Greenhouse Gases and Water Use Planning

Introduction

The Water Use Planning (WUP) process being applied to BC Hydro's hydroelectric facilities is a collaborative process that strives to reach agreement on a set of operating rules for each facility that considers the full range of water use interests, while respecting legislative and other boundaries. These interests include a variety of cultural, economic, environmental, safety and social objectives.

One likely outcome of the WUP program[1] is an overall reduction in energy production from BC Hydro's hydro-generation facilities. Greenhouse gas (GHG) emissions are expected to increase off site as a result of this decrease because the source of replacement power [planned for in BC Hydro's 2000 Integrated Electricity Plan] is primarily combined cycle natural gas turbine (CCGT) generation, a more GHG intensive energy source than current hydro-resources.

This information sheet provides background to help WUP Committee Members consider the GHG impacts of WUP operational changes at a facility if they decide to include a GHG objective/performance measure [Step 4 of the WUP process]. It also looks at how WUP and GHGs are linked through the electricity planning process.

Climate Change Background

Human activities, such as the burning of fossil fuels, are widely believed to be adding significant quantities of carbon dioxide (CO_2) and other greenhouse gases to the earth's atmosphere. The general consensus of the scientific community is that these elevated levels of greenhouse gases are causing global climate change.

Climate change is considered a serious environmental and sustainability issue that could result in significant impacts on a global scale, although some regions will be more adversely affected than others. Climate change in British Columbia is predicted to alter weather patterns with effects that include more extreme weather events, increased rainfall and decreased snowfall on the coast, altered stream flows resulting in more frequent spring floods, declining fish stocks and increased frequency of forest fires and pest infestation.

Canada, the Province of British Columbia and BC Hydro have all committed to take steps to address climate change including efforts to manage GHG emissions. For example, BC Hydro is taking action through a variety of initiatives, including: a commitment to offset 50% of net GHG emissions from two new CCGT natural gas-fired generation plants, new load met with 10% green power, Resource Smart and Power Smart programs, and investigation of new alternative renewable energy sources such as wind and wave energy.

[1] WUP program: the application of the WUP process to all facilities in BC Hydro's hydroelectric system.

Connecting Electricity Planning and Water Use Planning

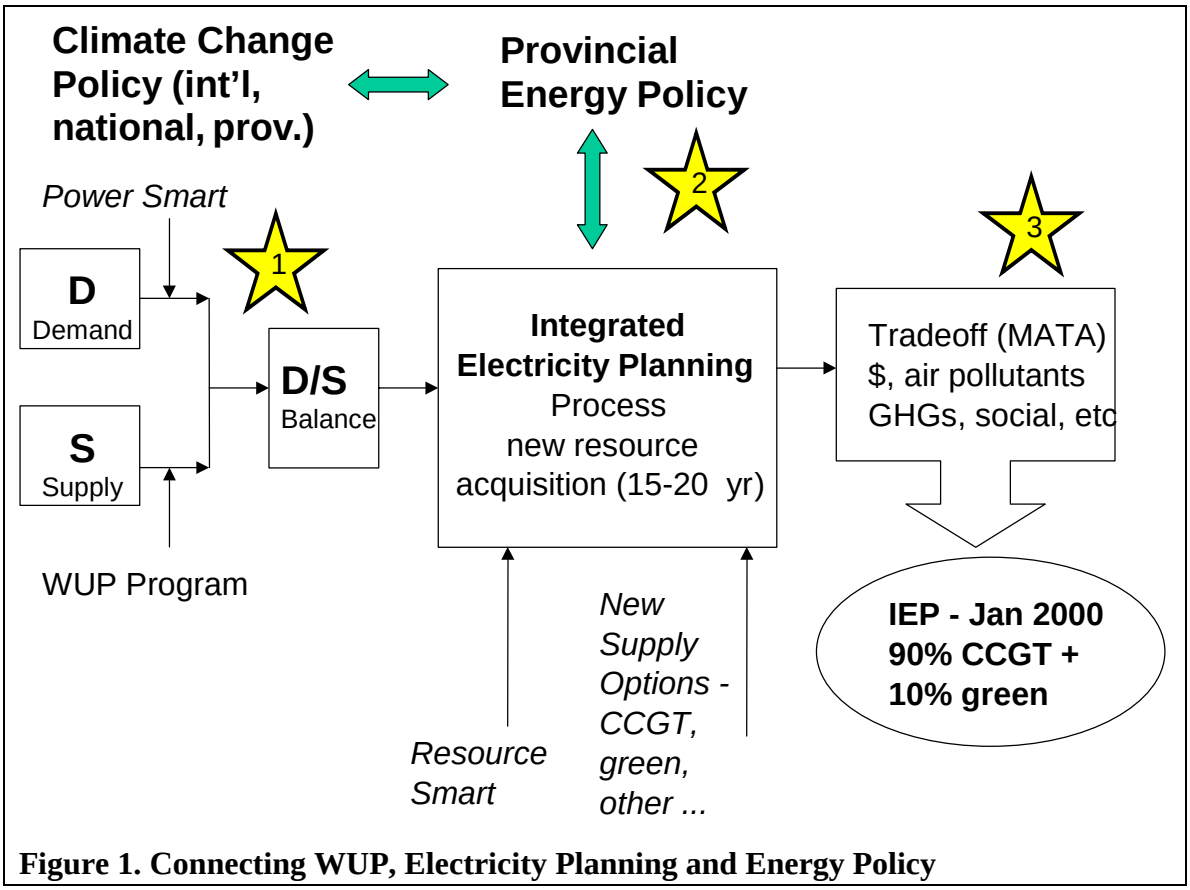

Figure 1. Connecting WUP, Electricity Planning and Energy Policy

BC Hydro plans for new resources in the electricity planning process (Figure 1). Water Use Plans is connected to the IEP process because it will likely affect the existing resource base, and therefore the need for replacement (new) resources.

1 Simply put, the integrated electricity planning (IEP) process balances existing sources of supply against forecast demand, and identifies new supply options needed to ensure that demand can be met.

2 Taking direction from (provincial, national and international) energy and climate change policies, the IEP process evaluates alternative new supply options and selects future energy resources.

3 Through a multi-attribute trade-off analysis (MATA), the IEP process attempts to achieve a balance in meeting the following objectives:

- Minimize the cost of electricity services to customers.
- Provide reliable supply that meets customer needs and expectations.
- Minimize adverse and promote positive environmental impacts.
- Provide positive socio-economic benefits in BC.
- Promote implementation of appropriate new and existing technologies.

BC Hydro's 2000 Integrated Electricity Plan lists GHG emissions as an attribute under the environment account for purposes of the trade-off analysis and notes that "greenhouse gas emissions have become an increasingly important consideration in the evaluation of resource options."

The WUP process looks at outcomes that, once implemented, will adjust (likely decrease) BC Hydro's existing hydro-electricity resource base (supply). As such, WUP outcomes affect the electricity planning and BC Hydro recognizes a need to plan for and replace the expected reduction in hydroelectric production capability with new replacement power.

Given this link between replacement power and WUP decisions, a change in GHG emissions is a potential impact of a WUP decision and could therefore be an objective in a WUP process. However, inclusion of objectives remains the decision of WUP Committee Members. In assessing inclusion of a GHG objective, a WUP Committee should consider whether it is a factor that one or more Members will use in judging across alternatives and the availability of information to calculate a performance measure.

Characterizing the GHG Impacts of WUP Operating Alternatives

The standard measure for quantifying GHG emissions is metric tonnes of carbon dioxide equivalent (abbreviated as t CO_2e). Some GHGs are more powerful than others in terms of their ability to trap heat in the atmosphere. In order to compare GHGs on a common basis they are converted to carbon dioxide equivalents by multiplying their mass by a factor referred to as "Global Warming Potential" or GWP. In the case of fossil fuel combustion, three greenhouse gases (carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O)) are produced, with CO_2 comprising approximately 99% of these emissions and methane and nitrous oxide contributing very small amounts (approximately 1%).

WUP Replacement Power / Choosing New Energy Supply

The specific source of replacement power will determine the GHG impact of WUP changes. Several options for replacement power were considered in a background study (see inset: Background Study), ranging from GHG intensive sources such as natural-gas fired, single-cycle, peaking plants to GHG neutral green energy supply (see FAQ: Green Supply). The replacement source selected for use in WUPs was the average GHG emissions factor of new resources in the electricity plan, because it:

- represents the most realistic future replacement power upon which to base longer term planning decisions like WUP;
- offers a straightforward reference for calculating the "GHG Factor" used to characterize GHG emissions;
- is consistent with the underlying assumptions used to evaluate the financial impacts of changes in energy production due to WUPs; and
- links the WUP process to the broader electricity planning, and energy and climate change policy development processes within BC Hydro and the Province.

In its 2000 Integrated Electricity Plan, BC Hydro evaluated options for new supply [including CCGT, large and micro-hydro, market purchases and woodwaste] under different resource portfolio scenarios (combination of supply choices). The resource portfolio chosen was 90% CCGT and 10% green energy supply. Green energy supply includes micro-hydro, woodwaste, wind, wave and other resources considered clean and renewable with low net environmental impacts. Assuming CCGT GHG emissions are 340 t CO_2e/GWh and green energy is GHG neutral, this yields an average GHG emission factor for new energy supply equal to 306 t CO_2e/GWh*.

GHG Performance Measure

To quantify GHG impacts as a WUP performance measure [Step 4 of the WUP Process), the GHG **impact** of each operating alternative is estimated by multiplying the **change** in average energy production by the GHG emissions **intensity** of the replacement power:

IMPACT GHG's (t CO_2e)	=	**CHANGE** Δ Energy (GWh)	X	**INTENSITY** GHG Factor (t CO_2e per GW

where:

Impact = Average annual GHG impact (increase or decrease) calculated in tonnes of CO_2 equivalent;

Change = Difference in annual average energy production between the current operation and the operating alternative; units in gigawatt hours (GWh)

Intensity = Average GHG emissions intensity of replacement power; units in t CO_2e/GWh (* the current recommended estimate of intensity, based on BC Hydro's most recent electricity plan, is 306 t CO_2e/GWh *)

As the sample calculation in Table 1 shows, an increase in GHG emissions (Alternative B) represents an environmental impact, whereas a decrease in GHG emissions (Alternative C) represents an environmental benefit. The "Annual Change in GWh" is the replacement supply that will be added or offset as a result of the WUP alternative.

Table 1: Sample Calculation – Using Hypothetical GWh Values

	ALTERNATIVE A	ALTERNATIVE B	ALTERNATIVE C
Energy Production Current Operation	1,000 GWh	1,000 GWh	1,000 GWh
Energy Production Operating Alternative	1,000 GWh	850 GWh	1,100 GWh
Annual Change GWh (needing to be replaced)	0 GWh	+ 150 GWh	- 100 GWh
Annual Change in GHG emissions	0	150 x 306 = 45,900 t CO_2e	- 100 x 306 = - 30,600 t CO_2e
Interpretation	No GHG impact	GHG emissions will increase	GHG emissions will decrease

Considering GHGs in the Trade-Off Analysis

To help participants assess their own GHG impacts values and weights, it may be helpful to place GHG impacts into context, "WUP alternative" GHG emissions can be expressed relative to other emission sources, such as GHG emissions from BC Hydro's system [2,276,000 t CO_2e in calendar 2000]. Table 2 provides additional reference points, and shows how Alternative B from Table 1's Sample Calculation would be placed in the context of these numbers.

The performance measure calculation provides information to the WUP process on the GHG impacts of different operating alternatives. As with other performance measures, the relative weight placed on GHG impacts when comparing alternatives will be an individual Committee Member's decision. It is likely that Members will differ in the weight (i.e. importance) each gives to GHG impacts. The values of the individual Members can be expressed during the discussion of trade-offs [Step 7 of the process] across different operating alternatives for each facility.

The inclusion of the larger numbers in this table is not intended to diminish the GHG impacts from a particular facility. The scale of other performance measures considered in the trade-off analysis at the individual facility level is also likely to be small when looked at relative to system or provincial levels.

Table 2: Reference GHG Emissions Data & Damage Costs

Source of Emissions	**Annual GHG Emissions t CO_2e/yr**	**Alternative B from Table 1** 45,900 t CO_2e	**Reference**
Average Home (BC)	5	918,000%	Environment Canada
BC Hydro System (2000)	2,276,000	2.017%	BC Hydro 2001 Greenhouse Gas Report
Province of BC (1998)	61,100,000	0.075%	Environment Canada
Western Grid (Western System Coordinating Council) – 1998	343,000,000	0.013%	MWA Estimate
Canada (1999)	682,000,000	0.007%	Natural Resources Canada
Other:			
GHG damage cost range*	$5 to $25/t CO_2e	$229,500 to $1,147,500	Shaffer et al (2001); Burrard CBA report

* Estimation of GHG damage costs is very uncertain because of the many unknowns associated with the timing and characteristics of climate change impacts.

Addressing Some Frequently Asked Questions

Q: What About Green Supply Options?

Can reduction in hydro-electric generation be replaced with GHG-neutral green supply options, such as conservation and energy efficiency (Power Smart), green energy resources (wind, micro-hydro, etc.) and/or improved hydro resource use efficiency (Resource Smart)?

The **need for new energy supply** [= Forecast load growth (net amount after Power Smart and energy efficiency reductions) + WUP program losses] is met with **new energy supply** [= New CCGT thermal generation + New green generation + energy purchases – Resource Smart gains].

There is currently no framework within either the electricity planning or system operations processes for specifically allocating "green supply" as the WUP replacement power. Once new green energy supply is brought on line, it becomes part of the BC Hydro system's operations/grid and contributes to meeting all system needs including both customer demand and WUP power losses.

Based on electricity planning estimates (BC Hydro's 2000 Integrated Electricity Plan) and more current information where available, the "green supply" resources that have been identified will not completely meet expected customer load growth *and* WUP program losses. Note that these estimates of "green supply" involve some balance of costs, environmental benefits, technical assessment and availability of supply and are reassessed with each new electricity plan.

Q: What about electricity trade?

Can reduction in hydro-electric generation be replaced by reducing electricity trade (with no new thermal resources)?

Electricity trading allows for more efficient overall utilization of ***existing*** resources by improving the operating and economic efficiency across the entire trading system (which includes BC, Alberta, the western U.S.A. and portions of Mexico). It is currently BC policy to meet domestic load with domestic supply, although there may be years when energy imports exceed exports for a variety of reasons, such as market conditions, low water levels and the supply/demand balance in the BC Hydro system. Since electricity trade typically involves short term decisions regarding the use of existing facilities, it can reasonably be excluded from consideration as a possible GHG impact of WUP decisions, which are considered in line with long term electricity planning.

Q: Are there other GHG impacts associated with WUP operational changes?

Other possible GHG impacts include increased recreational use of reservoirs (by power boats, vehicles, etc.) and physical changes to the hydro reservoir (e.g accelerated decay of flooded plant material due to lower reservoir levels or increased CO_2 uptake from the atmosphere due to shoreline re-vegetation, etc.). These impacts are considered relatively small and too difficult to quantify for inclusion in the GHG performance measure.

Background Study

The WUP Management Committee (WUP MC) and Resource Valuation Advisory Team (RVAT) hired the independent consulting firm MWA Consultants to provide an objective overview of the GHG issue within the context of WUP, including methods to characterize the GHG impact. This study included interviews with numerous individuals involved in the WUP process to identify concerns, questions and solutions. A detailed discussion paper that documents MWA's analysis and research is available from BC Hydro's Water Use Planning.

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