Performance Indicator: Maximize Megawatt Production

Technical Working Group: Hydropower TWG

Research by: Hydropower TWG, Established flows for power formulas

Modeled by: Mark Lorie in the shared vision model. The power entities in the development of John Ching's model.

Activity represented by this indicator: Generation of hydropower

Link to water levels: In general higher water levels on Lake Ontario call for higher outflows. This will provide for more megawatt production. However, if flows are too high, they can exceed the capacity of the plants. At the Moses-Saunders and Beauharnois power plants, higher outflows will lower the operating head which is a factor in megawatt production. However, due to regulation requirements in Lake St. Francis, Hydro Quebec must keep Lake St. Francis within a 30 cm range.

Importance: Maximizing megawatt production is a goal of all the hydropower entities. Because Hydro Quebec does not perform peaking operations at Beauharnois, this PI is critical to their operations. Plans that reduce megawatt production will cause the price of electricity to all users to increase due to the nature of the electricity markets. This is discussed in detail in the contextual narrative. Also, the foregone electricity will be made up by alternate sources that are more expensive and contribute to reduced air quality.

Performance Indicator Metrics: Typically, flows in excess of 7500 cms exceed the point of best efficiency for the Hydro Quebec plant at Beauharnois. The incremental water is turbined at 50% efficiency at Beauharnois or at Ceders. Above 9000 m^3/s, the water is spilled. These numbers are subject to adjustment with the maintenance of units.

Temporal Validity: Valid for the entire year with the exception of the ice formation season that will be discussed in another PI summary.

Spatial Validity: Valid for outflows at the Moses-Saunders and Beauharnois generating stations.

Links with hydrology used to create the PI algorithm.

Hydropower production is a function of the outflows and operating head. The head is defined as the difference between the water level immediately upstream of the power station (forebay) and immediately downstream (tailrace) of the plant.

Algorithm: A computer program was provided for the Shared Vision Model and takes into account all the local hydraulic parameters and the rating curves for the units.

Validation: The formulas to determine power have been modeled and field tested. For Moses-Saunders, they have been validated by the Gauging Committee and approved by the International St. Lawrence River Board of Control. They are the basis for the rating tables used by the power entities in measuring outflows and reporting to the International Joint Commission.

Documentation and References: Rating tables used by the power entities have been in operation since inception of the project. They are accepted by the IJC. They have been updated and tested as generating units have been upgraded.

Risk and uncertainty assessment: This PI is objectively measurable. There is risk that a selected plan may negatively impact hydropower's ability to operated at best efficiency however, there is little uncertainly of the ability to measure that impact.

Performance Indicator: Maximize The Value of Megawatt Production

Technical Working Group: Hydropower TWG

Research by: Hydropower TWG, Synapse Energy Economics Inc.

Modeled by: Mark Lorie in the shared vision model. The power entities in the development of John Ching's model.

Activity represented by this indicator: Increase electricity production during periods of high demand and reducing electricity production during periods of low demand.

Link to water levels: Water levels on Lake Ontario determine outflows. Rules regarding peaking (the ability to change hourly flows such that the daily flow remains unchanged as if peaking had not occurred) dictate that peaking cannot occur when daily flows are in excess of 7,930 cms.

Importance: Ontario and New York have a mix of generation that includes hydro as well as nuclear and fossil fuels. Hydropower is the least costly, most dependable source of power and it does not create air emissions. When hydropower can be increased during periods of high demand and decreased during periods of low demand it reduces the overall cost of power both economically and environmentally. Quebec's source of electricity is practically 100% hydropower. As such they don't consider this PI as critical as the first PI.

Performance Indicator Metrics: Flows in excess of 7,930 cms will not allow for peaking. Also historical demand for power and projected value of electricity over time

Temporal Validity: There are seasonal and hourly periods of peak and off peak demand. Spring and Fall are usually lower demand periods. Winter and Summer are considered peak periods. On a daily basis the hours of 22:00 through 06:00 are usually lower demand periods and 07:00 through 21:00 are usually high demand periods.

Spatial Validity: Electricity consumers in New York and Ontario.

Links with hydrology used to create the PI algorithm.

Periods of low flow will cause reduced generation. Outflows in excess of 7,930 cms will generate more power overall but will not allow for peaking.

Algorithm: A computer program was provided for the Shared Vision Model and takes into account all the local hydraulic parameters and the rating curves for the units.

Validation: Historical demand for power and prices are available. In addition an independent consultant, Synapse has provided their estimate of future values of generation.

Documentation and References: Synapse report to the Study Board, Historical market data, regulatory requirements to expand use of renewable resources for fuel.

Risk and uncertainty assessment: Indications are that the demand for power is expected to increase. Regulations to decrease dependence on foreign oil and to increase the use of renewable fuels are likely to cause increased prices of electricity. Climatic changes could cause lower water levels resulting in reduced water for hydropower generation. A regulation plan that causes higher outflows during periods of lower demand and vice versa could negatively impact the consumers of electricity in the New York, Ontario and Quebec markets.

Performance Indicator: **Predictability of Outflows**

Technical Working Group: Hydropower TWG

Research by: Hydropower TWG

Modeled by: Mark Lorie in the shared vision model. The power entities in the development of John Ching's model.

Activity represented by this indicator: This PI refers to the ability to look forward and predict whether outflows will be increasing or decreasing. Predictability of outflows allows for planned maintenance. It also contributes to the stability of the electricity markets.

Link to water levels: Water levels on Lake Ontario determine outflows. Lake Ontario rises and falls in a seasonal (predictable) pattern. A regulation plan that is premised on releasing water in relation to the water levels will be predictable.

Importance: This PI is important for hydropower, but it has importance for other interests as well. Maintenance at the power plants must be performed regularly. Often this requires that several units be removed from service simultaneously. For instance work on a transformer at Moses-Saunders will require a bank of units (4 unit tied together electrically) to be out of service. Power entities try to remove these units when outflows are lower and expect to remain lower. If flows increase unexpected during an outage then generation will be lost by running inefficiently at best and by spilling the water at worst. For Beauharnois, the best efficiency point is relatively low and each opportunity for unit maintenance must be used. The predictability is extremely important for proper scheduling.

Unexpected reductions in outflows will impact the price of electricity in the markets particularly if they occur during high demand periods such as a summer heat wave.

Performance Indicator Metrics: This is dependent on the flow routing techniques used in the plan. Each plan should be run to evaluate its reaction to a set of conditions. (Ex. How do different plans react to a sudden minor or major rain fall, at different periods of the year? Does one plan over react in comparison to the others in different situations?). This should be done by a detailed analysis of a limited number of plan options. The present global approach used by the PIAG does not provide for a good evaluation of this parameter.

Temporal Validity: Ongoing

Spatial Validity: n/a

Links with hydrology used to create the PI algorithm.

Increasing levels on Lake Ontario normally predict increasing outflows and decreasing levels on Lake Ontario should be an indicator that outflows will decrease.

Algorithm:

Validation: Calculation of lost generation if flows suddenly increase during periods of unit maintenance.

Documentation and References: Hydropower TWG

Risk and uncertainty assessment: This PI attempts to reduce uncertainty of future outflows. If a regulation plan is selected that directs flows to fluctuate widely and in no predictable pattern then generation will be lost. This can be calculated. This uncertainty will cause unpredictable water level fluctuations in Lake St. Lawrence and downstream to Montreal. This will have negative impacts on property owners and recreational boaters.

Performance Indicator: **Stability of Outflows**

Technical Working Group: Hydropower TWG

Research by: Hydropower TWG

Modeled by: Mark Lorie in the shared vision model. The power entities in the development of John Ching's model.

Activity represented by this indicator: This PI refers to the magnitude of variation in outflows from one quarter month to the next. If flows increase too much, lost efficiency and megawatts will result. If flows decrease too much, there may not be enough generation to meet demand which will drive up costs of power.

Link to water levels: Water levels on Lake Ontario determine outflows. Lake Ontario rises and falls in a stable pattern. A regulation plan that is premised on releasing water in relation to the water levels will be relatively stable.

Importance: This PI is a complement of the predictability PI. This refers to the magnitude of fluctuation in outflows from one period to the next. For instance if outflows for quarter month periods are as follows: 7,500 cms, 8,000 cms, 7,000 cms and 7,500 cms, this gives the false appearance that monthly flows are stable. In fact there is no change from in outflows from the first and last period. However the flows fluctuate dramatically from period to period. This impacts outage planning, capacity requirements, and water levels.

The following two paragraphs are taken from the predictability PI but they are valid for the stability PI as well. This PI is important for hydropower, but it has importance for other interests as well. Maintenance at the power plants must be performed regularly. Often this requires that several units be removed from service simultaneously. For instance work on a transformer at Moses-Saunders will require a bank of units (4 unit tied together electrically) to be out of service. Power entities try to remove these units when outflows are lower and expect to remain lower. If flows increase unexpected during an outage then generation will be lost by running inefficiently at best and by spilling the water at worst.

Unexpected reductions in outflows will impact the price of electricity in the markets particularly if they occur during high demand periods such as a summer heat wave.

Performance Indicator Metrics: 1958DD performs well for this PI. A comparison of results to 1958DD to plan options would indicate their performance.

Temporal Validity: ongoing

Spatial Validity: n/a

Links with hydrology used to create the PI algorithm.

Increasing levels on Lake Ontario should predict increasing outflows and decreasing levels on Lake Ontario should be an indicator that outflows will decrease.

Algorithm: Hydro-Quebec's algorithm is based on the sum of the absolute difference between the plan flow and the 5 weeks moving average of the weekly outflow. That sum is transformed to energy losses by using a loss coefficient of 0.10 MW/m^3/s, applied only to flow exceeding 6500 m^3/s. This a good approximation for Hydro-Quebec.

Validation: Calculation of lost generation if flows suddenly increase during periods of unit maintenance.

Documentation and References: Hydropower TWG

Risk and uncertainty assessment: This PI attempts to reduce uncertainty of future outflows. If a regulation plan is selected that directs flows to fluctuate widely and in no predictable pattern then generation will likely be lost. This uncertainty will cause unpredictable water level fluctuations in Lake St. Lawrence and downstream to Montreal. This will have negative impacts on property owners and recreational boaters.

Performance Indicator: **Ice Formation**

Technical Working Group: Hydropower TWG

Research by: Hydropower TWG

Modeled by: Mark Lorie in the shared vision model. The power entities in the development of John Ching's model.

Activity represented by this indicator: This PI refers to the requirement to reduce outflows as conditions dictate to form a stable ice cover.

Link to water levels: This PI is determined by weather conditions. Ice historically begins forming in the Beauharnois canal one to two weeks prior to forming in Lake St. Lawrence.

Importance: This PI is critical to all interests. A stable ice cover will allow flows to be released in accordance with the regulation. If the ice cover is weak or if and ice jam or hanging dam forms, then releases will be restricted. This can cause a drop in the operating head, and potentially cause some municipal water supplies to be jeopardized. In the spring, flooding can occur when the jams release.

Performance Indicator Metrics: Ice begins forming when water temperatures approach 0 degrees Celsius.

Temporal Validity: This PI is critical during the winter months. Ice historically forms in January but historical records show this varies. Water and air temperatures are more reliable indicators of when ice will form.

Spatial Validity: Beauharnois canal and Lake St. Lawrence from the power dam to Ogdensburg, NY and Prescott, Ontario

Links with hydrology used to create the PI algorithm.
Velocities of 2 feet per second will promote a stable ice cover. River flows of 6,230 cms will allow for velocities of 2 feet per second.

Algorithm: The flow limitations in plan 1958D are correct, subject to adjustment with the real date of ice cover formation. A new plan should follow a similar pattern.

Validation: Calculations by the Corps of Engineers during system design and construction.

Documentation and References:

Risk and uncertainty assessment: There is risk to all interest groups if ice is not allowed to form and stabilize. Flexibility should be built into all plans to allow for flow reductions to form ice.

Performance Indicator: **Spill at Long Sault Dam**

Technical Working Group: Hydropower TWG

Research by: Hydropower TWG

Modeled by: The SVM should indicate when flows are in excess of the plant capacity at Moses-Saunders. Spill during the season from April 1 to mid June should be avoided to avoid fish spawning.

Activity represented by this indicator: This PI refers to spilling water through Long Sault Dam when river flows exceed the capacity of the generating units at the Moses-Saunders station.

Link to water levels: High water levels on Lake Ontario dictate high outflows.

Importance: Since the facility became operational, spills at Long Sault Dam into the South Channel have occurred infrequently and in varied amounts. As a result, a warm water aquatic habitat has developed in what is essentially a backwater habitat in the St. Lawrence River. During spill events in early spring and early summer, the potential exists for cooler river water to spill into the warmer, shallow-water habitats of the upper end of the South Channel, causing concern for the propagation and survival of warm-water species immediately downstream of the dam that use this area preferentially as spawning and nursery habitat.

Economically, hydropower generation that is spilled is forever lost. This is addressed in the PI above that seeks to maximize the value of hydropower generation.

Performance Indicator Metrics: The combined capacity of the Moses-Saunders station is approximately 10,000 cms when all 32 generators are in service. Total discharge per unit is approximately 315 cms. Assuming that NYPA and OPG each have one unit out of service at any given time, the total plant capacity is realistically closer to 9,450-9,500 cms.

Temporal Validity: This PI is critical during the spring months. Fish spawning occurs during the period from mid-April through the end of June in the South Channel. This is a warm water environment relative to the rest of the river. Spillage introduces cold water which is thought to be harmful to fish spawning during this period. This is addressed in further detail in the contextual narrative and in NYPA's FERC license.

Spatial Validity: South Channel immediately downstream of Long Sault Dam.

Links with hydrology used to create the PI algorithm. The upper bound of the four foot range on Lake Ontario is 75.37 meters. When levels exceed 75.37 m the regulation plan seeks to drive down the level with high outflows.

Algorithm: Outflows in excess of 9,450 cms will tend to cause spill at Long Sault Dam.

Validation:

Documentation and References:

Risk and uncertainty assessment: Spill at Long Sault dam is infrequent. There is uncertainty regarding the impact on fish species during spill. Water temperature monitoring and dissolved gases monitoring will take place when spill is required to try to determine the impact on the fish habitat.