2012 Integrated Resource Plan

BC hydro

Appendix

5B

Quantifying DSM Uncertainty

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1 Introduction

BC Hydro continues to be a North American leader in pursuing energy savings in response to increasing electricity demand. BC Hydro is expected to meet the majority of its load growth through energy conservation to achieve the B.C. *Clean Energy Act* energy conservation objective. As such, a considerable effort to better understand the uncertainty inherent in this demand-side resource and incorporate it into the decision-making framework is warranted.

Appendix 5A is a generic description of some of the tools used in the Risk Framework to quantify uncertainty. This Appendix will demonstrate how these tools were applied in the case of quantifying the uncertainty around DSM savings estimates.

This appendix will focus on energy savings and uncertainty arising from three strategic elements of DSM:

- Programs;
- Codes and Standards; and
- Rate structures,

and will also address uncertainty of associated capacity savings resulting from these three DSM tools. Additional details regarding the composition of these tools can be found in Chapter 3 of the IRP.

The goal of this Appendix is to provide an additional level of detail regarding the calculation of the DSM uncertainty estimates presented in Chapter 5 of the IRP. As this Appendix is a companion piece to the main body, substantive comments and observations of the results can be found in Chapter 5.

2 Energy Savings from Programs

Program savings are made up of over twenty-five individual programs spread across the residential, commercial, and industrial customer groups. While BC Hydro does have extensive experience working with its customer groups to encourage energy conservation and efficiency, the fact that DSM depends on voluntary customer participation makes forecasting DSM savings inherently uncertain. As a result, the performance risk of these energy savings was made a key part of the IRP Risk Framework's quantitative uncertainty analysis.

While each individual DSM program was planned to achieve a certain level of energy savings by F2020, the level of energy savings per program is subject to two key drivers of uncertainty;

- The participation rate of customers for that program; and
- The energy savings per participant.

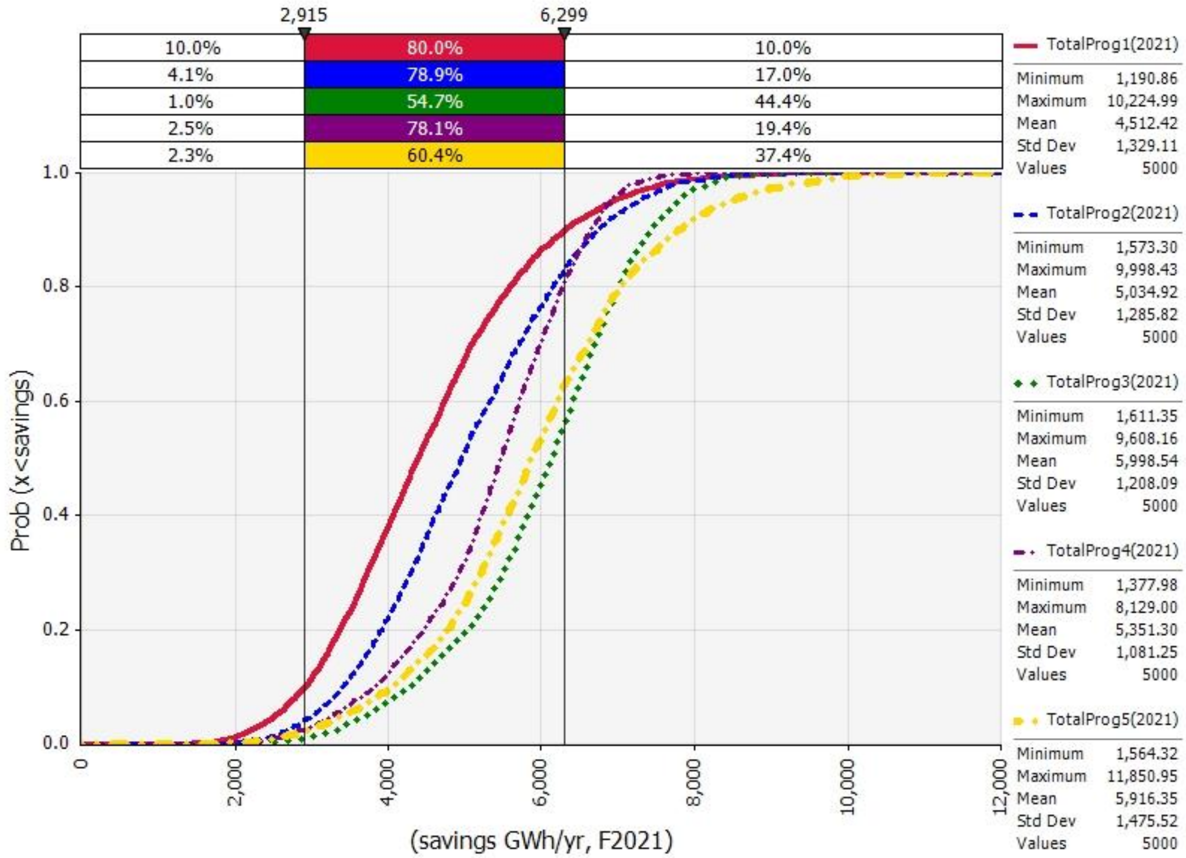
Total savings from DSM programs was estimated as simply the sum of the twenty-five individual DSM programs. However, calculating the spread of uncertainty was more involved as significant interdependencies amongst some of the key drivers of uncertainty are expected; failing to capture these interrelationships would significantly understate the spread of uncertainty around DSM Program savings.

The first key interrelationship estimated was participation rates. It was felt that BC Hydro's DSM promotion and marketing strategy and the creation of a "conservation culture" through raised awareness, advertising, or accessible energy saving information could be seen as a common influence across all sectors. As a result, BC Hydro staff estimated a moderate correlation of 0.5 amongst participation rates across all programs and across all customer classes.

A second set of important relationships was that between the participation rate and the savings per participant for each program. It was felt that a DSM program that delivered more savings per participant than planned would draw in more participants, but that those that did not deliver high savings per participant would see fewer participants involved. BC Hydro staff estimated that there would be a correlation of about 0.3 for this relationship. This means that these variables would tend to move together, but that it would not be uncommon to find higher than planned participation rates even when savings for that program were lower than planned, and lower than planned participation rates for some programs even when savings per participant were higher than planned.

Total DSM program savings were taken as a sum of the savings from the twenty-five individual programs. The savings from each program was a random variable, depending on the product of the participation and the savings per participant. Taking into account interrelationships amongst these random variables, a Monte Carlo simulation analysis was carried out using 5,000 random draws to calculate the total savings across all customer classes. The results are shown in Figure 1.

Figure 1 DSM Program Savings Uncertainty (GWh/year, F2021)



This cumulative distribution function is read in the following way. The legend on the right hand side denotes the total programs savings from each of the five DSM options in F2021. The horizontal axis denotes savings in F2021. The vertical axis gives the probability of seeing that level of savings or less. As an example, DSM Option 1 (the solid line) transects the point (0.4, 4,000). That means there is a 40 per cent chance that DSM Option 1 programs will deliver less than 4,000 GWh/year savings in F2021.

The results of this analysis are presented Table 5.4 of Chapter 5 of the IRP where the mean is reported as well as the P10 and P90 statistics to give readers an idea of the spread of uncertainty.

3 Energy Savings From Codes and Standards

BC Hydro included over fifty potential changes to codes and standards that could be encouraged or accelerated to achieve energy savings, including changes to both federal and provincial regulations.

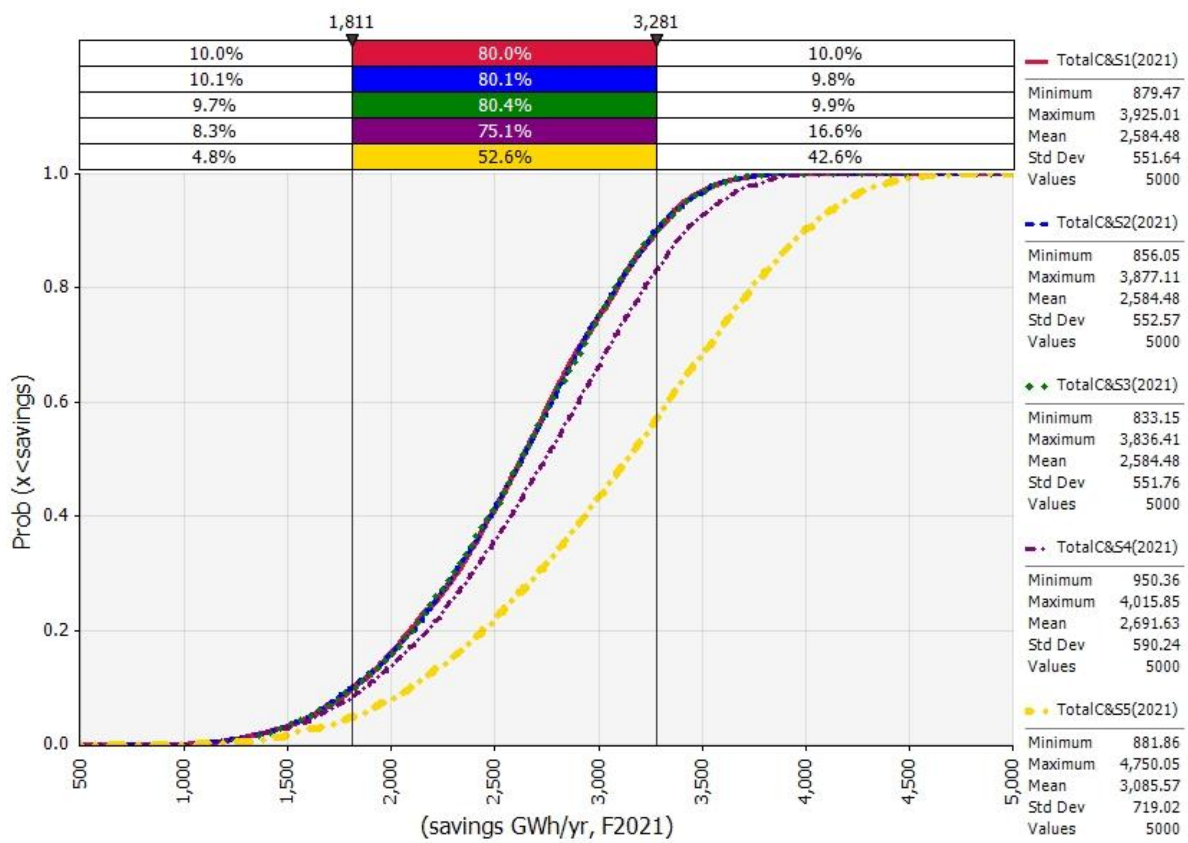
The estimates of these savings were subject to several sources of uncertainty, including the timing and efficacy of these changes due to support from the business community, the general public and policy makers, and the level and rate of adoption and compliance with these changes by end users. BC Hydro staff participated in several workshops to elicit ranges and probabilities around these energy savings estimates. These conversations followed similar guidelines to those used when discussing the potential success of DSM programs.

The total amount of energy savings attributable to changes codes and standards was treated as the sum of all of the individual codes and standards changes. However, the spread of uncertainty around this estimate required additional analysis as BC Hydro staff identified several ways in which the success (or lack of success) amongst the codes and standards would probably be correlated.

Staff identified several common drivers of uncertainty for changes to codes and standards including continued support from the business community, general public and policy makers. It is expected that the success or lack of success with codes and standards savings might tend to move together. However, this correlation is not perfect as there are different levels of decision makers, and each code and standard is also subject to resistance or support from diverse stakeholders. The estimate was that this effect could be strong, but there was not enough information to differentiate amongst different levels of government/ decision makers. As a result, the IRP risk framework used a correlation of 0.6 amongst all changes.

Savings from changes to codes and standards was calculated as the sum of the savings arising from each of the roughly fifty changes to regulations. Using the estimated energy savings, the probability distributions, and the assumed relationships among these efforts, a Monte Carlo simulation analysis was run using 5,000 random draws to estimate the expected level of energy savings and the spread of outcomes around this mean. These results are summed up in Figure 2.

Figure 2 DSM Codes and Standards Savings Uncertainty (GWh/year, F2021)



The results of this analysis are presented in Table 5.5 of Chapter 5 of the IRP, where the mean is reported as well as the P10 and P90 statistics to give readers an idea of the spread of uncertainty.

4 Energy Savings From Rate Structures

Estimates of energy savings arising from rate design are uncertain, particularly in B.C. where, until recent years, customers had been facing low and stable rates. So data specific to this jurisdiction is only now becoming available to guide forecasts. As a result, it was important to consider the range of uncertainty around rate savings estimates.

To capture the range of uncertainty, rate savings were forecast using a wide range of elasticity of demand estimates. Elasticity of demand is a parameter that describes the percentage change in quantity consumed divided by the percentage change in the price charged. The ranges of elasticity estimates used are shown in Table 1.

Table 1 Elasticity of Demand Estimates

	Low Estimate	**Mid Estimate**	**High Estimate**
Residential Rates			
Elasticity Parameter	-0.05	-0.1	-0.15
Probability (%)	30	40	30
Commercial Rates			
Elasticity Parameter	-0.05	-0.1	-0.15
Probability (%)	33	34	33
Industrial Rates (Distribution)			
Elasticity Parameter	-0.05	-0.1	-0.15
Probability (%)	33	34	33
Industrial Rates (Transmission)	Minimum Estimate	Mid Estimate	Maximum Estimate
GWh/year savings, F2021	62	531	2,424

The one exception to this method of capturing uncertainty is in the estimate for savings from Industrial Transmission rates. Since these are targeted at a much smaller number of individual customers, savings were estimated by eliciting a range of subjective forecasts from BC Hydro staff. These are reported in the bottom row of the table above.

A simple additive model was assumed for the total rates savings across all customer classes; the total rates savings was calculated as the sum of rate savings from each rate class.

However, calculating the appropriate range of rate savings required more than just adding up the individual results. It was identified that the performance of the rate structures across rate classes was probably interrelated; capturing some aspects of these correlations was needed in order to get a better sense of the spread of uncertainty around the average.

Concerning the elasticity measures, it was felt that the ability to respond to changing energy prices is probably similar amongst the commercial and industrial customers. However, these customers' ability to respond are probably not correlated to the ability of residential customers to respond in the face of new rate structures.

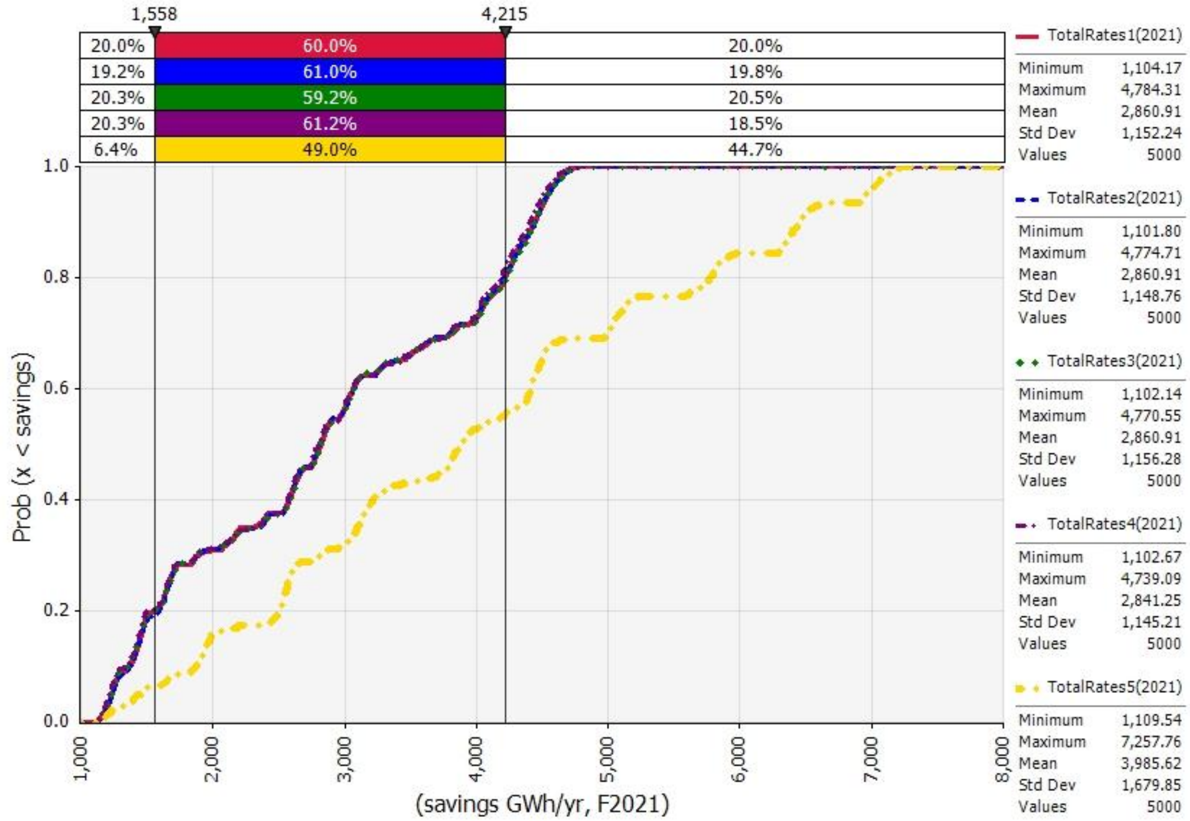
Table 2 summarizes this in the following way. Savings arising from rate changes seen at the business level (commercial and industrial) were estimated to be strongly correlated (0.9), but only loosely correlated to savings seen from residential customers (0.1).

Table 2 Correlation Matrix - Interrelationships Among Rate Structure Savings by Sector

	Residential	Commercial	Industrial (Distribution)	Industrial (Transmission)
Residential	1			
Commercial	0.1	1		
Industrial (Distribution)	0.1	0.9	1	
Industrial (Transmission)	0.1	0.9	0.9	1

Total rate savings was taken as the sum of rate savings from each customer class. Taking interrelationships into account, a Monte Carlo simulation analysis was carried out using 5,000 random draws to calculate the total savings across all customer classes. The results are shown in Figure 3.

Figure 3 DSM Rate Structure Savings Uncertainty (GWh/year, F2021)



Given initiation and implementation timing, additional savings from new rate designs for Option 4 only show up in the data past F2021. Therefore, the estimated rate savings uncertainty for Options 1 to 3 and Option 4 look similar in F2021. As a result, the uncertainty estimates derived here understate the additional uncertainty arising from shifting from Option 3 rate structures to the new rate designs for Option 4.

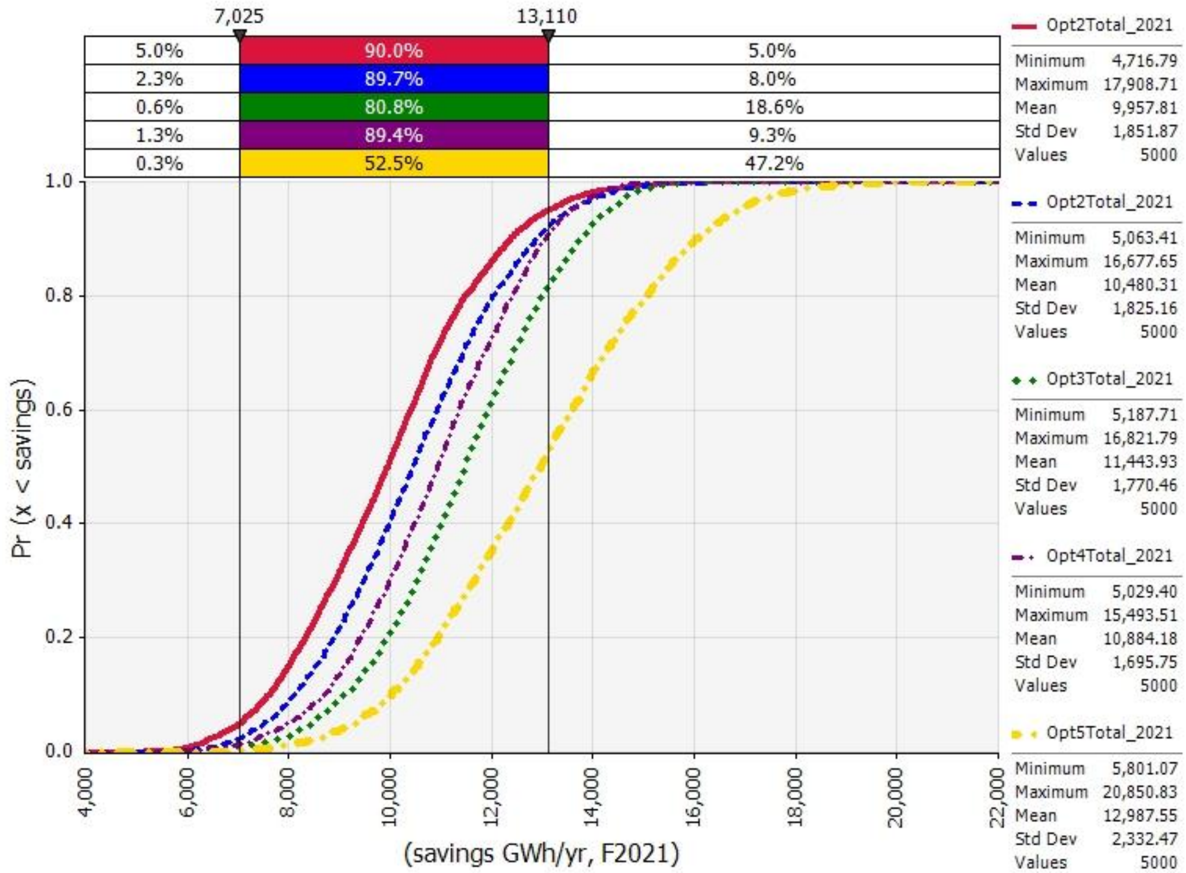
The results of this analysis are presented in Table 5.6 of Chapter 5 of the IRP where the mean is reported as well as the P10 and P90 statistics to give readers an idea of the spread of uncertainty.

5 Total DSM Energy Savings

The total energy savings from DSM was modelled as a sum of the energy savings across customer classes arising from programs, changes to codes and standards, and conservation rate structures. It was assumed that the level of energy savings arising from each of these three DSM tools (programs, codes and standards, and rate structures) was independent from each other.

A Monte Carlo simulation analysis was carried out and 5,000 random draws were used to calculate the mean and spread of outcomes for all DSM savings. The results for this are shown in Figure 4. Since the total savings was calculated as a line-by-line aggregation across the three DSM tools, this is referred to here as a "bottom-up" analysis.

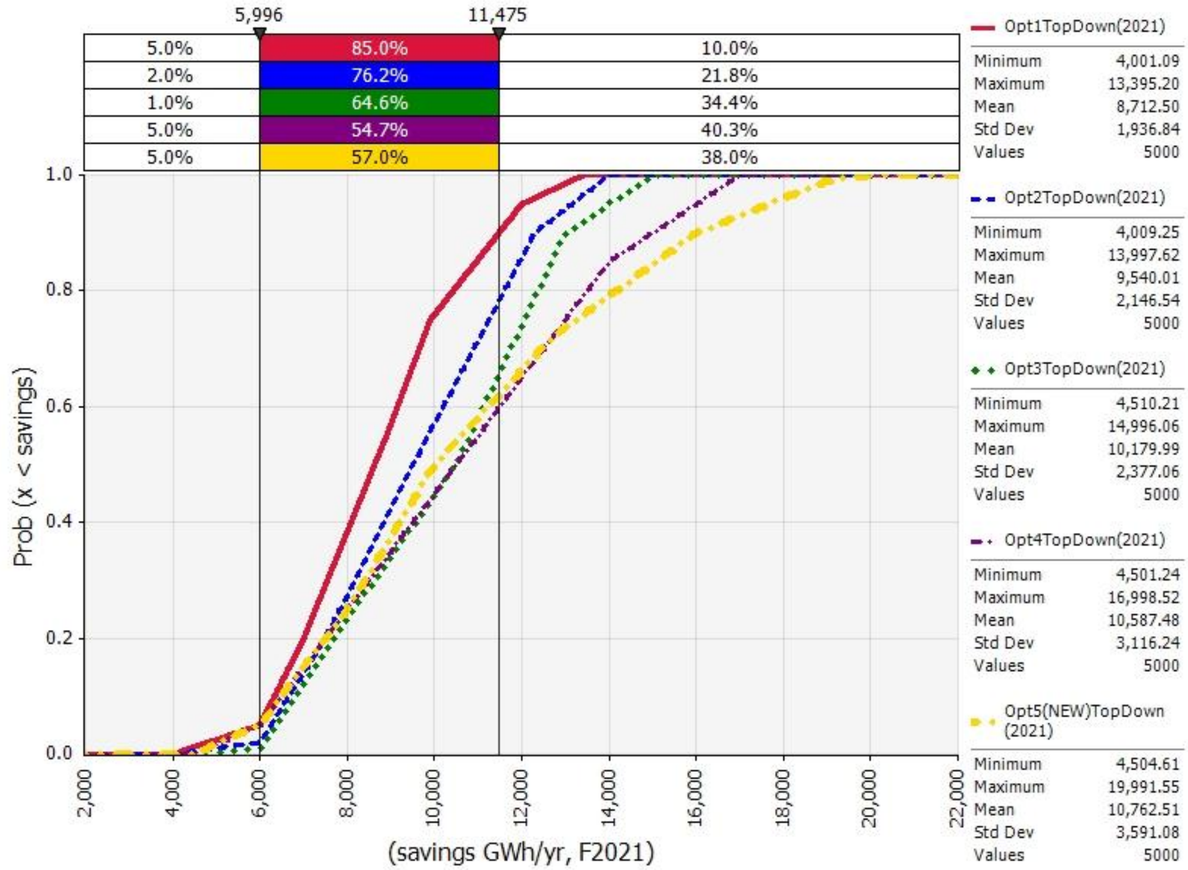
Figure 4 Total DSM Savings Uncertainty – Bottom Up Analysis (GWh/year, F2021)



The results of this analysis are presented in Table 5.7 of Chapter 5 of the IRP, where the mean is reported as well as the P10 and P90 statistics to give readers an idea of the spread of uncertainty.

As discussed in Chapter 5, a more holistic approach was taken to DSM savings uncertainty, using the bottom-up results as a starting point for discussion, but then also taking into account how the different DSM tools might interact and lead to savings much greater or much smaller than anticipated. The results of this top down assessment are shown below.

Figure 5 Total DSM Savings Uncertainty – Top Down Analysis (Gwh/year, F2021)

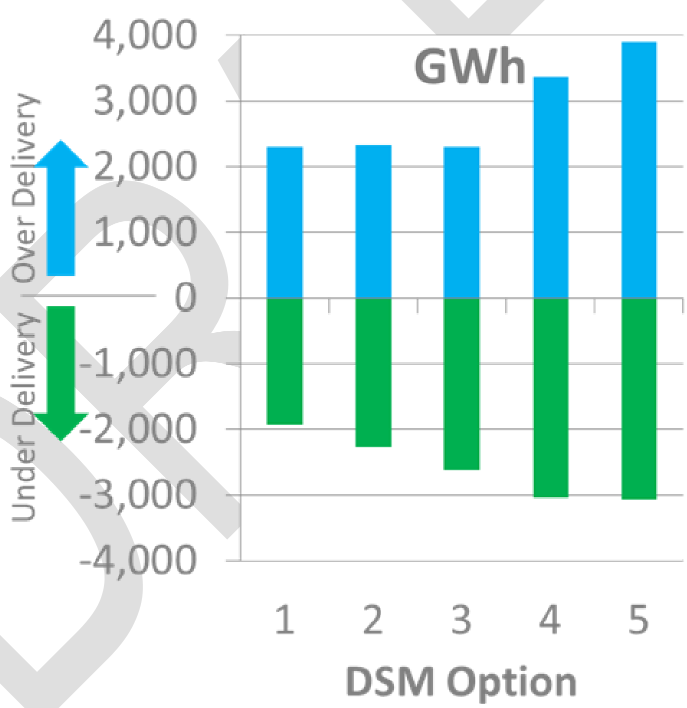


The results of this analysis are presented in Table 5.8 of Chapter 5 of the IRP, where the mean is reported as well as the P10 and P90 statistics to give readers an idea of the spread of uncertainty. A comparison between the bottom up and top down results is presented in section 5.2.3.2.1.

Section 5.2.3.2 also traces out how the results derived from Figure 5 and Table 8 (from Chapter 5) are translated into a form that is the basis for the net load and net gap results used in the portfolio modelling. A second reconciliation of interest would be between the results in Chapter 5, Table 5.8 and the DSM savings presented in the Resource Options Report. The savings estimates in the DSM Resource Options Report represent initial estimates, before any adjustments were made for uncertainty. As a result, those estimates and the mean values used in modelling for the IRP will differ.

Figure 6 below reproduces Figure 5-5 of section 5.2.3.2.1 of the IRP. This was produced by taking the difference between the mid-level of DSM energy savings to the high and the low levels of DSM savings. The year F2020 was taken as an arbitrary point in time to illustrate the point. Results were similar although smaller for earlier years.

Figure 6 Size of Deviation from Mid-Energy Savings Forecast (F2020)



Note by construction that the calculated probability of seeing these values is 20 per cent as they were taken from the upper and lower branches of the DSM probability tree (refer to Figure 2 in Appendix 5A). Higher and lower values are also possible, but at a lower probability.

6 Energy Associated Capacity Savings

As discussed above, while the energy savings associated with energy-focused DSM are uncertain, there is an additional level of uncertainty introduced when calculating the capacity savings associated with these energy savings. This topic is addressed briefly in sections 5.2.3.2.1 and 6.10.6 of the IRP. Additional details underlying these analyses are provided here.

Energy savings will translate into capacity savings to the extent that the individual sources of energy savings (e.g., reduction in energy used for lighting, heating, cooling) occur in the short time frame that defines peak load. A capacity factor is the mathematical parameter that translates GWh (energy) savings into MW (capacity) savings. If the bulk of energy savings occurs during weekday, evening, dark, and winter hours (e.g., savings on residential lighting), then the capacity factor will be high since this is when the system peak occurs. But if energy savings is spread out evenly across all hours of the year, then peak savings will be low and the capacity factor will be low.

BC Hydro staff identified three key drivers of uncertainty when estimating capacity factors:

- Measurements of peak load by end use;
- The shape of energy savings applied to load; and
- Extrapolating results into the future (forecasting).

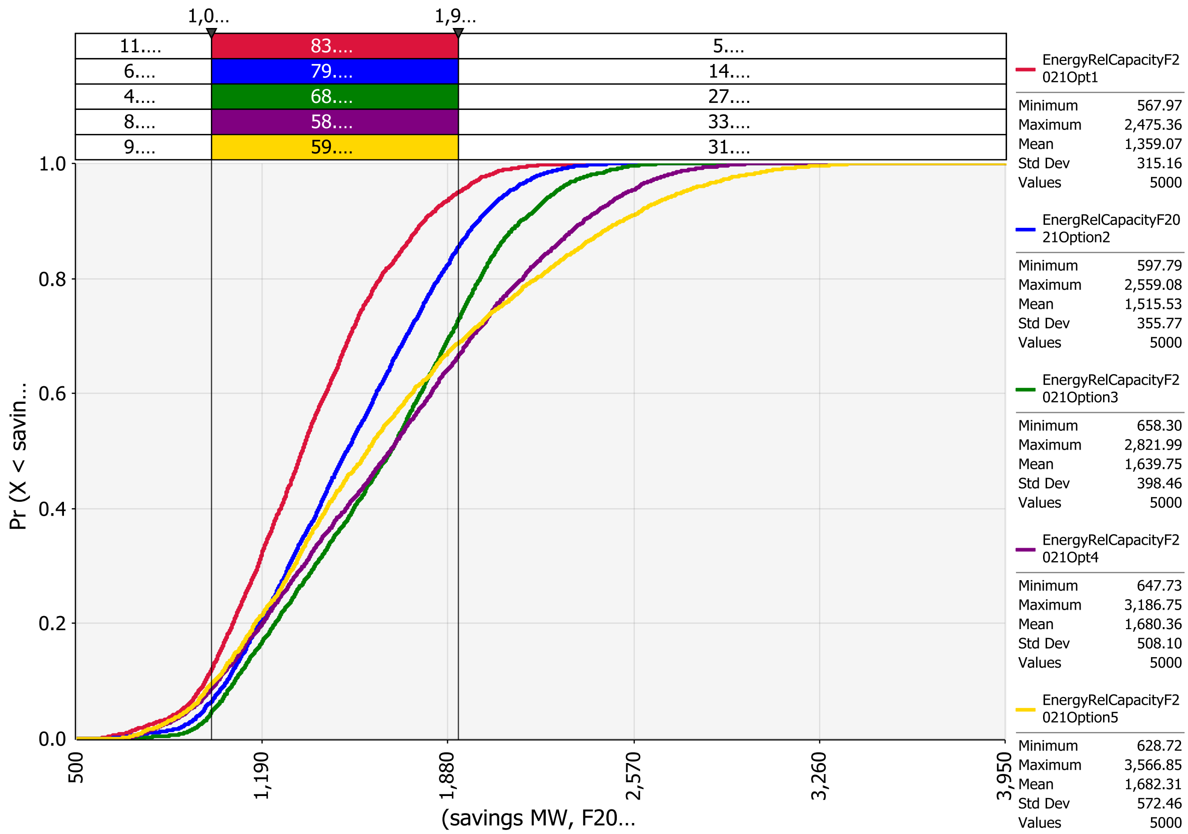
Since these influences may vary, depending on customer class, the relative importance of each of these was considered for the residential, commercial, and industrial customers. A range of capacity factors and a best estimate was derived for each customer class that took into account these factors. An additional distinction was made between savings arising from customers' behavioural change versus other DSM measures, for example the installation of energy-efficient equipment. These ranges are reproduced in Table 3.

Table 3 Capacity Factor Estimates, by Customer Class

	Capacity Factor Estimates		
	Lower Bound	**Most Likely Estimate**	**Upper Bound**
Behaviour **Industrial**	0.1	0.13	0.14
Commercial	0.12	0.14	0.15
Residential	0.14	0.215	0.32
All other DSM **Industrial**	0.1	0.12	0.14
Commercial	0.12	0.135	0.16
Residential	0.15	0.2	0.27

Using these estimates, triangular distributions were used to capture the range of possible values and their associated probabilities for capacity factors. A Monte Carlo simulation was undertaken using 5,000 draws to derive a distribution of possible capacity factor values across all customer classes. When multiplied by the energy savings in each customer class and summed, this gave an estimate of total capacity savings for each DSM option. This is reproduced below in Figure 7.

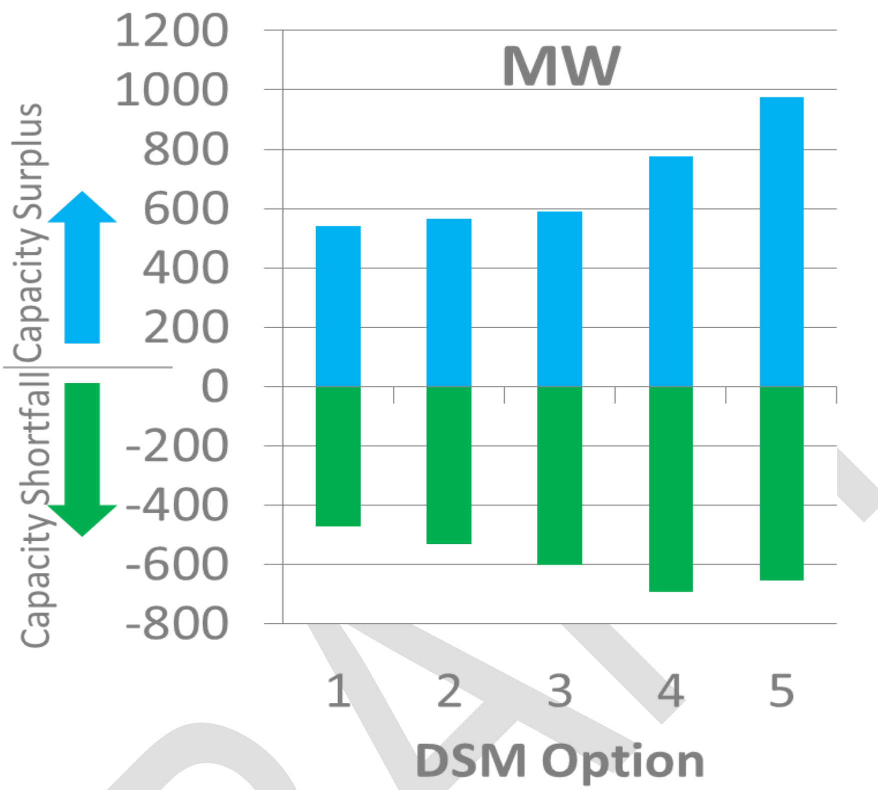
Figure 7 Energy Associated Capacity Savings (MW, F2021)



One way of looking at uncertainty around capacity arising from DSM savings to is to examine the standard deviation statistics listed at the right-hand side of Figure 7. As Figure 7 shows, moving to higher levels of DSM increases the uncertainty.

The spread of uncertainty is not directly related to downside risk, however. Figure 8 reproduces Figure 6-39 from section 6.10.6 of the IRP, showing how much BC Hydro could be surprised if DSM capacity savings differ from the expected amount.

Figure 8 **Size of Deviation from Mid Capacity Savings Forecast (F2020)**



The quantities are derived from calculating the difference between the mid and the high and low DSM savings outcomes in F2020. In particular, this shows how the magnitude of a capacity shortfall changes across DSM options. As with this view on energy, the year F2020 was chosen arbitrarily for illustrative purposes. Similar results, albeit smaller, were found for earlier years.

7 Overall Conclusions Regarding DSM Savings Uncertainty

While energy conservation continues to be BC Hydro's first and best response to load growth, the inherent uncertainty in DSM savings, the degree of reliance BC Hydro is placing on this resource, and the uniqueness of the tools used to characterize this uncertainty for decision making continue to warrant the extra effort and attention displayed in this IRP.

Despite the advancement in understanding around some of these issues (see the conclusion of section 5.2.3.2 for a more complete discussion), uncertainty around the large DSM savings being targeted continues to be a central issue in long-term energy planning. These are difficult issues and none of them can be considered “solved”. Moreover, data sets and learning continue to evolve over time, even over the course of an energy planning cycle. So while the focus of this Appendix has been on the quantification of DSM uncertainty, it is important to keep in mind that professional judgment will continue to play an important role in both the interpretation of data and in balancing DSM deliverability risk with other key energy planning objectives.