encourage water efficiencies could reduce demand. Full-cost pricing is likely to encourage water conservation while allowing utilities to recuperate costs. Water efficiency programs should be developed and evaluated. Water efficiency labeling (similar to the Energy Star program) and private water trusts are examples of potential programs that could have a positive impact.

In general, governments need to follow and encourage the principles of adaptive management in developing water-related policies, particularly with respect to climate change impacts and adaptation. Our ability to manage will improve only as our scientific understanding increases. We need to integrate flexibility into all forms of policy development.

In-stream Flow Requirements and Ecosystem Needs

Improving the science surrounding in-stream flow requirements is a major priority. Part of this process will be to define what in-stream flow requirements are – this would benefit from academic collaboration on both sides of the border. Advancements in this area will have important policy implications, because a metric for aquatic ecosystem needs will provide a defensible basis for water-use reduction claims and allocation policies.

Establishing the links between surface water and groundwater is another research priority that is closely related to ensuring that we are meeting ecosystem needs. Taking a holistic approach to managing water that is inclusive of ground and surface resources, and mindful of their different systems (i.e., aquifers and watersheds), will allow managers to develop conjunctive-use strategies that will protect in-stream flow requirements and the needs of ecosystems. There are legislative issues that need to be addressed – particularly in Canada, where surface and groundwater responsibilities can fall within separate agencies.

Other Suggestions

In addition to the common themes that emerged from discussion, there were a handful of other suggestions that are worth mentioning. The participants identified the need to research the potential of rain-fed agriculture as an alternative to irrigation and the public health implications of climate related impacts on water. Work on the inequities of per-capita water and energy consumption was also proposed.

Conclusions and Next Steps

The exchange between the meeting's participants was rich and informative and the level of convergence on important issues was both telling and encouraging. In terms of next steps, it is felt that there is value-added in continuing bilateral discussions: several options for collaboration and advancement of key issues were discussed.

First, it will be important to engage stakeholders that were not present at the October meeting: specifically, industry representatives from the energy sector and American academia. With those key inclusions, both place-based and issue-based collaborations were proposed as next steps.

The participants suggested forming political and academic partnerships in important transboundary regions, such as the Great Lakes, to advance the research topics discussed. They also suggested comparing two jurisdictions with comparable geography on either side of the border (such as Saskatchewan and Kansas) to see how different institutions are addressing water and climate issues on a similar landscape. A comparison of legislative solutions and approaches at the national level may also prove to be a useful exercise.

There was consensus that much of the expertise to research the scientific needs resides in academia in both the US and Canada. As a next step, the participants suggested that a university consortia be established to address one or two of the themes that have emerged from the meeting's discussions, such as in-stream flow needs. The consortium could address specific questions and concerns and help to develop a common understanding of the topic despite differences in research methods. Regardless of the approach, any further collaborations and discussions should be multidisciplinary, with active participation from industry, government and relevant research institutes, and should focus on science policy integration.

In addition to discussing important topics related to water, a key purpose of the October meeting was to strengthen links between Canadian and US think-tanks and academics. Given the level of exchange between participants, it is believed that new connections have been formed. The strength of these connections will be demonstrated by continued and sustained interaction. The identification of key policy and science needs has created an opportunity to advance key issues that are important to both Canada and the US in a collaborative, multidisciplinary and productive manner, and to communicate the importance of water to those beyond the water community.

Definitions

Adaptive management refers to approaches that make conscious efforts to learn from policy implementation, establish a more rigorous and systematic approach to learning, and facilitate continuous efforts to learn from policy implementation.

Mainstreaming (in this context) is the process of assessing the implications of climate change on any planned action, including legislation, policies or programs, in all areas and at all levels.

Soft path methodology focuses on scenario planning through a technique called "backcasting." First, it defines a sustainable and desire future state for society's management of water sources and uses. It then works backward to identify policies and programs that will connect the present to the future.

Distributive governance refers to shifting conventional government toward an organizational model that is more collaborative in style. Decision-making becomes more distributed (a concept that should be distinguished from decentralization). Distributive governance involves moving from *governments* to *governance*; from *regulating* to *shared responsibility*; and, from *water* management to *watershed* management.

Further Reading

Background Material

Presentation and papers that were provided to participants of the October meeting can be found at the following link: <http://policyresearch.gc.ca/page.asp?pagenm=ev_pas_Agenda-Presentations_Oct-2_water>

PRI Documents

The PRI has a number of water-related publications (listed below) that touch on some of the themes discussed in this paper. They can be accessed using the following link: <http://policyresearch.gc.ca/page.asp?redir=on&pagenm=rp_sd_pub&project=SD>

Does Pricing Water Reduce Agricultural Demand? An Example from British Columbia
Briefing Note
February 2007

Wet Industry: An Opportunity for Strategic Municipal Water Demand Management
Briefing Note
June 2005

Integrated Landscape Management Modelling
Workshop Report
June 2005

Towards a National Capacity for Integrated Landscape Management Modelling
Briefing Note
May 2005

Market-Based Instruments for Water Demand Management I: The Use of Pricing and Taxes
Briefing Note
February 2005

Market-Based Instruments for Water Demand Management II: Water Markets
Briefing Note
February 2005

Economic Instruments for Water Demand Management in an Integrated Water Resources Management Framework
Synthesis Report
February 2005

Integrated Landscape Management Models for Sustainable Development Policy Making
Briefing Note
January 2005

Integrated Water Resource Management
Briefing Note
June 2004

Appendix 1 – Agenda for October 2, 2007 Meeting on Water

8:30	Arrival

Opening

9:00	Welcome and introductions
9:15	Setting the stage

Session 1: Water: Adapting to Climate Change

Chair	Howard Alper
9:35	Context
9:45	State of the Science: Global Warming Impacts on North American Water Resources (presentations followed by 15 minutes discussion) - Predicted future water availability - Ecosystem impacts
10:15	Break
10:35	Near-term strategies (presentations followed by 20 minutes discussion) - allocation efficiency - efficiency technologies
11:10	Big Picture Options (presentations followed by 20 minutes discussion)
11:40	General Discussion on Water and Climate Change (30 minutes) - What are the water and climate change policy issues? - What science is needed for policy in this area?
12:10	Lunch

Session 2: The Water-Energy Nexus

Chair	Heather Munroe-Blum
1:00	Context
1:10	The Energy-Water Nexus (presentations followed by 15 minutes discussion) - energy used in the municipal, industrial and agricultural water sectors - water used in electricity production, water used in fuel production

1:40 Near-term strategies (presentations followed by 15 minutes discussion)
  - energy savings from water conservation and energy-saving water technologies energy conservation/efficiency impacts on water use

2:00 Break

2:20 Big Picture Options (presentations followed by 20 minutes discussion)

2:50 General Discussion on the Water-Energy Nexus (30 minutes)
  - What are the Water-Energy Nexus policy issues?
  - What science is needed for policy in this area?

3:30 General Discussion on water issues and next steps (60 minutes)

4:30 Adjourn

Appendix 2 – List of Participants

Robert de Loe	University of Guelph
Isobel Heathcote	Dean of Graduate Studies University of Guelph
Chandra Madramootoo	Dean, Faculty of Agricultural and Environmental Sciences McGill University.
Jim Bruce	Soil & Water Conservation Society
Rick Findlay	Director, Water Programme Pollution Probe
David Brooks	Friends of the Earth
Rene Roy	Ouranos/Hydro Quebec
John H Carey	Director General Environment Canada Water Science and Technology
Murray Clamen	Secretary International Joint Commission, Canadian Section
Mark Servos	Canada Research Chair in Water Quality Protection, Scientific Director University of Waterloo
Paul Freedman	Vice President (elect) Water Environment Federation
Tracy Mehan	Principal The Cadmus Group
Edward Osann	Potomac Resources, Inc.
Alan Roberson	Director of Security and Regulatory Affairs American Water Works Association
Robert Engelman	Vice-President Program World Watch Institute
Debra Knopman	Vice President and Director RAND Infrastructure, Safety and Environment Division
Robert M. Hirsch	Associate Director for Water US Geological Survey
Timothy L. Miller	Chief of the Office of Water Quality US Geological Survey
David Biette	Director of Canada Institute Woodrow Wilson International Center for Scholars
Kristopher Carr	Program Assistant Woodrow Wilson International Center for Scholars
Lisa Bourget	Secretary International Joint Commission, U.S. Section.
Jeff Peterson	US Environmental Protection Agency Office of Water
Sheila Tooze	Environment and Fisheries Officer Canadian Embassy in Washington

Rene Laprise	Ouranos / Université du Québec à Montréal
Michael Horgan	Deputy Minister Environment Canada
Michael Martin	Assistant Deputy Minister Environment Canada
Roger Roberge	Environment Canada Strategic Policy Branch
Geoff Munro	Associate Assistant Deputy Minister and Chief Scientist Science and Policy Integration Natural Resources Canada
Paul Allen	Assistant Director, Freshwater Policy Science and Policy Integration Natural Resources Canada
Chad Westmacott	Senior Policy Analyst Energy Policy Sector Natural Resources Canada
Thomas Townsend	Executive Head Policy Research Initiative
Anne Morin	Policy Research Officer Policy Research Initiative
Michael Goldbloom	Vice-Principal of Inter-Institutional Relations McGill University
Heather Munroe-Blum	Principal and Vice-Chancellor McGill University
Howard Alper	Chair Science, Technology and Innovation Council