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Critical Review of the Reliability Assessment Prepared for the Régie de l'énergie

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1. Introduction

We have been provided with a copy of a report entitled, “An Assessment of Hydro-Québec’s Security of Supply in Accordance with their Energy Reliability Criteria” (the “Report”) prepared in December 1998 for the Régie de l’énergie by Gene Biggerstaff, Nicholas A. Dodge and Richard L. Mittelstadt (the “Consultants”). We have also been provided copies of many of the documents provided to the Consultants by the Régie, and records of many of their exchanges with Régie staff.

While the Report is in many ways a competent and workmanlike analysis of the limited information provided by Hydro-Québec, it is severely limited by the authors' uncritical adoption of Hydro-Québec's data and key assumptions. In the following sections, we will briefly assess the adequacy of this report for decision making with respect to Hydro-Québec's firm energy capacity and hence the energy reliability of the Hydro-Québec system.

It should be noted that substantial elements of this report have been deleted, apparently in response to Hydro-Québec's request that certain data be treated as confidential. We will also briefly address the reasonableness of these claims.

2. The experts' findings and recommendations

On the basis of the limited information made available by Hydro-Québec, the Consultants conclude that Hydro-Québec is able to meet firm loads within its energy reliability criteria for the near term. Despite the limitations detailed below, they made a number of significant findings:

1) that Hydro-Québec's approach to hydrological analysis requires expert review (p. 21),

2) that Hydro-Québec's studies on reliability criteria are outdated and should be revised (p. 22),

3) that the critical period methodology now used by Hydro-Québec overestimates system reliability by ignoring demand variations (p. 24),

4) that Hydro-Québec has consistently been operating its reservoirs at levels far below those considered optimal (70% at Nov. 1) (p. 9),

5) that Hydro-Québec chose to operate reservoirs at low levels in order to permit additional export sales since 1995 (pp. 24-25), and that this resulted in both increased risk of load shedding (p. 25) and decreased production efficiency, due primarily to loss of head (p. 26), and

6) that the situation in the fall of 1998 was of sufficient urgency to require immediate implementation of exceptional measures and month-by-month oversight by the Régie to ensure respect of reliability criteria.

The consultants also made a number of valuable suggestions and recommendations:

1) that the Régie establish an annual monitoring program, including operating plans for coming years based on worst-case conditions (pp. 31-32),

2) that, if it appeared that exceptional measures would be required, Hydro-Québec report to the Régie on a monthly basis,

3) that Hydro-Québec should be required to inform the Régie of its planned non-firm sales and to demonstrate that these sales would not adversely impact their energy reserves (p. 32),

4) that the Régie establish a rule curve to determine, at any given moment, whether surplus sales should be allowed, whether surplus water should be stored, or whether more drastic measures should be undertaken to augment reserves (pp. 32-33), and

5) that the financial risks resulting from operating reservoirs at low levels should be borne by those parties benefitting from that policy (p. 29).

However, their analysis suffers from several important weaknesses. The most significant involve the uncritical acceptance of Hydro-Québec's estimates of what is "normal" runoff, as well as the uncritical adoption of Hydro-Québec's "critical period" methodology. Because of these and other weaknesses, the Consultants' conclusion that the security of supply is assured is not well-founded.

3. Flaws in the Consultants' analysis

The Report mainly tests whether the assumptions made by Hydro-Québec would lead to Hydro-Québec's conclusions. However, verifying whether yesterday's methods and yesterday's data are internally consistent is not adequate to determine the real energy capabilities of the Hydro-Québec system, or the actual degree of reliability that it can provide. Without robust answers to these questions, it is impossible to conclude that Hydro-Québec's reservoir management — and in particular, its past and projected levels of discretionary export sales — are consistent with their energy reliability criteria.

Apart from the determination of the expected value of future runoff (the "normal" scenario), the Consultants' analysis has other shortcomings that cause them to overestimate Hydro-Québec's energy reliability. These include the treatment of the uncertainty of demand projections, the assumptions regarding Hydro-Québec's ability to build additional generation and transmission

resources within a short lead time, and the use of critical periods instead of a stochastic methodology.

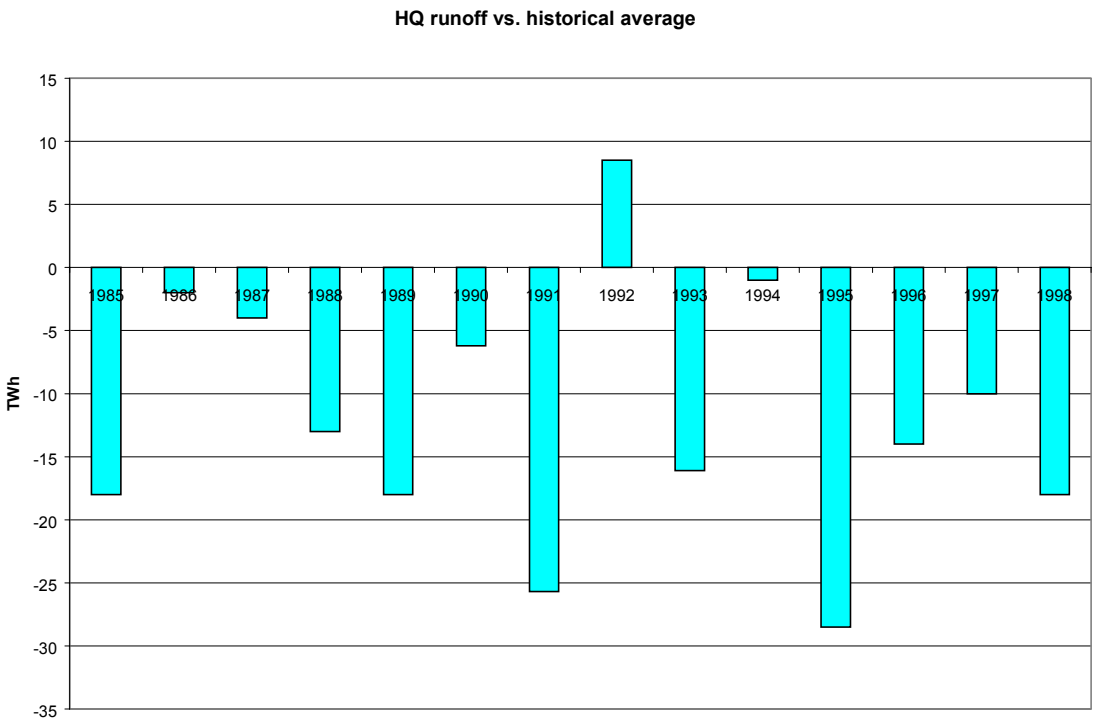
3.1 Expected inflows

3.1.1. While casting doubt on its validity, the Consultants nevertheless use Hydro-Québec's long-term average runoff as the basis of their analysis

In their recommendation that Hydro-Québec retain "a consultant familiar with drought hydrology and the potential impact of the recent trend toward more extremes in meteorological activity," the Consultants display a certain discomfort with Hydro-Québec's assertion that the long-term average runoff is the best estimate of future runoff. Indeed, they raise several concerns regarding Hydro-Québec's analysis, questioning both the adequacy of the historical record and the use of deterministic streamflow records. However, despite these concerns, they performed no independent analysis of the hydrological record and in the end accepted Hydro-Québec's use of long-term mean runoff as the appropriate value for expected runoff in coming years. Given the findings described below, the uncritical acceptance of this hypothesis casts important doubt on their primary conclusion that Hydro-Québec is in compliance with its reliability criteria.

3.1.2. Kalman filter analysis suggests that expected inflows are now significantly lower than the historical average

As the Consultants note on page 11 of the Report, 1992 was the last year in which runoff was well above its historical average. (Hydro-Québec uses an adjusted streamflow record starting in 1943.) In fact, the below-average series extends far earlier; 1992 has been the *only* year with "above-average" runoff since 1985, as shown in the following chart:



Based on the assumptions used by Hydro-Québec and by the Consultants, whereby expected inflows are constant over time with a standard deviation of about 20 TWh, the probability of a sequence such as this, which constitutes a cumulative deficit of 163 TWh over a 14-year period, is extremely low. The cumulative surplus of +150 TWh experienced in the 8-year sequence from 1976 through 1983 would be an even more rare occurrence.

However, admitting the possibility that the actual underlying "normal" runoff is not constant but varies over time may be a much better explanation for these events. The Kalman Filter analysis carried out by McCullough Research supports the latter conclusion.[1] Kalman Filters are statistical tools originally developed to extract the useful information from a noisy radio signal. Kalman Filters have been used extensively in economics, finance and engineering to analyze highly variable time series, when their underlying expected values may change over time.[2]

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[1] Robert McCullough, "Reliability Planning and Hydraulic Inflows in Quebec," June 2, 2000, 13 pp.

[2] The seminal article in the field is R. E. Kalman, "A New Approach To Linear Filtering And Prediction Problems," *Journal of Basic Engineering*, March 1960. For an excellent practical introduction to Kalman filters, see Richard Meinhold and Nozer D. Singpurwalla, "Understanding the Kalman Filter," *American Statistician* May 1983. A good exposition of current best practice can be found in James D. Hamilton, *Time Series Analysis* (Princeton University Press, 1994).

McCullough applied a simple Kalman Filter to Hydro-Québec's actual inflow data, in order to determine the most likely underlying values for normal runoff. According to McCullough:

> The Kalman Filter is a highly adaptive analytical technique and does not require the kinds of stability and regularity assumptions necessary to appropriately apply simple regression models. **In particular, unlike Hydro-Québec's approach, this technique does not require strong assumptions about the long term average and variability of inflows. It admits the possibility that, over time, climatic changes may alter the "normal" level of inflows.** Furthermore, a simple Kalman Filter model does not insist that the expected inflow shift over time in any artificial pattern, such as a linear increase or decrease. The Kalman Filter lets the data speak for itself.[3]

McCullough's Kalman Filter analysis of Hydro-Québec's inflow data suggests that the current expected value is just 166 TWh. This is well below the 180 TWh value used by the Consultants in their reliability analysis (Appendix C, Part 2 to the Report).[4] It is not possible to review analysis on the basis of which the Consultants concluded that Hydro-Québec is able to meet its reliability criterion for the next several years, because the entire analysis has been censored (see Appendix 1, doc 3).[5] However, it is clear that if Hydro-Québec is just barely meeting its energy reliability criteria with an expected value of 180 TWh for annual inflows, it is probably not in compliance if the expected value of the inflows is only 166 TWh.

3.1.3. Climate Change

As noted earlier, the Consultants are somewhat skeptical as to the adequacy of Hydro-Québec's hydrological record, which they characterize as "limited" (p. 21). They further point out that the volatility of hydrologic and meteorological phenomena has been increasing in recent years, and that the literature suggests that weather patterns are reverting from an extended period of relatively consistent conditions to a long-term scenario of wider extremes.

Surprisingly, however, the Consultants fail to mention the possibility that global warming might affect runoff. There is no doubt that we have entered into a period of significant climatic change, almost certainly related to the increased levels of greenhouse gases in the atmosphere. There is very considerable uncertainty as to the degree, or even the direction of the effects these changes will have on runoff in a given region. However, it is widely accepted that climate change will affect local and regional hydrology, and that this creates considerable uncertainty as to future inflows.

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[3] McCullough, *op. cit.,* p. 12.

[4] Expected energy production from the existing system (including thermal sources as well as purchases) declined from 190 TWh in the *Strategic Plan 1998-2002* to 185 TWh in the *Strategic Plan 2000-2004*. While no explanation is provided in the Plan, Hydro-Québec's responses to questions from the Consultants indicate that average runoff has declined. Hydro-Québec, "Questions des experts, 4 décembre 1998," question 10 (Appendix 1, doc. 1). Another document provided to the Consultants shows that Hydro-Québec considers its expected inflows to be 178 TWh (App. 1, doc. 2, tableau B).

[5] Report, p. 26 and Appendix C, Part 1.

A report currently under preparation for the World Commission on Dams reviews the state of current knowledge on the effects of climate change on large dams and their management, including dam safety, reservoir yield and reliability and reservoir operations. The draft report concludes:

> "The major implications of climate change for dams and reservoirs are firstly that the future can no longer be assumed to be like the past, and secondly that the future is uncertain."[6]

The direct effects of climate change on reservoir reliability were modelled by Peter Robinson of the University of North Carolina, in research reported on in the *International Journal of Climatology* in 1997.[7] Based on reservoir-load pairings in the eastern U.S. Robinson explored the effects of various temperature/precipitation scenarios drawn from general circulation models (GCM) on reservoir drawdown and reliability.

Robinson found that "hydroelectric generating systems are highly sensitive to climatic fluctuations. Relatively small climate changes can lead to major changes in the draw-down of reservoir levels. A warm dry climate scenario, such as is commonly suggested as arising from anthropogenically induced climate change, led to major increases [in draw-down]." Furthermore, he notes that the climatic influence "varied greatly from one region to another, and was highly dependent on the timing of dry spells and their relationship to temperature. As a result the time series of annual minimum reservoir depths was modified in a complex way which varied with location and scenario."[8]

He concludes that his results, "strongly suggest that estimates of the reliability of a reservoir to provide power during dry periods under a changed climate cannot be made by simple extrapolation of current conditions."[9]

Based on these results and others reported by Arnell and Hulme, it would be appropriate to assume that the uncertainty of future inflows would increase, thereby decreasing the firm energy capability of the Hydro-Québec system. Combined with the decrease in average inflows noted above, this increased uncertainty further reduces the energy reliability of the existing reservoir system, though its net impact on reliability will depend on the extent of corresponding reduction in heating loads**.**

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[6] Nigel Arnell and Mike Hulme, *Dams and global change: implications of climate change for large* dams *and their management,* draft thematic review prepared for the World Commission on Dams, Nov. 15, 1999, p. 1.

[7] Peter Robinson, "Climate Change and Hydropower Generation," *Intl J. Climatology* 17:983-997 (1997).

[8] *Ibid*., p. 995.

[9] *Ibid*., p. 991.

3.2 Demand variability

The Consultants correctly note that Hydro-Québec's analysis excludes variability related to demand projections,[10] resulting in over-estimating system reliability (p. 24). It is clear from their communications with the Régie that they were quite concerned about this issue,[11] particularly since, as they point out, one of the main reasons for Hydro-Québec's revising its drought criteria in 1991 was precisely to take demand variations into account.[12]

However, they inexplicably fail to adjust for this error in their numerical analysis, and fail to draw the logical conclusion that system reliability is over-estimated. Instead, they rather ironically point out that "it is unrealistic to assume that any forecast is not subject to variation," and suggest that, in the future, demand variation be included in the reliability analysis.

There is no doubt that omitting demand-related uncertainty leads to an overestimation of reliability and an underestimation of risk. Its inclusion would necessarily push the bounds of the 98% confidence interval to lower levels, increasing the probability of running the reservoirs dry.

The Consultants recognize this problem, but incorrectly describe it as a compliance issue (p. 5). It is not. It is a methodological error that results in overestimation of reliability, and thus calls into question the finding that Hydro-Québec is able to meet its energy reliability criteria.

3.3 Assumptions regarding ability to build new resources

While it is not stated in their report, the Consultants made clear in their communications with the Régie that their assessment that energy supply reliability is adequate depends on the key assumption that, should it need to do so, Hydro-Québec could develop new generation and/or transmission resources within a two-year time frame.[13] Such an assumption is in violation of the terms of reference provided by the Régie to the Consultants, unsupported by any factual information, and dubious, unless Hydro-Québec is able to obtain emergency decrees exempting new projects from review required by statute.

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[10] E-mail from P. Lavoie to R. Mittelstadt, December 11, 1998: "Hydro-Québec has confirmed to us this morning that the 39 and 64 TWh values do not include load variations" (Appendix 2, doc. 1)

[11] E-mail from R. Mittelstadt to C. Dupuis, undated (Appendix 2, doc. 2).

[12] Report, note 34. The Report also indicates (note 27) that the critical period is normally the most adverse historical sequence, *taking into account both flows and demand.*

[13] E-mail (undated) from R. Mittelstadt to C. Dupuis, "Two-Year Worst Case" (Appendix 2, doc. 2); e-mail of December 14, 1998 from C. Dupuis to R. Mittelstadt and G. Biggerstaff, "reliability criteria" (Appendix 2, doc. 3); E-mail (undated) from R. Mittelstadt to C. Dupuis, "Re: reliability criteria" (Appendix 2, doc. 4).

In one of the presentations made by the Régie to the Consultants at the beginning of their contract, it was specified that "New equipment [is] not an option – low runoffs is an operational problem to be solved with existing facilities."[14] The question they were to answer was thus: does the *existing* system provide adequate energy reliability, taking into consideration the way it is currently being used (including exports)? They were explicitly instructed *not* to consider the addition of new resources in answering that question. However, in his e-mail communications with the Régie, Consultant R. Mittelstadt made it clear that the report's conclusions were in fact predicated on the unsupported assumption that new resources could be developed within a two-year period.[15]

Based on the information made available to the RNCREQ by the Régie, it appears that the Consultants were provided with no information which would lead them to believe that Hydro-Québec could, if necessary, develop generation or transmission resources within a two-year period for reliability purposes. Furthermore, there is nothing in Hydro-Québec's recent history that would suggest it can develop resources under such an accelerated schedule. The SM-3 project, soon to be completed, will have taken more than 14 years to construct, from the date when the project was formally submitted to the Ministère de l'environnement for approval.[16] More recently, the diversion projects announced in 1997 will not be on-line before 2001, at the earliest. And no projects have yet to go through the new approval process established under section 73 of the *Act respecting the Régie de l'énergie.*

Indeed, the only Hydro-Québec developments that could provide support to the notion of a two-year project cycle are the "bouclage" transmission projects announced following the 1998 ice storm. As is well known, these projects were exempted from environmental review and other processes by Cabinet decrees, which were later determined to be illegal.[17] It would indeed be shocking if the Régie were to determine that current reservoir management practices are adequate based on the possibility of turning to such extreme measures in the event that runoff does not improve to its earlier levels.

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[14] Régie de l'énergie, *Energy Reliability Criteria : Methodology and Recent Experience,* slide presentation, November 30, 1998, p. 23 (Appendix 2, doc. 5).

[15] "Yes, now I remember. A key factor was that Hydro-Québec was assumed to be able to bring new generation on-line to take care of critical periods longer than two years." E-mail (undated) from R. Mittelstadt to C. Dupuis, "Re: reliability criteria" (Appendix 2, doc. 4).

[16] The *avis de projet* was filed with the Ministère de l'environnement in June 1987. The *rapport d'avant-projet phase 2,* which served as an environmental impact statement, was filed in July 1991. The BAPE was mandated to hold hearings in 1992, and filed its report in June 1993. The governmental certificate of authorization was decreed in February 1994, and the project is expected to come on line in 2001.

[17] Their construction was retroactively authorized by Bill 42, *An Act respecting the construction of infrastructures and equipment by Hydro-Québec on account of the ice storm of 5 to 9 January 1998,* adopted June 17, 1999. The constitutionality of this *Act* is currently under challenge before the Québec Superior Court.

While in many areas gas turbine plants can be developed within a short timeframe, there is no reason to believe this is the case in Quebec, where there is considerable political opposition thermal generation and where there is no policy in place authorizing such construction. If Hydro-Québec intends to build gas generation on an emergency basis should a combination of exports and low runoff drive reservoir levels to unacceptable levels, this policy should be announced and debated in the appropriate forum.

Due to the enormous interannual storage capability of Hydro-Québec's reservoir system, the impacts of an unsustainable level of exports may not be felt for several years. As the Consultants point out, were it not for short-term exports between 1995 and 1997, Hydro-Québec's reservoir levels on November 1, 1997 would have been 70% rather than 52%. One can also safely conclude that the short-term export sales of 7.7 TWh in 1998 played a role in driving the reservoir level down to 45% on November 1, 1998.[18] Resolving today's (or tomorrow's) reliability problem by building new generation resources would mean that we are **building in 2000-2002 to supply export sales made in 1995-98.** Given the obligation under the *Act respecting the Régie de l'énergie* to take the public interest, including environmental and social concerns, into account in authorizing new generation, this is clearly not an appropriate way to proceed.

3.4 Critical periods

The consultants recognized that the major shift in Hydro-Québec's reliability planning that took place around 1990 consisted largely of replacing a methodology based on a four-year "critical period" with one based on stochastic analysis of supply and demand variations (pp. 13-14). There is no doubt that Hydro-Québec has the tools to stochastically assess its system energy reliability on an ongoing basis, taking into account the variability of both supply and demand. As McCullough explains, the NEPTUNE model, in use since the early 1990s, has all these capabilities.[19] The consultants' failure to insist on access to the models used by Hydro-Québec severely limits the usefulness of their analysis.

Instead, the Consultants simply relied instead on Hydro-Québec's assertions regarding the results of its modelling. Following their December 4 meeting with Hydro-Québec, the Consultants asked:

> Is the energy reliability criteria [sic] and its quantitative expression corresponding to a deficit over one year of 39 TWh, 64 TWh over 2 years and 87 TWh over three years still valid today?

To which Hydro-Québec responded:

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[18] Report, p. 16.

[19] To the best of our knowledge, NEPTUNE functions on an annual cycle; Hydro-Québec undoubtedly uses other tools for modelling flows on monthly and daily cycles. It is of course possible that it has been updated or replaced in recent years. In any case, these tools should be publicly reviewed to provide assurance that shortsighted technical limitations such as those described here have been eliminated.

> Yes. Even though the generation system has increased in size since 1991, the average runoff has gone down, which has a compensatory effect. Recent test [sic] show that the extreme scenarios of –39 TWh over one year, -64 TWh over two years and –87 TWh over three years are still valid.[20]

Neither the accuracy of these figures nor the modelling that produced them were ever reviewed. Indeed, the Consultants had already recognized that these limits excluded any variability based on demand, as mentioned above — a major methodological error. Furthermore, uncritically following the approach selected by Hydro-Québec, they then used these figures to derive a fixed "critical period," applying a methodology that has not been state-of-the-art for several decades.

In effect, the reliability question has been reduced to asking whether or not Hydro-Québec could respond to a "worst-case" sequence of –39 TWh in the first year, -25 TWh in the second year, -23 TWh in the third year and –20 TWh in the fourth year.[21] This differs from the old critical period methodology only in that the sequence is not directly derived from an actual four-year historical period, but has been generated by computational tools.[22]

As such, this approach has all the flaws of the outmoded critical period methodology, and forgoes all the additional sophistication in stochastic modelling that computers have made possible in the last 15-20 years. Furthermore, in addition to relying on the unsupported (and unsupportable) assumption that Hydro-Québec can build generation or transmission within a two-year time frame, it is based on the incorrect assumption that there is only one adverse sequence one need worry about, composed of declining deficits. In fact, there are a multiplicity of adverse scenarios with a probability of occurrence of considerably greater than 2% which Hydro-Québec would apparently not be able to handle.

If the appropriate analysis period were just one year, the Consultants would be correct in concluding that the system need not be able to respond to inflows lower than 39 TWh below the historical average, assuming a standard deviation of 19.5 TWh and a 98% reliability criterion. Greater deficits are of course possible, but, for a one-year period, their likelihood is less than 2%. However, over a two-year period, the likelihood that inflows in both years will be –39 TWh or better falls to about 96%. More generally, the likelihood of a single-year result of worse than -39 TWh is equal to:

$$P = 1 - 0.98^n$$

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[20] Hydro-Québec, "Questions des experts, 4 décembre 1998," question 10 (Appendix 1, doc. 1).

[21] E-mail of December 14, 1998 from C. Dupuis to Richard Mittelstadt and Gene Biggerstaff, "reliability criteria" (Appendix 2, doc. 3).

[22] In an e-mail to the Régie on December 10, 1998, Consultant Richard Mittelstadt wrote: "Critical period usually refers to the most adverse sequence of flows in a river basin for a given set of storage projects. This corresponds to Hydro-Québec's old 1960-63 adverse flow sequence. But I suppose we could *loosely* use the term "critical period" to refer to the period used in conjunction with Hydro-Québec's new energy reliability criteria." (italics added, Appendix 2, doc. 6).

The probability of at least one year in a multi-year period having a shortfall worse than -39 TWh is therefore as shown in the following table:

number of years	probability
1	2.28%
2	4.50%
3	6.67%
4	8.79%
5	10.87%
6	12.90%
7	14.88%

As the Consultants correctly note, the length of the period required to assess energy reliability varies as a function of the ratio of energy storage to annual energy inflows. For a system with no storage at all, the reliability analysis is obviously limited to a one-year period. The more storage in the system, the more important it is to look at multi-year scenarios. According to the Consultants, with storage approximately equal to a full year's runoff (a storage:runoff ratio of about 1), the appropriate period for reliability analysis of the Hydro-Québec system is *at least* four years.[23] This is consistent with Hydro-Québec's own 1992 analysis, which is based on a seven-year period.

Thus, the 98% confidence limit would include not only the (-39, -25) sequence described in the e-mails quoted above, but is also includes sequences such as (-10, -45), even though the probability of –45 in a single year would be less than 2%. Similarly, the three-year threshold of –87 TWh would include outcomes such as (-18, -23, -44) or (0, -43, -43). By the same token, the seven-year 98% confidence zone to which Hydro-Québec is legally obligated to be able to respond includes three- and four-year adverse sequences significantly worse than the "critical period" analyzed by the Régie.[24]

The probability of outcomes such as these is *greater than* 2%; thus, the Hydro-Québec system must be able to respond to them in order to meet its professed reliability criterion and its legal obligations.[25] It seems clear from the Consultants' analysis that it would not be able to do so. As the quoted passage above makes clear, the worst-case "critical period" used is based on inflows of –39 TWh *in the first year*, with lesser deficits in the following years. This particular sequence would be far easier to manage than either of the three-year sequences mentioned above. Nothing in the Report suggests that Hydro-Québec could respond to such sequences without significant loss of load.

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[23] Report, p. 23.

[24] The probabilities for multi-year "failures" are difficult to compute. For example, two consecutive years totaling less than -64 in a seven year period can occur in six different ways, and these event are not independent — an event across years 2 and 3 is influenced by whether an event occurs across years 1 and 2 or across years 3 and 4. Even –64 over 3 years (e.g. –30, +5, -39) could cause a problem, depending on the actions taken in years 1 and 2.

[25] See Appendix 2, doc. 3.

4. The Consultants conclusions

4.1 Adequacy of supply

The Consultants' conclude that "Hydro-Québec is capable of providing an adequate supply to meet firm energy loads within its established reliability criteria through the spring of 2002." At the same time, they indicate that doing so will require the use of exceptional measures, including termination of non-firm sales, running thermal generation and purchasing energy from neighboring utilities (p. 5).

It should be noted, first of all, that this conclusion applies only to a very limited time frame, and that it is based on an analysis that suffers from the flaws described above.

In addition, the Consultants recommend several measures to ensure compliance with the criteria. Indeed, their conclusion that reliability is adequate through 2002 is *conditional* on the application of appropriate levels of exceptional measures. Their recommendations for monthly monitoring and for followup by the Régie thus represent a critical part of their conclusion:

> It is deemed *essential* that a monthly monitoring and followup program be established *immediately* with Hydro-Québec to give *sufficient assurance* to the Régie that the exceptional measures considered *essential to meet the energy reliability criteria* are being implemented.[26] (italics added)

In particular, they consider essential that:

> each month, … Hydro-Québec should provide to the Régie updated information on actual and forecasted supply, demand and reserves, and the results of the actions taken to implement the exceptional measures. Hydro-Québec should also make available the snow accumulation data gathered through snow surveys, as well as their estimate of the snowmelt runoff.
>
> Based on real demand and supply, adjustments to the exceptional measures program for the remaining period *will be agreed upon between Hydro-Québec and the Régie.*[27] (italics added)

This program was deemed to be essential through May 1, 1999, when a determination would be made whether or not it should continue "if water conditions continue to be serious."

While it does appear that Hydro-Québec has periodically provided certain data to the Régie, the Régie has indicated to the RNCREQ that it has not provided these data to the Consultants or to

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[26] Report, p. 31.

[27] *Ibid.*

any other outside experts.[28] Furthermore, the RNCREQ has been informed by the Régie that it has made no decision, determination or order to adopt in whole or in part the Consultants' recommendations,[29] nor has it communicated with the Ministère des ressources naturelles concerning the Report.[30]

It appears from the Régie's response that its own staff have analyzed these data and made recommendations based on them to the Régie.[31] However, as noted above, the Régie to date has taken no action whatsoever in this file. It has neither endorsed the Consultants' conclusions, nor acted on their recommendations. It thus appears that at least one of the conditions established by the Consultants (exceptional measures program to be agreed upon by the Régie) has not been fulfilled.

For future years, the Consultants recommend that each November,

- Hydro-Québec should present their projected reservoir operation for the coming year, given their expected loads and the amount of water available in storage.
- Hydro-Québec should present plans for how they would operate their reservoirs in the two succeeding years if the adverse sequence of runoff defined by their energy reserve criteria should occur. …
- Hydro-Québec should also show planned non-firm sales [exports] and demonstrate that these sales would not adversely impact their energy reserves.

Based on the information obtained by the RNCREQ, it would appear that these recommendations have also been ignored. The Régie held two meetings with Hydro-Québec on this issue in September 1999, but no documents were filed.[32] The Régie did request that Hydro-Québec provide it with runoff data for 1999, but did not request the projections and plans mentioned above; the documents made available to us do not indicate whether or not Hydro-Québec provided the requested information.

4.2 Risks and benefits

It seems clear that the Consultants consider the current low reservoir levels to be undesirable. When they asked Hydro-Québec why it does not raise its water levels, it responded:

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[28] Letter from Mtre. V. Dubois to Mtre. C. O'Brien, March 9, 2000, response to information requests 1 and 3 (Appendix 3, doc. 1).

[29] Letter from Mtre. V. Dubois to Mtre. C. O'Brien, January 17, 2000 (Appendix 3, doc. 2).

[30] Letter from Mtre. V. Dubois to Mtre. C. O'Brien, March 9, 2000, response to information request 6 (Appendix 3, doc. 1).

[31] Letter from Mtre. V. Dubois to Mtre. C. O'Brien, March 9, 2000, response to information request 4 (Appendix 3, doc. 1). The Régie has refused to provide access to these recommendations.

[32] Letter from Mtre. V. Dubois to Mtre. C. O'Brien, December 14, 1999 (Appendix 3, doc. 3).

> *Hydro-Québec uses a commercial approach to manage its reservoirs*, while respecting its energy reliability criteria. This approach is based on financial arbitration, which is up to the company, and which it uses to maximize the return on its assets. … The target energy stocks are sufficient to respect the energy reliability criterion in the event of low runoff with a very low probability of occurrence of 2%.[33] (our italics)

It thus appears that the current low levels are the direct result of a policy choice by Hydro-Québec to maintain exports at the highest level compatible with (its understanding of) its energy reliability criteria. However, as we have seen, its faulty analysis of the 2% criterion (adopted uncritically by the Régie and its Consultants), combined with its overly optimistic assumptions about future inflows, means that the real risk it is incurring is substantially greater than 2%.

This new policy has never been explained nor justified, either publicly or, according to the documents made available to us, before the Régie. Under favorable inflow conditions, it may well lead to increased profitability. However, this benefit must be measured versus the increased financial and supply security risks it inevitably creates in the event of adverse inflow scenarios with a probability of greater than 2%. While Hydro-Québec may have carried out such an analysis internally, it has never been submitted to public scrutiny.

As noted earlier, the Consultants recognize that "the lowering of reservoir levels to engage in export sales results in either a measurable decrease in system reliability or the possible increased use of exceptional measures." They correctly conclude "that the financial risks resulting from operating reservoirs at low levels should be borne by those parties benefitting from that policy,"[34] though they neither quantified those risks nor indicated who bears them.

Finally, it appears likely that operating reservoirs at lower levels in accordance with this new policy may increase their emissions of greenhouse gases in the short and in the long term, by increasing emissions of methane relative to those of carbon dioxide.[35] Depending on the magnitude of this effect, it could be an important factor in determining the optimal reservoir management regime.

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[33] Hydro-Québec, *Questions des experts,* December 4, 1998, Response 2 (our translation) (Appendix 1, doc. 1).

[34] Report, p. 29.

[35] P.E. Yundt, *Estimation of Greenhouse Gas Emissions from Canadian Hydroelectric Dams and Reservoirs* (for Environment Canada), March 1996, p. 13; Moore, T.R., and Dalva M., 1993, "The influence of temperature and water table position on carbon dioxide and methane emissions from laboratory columns of peatland soils," *J. of Soil Science* 44:651-664; Duchemin, E., 2000, Hydroélectricité et gaz à effet de serre: évaluation des émisssions des différents gaz et identification des processus biogéochimiques de leur production, Thèse de Doctorat, Université du Québec à Montréal, 321p.

5. Confidentiality and other issues

5.1 Confidentiality

In the copy of the Consultants' Report provided to the RNCREQ by the Régie, considerable amounts of information were blacked out in response to Hydro-Québec's request for confidential treatment of the information it provided. It is clear from the Régie's correspondance that it did not exercise its discretion, but rather treated as confidential all information for which Hydro-Québec requested such treatment, in accordance with its *Politique concernant la gestion des documents confidentiels relatifs aux dossiers de requête*, adopted by the Régie du gaz naturel in 1990 and revised in 1994.[36] This policy establishes no procedures by which the Régie would determine whether or not a request for confidential treatment should be granted, nor does it provide for third parties to challenge such a request. Indeed, it was only upon receipt of a letter from Hydro-Québec abandoning (without explanation) its claim of confidentiality for certain information that the Régie released the Report to the RNCREQ.[37]

Most of the deletions are of quantitative information, such as Hydro-Québec's projected firm and non-firm loads for 1999, 2000 and 2001 (p. 19), but at times entire sentences are blacked out. The information kept secret includes:

1) quantities of exceptional measures available (pp. 26 and 30),

2) quantities of exceptional measures that may be required in coming years if low runoff continues (p. 2),

3) minimum reservoir levels required in May 1999 to allow Hydro-Québec to meet its energy reliability criteria (p. 31),

4) monthly forecasts of supply and demand for the period November 1998 - May 1999 (p. 31), and

5) estimated annual generation for Sainte-Marguerite-3.[38]

No explanation was provided by Hydro-Québec — and none was requested by the Régie — as to the justification for each claim.

It is of course incorrect to suggest that past forecasts for a period that has already ended should be commercially sensitive. It is also unjustified to claim that past forecasts of future conditions are

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[36] It should be noted that this policy specifies that it applies only to documents filed with the *greffe* in the context of an inquiry. The Régie has made clear, however, that it has not undertaken an inquiry into the security of supply, but merely an administrative process.

[37] Letter from Mtre. F. J. Morel to Mtre. V. Dubois, October 15, 1999 (Appendix 3, doc. 4).

[38] See e-mail from C. Dupuis to G. Biggerstaff, December 11, 1998 (Appendix 2, doc. 7).

commercially sensitive. Current forecasts of market conditions in the coming months may well have commercial value, but the only harm that can accrue from divulging past forecasts is harm to the credibility of the forecaster.

In fact, the coarse nature of these data (monthly) makes it of very limited commercial value. Knowledge of HQ's planned monthly critical water operations tells a competitor very little about its ability to to exploit market peaks on an hourly/daily/weekly scale. Hydro-Québec's concerns about revealing even current monthly planning information is thus largely unjustified.

As we have indicated elsewhere, we are aware of no other region in North America where analyses related to hydroelectric reliability are hidden from public scrutiny.[39] We note that the consultants retained by the Régie were not asked to, and did not, provide recommendations concerning the appropriate degree of confidentiality or the appropriate degree of public involvement in reliability monitoring and planning. However, given their professional experience in the FERC and the Army Corps of Engineers, it would be surprising if they did not take for granted a degree of transparency and public involvement comparable to those they have experienced throughout their working lives.

For example, the Northwest Power Planning Council recently carried out a Regional Power Supply Adequacy/Reliability Study, looking into very similar issues in the Pacific Northwest. The study was carried out in the context of a public process, with regular meetings of a stakeholder advisory committee. Briefings and status reports were posted on the NWPPC web site; data and models were available to interested members of the public. A draft report was recently made available, the *Northwest Power Supply Adequacy/Reliability Study -- Phase 1 Report*, which contains detailed assumptions and modelling results for the hydro system.[40]

The commercial arguments invoked by Hydro-Québec to justify its secrecy concerning reliability information simply do not hold water. One can only conclude that its real purpose is to avoid informed debate and oversight concerning its generation planning and operations.

At the First World Forum on Energy Regulation, Mme Marie-Josée Nadeau, executive vice-president of Hydro-Québec, explained that the utility only considers real-time information to be commercially sensitive. Given that the Report was filed with the Régie in 1998, it is hard to reconcile this statement with Hydro-Québec's refusal to allow the Régie to make it public, in full.

5.2 Short-Term Firm Exports

In the questions they posed to Hydro-Québec, the consultants expressed a certain degree of surprise that Hydro-Québec considered its short-term sales objectives to be part of its demand. Indeed, in their own analysis of Hydro-Québec's demand, the consultants removed the short-term export objective to consider only firm demand (p. 19, Appendix B). At the same time, they

[39] McCullough, *Expert Report On Hydrological Data Confidentiality,* p. 2.

[40] See http://www.nwppc.org/pow_sup.htm.

accept Hydro-Québec's approach of including non-firm sales in demand figures, insofar as reduction of non-firm sales is considered an exceptional measure (p. 27).

The problem with this mixed approach is that, as the consultants themselves recognize (p. 15), the export objective becomes a firm demand insofar as Hydro-Québec succeeds in signing short-term firm export contracts, which can range from a few months to a year or more. Once such contracts are signed, those sales can no longer be reduced as an exceptional measure; failure to serve them is rather another form of load shedding. In leaving vague the distinction between short-term firm export sales and spot sales, additional uncertainty is created as to Hydro-Québec's ability to respond to low inflows. In failing to recommend any oversight over the signature of new firm export contracts, the consultants' proposed monitoring program leaves an important loophole that could sabotage its otherwise commendable oversight program.

5.3 Other Issues

Finally, it should be noted that the consultants' report contains a number of errors, some of which reflect their limited familiarity with the Hydro-Québec system. For example, they describe the storage capacity of the Caniapiscau Reservoir as being 88.7 TWh, and that of the Daniel Johnson Reservoir as being 32.9 TWh (p. 9). In fact, these figures represent the total storage of the La Grande and Manicouagan complexes, respectively, each of which includes several reservoirs.[41]

Finally, and most inexplicably, they state the energy reserves of the Columbia River system to be 518 TWh in a table on page 7. This table is of little use, as hydro operations in the Northwest do not rely on a fixed figure for total storage, due in large part to the significant environmental constraints on reservoir operations. Furthermore, this figure dramatically overstates the actual storage on the Columbia system.

6. Conclusions

The significance of the results shown above is that Hydro-Québec's current energy reliability is far from assured. The risk of the hydroelectric system running empty is substantially greater than the 2% reliability criterion adopted by government decree.[42]

The Consultants' Report lays out a series of emergency measures that would be adequate to keep energy reliability within acceptable limits in the short term, if Hydro-Québec's assumptions regarding load growth and inflows were correct. However, the Kalman Filter analysis reported above demonstrates that it is far more likely that they are not. If the future resembles the recent past more than the distant past, Hydro-Québec may face a real reliability problem in the short term, as a result of past and projected exports. Unless such exports are curtailed, Hydro-Québec will require significant new resources in the medium term. When exports are used to draw down

[41] Hydro-Québec, *Historique financier et statistiques divers, 1991-1995,* p. P-13.

[42] Described in "General Description of Hydro-Québec's System", p. 5 (Appendix 1, doc. 4).

reservoirs to unsustainable levels, which in turn require the development of new generating resources to re-establish reliability, the justification of investment in new resources is turned on its head.

Thus, the Consultants' recommendations — that each year Hydro-Québec should present the Régie with plans for how it would operate its reservoirs in the two succeeding years in the face of an adverse runoff and demand scenario, and that it should demonstrate that its show planned non-firm exports would not adversely impact its energy reserves — are essential. In the same way, the Régie must oversee the signing of export commitments to ensure that they do not compromise energy security.

It appears that none of these recommendations have been adopted and acted upon by the Régie. The Consultants' conclusion that the energy supply is secure was conditional upon the enactment of their recommendations, and these conditions have not been met. Thus, even if one accepts their analysis, it appears that the energy supply is not sufficiently secure. Furthermore, given the analytical weaknesses described above, we are forced to conclude that Hydro-Québec has failed to meet the 98% confidence limit prescribed by regulation.

There is no doubt that considerable hydrological investigation is urgently required. In the period of climatic uncertainty in which we live, the facile assumption that the future will be like the past is clearly unsupportable.[43] The Kalman Filter analysis gives a useful indication of what may lay ahead, but expert hydrological analysis, subject to critical review in a public forum, is essential. Given the likely need for significant new resources in the medium term, it is essential to move rapidly to carry out the resource planning process foreseen in the *Loi sur la Régie de l'énergie*, by which supply and demand-side resources can be compared on an equal footing and the optimal solution found, taking into account economic, environmental and social concerns.

With respect to confidentiality, it is extraordinary that the Régie applies a confidentiality policy that does not provide for the exercise of discretion in granting confidential treatment, nor for interested parties to challenge the merit of such claims. The right of Quebecers to engage in informed debate about matters as important as the security of their energy supply should not be forfeited out of respect for unsubstantiated claims of commercial sensitivity. When certain data are determined to indeed be sensitive, confidentiality agreements and other tools can be used to protect the utility's legitimate interests, without stifling reasoned debate, as is common practice in jurisdictions across North America.

Relying when necessary on the judicious use of such tools, there is no reason for the Régie not to carry out its oversight of Hydro-Québec's operations in a transparent way that allows interested parties to participate fully in the Régie's deliberations.

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[43] Even if the future is like the past, the past seems to vary in a more subtle way than envisioned by Hydro-Québec.