MANITOBA HYDRO
BOOK OF DOCUMENTS

EXAMINATION OF DR. A. KUBURSI
& DR. L. MAGEE

Up until the year 2000, risk managers focused on two main issues: financial risk management and a technical glitch many at the time predicted would bring industry and government to a standstill, something they called the Y2K bug.

2.1 Risk Management Evolution

Risk management has evolved from an obscure function of finance and insurance to an approach necessary for any organizational resilience. What started as a niche department with little or no ability to influence organizational behaviour has been transformed into a critical source of strategic planning with a direct line to top management. Best practice risk management puts this function at the heart of the Middle Office at the higher echelons of the Corporation's management. More importantly best practice risk management has migrated to all aspects of the organization and is a concern at every operating node and for every employee.

These changes seem to have been set in motion over fears about a computer programming glitch and some misplaced ones and zeros. Predictions about the impact of the Y2K bug were dire: without intensive investment in IT infrastructure, updates and redundancies, the moment January 1, 2000 hit the clocks airplanes could fall from the skies, electric grids could shut down and bank accounts could be erased.

Instead, nothing happened. Aside from small, localized disruptions of minor consequence the year 2000 entered with a whimper and the risk manager's worst fears never materialized. Nevertheless, Y2K triggered a shift in how organizations thought about risk management, and investment in the "space" changed significantly. For the first time risk managers were looking at how a single event could impact the entire operation. Focus shifted away from looking merely at financial risk implications and internal investment flows into IT risk management. The after-effects of Y2K engendered two distinct changes. The first argued that proactive investment in IT risk management and cooperative efforts across industries had averted disaster. The counter view suggested the entire saga was much ado about nothing. In the absence of a crisis it was hard to tell if investment in risk management was working. The occurrence of a crisis is considered as necessary for a culture shift. This has been, and continues to be, at the foundation of a corporation's interest in the discipline. MH is no exception to this rule. Without the

Finding 9
The probability of a drought occurrence is higher than those estimated by the Consultant or ICF. The costs of a 5 year drought are in the order of magnitude used by MH rather than those calculated by the Consultant and the inclusion of other risk factors increases measurably the drought costs. It is also clear that the water flow data are serially correlated and that a statistical process confirms that Manitoba Hydro is correctly using the low flow years in 1937-1942 as the basis of its dependable energy calculations. While a more severe drought than the one experienced in 1937-1942 is possible, its probability of occurrence is 24 times in 9400 years (or 1 in 392 years).

5.2.3 MH Risk Governance Issues

MH has made major progress in streamlining its risk management governance architecture and is continuing to make strides towards best practice. The Middle Office is functional and is entrusted with increasing risk management policy formulation, oversight responsibilities, identification of risk and some risk measurement. A large set of committees and procedures have been instituted to ground governance of risk into the full spectrum of the Organization.

The Consultant has been adamant in her criticisms of the Front Office for monopolising decisions and information and for not sharing its knowledge and systems with the Middle Office. The Consultant calls for segregation of duties and instituting two sets of eyes for reviewing all major estimations, decisions, interactions and reporting. This is claimed to mitigate errors and opportunities for misreporting and misstating of financial earnings and fraud. The Middle Office must be wholly independent from the Front Office if it is to undertake correctly and appropriately its oversight functions. Furthermore, the Middle Office must report to the Senior Vice President Finance and Administration and should be situated at a higher level of the Organization in order to discharge its responsibilities. The Consultant also asserts that MH Middle Office and risk management functions do not meet the best practice standards at other utilities. Furthermore, the skill set at the Middle Office is not strong enough to undertake seriously its new functions and responsibilities.

KPMG reviewed the governance structure at MH and reported that it is evolving and converging toward best practice at other utilities and is consistent with the recommendations of the Committee of Chief Risk Officers. KPMG is particularly satisfied with the Export Power Middle Office relationship with the rest of the Organization and particularly with the Chief Financial Officer. However, KPMG would like to see the market risk quantification capabilities of the Middle Office enhanced and the skill set available to it augmented by the required expertise in market and risk management (Risk Market Analyst and Credit Risk Analyst). Furthermore, newer and top of the mark risk quantification technologies (both software and hardware) should be made available and used at this Office.

KPMG Report highlights the recent stipulations of risk limits and transaction processing controls at MH. These, it is argued, have added rigour, transparency and clarity to risk management. Operational staff know exactly the limits within which they can operate and the reporting structure for authorization and sign-offs. Moreover, risk reports are now regularly produced and circulated. These reports are in formats that can be easily read and understood by Management and Board. Given that most of the transactions of MH are low risk in nature (as they are for short durations and within set limits) and given the conservative nature of MH's risk management practices, it appears that MH is able to manage its market, credit and even volume risks in a prudent manner.

Still, KPMG produced a long list of recommendations for MH to align its risk management with best practice. These include:

- Contract review should include risk quantification and assessment.
- Middle Office should be involved in the review of export contracts.
- Mark-to-Market methodologies should be used to assess all risks.
- Drought risk should be calculated regularly using probabilistic stress tests.
- MH has specified risk limits only to "power related transactions" in the area of Merchant Transactions and consumer credit. MH should continue to develop further limits and limitations on most transactions and the calculation of VaR wherever possible.

We concur generally with the KPMG assessment and the set of recommendations they have tendered, but have added a few of our own.

directly involved (Front Office) but an independent review must be undertaken by the Middle Office.

Many functions and activities in the organization are operating with deterministic models and frameworks. This is not particularly helpful for an organization that has taken the challenge to manage and control effectively and proactively all of its risks.

Finally, a detailed training program involving realistic simulation games dealing with risk occurrences and plans should be developed for the Organization. These training programs and learning by-doing practices have helped other organizations in dealing with their risk exposures and threats.

> ***Finding 10***
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> ICF International, Dr. Bhattachryya, KPMG, RiskAdvisory and KM all share the general appreciation that MH's Middle Office is evolving and that major progress has been made towards best practice. We all also recognize that much is needed in terms of strengthening the HR expertise set at the Middle Office, the independence of its functions, the MTM measures of all risks, the expansion of risk limits standards and process control limitations to all aspects of MH functions, the development of an Internal Responsibility Matrix, the need for quantification of risks at Middle Office, and its involvement in contract risk assessment. Most of us recognize that there is some merit in NYC's comments about risk governance issues with respect to the independence of the Middle Office and the greater need for oversight, but we all disagree with her claims of lack of competence in the CRMC, and the concealment and manipulation of data by the Front Office.

5.2.4 MH Risk Identification, Control, and Mitigation

Manitoba Hydro faces many risks, including some that are typically encountered by other power generating utilities and a few that are unique to MH. The generic list identified by MH includes 11 major categories and 48 subcategories. Even this list is not exhaustive. A

1. Infectious Disease
2. Union/ Employee Issues
3. Succession Planning
4. Technology

F. **Business Operational**

1. Supply Chain
2. Operational Controls

G. Reputation

H. **Governance / Regulatory / Legal**

1. Regulation and Licensing
2. Export Market Access
3. Legal Compliance
4. Contracts and Ventures
5. NERC/MRO Reliability Standards

I. **Aboriginal**

1. Relationships
2. Legal

J. Emerging Energy Technologies

K. Strategic

MH has developed systems to monitor and control key risks and to sustain information flows within the organization and to appropriate stakeholders concerning changes in risk profiles and their management within the Corporation risk tolerances. Likelihood, consequences and tolerances are colour coded and ranked as low, medium or high. The basis of this coding is not very clear and certainly is not based on revealed quantitative calculations.

The Corporation has also developed and instituted a Management Control Plan (MCP) with several committees and mechanisms to oversee all power related transactions in both Canada and the United States. The MCP is also supported by Power Sales Approval Authority Table. Under the MCP oversight of activities and processes, primarily those with major impact on business continuity and mission, is provided by three main bodies, the Manitoba Hydro Electric Board (MHEB), the Export Power Risk Management Committee (EPRMC) and the Power Sales and Operations Management Committee (PSOMC). There are also several other committees of supposedly significant influence which can assume critical roles in the overall functioning of the Organization. We will single out here the Corporate Risk Management Committee (CRMC), the Planning

Review Committee (PRC) and the Rates Review Committee (RRC). These are advisory and information generating committees but assume no executive and decision powers.

The MHEB exercises general oversight of the Corporation's operations and approves sales requiring new generation in concert with approving new generation or long-term sales exceeding 5 years and 100 MW. It carries out the duties, powers and functions of MH as set out in the Manitoba Hydro Act including:

- Provide for the continuance of a supply of power adequate for the needs of the Province.
- Engage in and promote economy and efficiency in the development, generation, transmission, distribution, supply and end-use power.
- Provide and market products, services and expertise related to development, generation, transmission, distribution, supply and end-use power, within and outside the Province.
- Market and supply power to persons outside the province on terms and conditions acceptable to the Board.
- Has the Statutory authority and obligation to provide policy direction to and oversee the management of the business and affairs of the Corporation and to ensure that the Corporation fulfills its statutory objectives in the public interest.

The EPRMC provides oversight of the management of financial risks and energy supply associated with MH's export activities. It is primarily responsible for the review and approval of risk mitigation strategies dealing with both long term and short term export sales. It reviews and approves criteria for managing risks associated with energy planning and operation as well as criteria for managing risks associated with short-term marketing transactions. It is also responsible for general drought management strategies and export market policies. It reviews and approves exceptions to the MCP.

The PSOMC provides oversight of financial products and transactions such as Financial Transmission Rights (FTRs) or Auction Revenue Rights (ARRs) and for the use of puts and call options, contracts for differences, swaps and other hedging instruments.

The three committees above are given executive authority and obligations. The committees below are not empowered to take decisions. They are primarily review committees and provide platforms for discussion and information.

assess the risks in their respective fields, but they should all funnel their expertise and calculations to the Middle Office.

The governance structure of risk management at MH can benefit from restructuring and re-alignment. The CRMC is now part of Finance & Administration Division and reports to the Senior VP of the Division. It is now on the Organizations' Organogram (Figure 2.7) at the lowest slot. Perhaps unintentionally, this placement conjures an image of lack of importance and lack of centrality of its stature, functions and contributions. The Middle Office is the appropriate place for the CRMC, but it has to be part of the SVP Office, possibly in the first slot. At this time, the CRMC is only an advisory body and is without any executive powers. The Front Office argues that it is not needed since 70% of the risks are volumetric and these can be easily, more efficiently and effectively handled by the Front Office.

There is an evident multiplicity of bodies dealing with risk (EPRMC, PSOMC, and CRMC, etc.). In itself, this is not a problem, but it becomes a problem in the absence of a well defined integrated and centralized structure that can harmonize the lines of authority, obligations and accountability. In the final analysis all of the risks must be combined and integrated. Dealing with all of them simultaneously is critical for the success of the Organization. Quantitative assessments of risks are based on a simultaneous evaluation of the impacts of all identified and quantified risks on a coherent basis with a focussed approach and integrated administrative structure. This can best be achieved through Joint Risk Management Committees organized and supervised by the Middle Office through CRMC.

Risk Preparedness Plans and manuals are needed for all costly risks. A Drought Preparedness Plan is a critical necessity. It must be completed and instituted in the working mechanisms of the organization immediately. The preparedness plans should not stop at the Drought Plan. There are many other emergencies and drastic events that may occur that need to be expected and plans made to deal with them. A broad preparedness plan can make substantial contributions to the effectiveness of risk management services and plans at MH.

Best practice requires that any business transaction should be evaluated on its own as well as in terms of all the risks that it may entail. This should be done by the business unit it would really be quite a useful exercise to get subject-matter experts and the middle office to work jointly on these things. So there would be always checks and balances and vetting and reconsideration.

MS. ANITA SOUTHALL: Just taking you to a specific quote on page 194 of your main report, in the second paragraph, there's a sentence towards the end of the paragraph that starts "At this time," and it's -- and the sentence reads:

> "At this time the CRMC is only an advisory body and is without any executive powers."

The next sentence is:

> "The front office argues that it is not needed since 70 percent of the risks are volumetric and these can be easily, more efficiently and effectively, handled by the front office."

Do you see that?

DR. ATIF KUBURSI: Yes.

MS. ANITA SOUTHALL: And that was the position being advanced by the front office during your report work?

DR. ATIF KUBURSI: Only with one (1) discussion.

dealing with risk must know, must have drills, and they should go through these exercises.

And, also, risk management is a very professional thing. I mean, it would require statisticians, econometricians, and people that are called subject-matter experts. And the organization can benefit and would find it worthwhile expenditure of resources on beefing up the skill sets of people who can identify, quantify, monitor, and deal with risk.

And that the story is then we went and tried to see that if this best practice section that I've talked about were applied to the Manitoba Hydro on a piece-by-piece basis, on a point-by-point basis, how does the picture come about? We were happy with what Ma -- Manitoba Hydro is doing. We'd be happier to see it assign a responsibility matrix. That's something we did not find.

We would be far happier to see that there's an individual-responsibility matrix that we know corresponding to every risk, even in the CRMC, the Corporate Risk Management Report, that there would be a person or a name or an office corresponding to every colour-coded things that would report to the vice-president or the manage -- you know, the front office and to the corresponding middle office people.

connections to any of the models. These experts will be involved on a needs basis and granted consulting assignments.

Seventh, we would like to see that every effort is made to establish full ownership of the model systems within MH and that MOST is not seen or perceived as being a "black box" that was developed generically outside the full control and mandate of the Organization.

Eighth, we would like to formulate the objective function wherever possible to minimize cost of generation and delivery rather than maximizing net revenues.

3.3.2 HERMES

First, by any standard HERMES is an impressive system; it developed over time and grew in complexity and utility.

Second, its developers are on staff and the source code is home stored.

Third, we are satisfied that the technical staff that support and run the model are competent and committed.

Fourth, we have seen a couple of demonstrations of the system and have seen its objective function and constraints as well as solution runs and outputs.

Fifth, it is a large system with over 8000 constraints and bounds and a larger number of variables. It is capable of generating a rich set of bases (linearly independent vectors) that define feasible solutions for the objective function to choose from among them the optimal one.

Sixth, we have seen forced solutions which reflected assigning huge costs to particular objective function coefficients. This is a standard practice in large LP systems but is still worrisome. There is always the fear that users select optimum solutions close to actual operations or desired solutions.

SPLASH is a critical component of the model family at MH. It plays a crucial role in simulating future alternatives and is depended upon to plan the system requirements for expansion in the future.

Recommendations

We are happy with the simulation structure of the system and the insights this can add to its utility. The three phased process of determining dependable energy to rule curve determination of elevation levels to minimizing production costs are interesting and valuable applications.

There are a number of issues, however, that need to be addressed: These are set out in the report.

9(e) **Dr. Magee would you do the same for the PRISM model at chapter 3.2.7 of the report (pages 97-103)?**

PRISM is a probabilistic model that accounts for uncertainty in long range scenarios for planning purposes. It incorporates load forecasts from the Electric Load Forecast Model, water flow and other hydraulic conditions from SPLASH, monthly distributions of electricity export prices, exchange rates, gas price forecasts, and scheduled maintenance.

Power Risk System Model (PRISM)

PRISM is an in-house model that was developed at MH with the help of Risk Advisory of Calgary. It marks a major step toward integrating probabilistic models in the planning and decision making structures at MH.

The system incorporates load forecasts from the Electric Load Forecast Model, water flow and other hydraulic conditions from SPLASH, monthly distributions of electricity export prices, exchange rates, gas price forecasts, and scheduled maintenance from different sources including HERMES. PRISM analysis introduces volatility in these variables and chooses probability distributions to represent them.

Hydraulic variables are assumed to replicate the 94 flows actually experienced between 1912 and 2005. Each year in this series is assumed to have an equal chance (probability) of being the first year. But once a given year is assumed to

There's a number of findings, Dr. Magee, at that page with regards to a whole listing of improvements that you and Dr. Kubursi were suggesting in the report.

Would you briefly describe the principal ones of those to the Board?

DR. LONNIE MAGEE: Yes. There are, in our view, no -- no grounds to believe that there exists a serious material risk for blackouts in Manitoba. The financial losses stemming from a severe drought are large, can deplete accumulated retained earnings of Manitoba Hydro in less than three (3) years.

Regarding the models, we feel there -- the models are serving their purposes and can be relied upon for operational planning and long-term planning. We recommend certain courses of action for improvement -- further improvement, upgrades, authentication procedures, documentation, and integration of the models. We deal with that in more detail later.

The middle office is evolving, and we recommend that it be placed directly in the office of the senior vice-president for administration and finance and be charged with reviewing and quantifying all risks, including long-term contract risks.

Regarding the long-term contracts, we feel

All what we're asking them is basically and fundamentally to experiment, to entertain, to move a little bit forward on these things. We are quite satisfied with our systems. We are quite happy with what we've seen. We are quite happy and recognize the capacities, the skills, and the dedication of the people, but we wanted a little bit more.

And -- and I think from a very top of the line, one (1) of the best utilities in Canada and any place, that it would be worthwhile looking into making it non-linear, integrating these models, putting more stochastic things, getting all these models together creating a community of modellers vetting these things, documenting things.

I -- I think we wanted to earn our money. And I -- I thought we -- we -- you know, we're -- we're basically being positive. I thought our marching orders were to what extent can you come from outside, shake a little bit of fire here, and get things moving in a direction that you think would be beneficial and in the best interests of Manitoba.

MR. GAVIN WOOD: Maybe staying away from the car analogy thi -- this time, specifically in answer to the Chair, should this Board be confident or have concern that if Manitoba Hydro doesn't accept the whole

SPLASH, if that was required, for instance, at -- the way that it's currently structured?

DR. ATIF KUBURSI: No. I mean, now those who run HERMES are running HERMES, those who run SPLASH run SPLASH, those who run MOST -- we found out that some of the people running MOST were in HERMES, and then some people who are in HERMES are in SPLASH. So there is really some cross-referencing here. What we wanted is this cross-reference to become formalized, that a modelling committee and community can be developed and made a formal structure that they would meet on a regular basis, not an informal one.

I mean, at one time, it was kind of interesting. We wanted to know how many people work with MOST, so we asked Manitoba Hydro to organize it. We all came together. We were -- we got a level of comfort that there are all these people who know each other. I mean, we sat back on the sides and saw what kind of a relationship and how well it's working. We were -- and how many, yes. I mean, okay. How many? How many, yes. Ten (10), twelve (12). We said it yesterday. All right.

And -- and -- and all we really wanted here is to get just a formal presence and increase the flow of information and the fluidity with these people coming together. They're working almost on a number of

THE CHAIRPERSON: If Manitoba Hydro accepted your recommendation and undertook the work and did it, would it provide, in your view, more support for their preferred development plan, or could?

DR. ATIF KUBURSI: As I mentioned, this -- this is an issue that is not related to accuracy of the models. It's more in terms of saving on resources, creating a more comfort level with the fact that you are all using same system and you're on the common page, so to speak, and ability to integrate and create a community of modellers that would be focussed.

The issue of accuracy, I think, is a little bit more difficult here, and I and Lonnie, we -- we felt that maybe we need to move into this more sophisticated system of dynamic programming, stochastic programming, where we think and have some level of experience from which we can talk -- because I've worked with dynamic programming and linear programming, stochastic and deterministic, and I know the complexity of the latter system is far larger than the first one. It would involve more resources, I -- I grant this. And in a perfect world, these wishes would be great, but there may be other compromises.

But in terms of accuracy, and dealing with the kind of issue that you're talking about, Mr.

Chairman, I feel that the non-linear systems, the dynamic programming, the stochastic, would have a bearing on it in a way that the linear system, static system, deterministic system, would not.

THE CHAIRPERSON: In other words, if they did do it, it's -- it potentially could some -- have some bearing on the degree of support, or non-support, for the development plan.

DR. ATIF KUBURSI: A degree, but the issues are how you structure the problem, what data do you use, what discount rate would you use, what is your forecast of the expected prices in the future, what can you generate and encapsulate in your contracts.

There's so many variables on these things, but as far as the models used in order to cho -- choose the preferred sequence, if you use exactly the same sets of data on both sides, the latter are likely to give you a marginal improvement over the former.

THE CHAIRPERSON: What I'm getting at is your -- your recommendation isn't what you would call an academic nicety. You're -- you're suggesting it's a significant improvement in their approach.

DR. ATIF KUBURSI: Yeah. It -- it's not just academic nicety. I am also suggesting that it would handle the kind of problems that you're dealing in a more

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All what we're asking them is basically and fundamentally to experiment, to entertain, to move a little bit forward on these things. We are quite satisfied with our systems. We are quite happy with what we've seen. We are quite happy and recognize the capacities, the skills, and the dedication of the people, but we wanted a little bit more.

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Appendix B. And with all the information that resides within Manitoba Hydro, it's a very simple thing to do.

And there would be some compromises, we recognize, because of different purposes, but we felt like these compromises probably are worth it because there are so many, in our view, benefits that could be reaped. You create a common solver. You could -- any changes to one system, it carries to all systems. You create seamless knowledge within the organization and an expertise that is transferrable. If one guy got sick, there is one guy from MOST that could come in here, and there would be a community of models. There is economies of scale and scope. If you want to vet the system with an oversight from outside, it's common to all of them.

And these were basically the reasons we felt strongly that it would be worth looking into this and preventing people raising questions of the sort: Oh, you're using different coefficients. Oh, you know, the generation estimates and the results from HERMES and this are at variance.

In our view, there are tangible and recognizable and reasonable benefits to putting all these things on a common platform.

MR. GAVIN WOOD: Did you have anything to add?

issues, three (3) separate questions to deal with. The dynamic versus static, deterministic versus stochastic, linear versus non-linear. And our hope would be is that we will say something and we will discuss with Manitoba Hydro these issues and see how we can deal with this issue.

THE CHAIRPERSON: See, the other part of it, to be direct, is -- is the -- the reference that was made to -- in Manitoba Hydro's rebuttal, to priority. I mean, that -- that's a significant aspect of all this.

DR. ATIF KUBURSI: Yeah, we recognize that. I mean, the -- the issue here involves what resources, what skills, what time, what is available, what complications would it really put in. In our view, I mean, it would be very hard to suggest that we know what the priority is, and we're not going to be presumptuous to tell Manitoba Hydro what -- what we would like to do is to show what other utilities, where they have used some of these systems, what did it take and how this may have improved or not improved. I mean, I'm -- we're trying, you know, here to see and evaluate in an open-mind and objective way.

Always, Mr. Chairman, you told us we have to be helpful. We're going to be helpful.

power utility in Canada is formulated as a large-scale linear programming algorithm and is solved using an advanced commercially available algebraic modeling language and a linear programming package. The model has been designed and implemented to be user-friendly, flexible, dynamic and a fast real time operational tool that portrays the complex nature of the optimization problem. Aside from the detailed representation of more than twenty hydro generating stations and a system of reservoirs, the model incorporates market information on the Alberta Power Pool and the US Markets and tie-line transfer capabilities. The optimizing model generates the maximum expected future value of net income and explicitly considers the uncertainty of system inflows and market prices. It has been upgraded to incorporate decision support for hedging of energy purchases with the goal of minimizing the risk exposure to commodity markets.[15]

The MH models are not very different from those used by Quebec Hydro or Ontario Power Generation (OPG) and other domestic or international utilities. The explicit modeling of uncertainty has not yet been incorporated into the similar MH models, although some, if not all, of the MH models have some heuristic dynamics and stochastic elements. It is worth noting here that Quebec too has developed "GESTAU" a stochastic and dynamic optimizing model.

It seems that both Quebec and BC have adopted more advanced systems than MH's Hydro Electric Reservoir Management Evaluation System (HERMES) or Simulation Program for Long Term Analysis of System Hydraulics (SPLASH), but these are still in the same general class of optimizing models of power operations and planning. The advantage of Quebec's and BC's is in the stochastic nature of their systems, which makes them more complex and perhaps more useful tools for risk management. But admittedly they are both difficult to manage and present results that are more difficult to interpret. They also fail to include all the complexities that HERMES encompasses. The stochastic nature is an improvement in that expected values (variables multiplied by their probability of occurrence) replace deterministic variables. HERMES is dynamic in a special way in that the HERMES variables have different time coordinates and are treated as different variables. HERMES, however, does not incorporate the hedging options for uncertain commodity markets.

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[15] Doug Smith. "BC. Hydro's Integration of Commodity Risk Management and Operations Planning." Water Management Decision-Support Software, A Two-Day Workshop, November 16-17, 2005.

CEATI

Water Management Decision-Support Software

The Challenge of Knowledgeable and Valued Decisions

A Two-Day Workshop - November, 16-17, 2005 - Niagara Falls, NY, USA

Today's hydroelectric generation water managers require sophisticated information systems to support business decision-making activities. This workshop will provide participants with additional insight into the application and development of advanced DSSs in the hydroelectric industry. A decision-support system should supplement, complement, or amplify the problem solving capability of water managers. This is often accomplished by presenting meaningful information using communication technology, interactive models, raw data, documents, and personal knowledge.

Specific to the field of water management, these applications gather and present information on meteorology, hydrology, geology, topography, channel hydraulics, environmental attributes, economics, water use activities or requirements, regulatory requirements and operating limits.

This workshop will bring decision-support software developers together with hydroelectric generation water management practitioners to further the development of water management tools.

Sessions Include:

1) **Experiences.** Many water managers use decision-support software to understand the many complexities of managing water. Drivers that can influence a water manager's decisions include availability, pricing, revenue, competing interests, operating limits and environmental impacts. This session will focus on experiences, more or less successful, water management practitioners have had using some of today's water management decision-support software.

2) **Recent Developments.** As the need for more knowledgeable and valued decisions increases so does the need for improved support technology. This session will focus on recent developments in decision-support technologies. Developers will have the opportunity to demonstrate where the technology is moving and highlight new tools.

3) **Future Needs.** This session will focus on what water managers feel is necessary from DSS to improve their decision-making abilities. The water managers will have an opportunity to express their needs, with the hope that these needs will be considered in the development of future support tools.

November 16

8:00 Continental Breakfast (Provided) / Registration

8:30 Welcome: Robert Metcalfe, WMIG Technology Coordinator

Session 1 : Experiences

8:45 - 9:00 Opening Comments: Richard Mueller, NYPA

9:00 - 9:45 Decision Support Systems for Improved Water Resources Management and Operations
Michael Kane, Riverside Technology
Jim Cooper, Earth Satellite Corp.

9:45 - 10:30 BC Hydro's Integration of Commodity Risk Management and Operations Planning
Doug Smith, BC Hydro

10:30 - 10:45 Break

10:45 - 11:30 Experiences in Ice Management on the Niagara River
Peter Kowalski, Ontario Power Generation

11:30 - 12:15 Long-Term Planning using the SPLASH DSS
Bruce Hinton, Manitoba Hydro

12:15 - 1:15 Lunch (Provided)

1:15 - 2:00 Using a DSS to Analyze the Medium-Term Planning and Operations of the Manitoba Hydro System
Jason Westmacott, Manitoba Hydro

2:00 - 2:45 Using a DSS to Determine the Implications Associated with Wind-Hydro Integration
Diana Hurdowar-Castro, Synexus Global Inc.
Bill Girling, Manitoba Hydro

2:45 - 3:00 Break

Session 2 : Recent Developments

3:00 - 3:15 Opening Comments: Sam Matheson, SaskPower

3:15 - 4:00 The Experiences from Implementing Decision Support Technology To Address Water Management Plans In An Operational Environment
Steven McArdle, 4DM Inc.
Chris Tonkin, Ontario Power Generation

4:00 - 4:45 Integration of Real-Time Unit Dispatching Optimization with SCADA and AGC
Tung Van Do, Powel-MiniMax Inc.

Session 2 continues on November 17

6:00 - 8:00 **Cocktail Reception**
hosted by the New York Power Authority
NYPA Power Vista (Transporation Provided)

New York Power Authority

November 17

8:00 Continental Breakfast (Provided)

Session 2 : Recent Developments

8:30 - 9:15	Implementing Soft Constraints in Hydroelectric Decision Support Systems **Hong Gao, Powel-MiniMax Inc.**
9:15 - 10:00	Hydro Modeling and Optimization Tools for Power System Operation and Flood Management **Vincent Balvet, SNC-Lavalin ECS** **Michel Tremblay, SNC-Lavalin**
10:00 - 10:15	Break
10:15 - 11:00	Hydro-Electric Generation Decision Support Systems (DSS) in Deregulated Markets **Nils Olav Tangvik, Powel ASA**
11:00 - 11:45	The HydroMet Decision Support System (HDSS): New Applications in Operational Hydrology **Michael Eilts,** **Weather Decision Technologies**
11:45 - 12:30	Anticipated Future Developments in DSS **Franco Petrucci, Meteorological Service of Canada**
12:30 - 1:30	Lunch (Provided)

Session 3 : Future Needs

1:30 - 1:45	Opening Comments: Robert Metcalfe, CEATI
1:45 - 2:30	Brascan Power Experience with DSS Applications **Richard St-Jean and Dale Peters, Brascan Power Corporation**
2:30 - 4:00	Roundtable Discussion Chaired by Robert Metcalfe, WMIG Technology Coordinator

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[redacted]

Below is a summary of MH's Pricing of electricity as determined in Long-Term Export Contracts (Source: Pricing of Long-Term Export Contracts, provided by Manitoba Hydro).

"Long-term electricity price forecasts and market analyses are usually purchased annually from a group of industry consultants (for the 2008 forecast 5 expert consultants were used). The forecasts are adjusted to a common Canada-US border pricing point and are aggregated on a weighted basis following a detailed analysis."

In addition, a [redacted] to the 'on peak' price forecast for dependable energy to reflect the expectation that [redacted] will be willing [redacted] over the long-term. This [redacted] reflects MH's historical experience in selling a high value, long-term product, backed by MH's dependable energy resources.

MH's Electricity Export Price Forecast is used as a benchmark for the setting of the minimum offer prices for long-term export sales. MH's actual offer prices may be higher reflecting the customer's alternative cost of supply and perceived demand for MH product. Final contract prices may reflect additional value provided to the customer or MH following negotiation. These may include, for example, more favourable escalation terms, ownership of environmental attributes or an appropriate sharing of transmission costs.

Furthermore, in conjunction with the price forecasts as inputs into the process of contract price determination, MH uses avoided cost analysis to benchmark the long term price against the counterparty's long term marginal costs. KPMG reports that although there is some evidence that this is done at MH (excel files), it is not done thoroughly enough or documented sufficiently to be a satisfactory procedure.

The price forecast and the avoided cost procedure are coupled in benchmarking the minimum offer price for long term exports. There are also other factors that influence the outcome of the contract negotiations. These include [redacted] It would be wrong to see the price in isolation of these additional values that a lower price may have been necessary to acquire these attributes.

It is also to be noted that the contracted price is a real price (nominal price adjusted for inflation). Real price increases over the term of the contract are stipulated in order to capture real increases in electricity prices. Typical escalators include the [redacted]

Whatever the value of the final price embedded in the long term contracts, it appears to be higher than the past average in the spot market. This is a comforting result but needs to be considered against marginal cost, average total cost and import prices before generalizations can be made about which party is subsidizing the other, or that the risk exposures in long term contracts is sufficiently mitigated. We will deal here with the first issue.

According to MH's recent Cost of Service study, costs attributable to export sales constituted approximately 13% of total costs, whereas export sales contributed 32% to total revenue. This shows that if the allocation of costs to domestic sales and exports is credible and believable, exports are contributing more to revenues than to cost and therefore it is quite likely they are contributing to the sustainability of low domestic rates. This question is contingent on a proper allocation of total costs.

MH has only four choices. It can sell its energy surplus in long term contracts or it can sell the surplus in the opportunity market either in real time (RT) or in the day ahead market (DA). Of course it can store the water for another period and refrain from generating in the current period. But in order to store there should be enough storage capacity. This we will assume it is there.

The optimal generation is determined by equating the prices to marginal costs and refraining from current production whenever expected price increases minus storage costs are higher than the interest rate. If prices in the long term market are higher than long term marginal cost, more should be sold in the long term or vice versa.

We have calculated the long term marginal cost of generation for MH; it is quite low and could be declining over the relevant range given the large fixed costs involved in generation. There is no question the prices negotiated are significantly higher than

from this is that with the curtailment of exports, mean losses from a more severe drought than the 1940 drought are mitigated to the extent that the losses are below the ni -- the 1940 drought scenario without curtailment, correct?

DR. ATIF KUBURSI: Correct, because this is exactly the way the scenario was constructed, is to keep everything the same except for the curtailment and see to what extent these curtailment provisions are going to mitigate -- cushion the impact of the drought.

MR. BYRON WILLIAMS: Thank you.

THE CHAIRPERSON: Were you assuming that the curtailment had no cost attached to it?

DR. ATIF KUBURSI: Yeah. I mean, the Chair has a -- a very important point here in the sense that if you were to curtail then there would be certain losses that you have to really filter back. We did not take care of that.

CONTINUED BY MR. BYRON WILLIAMS:

MR. BYRON WILLIAMS: That is an important point. Thank you for that, Mr. Chairman. But, Professor Kubursi, let's -- let's follow up on that point for a second, does that affect your overall conclusions in terms of the utility of the curtailment provisions?

DR. ATIF KUBURSI: No, but I mean it's a point to take into account, but the -- the -- the question, and I don't want to go into details because I may slip and say some of the confidential things, we won't, but the curtailment at the level that we did nothing would have made a major change. But depending on what level and what the prices are that would be ruling at the time, these issues may become important. I mean, remember -- I don't know if this is confidential -- can I speak to my counsel?

MR. BYRON WILLIAMS: Please do.

(BRIEF PAUSE)

DR. ATIF KUBURSI: We would like to confer with Manitoba Hydro to see if it is possible for us to talk about it, two (2) minutes.

MR. BYRON WILLIAMS: Certainly. And -- and Mr. Chairman and Mr. Vice-Chair, I should note that Ms. DeSorcy is here taking notes on my performance, so I'll encourage you to be kind to me.

(BRIEF PAUSE)

DR. ATIF KUBURSI: Okay. We got the

clearance. I mean, what -- what we basically --

MR. BYRON WILLIAMS: Just one second. I -- I apologize, Professor Kubursi. Please proceed.

DR. ATIF KUBURSI: Sorry, I didn't notice. No, I mean, we -- we can talk about it. There are -- no liqui -- you know, liquify -- what do you call it? LD is the liquified -- what's the word -- liquidating damages, all right, but there's opportunity cost. But it could also be these things, the market cost could be higher, the contract cost could be higher than the market, or the market could be lower than the contract, so you could buy things, cheaper things and -- and then sell it.

So there are opportunity costs, but these opportunity costs are not in any particular way unless you know the spread between the price of the mark -- of the contract versus the market price.

MR. BYRON WILLIAMS: And just to -- and -- and I thank you for the description. Just to go back to the original question, your conclusions that the curtailments were a -- a major achievement in -- in -- in terms of the new contracts, those are still your conclusions, sir?

DR. ATIF KUBURSI: Yes, to the extent that definitely the opportunity costs are low. I mean, if you could conjure a situation in which the opportunity costs are high, one has to then take into consideration these, and then re-run the situation with these provisions into the equation.

THE CHAIRPERSON: You presumably -- are you suggesting that you could have a curtailment where the -- there's a strong disincentive to actually declare it?

DR. ATIF KUBURSI: Sorry, Mr. Chairman, can I -- I -- I didn't get this one?

THE CHAIRPERSON: There could be a situation in which you have adverse water conditions but the -- the financial conditions be -- be such that the -- that it's a strong disincentive to declare it?

DR. ATIF KUBURSI: Yeah, that's true.

CONTINUED BY MR. BYRON WILLIAMS:

MR. BYRON WILLIAMS: Professor Kubursi, one (1) last question for you and for -- for a few moments anyways, and it's a quick one. I -- I'd just ask you to turn to page 32 of the yellow book of documents, sir. And it's really a definition I'm looking for. On line -- that's page 32 in the top right-hand corner, and it's an excerpt from transcript page 6,335. On line 5, Professor Kubursi, you used the word "covariance." Do

#12

marginal cost. This means that if MH has more capacity it should use it in long term export sales.

The question of total cost and average cost is different. Our calculations are heuristic but point to a higher average cost for exports than the one claimed in the Cost of Service, but our estimates are still far below price. If there is any ambiguity here, it is over the proportion of total cost defrayed by exports, and not over export revenues exceeding average cost.

> ***Finding 12***
>
> Contract prices embedded in long term contracts are sufficiently higher than historical average spot MISO prices. These prices are carefully constructed using weighted long term forecasts and hopefully estimates of the long run marginal cost of counterparties. The export prices are higher than long run marginal cost of MH and average total cost. This suggests that export revenues can be relied upon to subsidize domestic rates when they are higher than import prices. We are not in a position to verify the claim in the Cost of Service that exports account for only 13% of total cost but we can verify that they contribute 32% of total revenue.

5.2.4.1.4 Is MH's Book Oversold?

The Consultant claims that dependable energy is incorrectly estimated by MH. While it is not explicitly stated, the Consultant is not happy about using the lowest water flow data before 1942 in estimating dependable energy. She has already voiced concern about this data. But her objection is centered on including wind and even expensive thermal energy from inefficient gas turbines and unclean coal in the calculation of dependable energy.

NYC would prefer that all surpluses be sold in the spot market. She showed some evidence over a very short period that spot prices exceeded contract prices and that even off-peak prices in some (2006/07) winters have exceeded on-peak prices. These exceptions are not sustained and the trends are of a different kind where on-peak prices are higher than off-peak. Long term contract prices exceeded spot on-peak prices for most of the years except for some parts of 2006 and most of 2007.

[redacted] The latter only reflects the changes in prices in a basket of consumer goods, whereas the implicit GDP deflator reflects price changes in the entire basket of final goods and services produced over a year. The escalators are not linked to market prices of electricity because that would change the fixed price contract into a variable one which contradicts the logic of fixed price contracts.

The specifics of these escalations are clear and can be summarized as follows:

The contract with [redacted] allows the escalation of [redacted] If, however, the [redacted] then capacity and energy prices from [redacted] calculated using [redacted]

In the [redacted] contract, the capacity [redacted] until April 2022; no escalation after 2022, but the capacity price is not allowed in any year to fall below [redacted] in 2008 dollars. The [redacted] The fixed energy price in any year is not allowed to fall below [redacted] in 2008 dollars.

In the [redacted] contract, the [redacted] in 2008 dollars. The guaranteed energy price is [redacted] in 2008 dollars.

These prices are [redacted] The reasons why counterparties will pay these relatively prices are based on four factors:

A) Guaranteed access to a large pool of reliable energy.

B) Access to clean (carbon free) energy with environmental attributes transferred to them.

C) Avoided risks of price changes. They are guaranteed a firm price with certainty.

D) The major part of the volumetric risk is assumed by MH.

Manitoba Hydro 2010 GRA

Information Requests of RCM/TREE

RCM/TREE/Independent Experts 10
Reference Independent Expert Report, p. 215

a) Please provide the missing adjective between "relatively" and "prices" in the sentence that reads: "The reasons why counterparties will pay these relatively prices are based on four factors".

b) Please explain what the authors are relying on as the point of comparison, when they state that the contract prices are "relatively [missing adjective]."

ANSWER:

a) The missing adjective is: "high"

b) KM relied on the MISO prices past and present

-- also, if -- if you wish to have reference, it's Tab 15 in our reference book of documents. And in that tab it would be starting at the second page of the tab and the KM response to PUB-KM-35, the IR.

MR. GAVIN WOOD: He's got all of that now.

MS. ANITA SOUTHALL: Thank you.

CONTINUED BY MS. ANITA SOUTHALL:

MS. ANITA SOUTHALL: Here there's a recommendation that Manitoba Hydro consider a hydrological submodel to compliment HERMES and SPLASH as water management issues become more complicated under possible climatic change.

Could you just comment on the underlying rationale, Doctors, as to the benefits of such a submodel?

(BRIEF PAUSE)

DR. ATIF KUBURSI: I'm sure you can appreciate, Counsel, we're not hydrologists, all right. And the issue here is we handled and we examined the antecedent forecasts, right. I mean, the way we now deal with things is that we look at the previous period and see how it relates to a current period, and we use the current period to forecast the next period.

So it is a hydrology of sorts but literally structured on lags. It may be possible to think that this can be complemented by a precipitation model, prediction of the precipitation. And if we integrate the precipitation, you don't need the past to tell you what's going to be in the future. You might really have a separate forecast on the level of precipitation. So the hydrology we're talking about is the precipitation level.

There may be other variables. I mean, you take a basin of water. There is inflow, right, coming from precipitation. There is outflow as you take it out, plus the evaporation losses. If you take all these variables into account, you could complement this antecedent forecast by this structural forecast that would come from using the information from hydrology on the likelihood of having water at a given level.

MR. ROBERT MAYER: Doctor, again, maybe I'm venturing into something I don't know any -- very much about, but I do know a little bit about weather forecasting, and I know that Environment Canada will tell you that although they can give you reasonably accurate forecasting a couple of days out with respect to your weather, they can't -- they can't do that with respect to precipitation.

So I'm -- I'm wondering what kind of forecast we're talking about when presumably the agency in Canada that is most responsible for coming up with that information readily admits that they haven't figured out how to do it yet.

DR. ATIF KUBURSI: I hate to tell you, Mr. Mayer, that they are better forecasters than economists --

MR. ROBERT MAYER: That's scary.

DR. ATIF KUBURSI: -- but it doesn't say -- yeah, it is. And their models have improved quite a bit. I mean, what we're suggesting here is that -- and -- and it's worth probing again. I mean, I know resources are not infinite, and one has to balance the benefits from a particular addition to the cost of these, but you're talking about hydrology, and we're talking about some structural breaks that are likely to come into the system because of climatic changes. And therefore the past would become a very poor estimate of the future.

And what we're suggesting here is to probe, to evaluate, to integrate, maybe with the University of Manitoba hydrologists -- I understand now that Manitoba Hydro is already investing quite a bit of money in a chair and other people -- to what extent some of this information, some of the modelling, some of the abilities and experiences that these people bring to bear, because I don't believe hydrologists are absolutely people without any sufficient or interesting things they can contribute. And these -- these are the kind of things we're talking about.

MR. ROBERT MAYER: Doctor, it may interest you to know that when we heard the Clean Environment Commission hearings with respect to the construction of Wuskwatim, we did get some significant evidence from Manitoba Hydro to the effect, at that time in any event, they were relatively confident with climate change there would be more rain.

The problem was they had no -- were unable to give any estimate as to what would happen as a result of evaporation. That is the evidence we heard. And that was a number of years ago, of course, but I'm not sure that they got that problem solved yet.

DR. ATIF KUBURSI: I -- I mean, nobody is suggesting here that the -- the issue is very simple. I -- as you know, the science is still not very strong on these things, but there is now almost a consensus that -- that the precipitation in the northern part is going to rise, but the temperature is also going to rise, so you're going to get increase in inflow but also increase in outflow. What is the net balance?

I mean, I'm hanging by the skin of my teeth on issues like this, so I'm not going to pronounce or -- or say things. But all we're really saying is that if there is something that could be gained from hydrologists and they can contribute to this issue here, I want to see that we experiment with models that do not depend purely on historical lags but that they could possibly integrate into them structural variables of the sort, that's all.

DR. LONNIE MAGEE: Can -- can I add -- add --

CONTINUED BY MS. ANITA SOUTHALL:

MS. ANITA SOUTHALL: I'm sorry. Yes, of course.

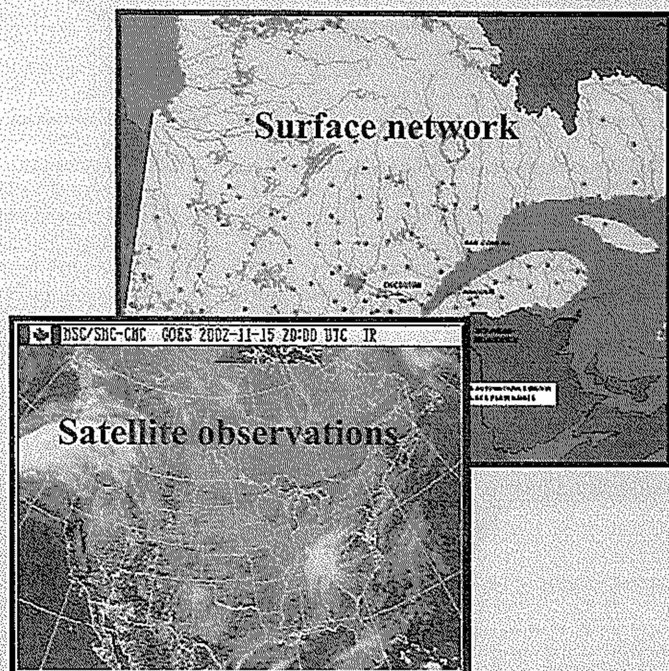
DR. LONNIE MAGEE: So we're -- we're not only talking about using weather forecasts and -- and climate change issues, but just, as economists, we're -- the other -- other social scientists kind of make fun of our tendency to grab everything we can find that's available that might help to predict things. So we -- we had the impression that -- that the model's specification that were being used for these forecasts are -- they're

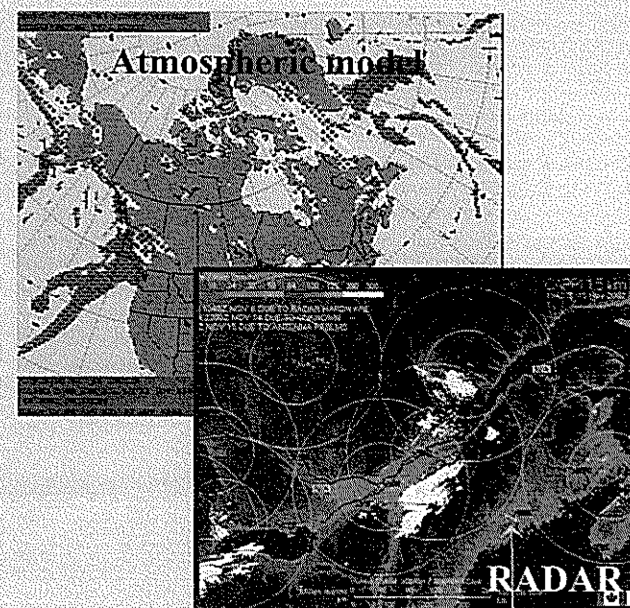
Manitoba Hydro · University of Manitoba · Environment Canada

Project # : G282

Canadian Precipitation Analysis (CaPA)

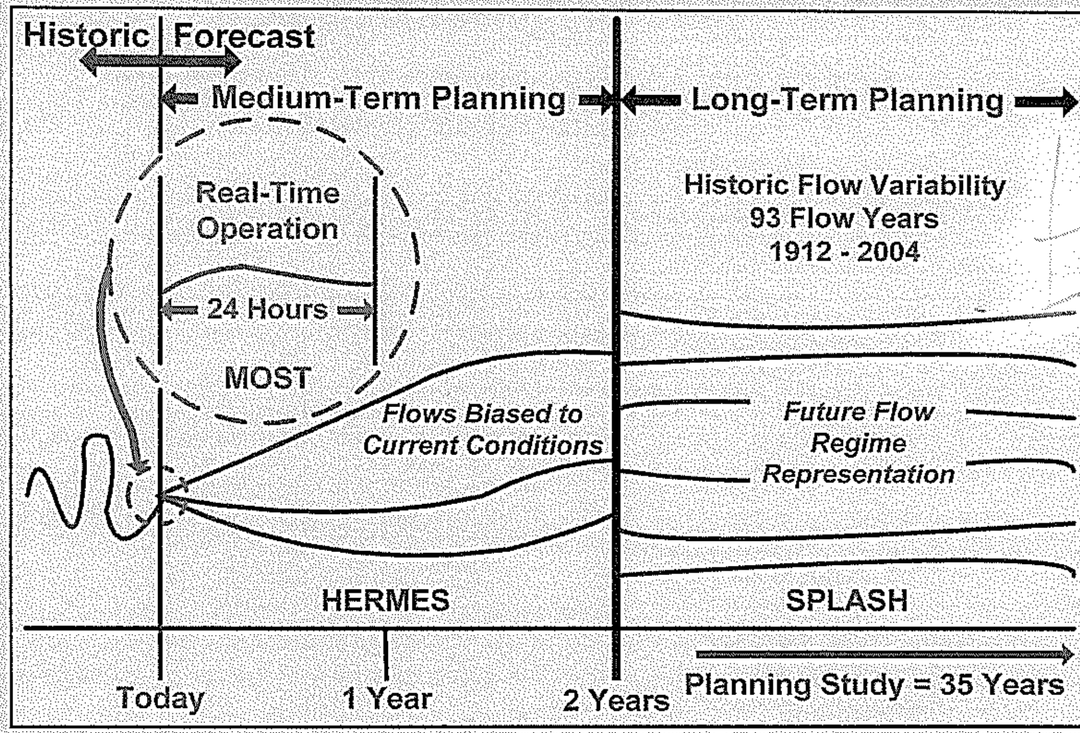
Combination of different sources of precipitation information into a single, gridded near real-time analysis plus 15 day forecast and hindcast.





Inflows

Should MH's forecasting system and long term planning rely solely on the historical record?



Manitoba Hydro | University of Manitoba

Model Enhancements

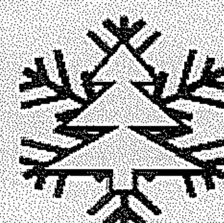
Lake Evaporation

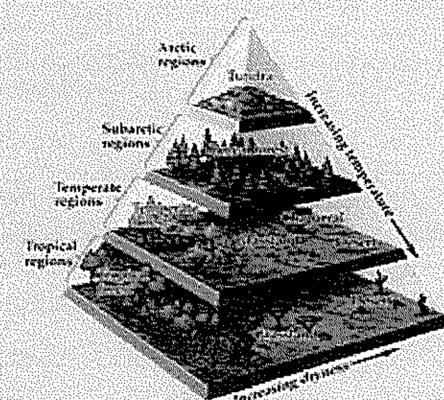
- Small Lake (in progress)- Project # : G234

Rainfall Disaggregation (in progress)- Project# : G261A

Lake Evaporation

- Large Lakes (proposed)

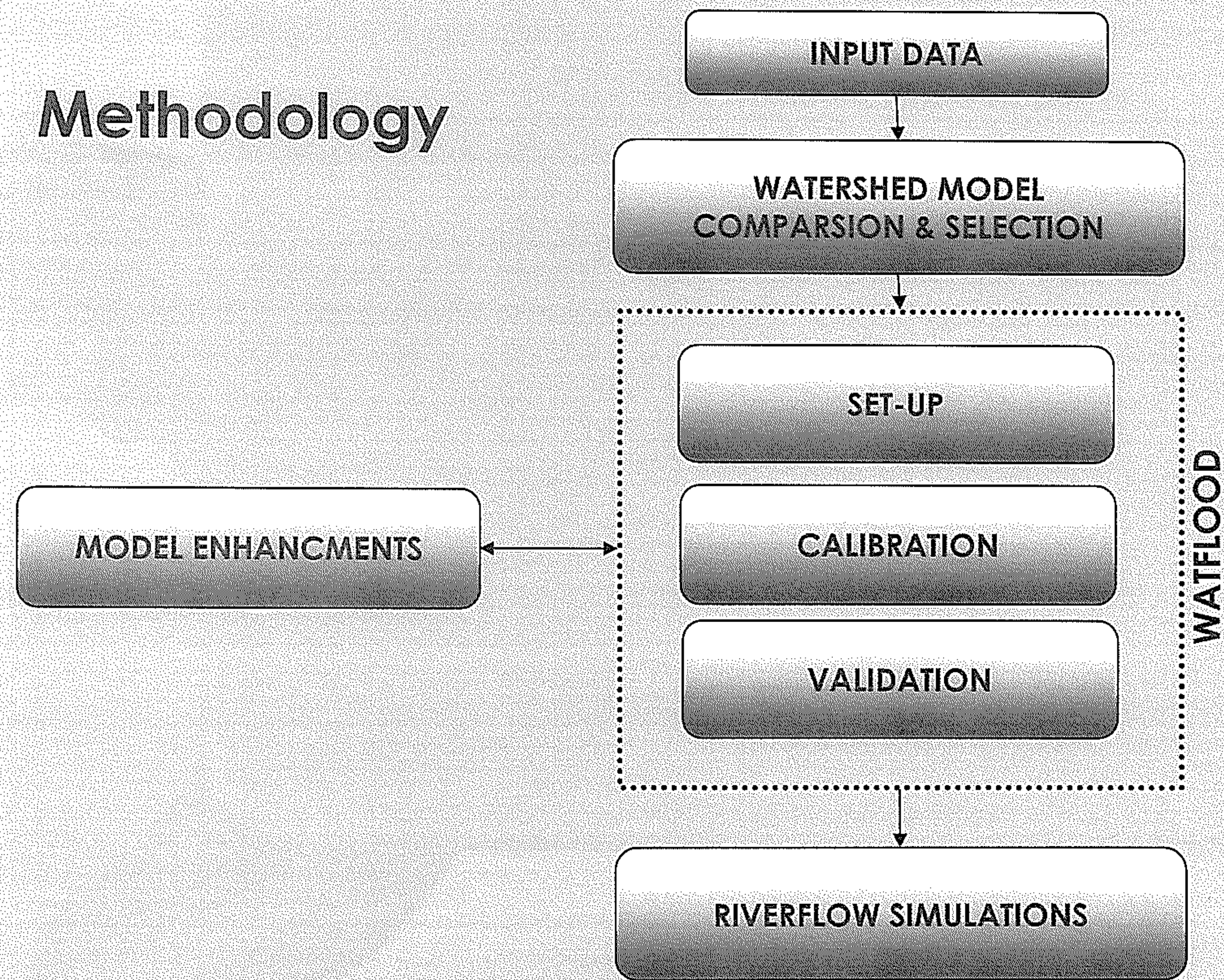




Snow Module (proposed)

Evolving Landcover (proposed)

Methodology



Watershed Model Selection

Churchill River Watershed (in progress- Project # G234)

- WATFLOOD
- HBEV
- HYDROTEL

Winnipeg River Watershed (proposed)

- WATFLOOD
- MESH
- HEC-HMS
- HYDROTEL

Manitoba Hydro

University of Manitoba

Table 6.1 – Manitoba Hydro Generation, Exports, Imports, Operating Revenues, Expenses and Debt. 2001-2007

	2001	2002	2003	2004	2005	2006	2007
Exchange Rate	1.5484	1.5704	1.4015	1.3015	1.2116	1.1341	1.0748
Load (GWh)	21,450	22,470	19,455	20,309	21,918	21,068	22,235
Unallocated Energy	3,750	4,386	1,048	1,466	1,880	2,365	2,326
Net Load	17,700	18,084	18,407	18,843	20,038	18,703	19,909
Domestic Price	4.84	4.93	4.81	4.88	4.86	4.90	5.10
Exports (GWh)	12,648	9,836	7,907	10,166	15,400	14,511	12,845
Firm	5,380	4,678	3,655	4,223	3,808	3,427	3,538
Non-Firm	4,378	2,732	587	2,494	8,291	8,886	7,525
Provincial Exports Firm	1,750	1,999	3,665	2,923	1,896	1,392	1,232
Provincial Exports Non-Firm	1,140	427	-	526	1,405	806	550
Prrovincial Imports - Total	2,890	2,426	3,665	3,449	3,301	2,198	1,782
Export Price							
Firm (US)	3.97	3.66	4.50	4.39	4.70	5.18	14.63
Non-Firm (US)	3.02	2.76	4.02	4.49	4.06	4.40	4.33
Firm (CDN)	6.14	5.74	6.31	5.72	5.69	5.88	15.72
Non-Firm (CDN)	4.67	4.33	5.63	5.84	4.92	4.99	4.65
Generation	34,098	32,306	27,362	30,475	37,318	35,579	35,080
Gross Domestic Revenue	856,703,087	891,517,142	885,365,397	919,516,928	973,853,847	916,423,088	1,015,377,462
Revenues from US Exports	535,439,197	387,288,907	263,583,469	387,027,445	624,689,571	644,733,114	906,531,354
Revenues from Other Provinces	160,688,000	133,231,700	231,261,500	197,914,000	177,008,400	122,069,000	219,245,400
Gross Revenues	1,552,830,284	1,412,037,749	1,380,210,365	1,504,458,373	1,775,551,818	1,683,225,202	2,141,154,216
Imports Total (GWh)	853	2,485	6,439	2,820	297	1,121	708
Imports from Provinces	195	342	533	266	66	302	174
Imports from US	658	2,143	5,906	2,554	231	819	534
Import Price (US)	3.97	1.92	3.05	4.83	3.44	3.94	4.57
Import Price (CDN)	6.14	3.01	4.28	6.28	4.17	4.47	4.91
Import Cost	52,421,234	74,909,250	275,268,800	177,255,497	12,380,058	50,094,897	34,772,604
Net Revenue (net of imports)	1,500,409,050	1,337,128,499	1,104,941,566	1,327,202,876	1,763,171,760	1,633,130,305	2,106,381,612
Marginal Cost ($/MWh)	1.09	1.53	3.26	1.52	1.30	0.98	1.04
Average Variable Cost	14.61	14.88	22.42	18.00	15.38	18.21	15.12
Average Total Cost	25.90	28.03	55.84	33.21	29.06	33.67	28.37
Operating Expenses	808,345,000	837,548,000	1,323,114,000	897,480,000	988,592,000	1,124,067,000	944,663,000
Wages and Salaries	247,249,000	196,265,000	276,506,000	301,733,000	312,317,000	349,038,000	348,627,000
Cost of Fuel Used	10,464,000	21,999,000	53,361,000	15,797,000	16,464,000	22,564,000	18,506,000
Cost of Material Used	23,477,000	23,815,000	23,979,000	25,384,000	27,831,000	10,120,000	16,039,000
Cost of Purchased Services	13,617,000	21,314,000	24,776,000	9,990,000	6,630,000	5,793,000	9,888,000
Cost of Repair and Maintenance	6,400,000	9,458,000	9,690,000	11,917,000	12,334,000	11,808,000	13,643,000
Royalty Expenses	112,784,000	102,856,000	71,455,000	47,542,000	68,103,000	112,497,000	13,767,000
Indirect Taxes	45,942,000	48,411,000	50,165,000	51,429,000	53,722,000	55,024,000	57,326,000
Other Expenses	-3,880,000	20,618,000	21,254,000	22,761,000	25,693,000	40,888,000	25,714,000
Electricity Purchased	108,388,000	129,171,000	515,570,000	119,659,000	162,398,000	203,648,000	115,224,000
Depreciation	243,904,000	263,641,000	276,358,000	291,268,000	303,100,000	312,687,000	325,929,000
Net Operating Income	692,064,050	499,580,499	-218,172,434	429,722,876	774,579,760	509,063,305	1,161,718,612
Long Term Debt (CDN)	7,269,896,000	6,924,890,000	7,114,613,000	7,047,576,000	7,051,016,000	6,822,361,000	7,217,181,000
Interest on L.T. Debt (CDN)	462,263,000	458,465,000	454,711,000	472,606,000	473,148,000	472,234,000	406,235,000
Effective Rate	6.36%	6.62%	6.39%	6.71%	6.71%	6.92%	5.63%
Net Operating Income (After Debt Chargers)	229,801,050	41,115,499	-672,883,434	-42,883,124	301,431,760	36,829,305	755,483,612

Sources: Statistics Canada, Annual Electric Power Generation, Transmission and Distribution Reports.
and http://www.bankofcanada.ca/en/rates/exchange_avg_pdf.html

Table 1

Manitoba Hydro Calendar Year Results vs. Select Table 6.1 Items

		2001	2002	2003	2004	2005	2006	2007
Manitoba Hydro	Load (GWh)	21,736	22,374	22,049	22,882	24,129	23,922	24,684
Stats Canada	Load (GWh)	21,450	22,470	19,455	20,309	21,918	21,068	22,235
	Variance	286	-96	2,594	2.573	2,211	2,854	2,449
Manitoba Hydro	Exports (GWh)	12,705	9,491	5,714	7,768	13,227	11,316	10,543
Stats Canada	Exports (GWh)	12,648	9,836	7,907	10,166	15,400	14,511	12,845
	Variance	57	-345	-2,193	-2,398	-2.173	-3,195	-2.302
Manitoba Hydro	Dependable (U.S.)	4,757	4,339	3,560	4,286	4,080	3,372	3,750
Stats Canada	Firm	5,380	4,678	3,655	4,223	3,808	3,427	3,538
	Variance	-623	-339	-95	63	272	-55	212
Manitoba Hydro	Opportunity (U.S.)	5,318	3,228	705	2,298	7,488	7,189	6,208
Stats Canada	Non-Firm	4,378	2,732	587	2,494	8,291	8,886	7,525
	Variance	940	496	118	-196	-803	-1,697	-1.317
Manitoba Hydro	Provinical Exports Dependable	1,493	1,458	834	89	81	151	100
Stats Canada	Provinical Exports Firm	1,750	1,999	3,665	2,923	1,896	1,392	1,232
	Variance	-257	-541	-2.831	-2,834	-1,815	-1,241	-1.132
Manitoba Hydro	Provincial Exports Opportunity	1,137	466	615	1,095	1,578	604	485
Stats Canada	Provincial Exports Non-Firm	1,140	427	0	526	1,405	806	550
	Variance	-3	39	615	569	173	-202	-65
Manitoba Hydro	Generation	33,511	29,571	21,225	27,746	37,042	34,137	34,113
Stats Canada	Generation	34,098	32,306	27,362	30,475	37,318	35,579	35,080
	Variance	-587	-2,735	-6,137	-2,729	-276	-1,442	-967
		2001	2002	2003	2004	2005	2006	2007
Manitoba Hydro	Revenues from US Exports	399,688,078	390,852,416	310,611,437	403,104,732	609,744,784	545,346,866	490,887,757
Stats Canada	Revenues from US Exports	535,439,197	387,288,907	263,583,469	387,027,445	624,689,571	644,733,114	906,531,354
	Variance	-135,751,119	3.563.509	47.027.968	16,077,287	-14,944,787	-99.386,248	-415,643.597
Manitoba Hydro	Revenues from Other Provinces	85,943,749	82,260,781	65,576,062	55,394,840	114,450,951	40,199,101	34,930,143
Stats Canada	Revenues from Other Provinces	160,688,000	133,231,700	231,261,500	197,914,000	177,008,400	122,069,000	219,245,400
	Variance	-74,744,251	-50.970,919	-165.685,438	-142.519,160	-62,557.449	-81,869,899	-184,315,257
Manitoba Hydro	Electricity Purchased	48,352,624	69,138,853	404,096,675	256,682,269	45,363,017	82,201,188	66,948,203
Stats Canada	Electricity Purchased	108,338,000	129,171,000	515,570,000	119,659,000	162,398,000	203,648,000	115,224,000
	Variance	-59,985,376	-60.032,147	-111.473,325	137.023,269	-117,034,983	-121,446,812	-48,275,797

Table 1 indicates significant variances in Manitoba Hydro Load, Generation, total Exports, US Firm and Non-Firm Exports, Canadian Firm and Non-Firm Exports, and Revenues from Canadian and US Exports. The following significant examples are noted:

a) Actual Manitoba Hydro load in 2006 was 23,922 GWh, 13.5% higher than shown in Table 6.1

b) Actual Manitoba Hydro Exports in 2006 were 11,316 GWh, 22% lower than shown in Table 6.1

c) Actual Manitoba Hydro US Dependable Exports in 2002 were 4,339 GWh, 7.2% lower than shown in Table 6.1

December 13, 2010, Mr. Jonathan Wallach further raises the issue that *"the extent to which drought-related costs are understated is unknown at this time"* and that *"as soon as feasible"... "it is critical that Manitoba Hydro determine the effect of perfect foresight on its drought-related financial losses"*. The following discussion provides an order of magnitude estimate of this potential understatement in order to put the issue into the appropriate perspective.

In order to determine the financial cost of drought, the first step is to determine the expected revenues and costs by utilizing a SPLASH simulation of all 94 flow conditions. The average of the 94 possible consequences is the expected value of revenues and costs that form the basis of the projections for the IFF. The simulated revenues and costs for a specific drought period are then compared to the expected case to determine the increased costs of thermal generation and import energy as well as the reduced revenues. The claim that the SPLASH methodology utilizes perfect foresight in making operating decisions on reservoir releases and energy purchases arises because this methodology assumes a repeat of the worst historical drought forcing a draw of reservoirs to minimum levels. Manitoba Hydro acknowledges that there may be some understatement in drought-related costs if alternative non-firm purchases ultimately prove to be available.

Should non-firm purchases prove to be available then there is the potential that this non-firm energy will also be available to displace expensive combustion turbine energy in Manitoba. Therefore, as acknowledged by KPMG on page 114 of their report, SPLASH modeling also has the potential to overestimate the cost of drought as follows *"To meet drought conditions, SPLASH will generally therefore assume that more use is made of MH's relatively inefficient thermal generating plants. In practice, less costly power is generally available from MISO and this tends to reduce the costs of the generation needed to cover the shortfall in energy from hydroelectric sources."* This was the situation in the drought of 2003 where the gas-fired generation was not operated significantly due to the availability of lower cost non-contracted imports. In order to estimate the magnitude of this potential offset, an assumption of 3,000 GWh of displaced Manitoba Hydro gas-fired generation over the 5-year drought period is reasonable which would produce a saving of $30/MWh as a conservative estimate. This results in a potential overestimate by SPLASH of about $90 million for the financial impact of a 5-year drought.

Conversely, using the same assumption regarding the availability of non-firm purchased energy to avoid the forced draw of reservoir storage, there is the potential that drought costs are underestimated by SPLASH because it fully draws storages to the minimum level. In actual operations it is likely that reservoirs will not be drawn to this minimum level because additional non-firm purchased energy may be available. Therefore, some storage could be maintained by purchasing energy instead of utilizing stored energy. This additional purchase would add to the cost of a drought as estimated by SPLASH. As an order of magnitude estimate associated with retaining water in storage, it is assumed that a storage buffer of 1.0 feet would be retained in Lake Winnipeg requiring an additional 2000 GWh of energy at an estimated cost of $50/MWh. This would translate into an additional drought cost of $100 million. When considered in combination with the $90 million reduction in cost that would likely occur in the operational time frame, the overstatement approximately offsets the underestimation. Therefore, the statement made by KM that the SPLASH estimate of drought cost is "seriously understated" is an overstatement of the issue.

There is an additional factor that must be considered in assessing the overall impact to the finances of Manitoba Hydro due to maintaining a storage buffer rather than using perfect foresight of when drought will end. The potential increase in drought cost resulting from maintaining a storage buffer is likely not a loss since the water that remains in storage has value in the period following the drought. This value would at least partially offset the additional cost of purchases during the drought period. This value of water in storage was acknowledged by KPMG on page 114 where they make the statement that *"The period following the drought will have more water in storage than assumed by SPLASH reducing future costs for imports and thermal generation"*. In most flow conditions that occur after the drought this water in storage will have value. There is only a small probability that water flows subsequent to the drought period reach near maximum values. In this rare case the value of the water in storage from the buffer would be negligible because it could not be utilized and would have to be spilled.