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2021 Integrated Resource Plan (IRP) Technical Advisory Committee (TAC) Meeting #6

November 26, 2020

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Welcome & meeting context

Basil Stumborg, BC Hydro

Kathy Lee, BC Hydro

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Virtual meeting etiquette

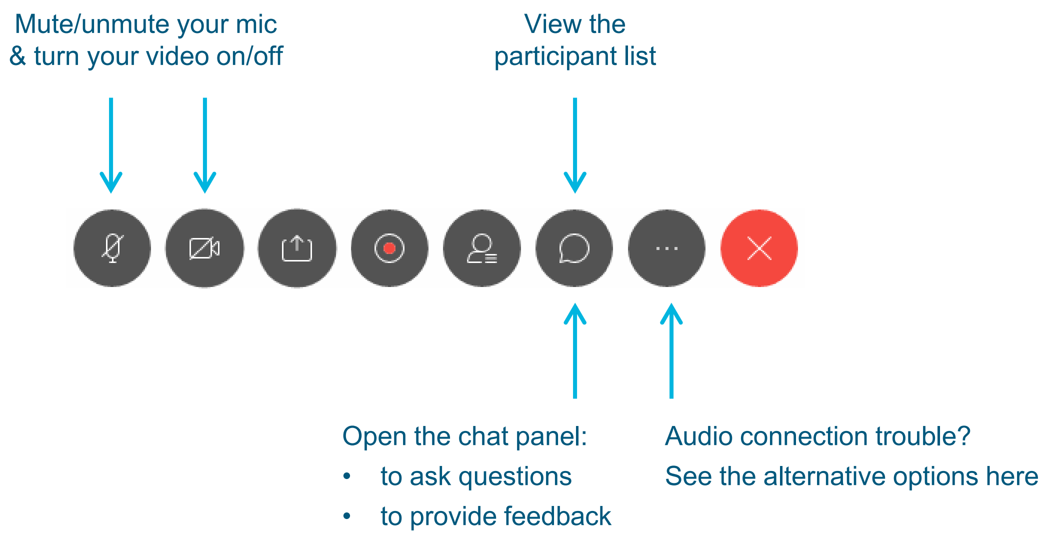
These principles should make our meetings more effective

- 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



Our broader consultation has launched

Indigenous Nations, customer and public engagement runs until January 2021

We are inviting TAC members to fill out the survey as an attributed submission.

Request submission by January 31, 2021. Will form part of our consultation record and be considered as we draft actions.

We will distribute a version of the survey for your submission following this meeting.

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We invite you to **join the Clean Power 2040 discussion** to have your say by **taking our survey** or joining one of our **online regional workshops**. Your feedback will help inform the development of our draft plan.

Take the survey now

www.bchydro/cleanpower2040

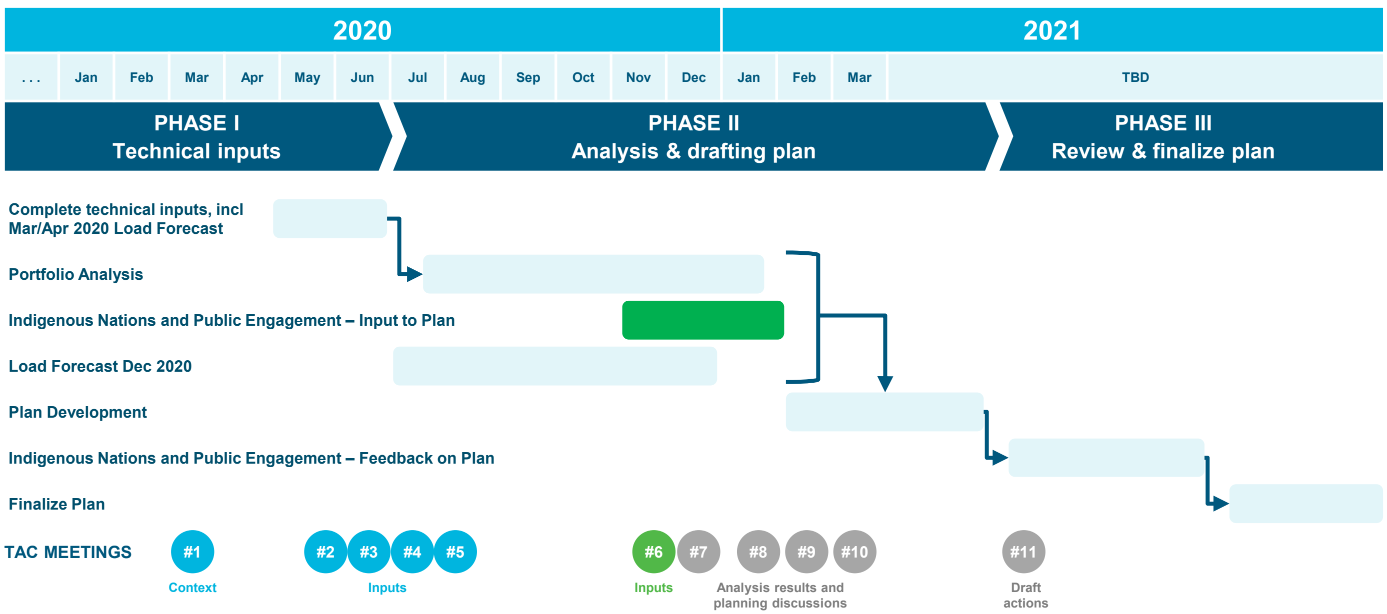
Update for TAC on Electrification Plan

Initial action plan and targets for low carbon electrification and load attraction

- Building on the Comprehensive Review the five year plan will consider a range of actions, including:
  - Rate design to support electrification
  - Low carbon electrification programs
  - Tariff changes to make it easier for customers to connect to our grid
  - Transmission and charging infrastructure
- BC Hydro will provide opportunities for engagement on the action plan that will be open to interested TAC members
- A number of the actions in the plan, such as rate design and tariff changes, will also have their own separate development and engagement processes
- An update and more details on engagement will be provided at the next TAC meeting (December 2020)

Recap from last meeting – IRP 2021 schedule

We're resuming our fall consultation and presenting remaining inputs prior to analysis review



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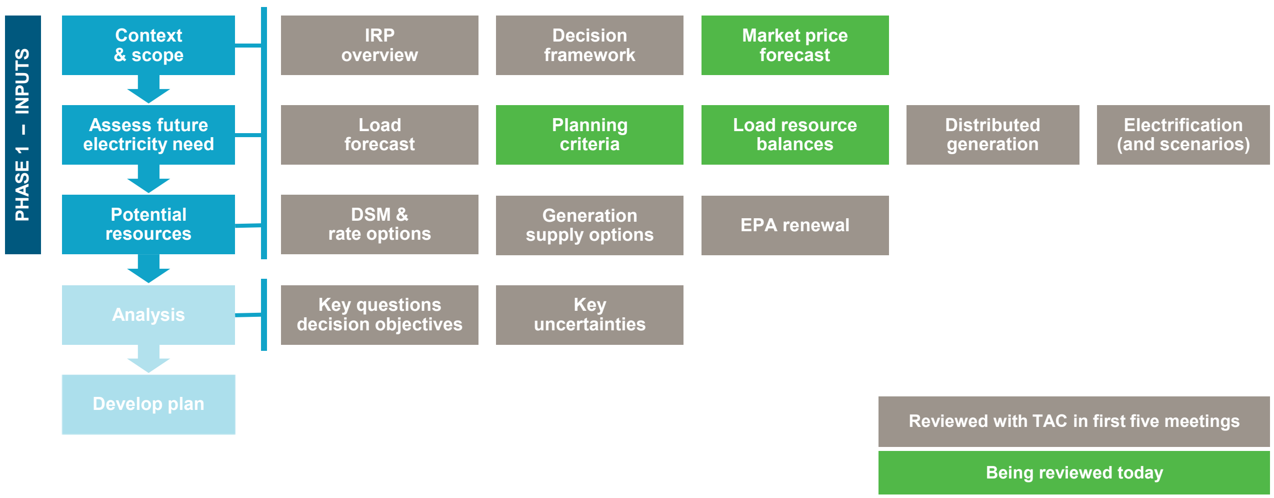
Mapping planning inputs with IRP steps

Phase 1 included gathering inputs and reviewing with TAC members



Agenda overview

Meeting purpose to complete our review of inputs in preparation for analysis discussions

9:00 START	TBD BREAK		12:00 LUNCH	TBD BREAK		3:30 CLOSE
Welcome & meeting context	Load resource balance (System)	Generation capacity planning		Load resource balance (Regional)	Market price forecast	Next steps
Basil Stumborg	Magdalena Rucker	Nan Dai		Magdalena Rucker	Amy Pryse-Phillips	Basil Stumborg

Load Resource Balance – System

Magdalena Rucker, BC Hydro

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Load Resource Balances assess need

The IRP determines the need for resources beyond what is existing and committed

- Load Resource Balances (LRBs) are comparisons of the 20-year outlooks of the demand (load) and supply (resources) for electricity
- They determine the timing and volume of additional resources required to meet customers' demand
- LRBs are developed for both energy and capacity to ensure both aspects of need are considered and met in the planning process
- The planning criteria plays a role in the load resource balance

Load Resource Balances assess need

As the starting point, LRBs includes only existing and committed resources

Existing and committed resources are assumed already in the resource stack:

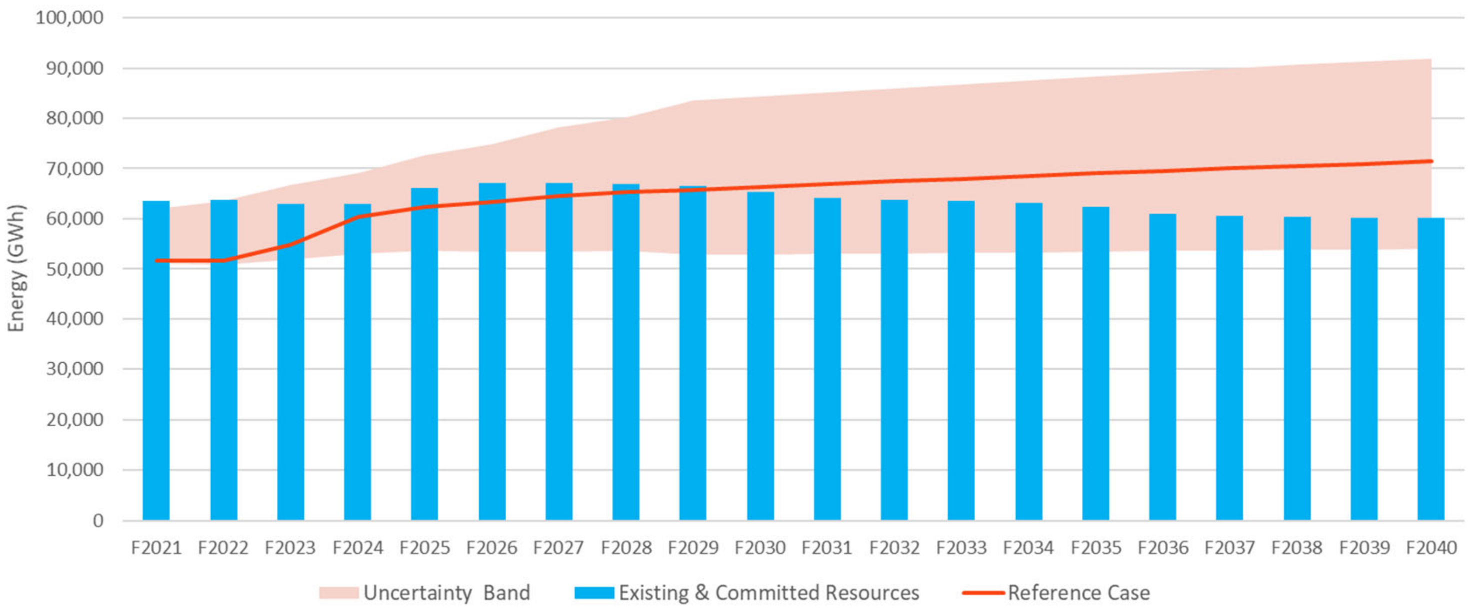
- Existing resources, e.g. Heritage assets, existing EPAs until their expiry date
- Committed resources, e.g. Site C

Examples of potential planned resources as outputs of the IRP:

- DSM programs beyond what is in F20-F21 RRA
- Electricity Purchase Agreement (EPA) renewals
- Revelstoke 6

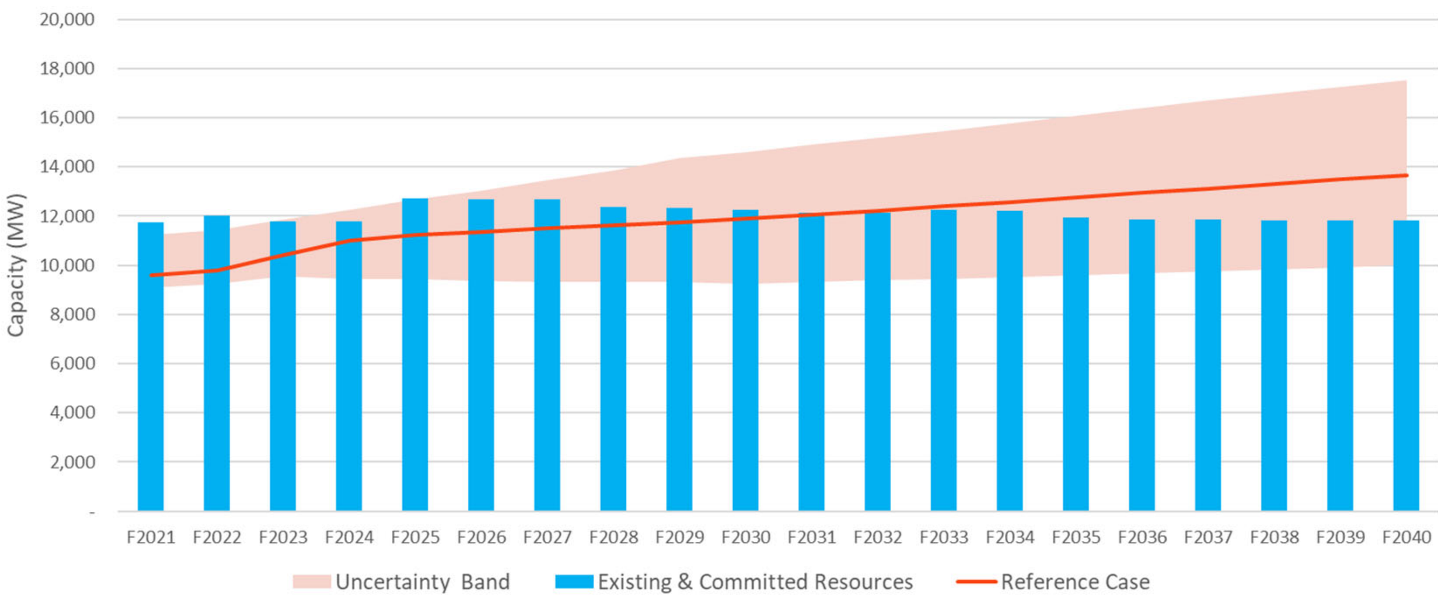
Load Resource Balance – Energy

We expect to have enough resources to meet B.C.'s energy needs for about 10 years



Load Resource Balance – Capacity

We also expect to have sufficient capacity resources for the same period



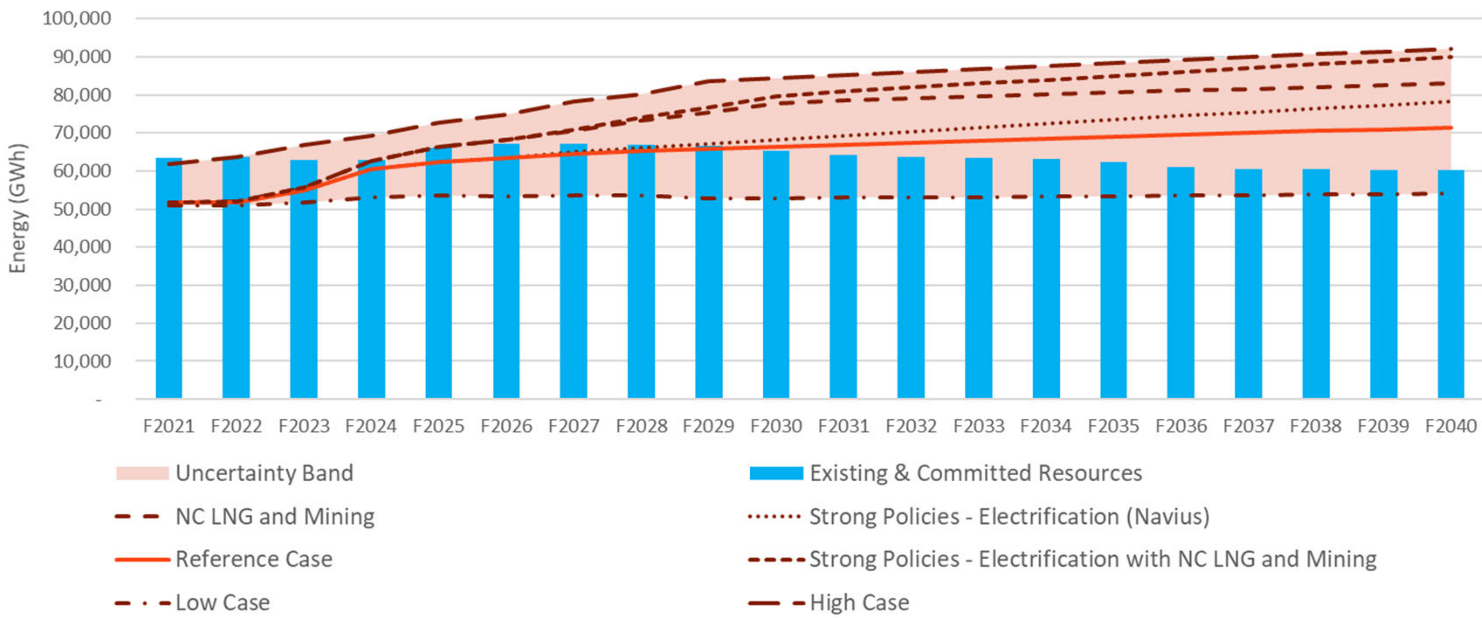
System Load Resource Balances

The Load Resource Balances (LRBs) will be updated prior to filing the IRP

- Load Resource Balances presented today:
  - have the April 2020 COVID Reference load forecast as the reference case
  - are being used in portfolio analysis this fall
  - analysis also includes testing load scenarios
- LRBs will be updated once the new load forecast is available in the new year

System Load Resource Balances

Load resource balances under various load scenarios



Existing resources in the LRB

Resources that are currently operating and are expected to continue through the planning horizon

Existing resources include:

- BC Hydro's existing generating facilities (except Alouette, Elko, Spillimacheen and one unit at Shuswap, which are currently out of service)
- Electricity purchase agreements currently in commercial operation (until their agreements expire)
- Forecasted savings from current codes and standards and rate structures; savings from approved DSM program expenditures

Committed resources in the LRB

Resources that are being advanced, have received authorization from Board of Directors to proceed to implementation and/or secured any required regulatory approvals

Committed Resources include:

- Site C and Lake Buntzen Unit 1 generator replacement project
- Future forecast codes and standards savings nearing implementation
- Two biomass projects eligible for renewal under the Biomass Energy Program
- Two Standing Offer Program (SOP) run-of-river projects with Indigenous Nations ownership/involvement excepted from the indefinite suspension of the SOP
- Five EPAs with seller's options to extend

Key findings for system-level Load Resource Balances

- There is no expectation of needing additional energy and capacity in roughly the first 10 years of the planning period
- The range of uncertainty suggests contingency planning for deviations from the reference load forecast will be important

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Generation Capacity Planning & the LRB

Nan Dai, BC Hydro

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Outline

Key input to the IRP

- What is capacity planning?
    - planning criteria and concepts
- Capacity assessment for existing resources
    - heritage hydro and IPPs
- Capacity assessment for non-traditional resources
    - preliminary results and findings

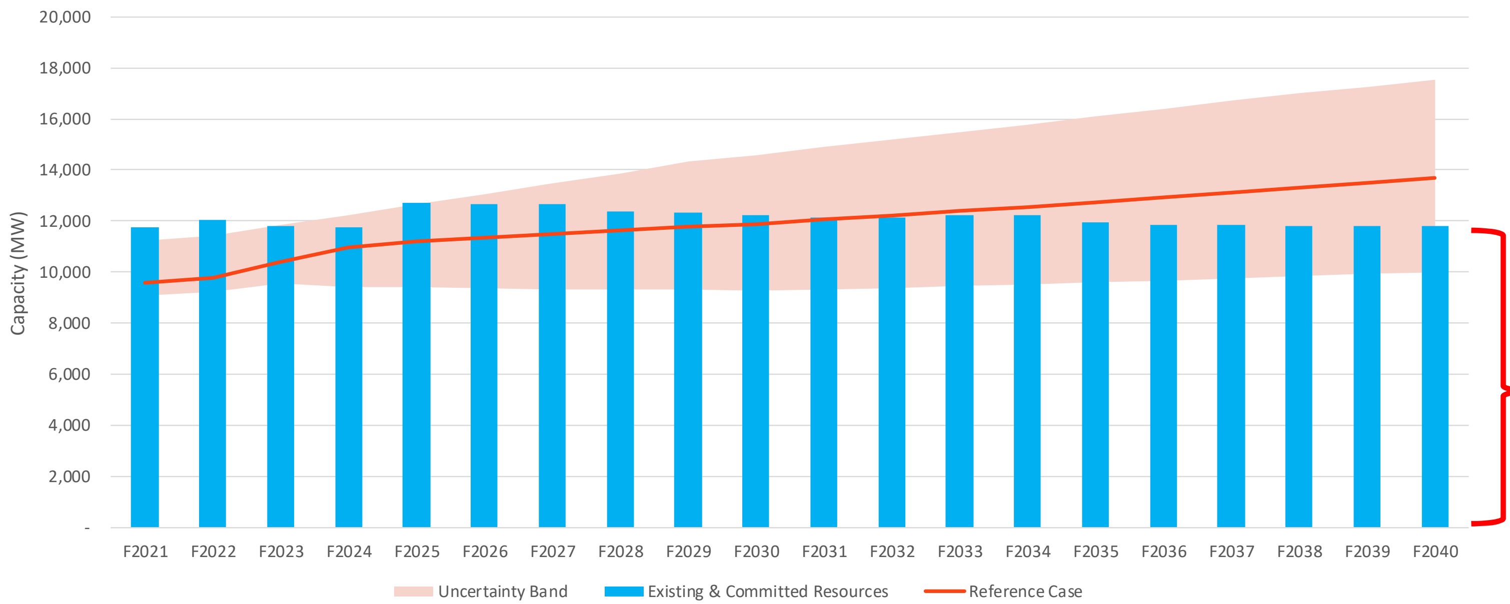
Potential capacity options

We have a range of options that provide capacity contributions

- Capacity contribution from future energy efficiency programs
- Revelstoke unit 6
- Geothermal…biomass…
- Capacity focused DSM, e.g. load curtailment, time of use rate
- Batteries
- Pumped storage

Generation capacity planning and the LRB

Generation capacity planning is to assess the capacity contribution of individual generation resource and to establish how the integrated generation system is able to reliably meet future peak electricity demand



System Peak Load Carrying Capability

- Dependable Capacity
- Effective Load Carrying Capability (ELCC)
- Planning Reserve

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System Peak Load Carrying Capability

Numerical representation in the LRB

System Peak Load Carrying Capability	=	Dependable Capacity	+	Effective Load Carrying Capability (ELCC)	-	Planning Reserve
		• Non-intermittent resources • Non-traditional resources?		• Intermittent resources • Non-traditional resources?		

Question: where will the non-traditional capacity resources (for B.C.) fit?

- Capacity focused DSM: only available at specific times or with limited availability (e.g. max number of calls per year vs a generating unit that is available year round)
- Battery and pumped storage: limited availability (e.g. a maximum duration of discharge of 4-6 hours) and depend on surplus off-peak energy for recharge

Loss of Load Expectation

Loss of Load Expectation (LOLE) is the capacity adequacy measure that guides capacity planning

How is capacity adequacy measured, and how reliable is reliable enough?

- Capacity adequacy (or inadequacy) is typically measured in terms of how often our total generation resources are insufficient to meet load.
- BC Hydro plans to a 1-day-in-10-years LOLE
  - This is the most common industry reliability standard used within the Western Electricity Coordinating Council (WECC) and others

Dependable Capacity

Represent the capacity contribution from non-intermittent generation resources

Dependable Capacity for BC Hydro heritage assets and non-intermittent IPP resources, refers to the capacity that a plant can reliably deliver for the duration of time in which it is required

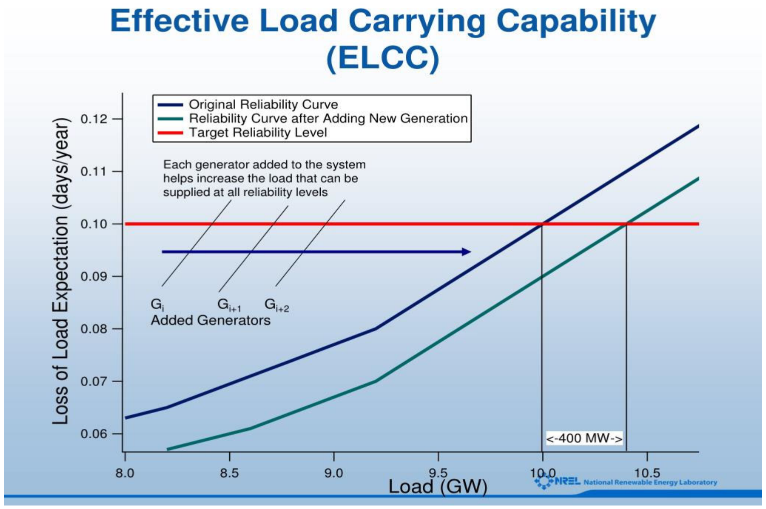
- For long-term planning it is the maximum capacity that a plant/unit can reliably provide for three hours per day in the peak load period during two weeks of continuous cold weather
- Dependable capacity assessment reflects fuel supply constraints, but not maintenance outages nor forced outages due to mechanical failure

Effective Load Carrying Capability

Represent the capacity contribution from intermittent generation resources.

Effective Load Carrying Capability (ELCC) for intermittent resources, defined as the amount by which the system's loads can increase when the resource is added to the system while maintaining the same system reliability (1-day-in-10-years LOLE)

- ELCC was first proposed by wind developers through the 2005 Resource Options Report engagement, and is consistent with industry practice



"Top FAQ's About Utility Integration of Renewables … and Answers" by Michael Milligan & Debbie Lew

Planning Reserve

Planning Reserve is additional generation buffer to account for the possibility of mechanical failure in generating resources or other unforeseen events

- All utilities have a Planning Reserve buffer, and it is a function of the mix of generation resources available (is a proxy for the resilience of our generation resources)
- Planning Reserve has been reduced to 12% of dependable capacity (from 14%), primarily driven by changes in the system:
  - removal of less reliable thermal units
    e.g. Burrard units with higher outage rates at typically 10% forced outage rate
  - addition of more reliable hydro units
    e.g. Mica Units 5 and 6, Revelstoke Unit 5 at typically 3-4% forced outage rate

IPP resource capacity assessment

Historical IPP data is used to assess capacity contribution from existing and committed IPP resources that will be used in the capacity LRB

- IPP resources are assessed on an aggregated basis by resource type, i.e. all wind resources across B.C. are aggregated for assessment and are assigned the same wind ELCC factor
- Uses historical hourly generation data over the peak periods:
  - from commercial operation date to March 31, 2019
  - during the three winter months of December to February
  - over the evening peak hours of 5:00pm to 8:00pm
- Capacity contribution is expressed as percentage of the nameplate installed capacity

IPP capacity assessment results

Results (as % of installed capacity) for existing and committed resources currently in LRB

Non-Intermittent Resource	Dependable capacity factor	Intermittent Resource	Effective load carrying capability factor
Biomass – stand-alone	96	Non-storage (run-of-river) hydro	15
Biomass associated with a customer load	62	Wind	24
Energy recovery generation	55	Solar	0
Municipal solid waste	89		
Biogas	72		
Natural gas-fired generation	90		
Storage hydro	76		

Heritage assets capacity assessment

Heritage assets are assessed individually using in-house proprietary models

Heritage assets are assessed differently depending on fuel availability.

- Heritage hydro assessment needs to consider water availability – is there a risk of running out of water during a two-week period in December to February, or does it depend on inflows to maintain the capacity output?
- Heritage thermal assessment assumes 100% fuel availability, and accordingly, the Prince Rupert Generating Station is assumed to be 100% of installed capacity

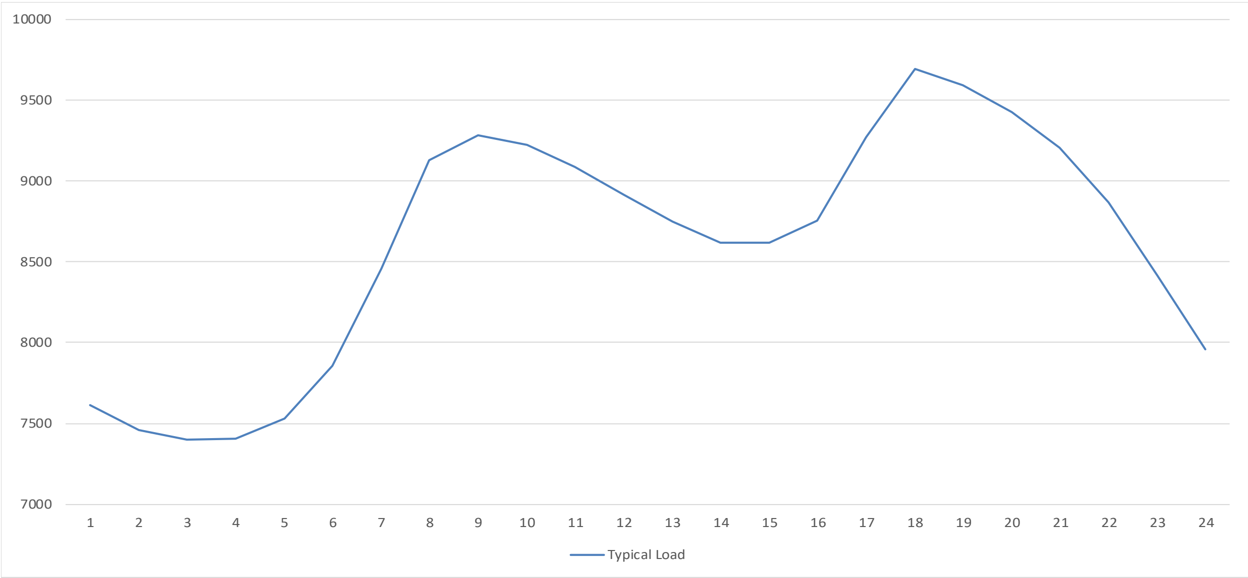
Non-traditional resource capacity assessment

Adopted LOLE based probabilistic approach

- The same 1-day-in-10-years LOLE standard applies
- Unlike traditional resources, we need to understand the impact on off-peak hours, in addition to the on-peak hours, to determine the reliability of the system
    - We focus on the hourly load shape of typical winter period (December to February), and determine how it changes when a new resource is added to the system (e.g. 50 MW battery, 1000 MW pumped storage, etc.)
    - We then determine the system's ability to reliably serve the new load shape, and how much more load the system can carry with the added non-traditional resource

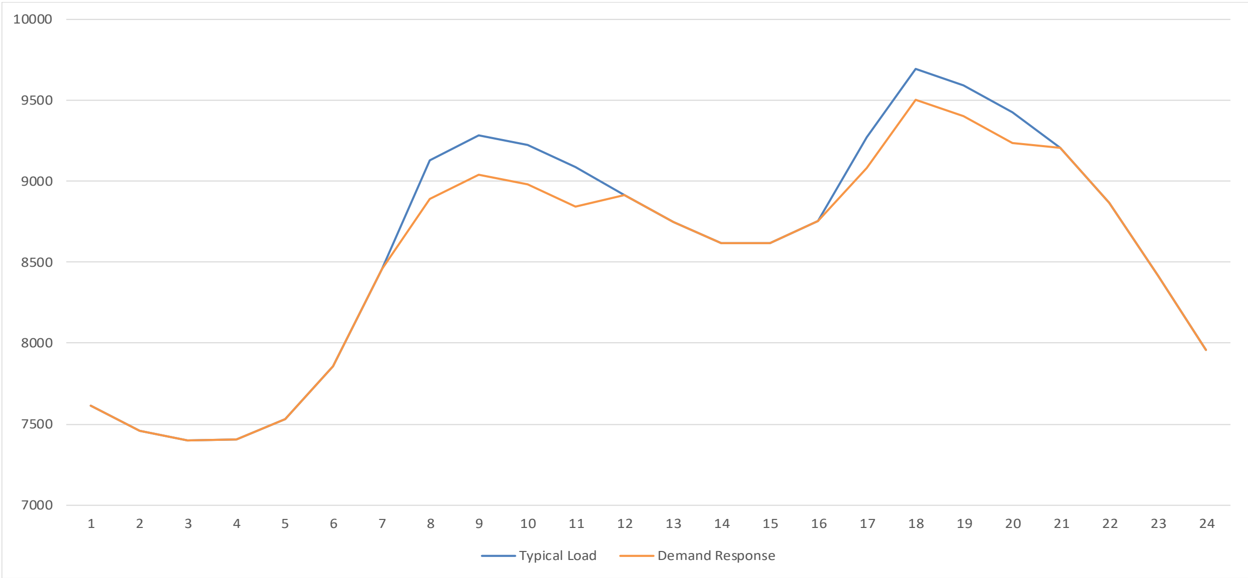
Load Profile – Average Winter Weekday

BC Hydro load profile clearly shows two daily peaks of ~4 hours each



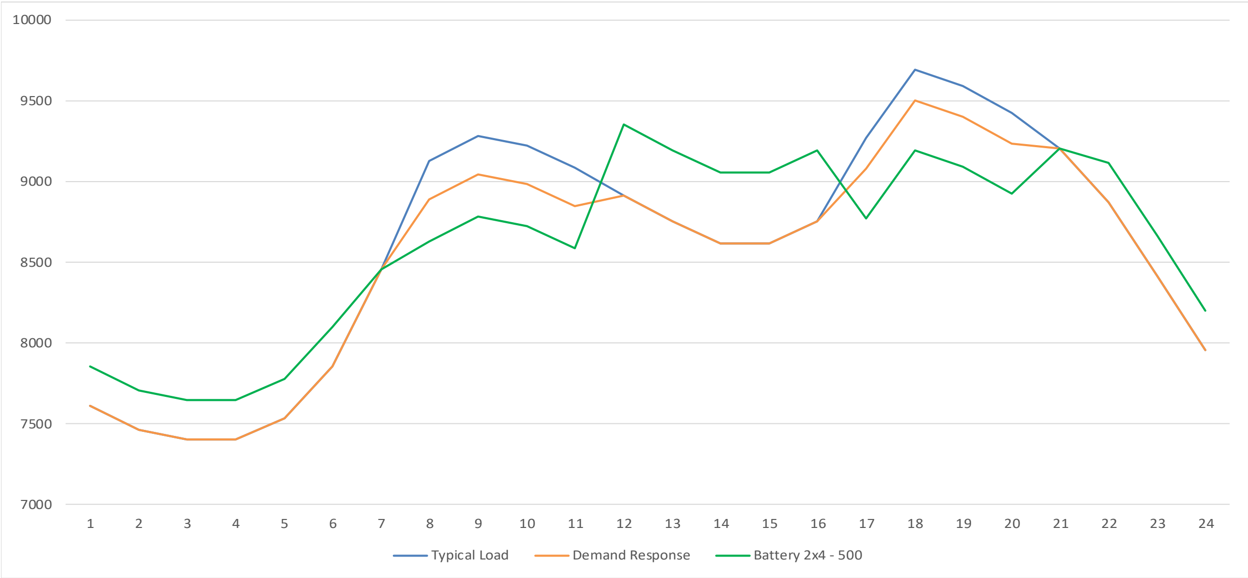
Consider Demand Response

Demand response is called 2X per day for 4-hours, reducing both morning and evening peaks without changing off-peak loads



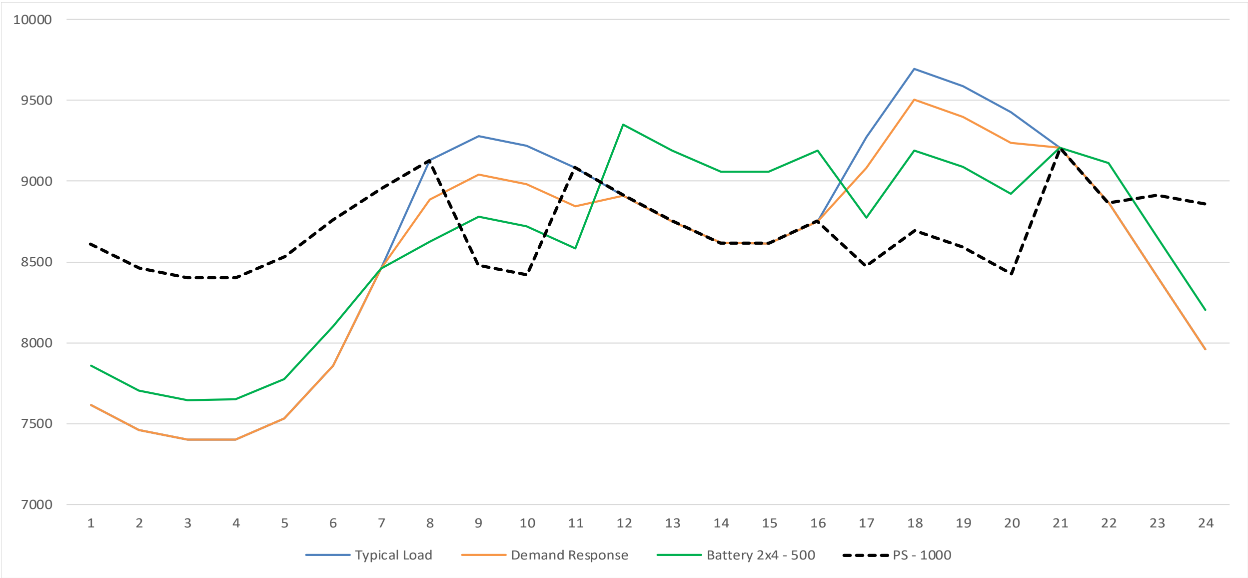
Consider Battery Storage

Battery storage (green) can reduce both peaks, but requirement to charge during mid-day shoulder period creates new peak, limiting the value of more and more battery storage



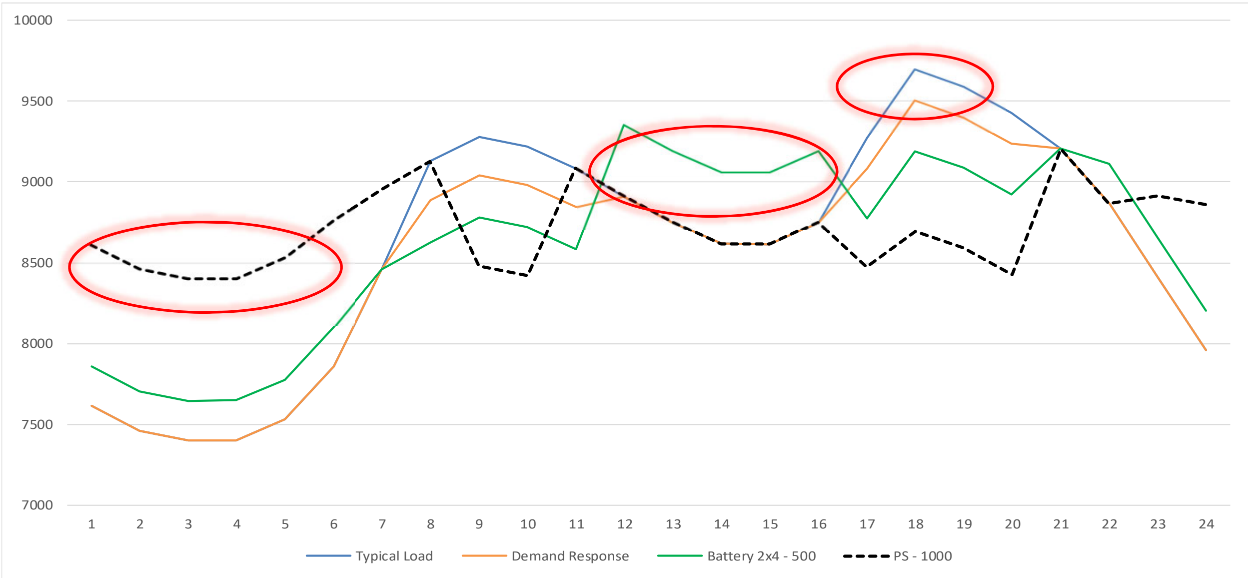
Consider Pumped Storage

With pumped storage (black), ~6 hour duration insufficient to serve total 8-hour peak, creating three new mini-peaks during the day with no real ‘off-peak’ period



Non-traditional capacity assessment findings

With more and more batteries or pumped storage, we will begin see new periods of high risk that are outside the normal 'peak load' periods



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Non-traditional capacity assessment findings

For the capacity focused DSM options, the capacity product design will have big impact on its capacity contribution

- All effective capacity results are based on the assumption of no load recovery.
- For load curtailment, the 16x36 design provides the highest capacity contribution at 100% which tested under different load profiles. Capacity contribution may decrease if the call is reduced under some load profiles.
- For demand response, the current design targeting evening peak will have bigger capacity contribution than the one targeting morning peak. However, considering the cost implication, it may not be worth asking for more calls as the no am peak support becomes a limiting factor.

Non-traditional capacity assessment findings

For the supply-side generation options with recharge requirement, how it is operated will have big impact on its capacity contribution

- The effective capacity results are subject to change with different operational assumptions in discharging/recharging requirement.
- For batteries, it could provide high capacity throughout the day if dispatched in morning and evening. With more batteries in operation, the recharge during mid-day shoulder period becomes problematic and limits the amount of batteries the system can cost-effectively accommodate.
- For pumped storage, it could provide needed capacity support if scheduled properly. Need to be mindful about its negative energy impact, especially when BCH already experiences winter energy constraints.

Preliminary results – capacity focused DSM options

Demand response has lower % due to limited duration and number of calls per season

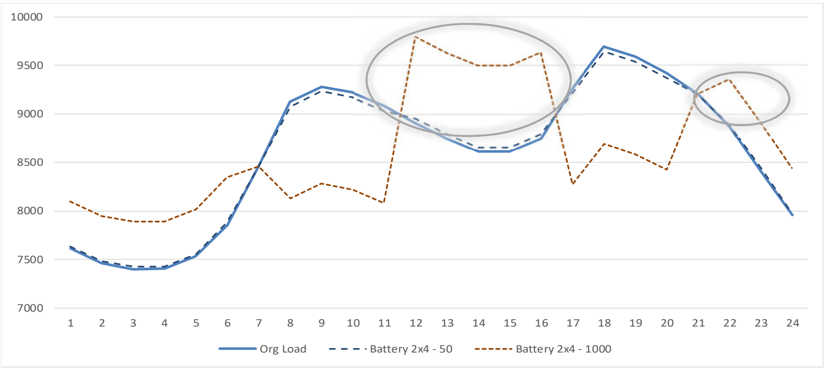
Product	Product Design (x # of calls)	MW	Effective Capacity (%)
Load Curtailment	16 hours/day (x 36)	84	100
Demand response (am & pm)	4-hr am & pm (x 10)	240 & 190	54 (54-73)*
Demand response (am)	4-hr am only (x 20)	240	8 (4-11)*
Demand response (pm)	4-hr pm only (x 20)	190	70 (67-85)*

Key takeaways:

- Load curtailment offers 100% reliable increases in system carrying capability.
- DR products targeting pm will have bigger contribution (70%) than the one targeting am (8%).
- The more the DSM capacity product could be called, the higher its capacity contribution.
- Assumptions about load shape matter. Effective Capacities in parenthesis show range if we look at historical F2016 to F2019 load shapes rather than a ‘typical’ one.

Preliminary results – batteries

4-hour batteries offer reliable capacity, but limited total MW due to mid-day recharging



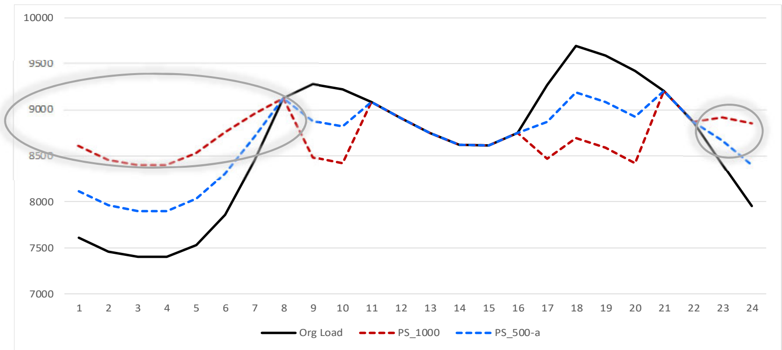
Product	MW	Effective Capacity (%)
Battery 2x4 – 50	50	97
Battery 2x4 – 250	250	88
Battery 2x4 – 500	500	62
Battery 2x4 – 750	750	24
Battery 2x4 – 1000	1000	-4

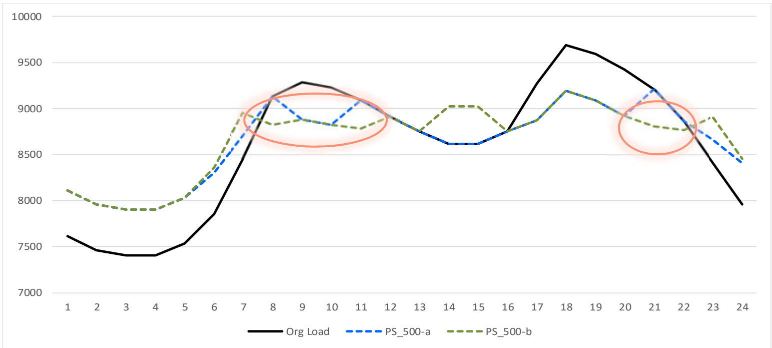
Key takeaways:

- The first 50 MW offers very good effective capacity (97%).
- As battery deployment grows to 500 MW, it reduces to 62% due to insufficient mid-day energy available for charging.
- Refinements in assumptions about how to stagger charging and discharging for fleets of battery resources would improve these estimates, but would require more battery systems used for insurance.

Preliminary results – pumped storage

Insufficient off-peak energy to recharge very large PS systems





Product	MW	Effective Capacity (%)
PS_1000	1000	51
PS_500-a	500	76
PS_500-b	500	84

Key takeaways:

- The 1000 MW PS (red line) consumes all off-peak energy for charging.
  - Would exacerbate the winter energy constraints BCH already experiences.
- Different discharging/recharging pattern assumptions can have large effect on effective capacity, e.g. ranging from 76 – 84% for the 500 MW PS.

Load Resource Balance – Regional

Magdalena Rucker, BC Hydro

BC Hydro
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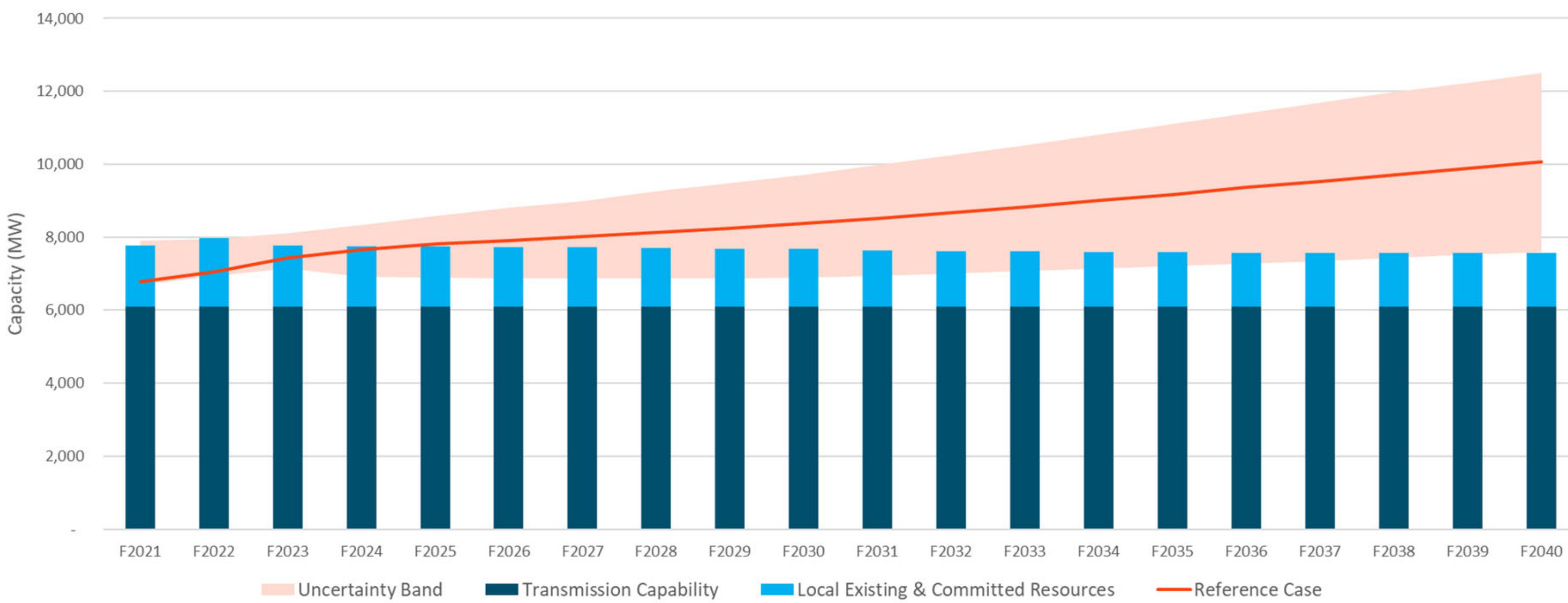
Regional capacity analysis

Capacity LRBs were created for four regions/ sub-regions/ areas

- The regional capacity LRBs include existing and committed:
    - resources in that area
    - transmission capability into that area
- Uses same reference Load Forecast as system LRBs
- Upcoming detailed transmission analysis will refine existing and committed transmission capabilities

Lower Mainland / Vancouver Island Region

We'll have to choose from our options soon



Lower Mainland / Vancouver Island Region – Options to meet demand

We have several options to meet future demand based on reference outlook

Options with current resources

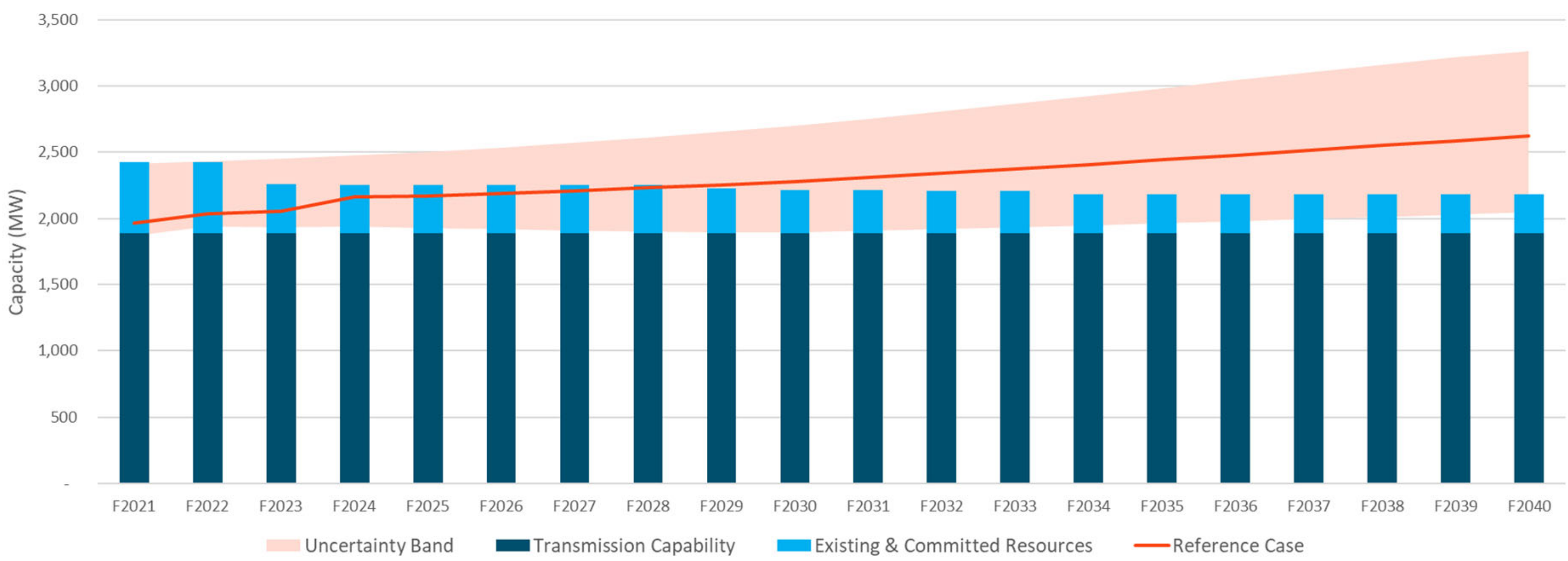
- Conservation and energy management initiatives (Energy efficiency, time varying rates and demand response)
- Options for expiring Electricity Purchase Agreements
- Wahleach generating station turbine replacement (+14 MW)
- BC Hydro small plants: Alouette (+21 MW)
- Seton Unit Upgrade (+6 MW)
- Burrard Synchronous Condenser and future use of site

Beyond 10 years

- Batteries and pumped storage
- Potential upgrades to transmission capacity from Interior to Lower Mainland
- Renewables with dependable capacity (e.g. small storage hydro)

Vancouver Island Sub-region

Expect to have enough capacity to meet demand until ~ F2029



Vancouver Island Sub-region – Options to meet demand

We have several options to meet future demand based on reference outlook

Options with current resources

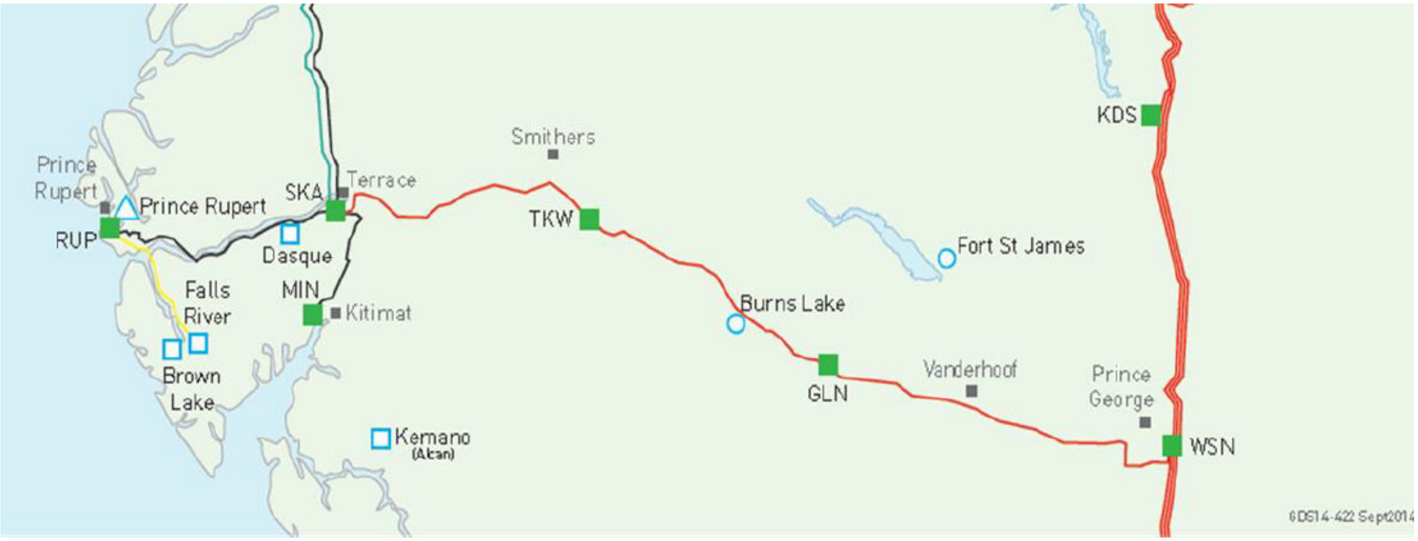
- Potential to renew expiring Electricity Purchase Agreements
- Conservation and energy management initiatives (energy efficiency, time varying rates and demand response)

Beyond 10 years

- Upgrade cable to Vancouver Island
- Batteries and pumped storage
- Renewables with dependable capacity (e.g. small storage hydro)

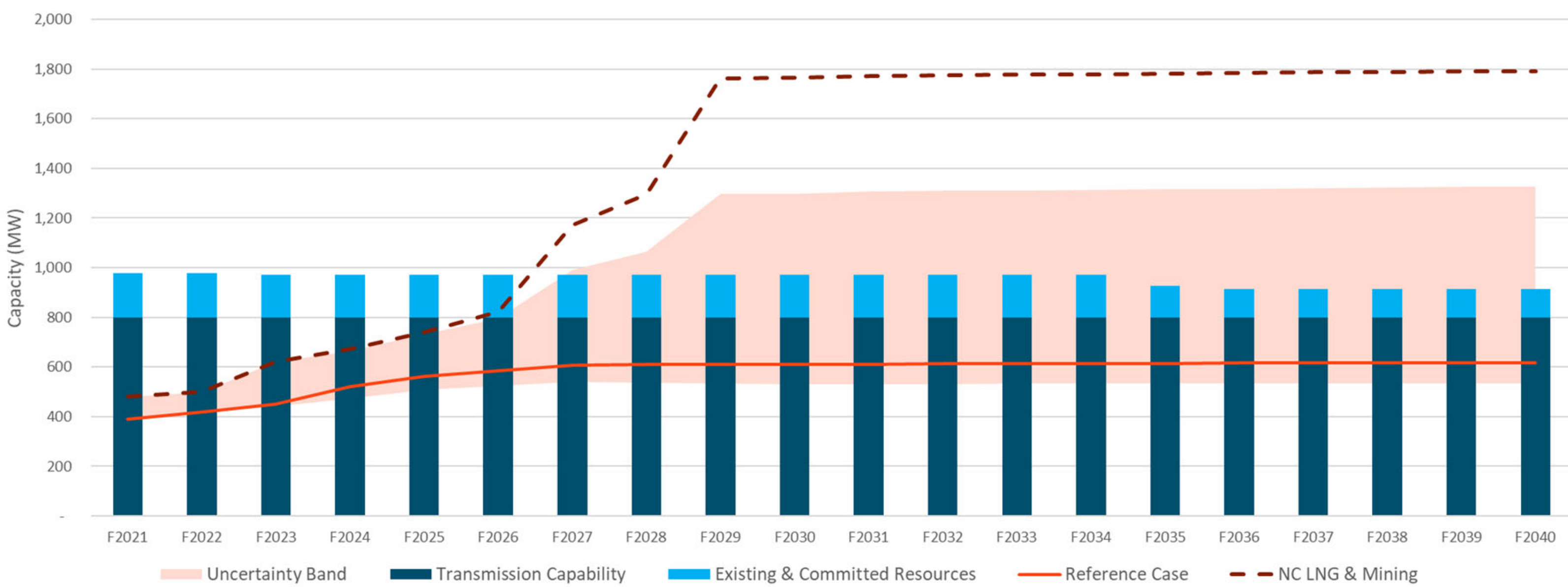
North Coast Region

The region is served by one long radial line



North Coast Region

Upside potential from LNG and mining loads



North Coast Region

Options available to meet higher demand scenarios envisioning more LNG and more mines

Preparing new transmission (consultation underway)

- Prince George to Terrace Capacitors project
- Twinning 287 kV (SKA to MIN) from Terrace to Kitimat

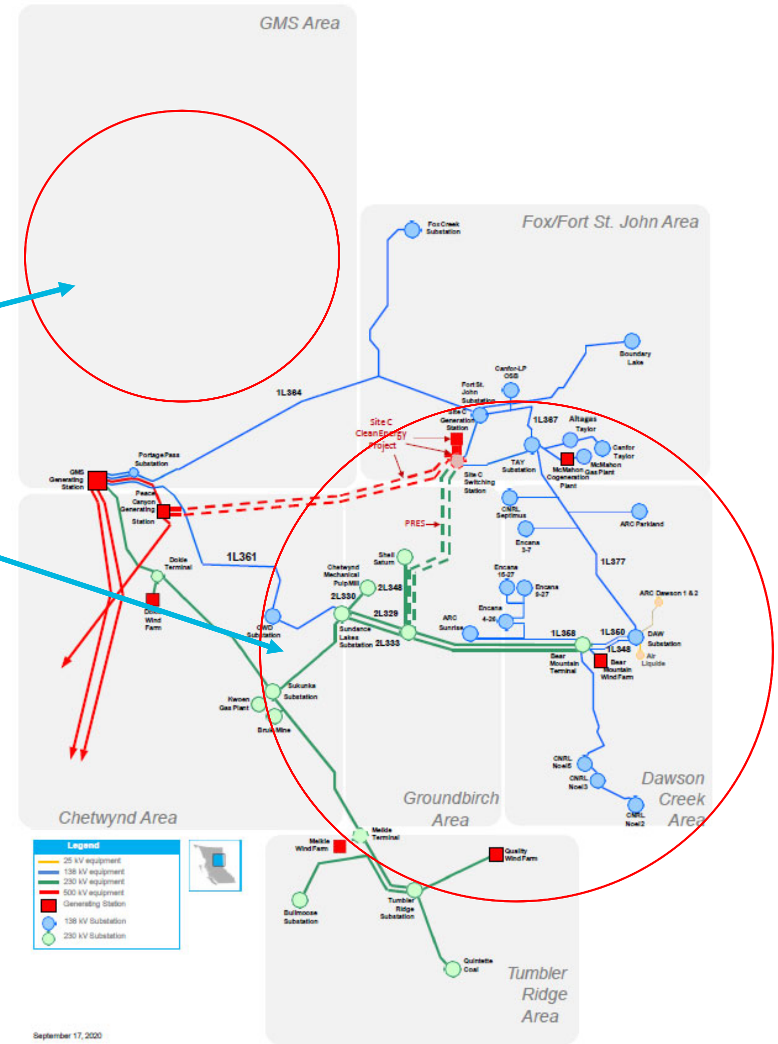
Future potential system need (if additional customer commitments with higher electrification)

- Twinning the transmission line from Prince George to Terrace
- Renewables:
  - Falls River (BC hydro facility)
  - Geothermal, small storage hydro
  - Pumped storage combined with local renewables (e.g. off-shore wind, run-of-river hydro)

Northeast (Peace) Region

Two areas within the broader Peace Region are of interest for this IRP

- North Montney (GMS) area
- Dawson Creek – Groundbirch area



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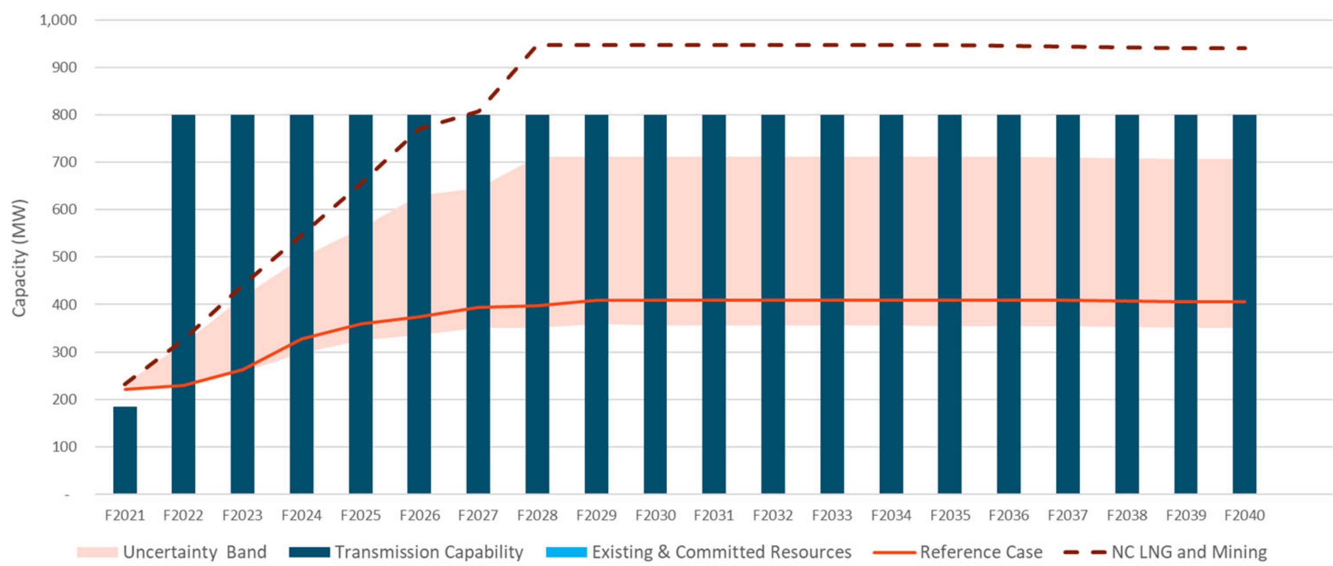
Dawson Creek – Groundbirch Area

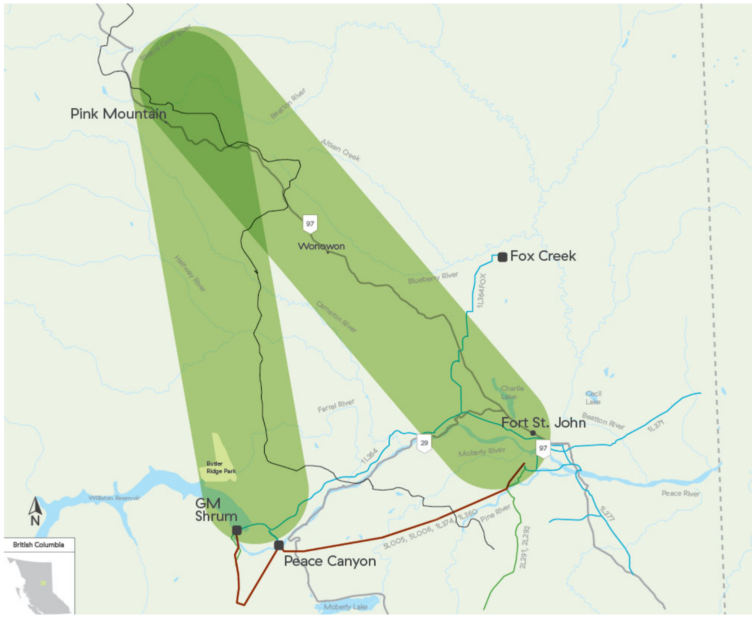
The demand supply outlook shows enough capacity in reference case but potential need for more reinforcement in higher scenario



North Montney (GMS) area

This region has no existing transmission line but has potential for electrification

- No customer commitments yet
- Preparing for new transmission if/when customer commitments occur



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Market Price Forecast

Amy Pryse-Phillips, BC Hydro

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Outline

Key input to the IRP

- What is the market price forecast?
- How is it used in the IRP analysis?
- How do we come up with it?
- June 2020 Mid-C price forecast
- Questions?

What is the market price forecast?

25-year forecast of Mid-C and Alberta Power Pool electricity prices

- Forecast of future prices in day-ahead markets at:
  1. Alberta Power Pool (APP)
  2. Mid-Columbia (Mid-C) trading hub
- Reflects long term average conditions, not short-term volatility
- Includes high and low scenarios to capture uncertainty
- Hourly prices for 25 years

How is the market price forecast used?

Input to portfolio modelling process

- Portfolio modelling tests the relative economics of various resource portfolios in meeting future demand
- The model determines the optimal portfolio of resources to meet the demand under a range of scenarios (load, resource costs, market prices, etc.)
- Market prices are an important input to this process:
    - Different scenarios result in different surplus/ deficit conditions
    - The market price inputs allow these surplus/ deficit conditions to be appropriately valued

How do we come up with it?

Third-party forecast with adjustments

- Hitachi ABB Power Grids "ABB Power Reference Case"
  - Assessment of trends in regional power, fuel, and environmental markets
  - Based on fundamentals of supply/ demand in these markets
  - Coverage of North America, Europe, Japan
- Long standing methodology
- Used by dozens of North American utilities / IPPs

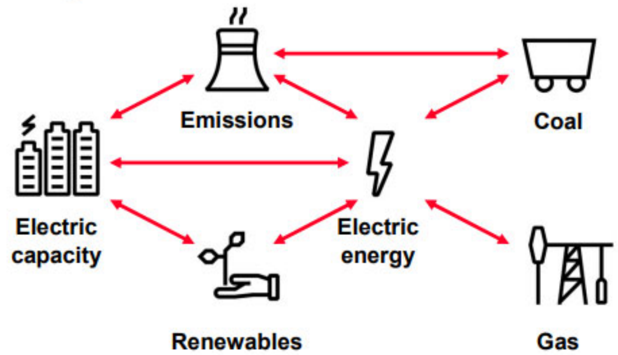
ABB Power Reference Case

Integrated model of regional power, fuels and environmental markets

Data

- Loads
- Generating unit characteristics
- Gas/coal supply and non-power demand curves
- Non-gas/coal fuel prices
- Transmission topology
- Non-power emission reduction supply curves
- Power market, emissions, and renewables rules

Integrated Model



Capacity
- Additions
- Retirements
- Retrofits

Prices
- Electric capacity
- Fuel
- Emissions
- RECs

PROMOD

Final electric energy prices

How do we come up with it?

ABB assumptions reviewed by internal specialists

- ABB assumptions reviewed by specialists in
  - BC Hydro Energy Planning & Analytics, Generation System Operations
  - Powerex
- Hourly generation dispatch model (PROMOD) re-run with updates to BC inputs (load, average generation) – found to have little effect on Mid-C price

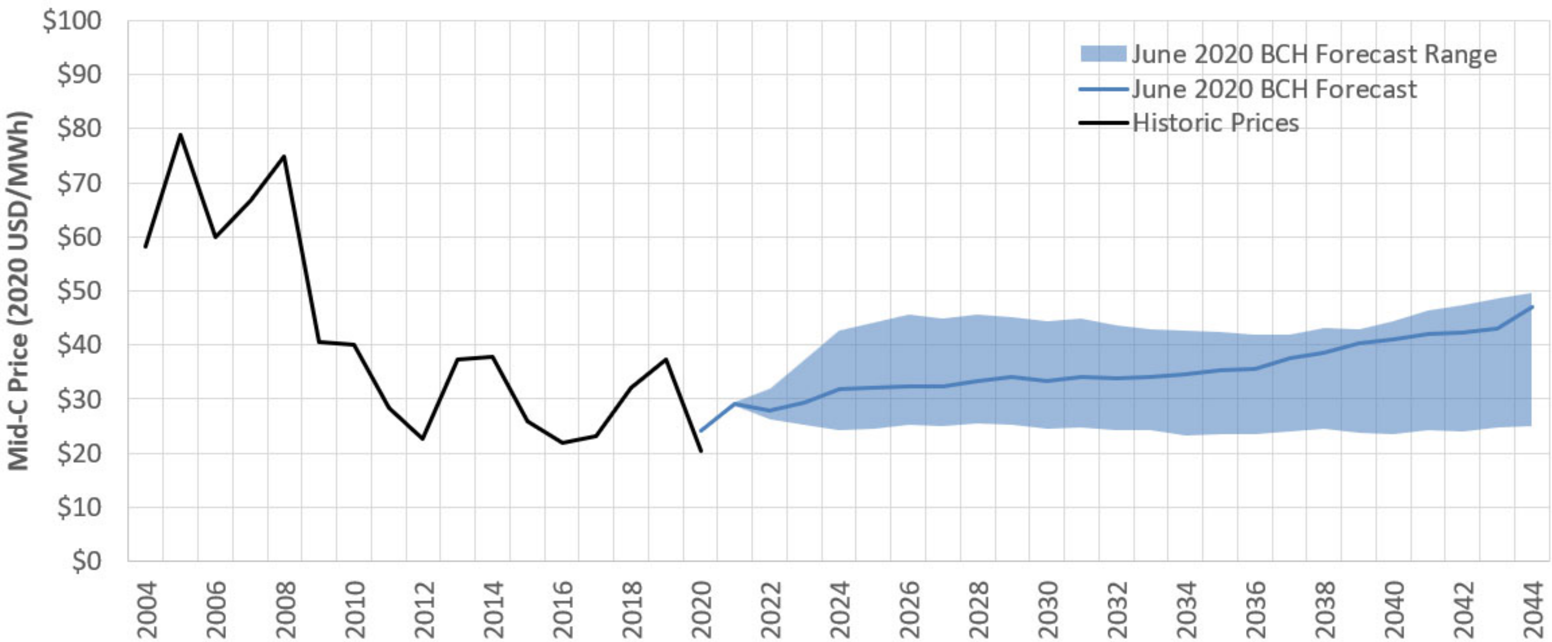
How do we come up with it?

Based on ABB Reference Case and Market Forward Prices

Period	Source of price forecast
Months 1-12 (year 1)	Market forward prices
Months 13-48 (years 2-4)	Blend of market forwards & ABB Reference Case
Months 49+ (years 5-25)	ABB Reference Case

June 2020 Mid-C price forecast

Forecast reflects long-term trends



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