Clean Power 2040
Powering the future

2021 Integrated Resource Plan (IRP) Technical Advisory Committee (TAC) Meeting #7

December 16, 2020

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Welcome & meeting context

Basil Stumborg, BC Hydro

Kathy Lee, BC Hydro

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Agenda overview

Meeting purpose – to present early modelling results and seek input on the approach to analyze elimination of the self-sufficiency provision

9:00 START		TBD BREAK		12:00 LUNCH		TBD BREAK	3:00 CLOSE
Welcome & meeting context	Energy Choices	Capacity Choices	Non-Cost Considerations		100% Clean & Self Sufficiency Energy	Self Sufficiency Capacity	Next steps
Kathy Lee	Basil Stumborg	Basil Stumborg	Basil Stumborg		Kathy Lee	Kathy Lee Dan O'Hearn	Basil Stumborg

Virtual meeting etiquette

These principles should make our meetings more effective

- As with in-person meetings, continue to have members participate and alternates observe
- Keep the conversation respectful by focusing on ideas, not the person
- Stay curious about new ideas
- Share the air time – to ensure everyone gets heard

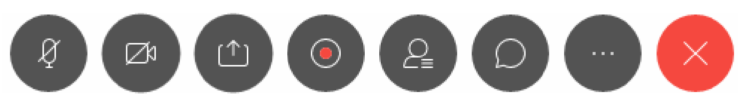
- To minimize distractions – keep yourself on mute
- We’ll use the chat box to seek input and ask questions
- We’ll not be recording these sessions, and ask for others not to record

Cisco Webex reminders

We'll be using a few basic tools, which you can find if you hover your mouse over the bottom of the screen

Mute/unmute your mic
& turn your video on/off

View the
participant list



Open the chat panel:
- to ask questions
- to provide feedback

Audio connection trouble?
See the alternative options here

Quick primer on portfolio modelling

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Portfolio Modelling in the IRP

The use of portfolio modelling in IRP development is widespread across the electricity industry

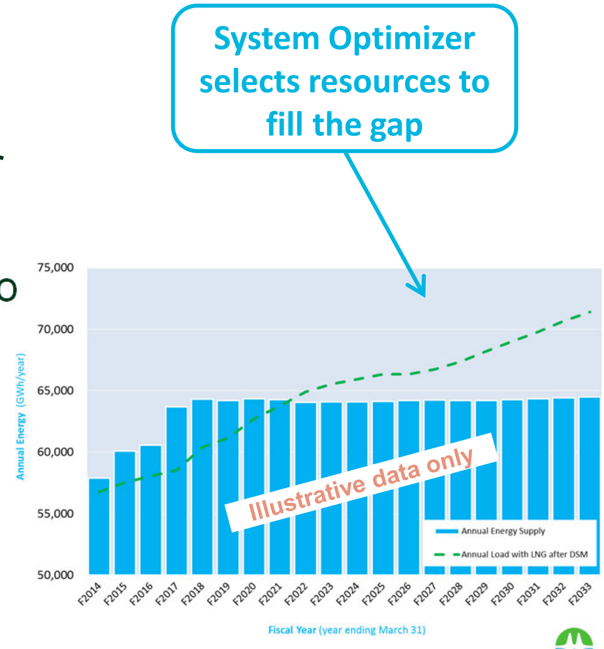
System Optimizer

- Offered by Hitachi ABB Power Grids
- Used for integrated resource planning by several other utilities (e.g. Tennessee Valley Authority, PacifiCorp, Duke Energy, Great River Energy, Southern California Edison)
- Similar models from other vendors (AURORAxmp and PLEXOS from Energy Exemplar, EnCompass by Anchor Power) are used by many utilities in resource planning

Use of System Optimizer

Cost of a portfolio includes cost of new generation and transmission, fuel, and import costs and export revenue

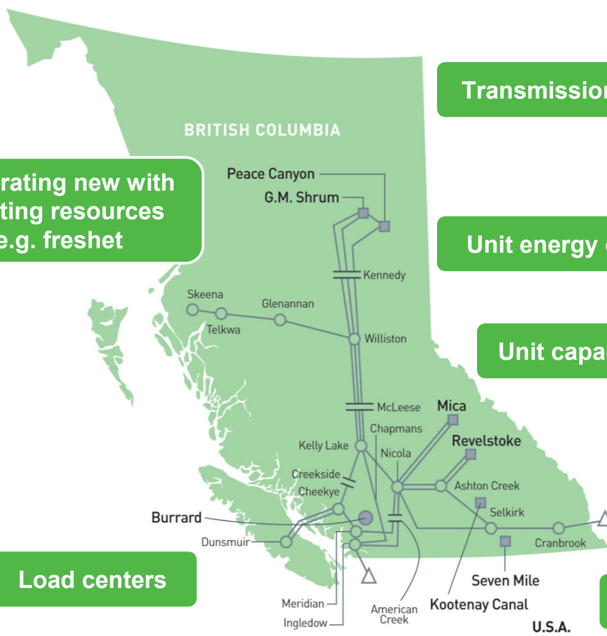
- System Optimizer uses a mixed integer programming algorithm to select a portfolio of future resources that minimizes cost (PV over a 20-year period)
- A typical run takes between several minutes to many days, depending on complexity
    - The model determines the lowest cost, feasible solution to filling the gap between existing and committed resources and future demand



Consideration in developing a portfolio

Characteristics of resources, demand, market prices, transmission system are all determinants in resource selection

Integrating new with existing resources e.g. freshet



Transmission to move power

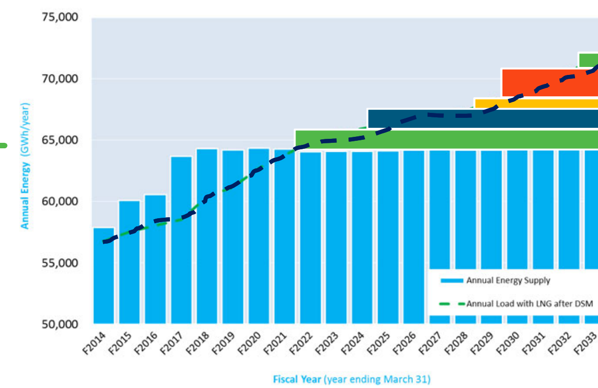
Unit energy cost

Unit capacity cost

Load centers

Export market

The model fills the supply/demand gap in energy and capacity in the lowest cost way



Portfolio

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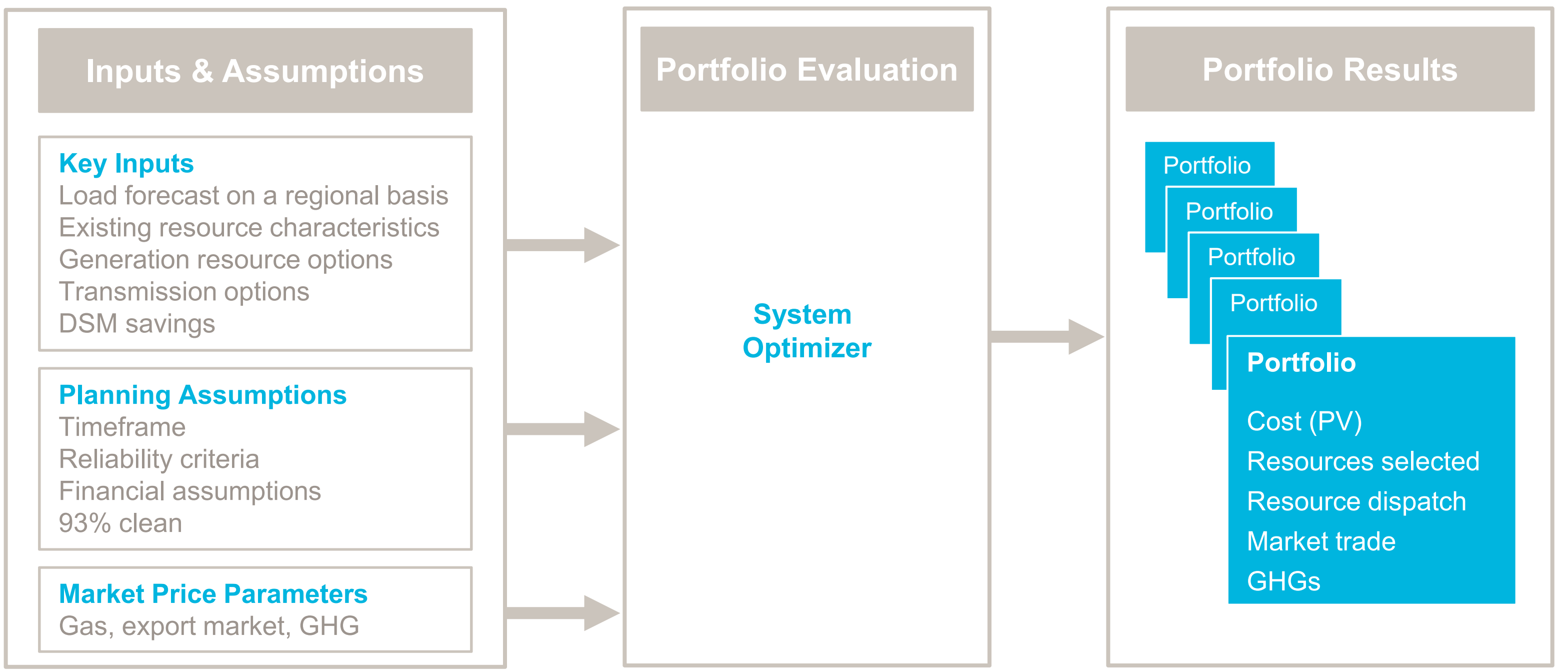
System Optimizer – inputs and outputs

IRP development involves model runs for multiple scenarios of load, market prices, and other uncertain factors



Reminder of Resource Options

These are the categories of resource option bundles, many having their own variations

- **DSM energy:** No DSM, current plan, more aggressive, new construction program, solar program
- **DSM capacity:** Direct load control, load curtailment, peak saver. EV DR removed for rate (below)
- **Rates:** Three suites developed by combing of Time of Use, Critical Peak Pricing, demand charges, and optional / default deployment strategies, EV peak reduction (in development)
- **IPP renewals:** No renewal vs. optional renewal for remaining asset life [if available] followed by optional renewal at refurbish cost vs renew at blended long term renewal cost
- **BC Hydro upgrades:** REV6, GMS1-5 capacity, Wahleach capacity, Alouette and Falls River redevelopment
- **BCH/IPP greenfield:** Wind, solar, batteries, pumped storage with cost decline estimates etc.

Modelling selects resource options based on generic transmission solutions. Detailed transmission analysis are being done on select portfolios of resource options.

Recap of Decision Framework Elements

FOR PRE-READ ONLY

Decision framework – recap

Motivation for showing simple cost results today against Reference Load Forecast

- System modelling run develops least cost portfolio that is a feasible solution for a given set of input assumptions:
  - Load forecast scenarios, prices, availability of resources
- Additional modelling is available to flesh out tradeoffs
  - Uncertainties/risks
  - Environmental impacts
  - Economic Development impacts
- Depth of analysis is a judgement call balancing:
  - Value of Information
  - Project Schedule
- The IRP Application will contain much more fulsome treatment

Decision framework – preview for today

General approach to complex, interconnected problems

Interconnected decisions – everything is linked to everything

General tactic when confronting difficult problems is to:

- Decompose the problem
- Analyze pieces separately
- Put individual pieces back together
- Check to see if simple answers capture more dynamic, interrelated issues

For this IRP, this seems to be unfolding in the following way:

- Looking at capacity needs in the LMVI region first
- Finding elements of a solution against Reference Load Forecast
- Looking at long term implications of these early term actions (energy and capacity)
- Looking at performance of these elements under uncertainty (performance, load forecast)
- Addressing regional considerations

Decision framework – preview for today

Motivation for showing NPV results today against Reference Load Forecast

First step – look at a low cost solution against Reference Load Forecast, and then:

- Vary individual elements
  - Lower/Mid/Higher levels
- To build understanding
- To surface non-financial impacts of interest
- To highlight tradeoffs

Subsequent steps will explore:

- Other load forecasts / scenarios
- Non-financial impacts

Roadmap for the Review of Preliminary Modelling Results

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Modelling supports decision making

Analysis to date has focused on least cost portfolio to meet reference case, more considerations (e.g. contingencies) to come

Portfolio modelling → **Decision Framework** → **Draft actions**

Lowest cost, feasible solution for a given load forecast or scenario

Deeper dive into tradeoffs (where warranted):

- Uncertainty/risk
- Consultation results
- Other impacts, e.g. environmental footprint, economic development

Roadmap & Objectives

Early modelling results

The following slides will look at modelling results in the following ways:

- Energy needs in the near term
- Capacity needs in the near term

The goal of these sections is to:

- Generate understanding of early modelling results
- Get a sense of what else besides "lowest cost" needs to be considered

Near-Term Energy Choices

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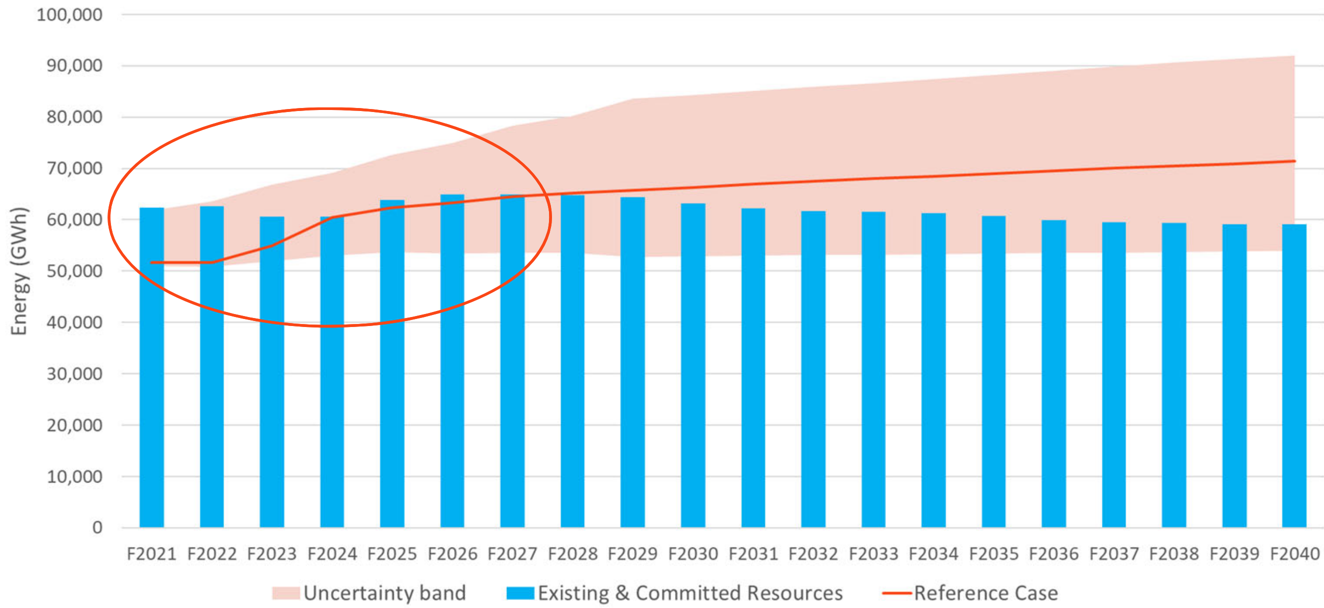
Load Resource Balance – Energy

We expect to have enough resources to meet B.C.'s energy needs for roughly a decade



Modelling results for energy choices

Insights will be used to unearth questions and/or point towards solutions

- Key ‘levers’ for IRP consideration:
  - Level of DSM Energy Efficiency
  - EPA renewals

Incremental value of DSM EE

DSM Energy Efficiency is cost effective in the ranges tested

- Energy Efficiency options presented to TAC earlier
- Some EE options are always above cost of new energy supply
- Modelling results show remaining EE can add value during surplus
    - Results driven by EE costs being below spot market

Description	Capacity Savings (MW) by 2040	NPV Savings over No DSM EE ($M)
Base DSM only	240	$1,200
Base + Higher DSM	430	$2,500

Incremental value of DSM EE

More analysis is needed to understand the other dimensions of financial impacts

Some additional insights

- EE level didn't affect EPA renewals during surplus
  - But it does change the date at which LRB switches to energy deficit
- Other financial considerations:
  - We expect rate impacts to move opposite to cost (TBC)
  - Figure shown are Total Resource Costs
    - Utility Cost calculations show Higher DSM less attractive (TBC)

Discussion & feedback

Let’s check in on the section that was just presented

Please share any questions or comments you may have:

- Clarification needed on this section?
- Additional information needed to inform your feedback on this section?
- Do you have feedback to help BCH make an informed decision on this topic?

Incremental value of EPA renewals

Insights from modelling different levels of DSM

- Modelling shows that it is cost effective to renew some EPAs during a system energy surplus.
- These results were driven by the assumption that certain projects with remaining asset life and a low cost of service will be viable at market price for a significant period of time (i.e.10 to 20 years)
- BC Hydro's actions for acquiring energy will be informed by these modelling results

Discussion & feedback

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Near-Term Capacity Choices

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Options that provide capacity – recap

Capacity- focused resource options considered

- **DSM Energy Efficiency:** Energy savings also come with significant capacity savings
- **Rates:** Time varying rates, including EV Peak Reduction
- **DSM Capacity Focused programs:** Demand Response, Industrial Load Curtailment
- **Batteries**: Up to 500MW considered
- **IPP renewals:** some capacity along with energy focused projects
- **BC Hydro upgrades:** Wahleach capacity, Revelstoke 6 etc.
- **BCH/IPP greenfield projects:** including small storage hydro and pumped storage projects

Incremental value of rates

Holding everything else constant, how do costs change as this is varied?

- Rate Design options shown to TAC previously
- Subsequent work has paired Base DR with all rate options
  - This better reflects the level of support required for successful rate design implementation
    - A modelling workaround
  - Detailed integration underway

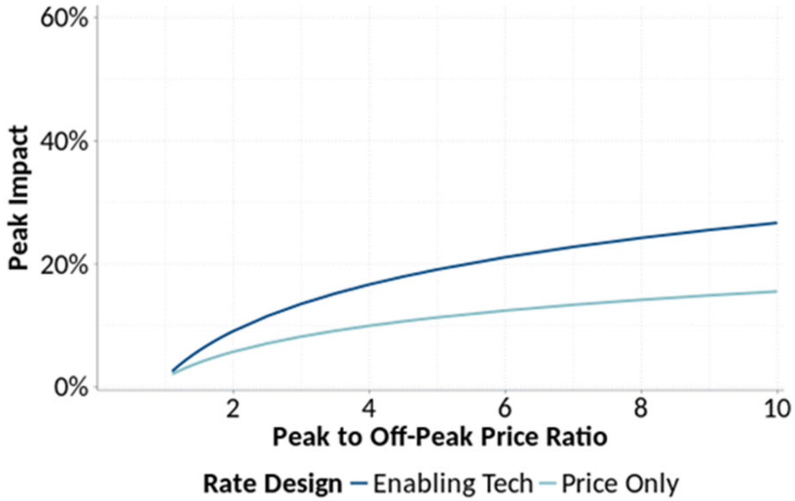
Pairing Demand Response and Rates

We'll be examining how integrate demand response and time varying rates for synergies

- Program support in other jurisdictions has been important to increase the likelihood of acceptance, adoption and success of the time-varying rate options
- Without meaningful incentive-based program support, customers will lack the necessary tools to respond appropriately and sufficiently to BC Hydro's proposed time based pricing signals
- We intend to use the base Demand Response program option as program support for the rate options – by combining the costs and the incremental MWs from the program option to the capacity savings of the rate options

Pairing Demand Response and Rates

Price Responsiveness
with and without Emerging Technology



Source: Brattle Group. Results from 334 pricing treatments collected in the Arcturus 2.0 database. Graph does not include 15 Variable Peak Pricing (VPP) treatments (3 without enabling technology and 12 with enabling technology). See Faruqui, Ahmad, Sanem Sergici, and Cody Warner, "Arcturus 2.0: A meta-analysis of time-varying rates for electricity." The Electricity Journal 30(10) (December 2017): 64-72.

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Incremental value of rates

Rates provide valuable capacity savings

- Initial modelling results show a high incremental value for Rate Design options
- This value comes from deferring or eliminating built options

Description	Capacity Savings (MW) by 2040	NPV savings over no new rate design ($M)
Rate Option 2	330	$100
Rate Option 3	580	$400

Incremental value of Demand Response

We have made changes to our Demand Response options

- Updates to our Demand Response options included:
  - Pairing of Base Demand Response with all rate options
  - Removing EV Demand Response in response to analysis showing other possibilities to address EV peak (see later slides)
- Savings from Demand Response programs are dependent on the rate structures in place, as they target the same customer loads

Another tool to address EV Peak Growth

We're exploring new DSM tools to target reducing EV peak growth

- Capacity growth in LM-VI driven mostly by EV adoption
  - EV uptake ramps up sharply after 2030
- BC Hydro load forecast assumes a 25% reduction in EV peak
  - But this is attributed to actions outside of BC Hydro
- EV Peak reduction is an opportunity within this IRP
  - What is the value of reducing EV peak load growth?

Incremental value of EV peak reduction

Even partial reductions of the EV peak can represent large capacity savings

- This IRP will explore the value of BC Hydro actions to reduce EV peak load growth
- Two levels of reduction will be examined
- Design and costing are underway

Option	Description	MW savings by 2040 (Incremental to no action)
No action	EV Peak Reduction left at 25% assumed in Reference Load Forecast	–
Level 1	EV Peak Reduction increased from 25% to 50%	570
Level 2	EV Peak Reduction increased from 25% to 75%	1100

Incremental value of EV peak reduction

These large capacity savings suggest that this approach could be valuable

- Preliminary results show a high value to reducing EV Peak load
- This value comes from deferring or avoiding built options
- Since costs of this program are not known, this is not a net cost view

Description	Capacity Savings (MW) by 2040	NPV Savings Incremental to No DSM EVPR ($M)
Level 1	540	$400
Level 2	1,030	$700

Discussion & feedback

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Uncertainty of DSM Portfolio

Range of potential outcomes

- Capacity savings in the Base Resource Plan will come from:
  - DSM Energy Efficiency
  - DSM Demand Response
  - Rates
  - EV Peak Reduction
- Each element has some underlying uncertainty inherent in its ability to achieve its planned savings
- The combined uncertainty needs to factor into the consideration of any potential Base Resource Plan solution

DSM Portfolio Uncertainty

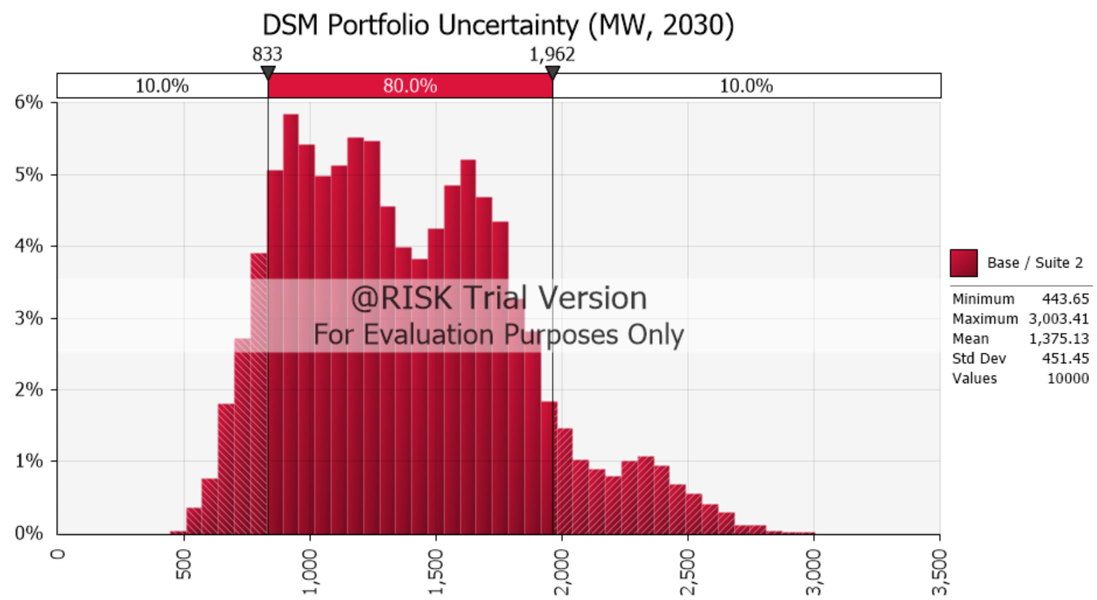
Range of potential outcomes for capacity savings in 2030

- DSM savings have undergone an assessment of savings uncertainty
  - Structured conversations developed probability distributions around planned savings
- These can be combined via Monte Carlo modelling to give a sense of savings uncertainty
- Results for a portfolio meeting Reference load shown on the next slide

Uncertainty of portfolio of DSM options

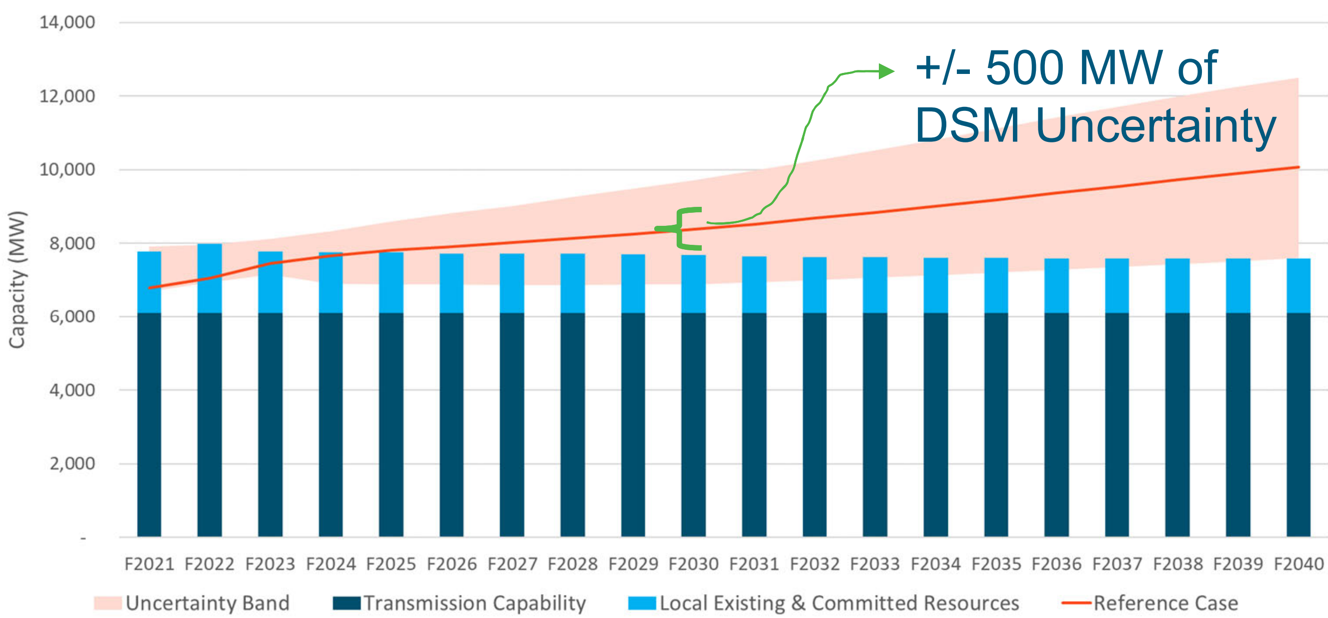
Range of potential outcomes for capacity savings in 2030

- Figure shows combined uncertainty of:
  - DSM EE(MW) (Base)
  - Demand Response (Base)
  - Rates (Suite 2)
  - EV Peak Reduction (25% - 50%)
- Portfolio composition is for illustration only
- Range of rate uncertainty is:
  - 10% chance of a +/- 500 MW miss



Uncertainty of portfolio of DSM options

DSM uncertainty can be viewed in the context of broader load uncertainty



How to react to uncertainty for IRP

The resources reviewed are enough to meet needs, but what about uncertainty?

- Both upside and downside uncertainty impact planning
  - Upside – may reduce need to build/procure
  - Downside – may need to be ready with other options
- Key part of the Plan will be flexibility to respond to uncertainty
  - Both load and DSM savings uncertainty need to be considered appropriately
  - Timelines will be important
    - When do we need to decide to stop current spending
    - When do we need to start backup (contingency) plans

Discussion & feedback

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Non-financial Considerations

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Bringing in Non-Cost Considerations

What else should be tracked, and how?

- Focus today has been modelled costs
- Combination of what has been shown could form a lowest cost IRP Base Plan
- What else needs to be taken into account?
  - Other financial considerations
  - Environmental considerations
  - Social (but non-financial) considerations

Other Financial Impacts

Costs are one of several financial lenses that can be used to compare options

- BC Hydro will be bringing back to TAC other financial metrics
  - Cost uncertainty
  - Rate Impacts
  - Other metrics for DSM comparisons (e.g. Utility Cost)
- Are we missing anything from this list?
- Any considerations for how / where these are applied?

Non-Financial Impacts – Environment

How can BC Hydro use this consideration to compare IRP options?

- BC Hydro currently calculates:
  - Footprint of added generation and transmission (at a high level)
  - GHG emissions of operations
- The Navius Report also includes GHG reductions associated with electrification loads
- Are we missing anything from this list?
- Any considerations for how / where these are applied?

Non-Financial Impacts – Social Impacts

The Clean Energy Act includes considerations regarding economic development

- BC Hydro currently can provide estimates for direct jobs for each portfolio
- Are we missing anything by just focusing on this?
- Any considerations for how / where these are applied?

Discussion & feedback

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100% Clean & Self Sufficiency

Kathy Lee, BC Hydro

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Clean Electricity & Self Sufficiency

Comprehensive Review of BC Hydro Phase Two Interim Report provided guidance to the IRP in these two policy areas

Clean Electricity Standard

“BC Hydro will assume a 100% clean electricity standard for the integrated grid when developing its Integrated Resource Plan.”

Self Sufficiency

“When developing its Integrated Resource Plan, BC Hydro will look at the impact of the elimination of the self-sufficiency provision.”

100% Clean Electricity Standard

Seeks to align clean policy with trade partners in the West

The Phase 2 Interim Report from the Comprehensive Review of BC Hydro states that:

- "BC Hydro could become the first jurisdiction to implement a 100% clean electricity standard."
- "States such as California, Washington, Nevada, Colorado and New Mexico have all set targets to achieve 100% clean energy standards in the 2040/2050 time frame."

The specifics of the standard need to await further government action, but there are high-level principles that can be discussed.

Aspects of the Clean Standard

Does not impose a clean requirement on in-province generation

- Incorporates trade – both imports and exports
- Considers the amount of load being served
- Considers the variability of clean supply
- Seeks to ensure that clean supply sold to others is not replaced by non-clean supply to domestic customers
- Over time: Clean Generation **+** Clean Imports ≥ Retail Sales **+** Clean Exports

Self Sufficiency Energy

Kathy Lee, BC Hydro

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Self Sufficiency

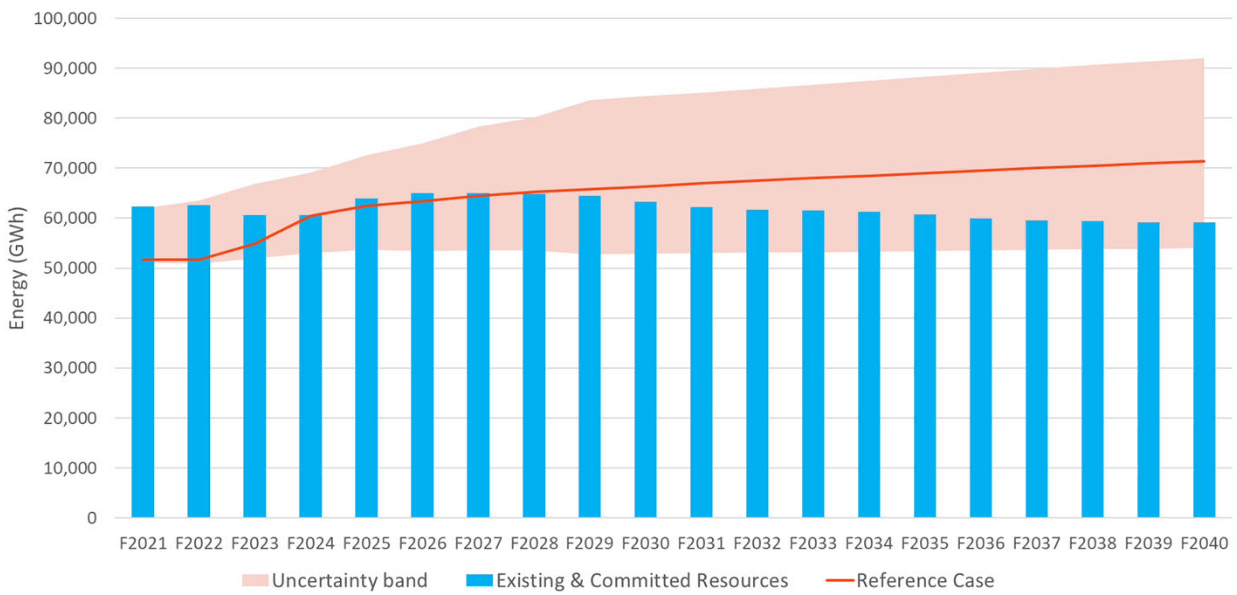
The Self Sufficiency requirement limits the amount we can rely on non-firm B.C. resources and/or the market

Clean Energy Act S6(2) and the **Electricity Self-Sufficiency Regulation** require BC Hydro to plan to have sufficient resources in B.C. to meet demand…

where the maximum amount of energy that can be counted on from the heritage system is the amount capable of being produced under average water conditions.

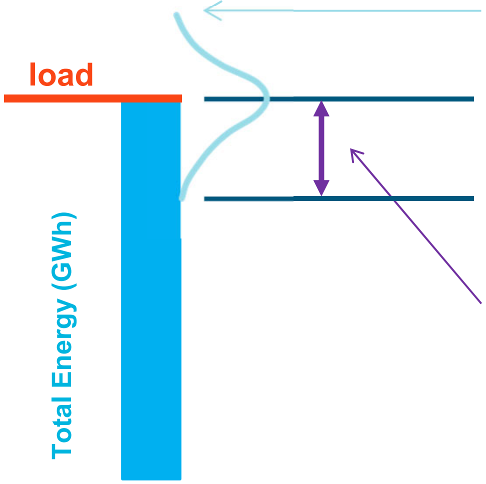
Current Energy LRB (December 2020)

Based on average water. Consistent with self-sufficiency requirement.



Current planning position

Average water sets the baseline for our analysis on self sufficiency removal



Water variability of heritage hydro system

Average water (GWh) – amount of generation under average water conditions

Critical water (GWh) – amount of generation under low / critical water conditions

Non-firm / imports – non-firm B.C. based generation and/or imports are used to fill gap in drier than average water conditions

Diagram is for illustrative purposes only

Planning position options

Looking at the impact of removing self-sufficiency: analysis examining between +/- 4000 GWh away from current planning position

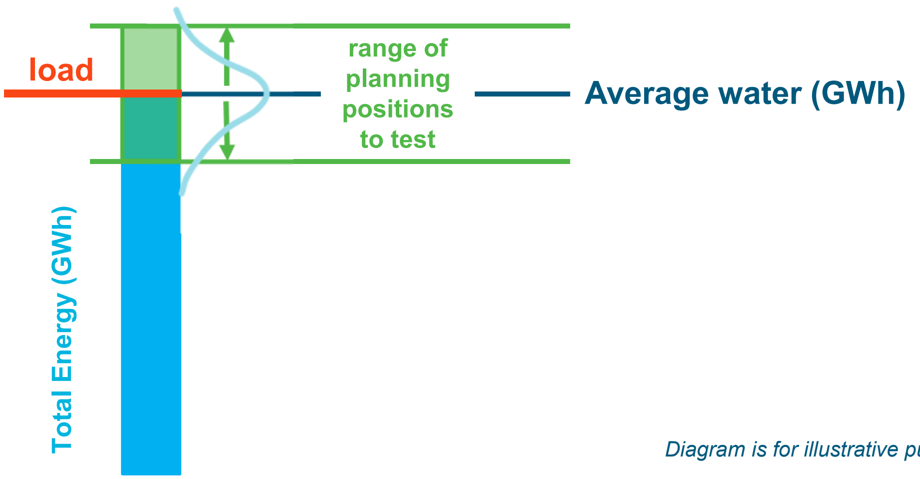


Diagram is for illustrative purposes only

Current planning position: surplus/deficit

By planning to average water, we would expect to have about equal amounts of surpluses and deficits over a long (80-year) period of water records

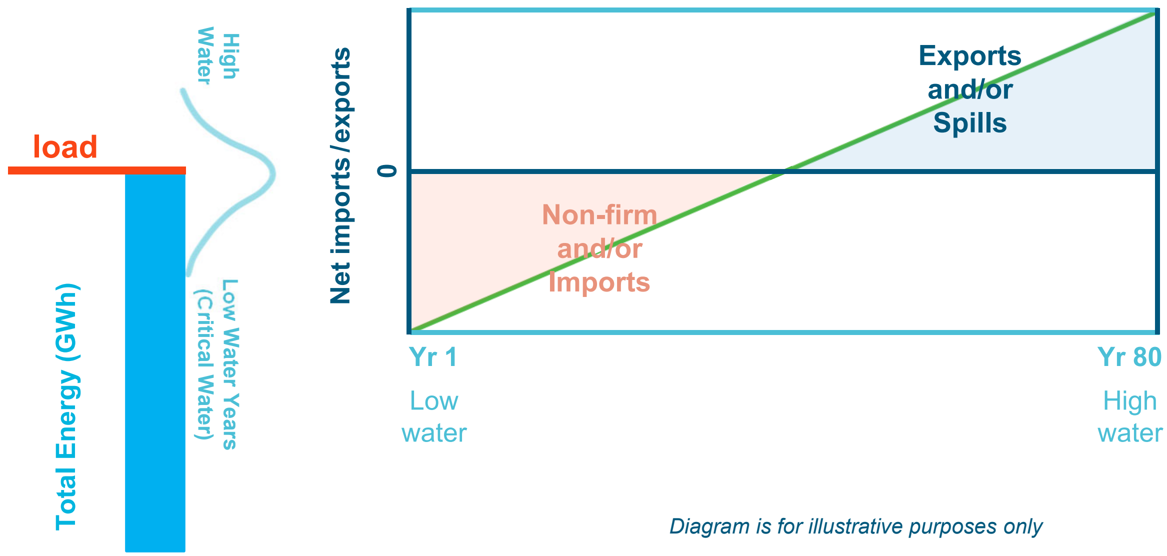
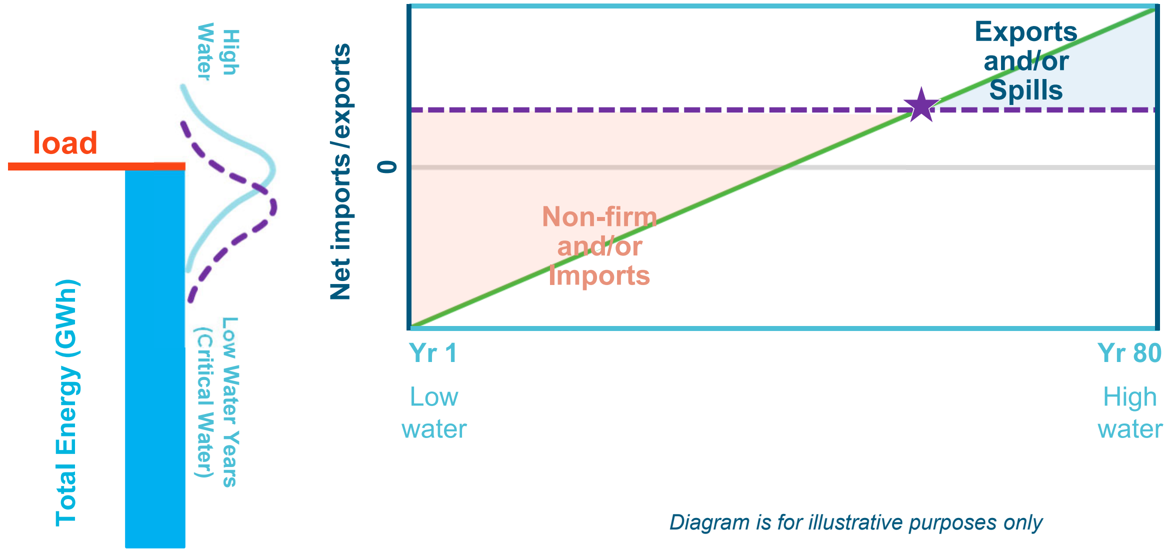


Diagram is for illustrative purposes only

Planning position options: surplus/deficit

Changing planning position would change the balance of surplus/deficit over the period of water records



If more water is assumed for planning purposes, BC Hydro would need less new resources.

BC Hydro will also be more likely to rely on non-firm B.C. resources or imports in any given operating year.

Diagram is for illustrative purposes only

Planning position options: surplus/deficit

Changing planning position would change the balance of surplus/deficit over the period of water records

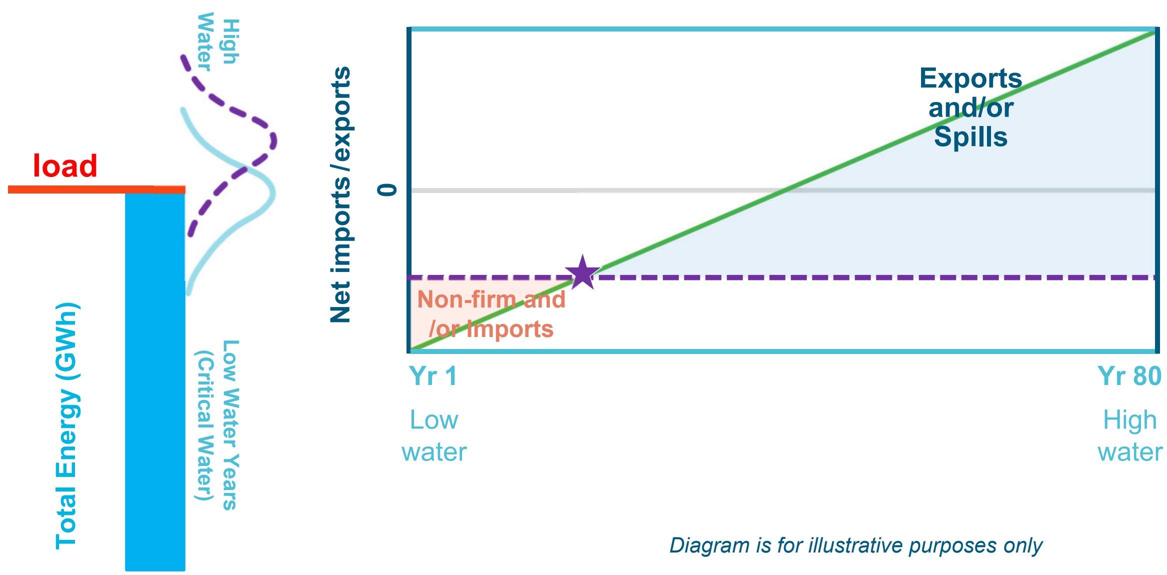


Diagram is for illustrative purposes only

If less water is assumed for planning purposes, BC Hydro would need more new resources.

BC Hydro will also be more likely to export or spill in any given operating year.

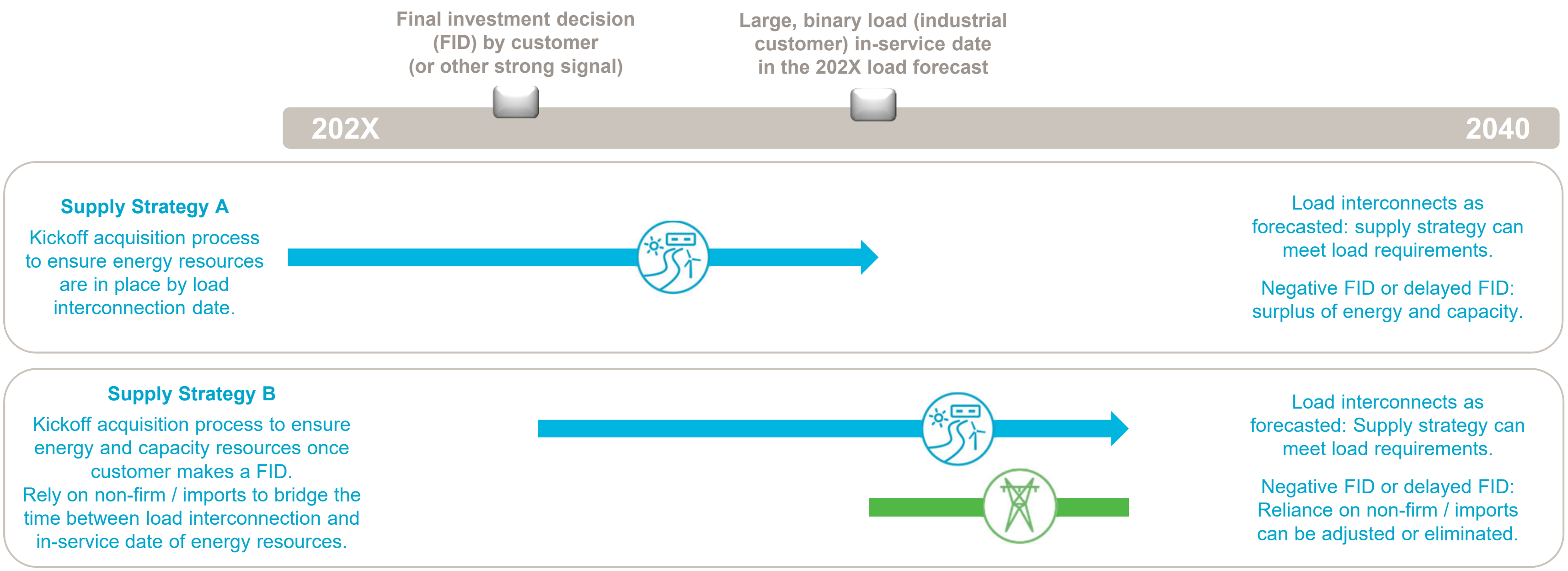
Planning position options: tradeoffs

Multiple IRP objectives would be influenced by changes to BC Hydro's energy planning position

- Reliability
  - Availability of market energy, especially during dry conditions when Pacific Northwest likely also dry
  - Transmission access availability to bring energy into the province
- Economic cost-benefits
  - Relative cost of market energy versus domestic energy
  - Operational flexibility
- Provincial economic development and environmental attributes including impacts of spill
- GHG emissions and BC Hydro's ability to meet 100% Clean Electricity Standard

Short-term use of non-firm B.C. / imports

Can be a bridge between the lead times between load interconnection and in-service date of energy resources



Discussion & feedback

Let's check in on the section that was just presented

Please share any questions or comments you may have:

- What other considerations should be captured in the analysis and decision process? What are the metrics that would describe the characteristics?
- Any other alternate use of a short-term non-firm / market imports?

Self Sufficiency Capacity

Kathy Lee, BC Hydro

Dan O'Hearn, Powerex

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Capacity planning – consideration

Capacity resources need to be much more reliable than energy resources

- Capacity is needed for a specific hour or hours
  - If capacity doesn’t show up at the time it is needed, the “lights go out”.
- Whereas, energy has the flexibility to be delivered over the year
  - Energy doesn’t need to show up exactly at the time it is needed. It can be delivered ahead of time or after within reason.

Out-of-province capacity – observations

Out-of-province capacity has reliability concerns

- Forecast capacity shortfalls in U.S. (quotes from a Northwest Power Pool report, October 2019):
  - *"The region may begin to experience capacity shortages as soon as next year."*
  - *"By the mid-2020s, the region may face a capacity deficit of thousands of megawatts."*
- Ongoing uncertainty about the quantity of the Canadian Entitlement (Powerex uses this to backstop imports to B.C.)
- Transmission access in U.S. and Alberta availability uncertain

Conditions for reliable capacity

Conditions to help make out-of-province capacity source a more reliable source

The following two conditions are required to help make out-of-province capacity a more reliable source:

- Physical Capacity must be contracted for ahead of time and be sufficiently firm
- Firm transmission secured from the source to the BC Hydro system

However, there are other delivery considerations depending on the regulatory/market environment of the source that could undermine the reliability of the source in practice.

Out-of-province capacity as an option

Out-of-province capacity does not appear to be an attractive option

- No compelling reason to believe bringing firm capacity from the U.S. to meet domestic load would be cheaper than build in B.C. capacity, especially clean capacity
- Reliability concerns
- However, it could be an option to consider as and when necessary to manage load and resource lead time uncertainty

Discussion & feedback

Let’s check in on the section that was just presented

Please share any questions or comments you may have:

- Any feedback on focusing the use of out-of-province capacity to mitigate uncertainties in this IRP?

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