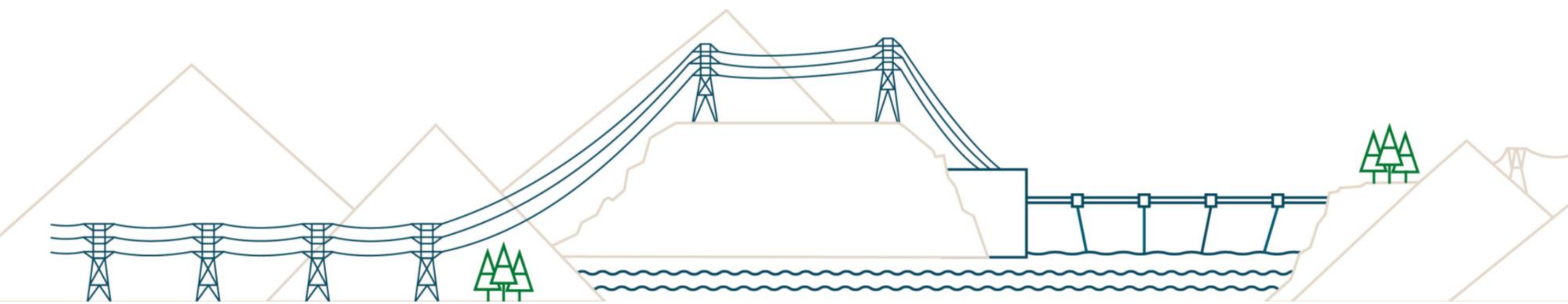
2021 Integrated Resource Plan (IRP) Technical Advisory Committee (TAC) Meeting #5



July 29, 2020

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Welcome & meeting context

Basil Stumborg, BC Hydro

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Agenda overview

Meeting purpose – to continue the review of modelling inputs before summer analysis begins

9:00 START		TBD BREAK		12:00 LUNCH	TBD BREAK		3:00 CLOSE
Welcome & Meeting Context	IRP Work Plan	Key IRP Questions	IRP Objectives & Key IRP Uncertainties		Generation Resource Options	Distributed Generation	Next Steps
Basil Stumborg	Kathy Lee	Kathy Lee	Basil Stumborg		Alex Tu	Alex Tu	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

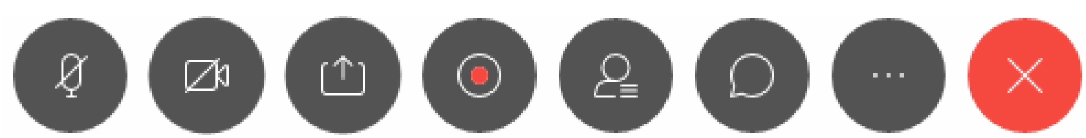
- To minimize distractions – keep yourself on mute
- We’ll use the chat box to seek input and ask questions
- We’ll not be recording these sessions, and ask for others not to record

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

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IRP workplan

Kathy Lee, BC Hydro

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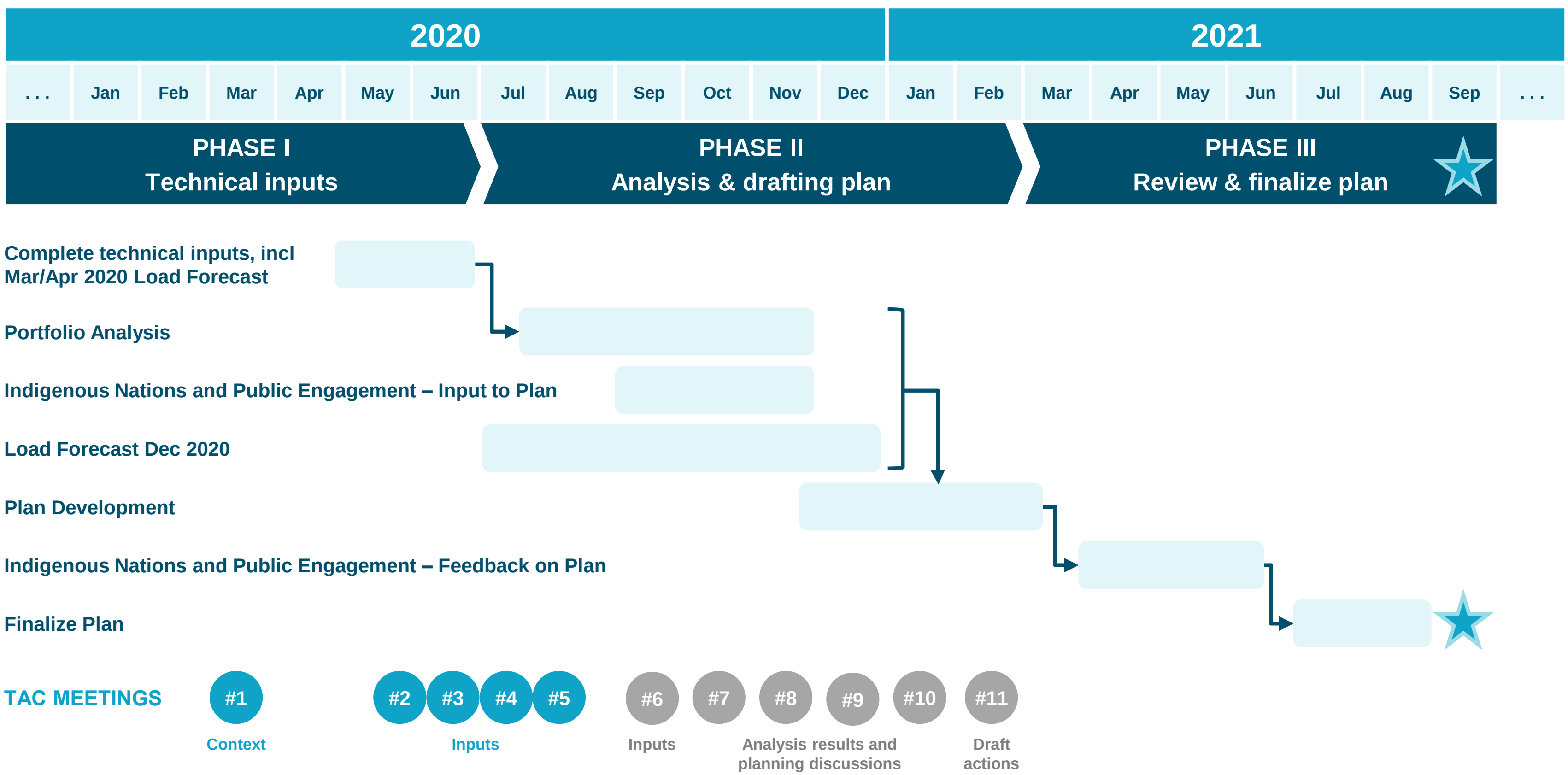
IRP work plan update

Highlighting opportunities for TAC member review and comments

- Following slide is a view of timelines and potential TAC meeting options
- Considerations when developing the IRP workplan and TAC meetings
  - An updated load forecast (December 2020)
  - Two rounds of consultation (fall, spring)
  - Consideration of consultation input
  - Application writing
  - A filing date of September 2021
- Workplan shows when TAC members will review inputs and analysis outputs
- Time slots are broadly set
  - Amount of meeting time is variable, roughly one day a month (+/- 50%)

IRP 2021 updated schedule

Critical path for a September 2021 filing



Mapping planning inputs with IRP steps

Phase 1 included gathering inputs and reviewing with TAC members

PHASE 1 – INPUTS

Context & scope	IRP overview	Decision framework	Market price forecast		
Assess future electricity need	Load forecast	Planning criteria	Load resource balances	*Distributed generation	Electrification (and scenarios)
Potential resources	DSM & rate options	Generation supply options	*EPA renewal		
Analysis	*Key questions decision objectives	*Key uncertainties			
Develop plan					

Reviewed with TAC in first 5 meetings
* Being reviewed today

To be reviewed in early September

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IRP work plan update

What the IRP team is looking for from TAC members

At the end of today, we will check in with you about the:

- Volume of meetings?
  - 1.5 days/month using Webex – is this a productive use of time?
- Balance of pre-read material to presentation of details?
- Right method and level of getting your feedback?

Key IRP questions

Kathy Lee, BC Hydro

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High-level IRP questions

Answers to these questions will be the key elements in our IRP

- How much DSM to pursue – energy efficiency, what is the role of demand response and rate options?
- What's the approach for renewing existing Electricity Purchase Agreements (EPAs)?
- Any exceptions to the default approach of sustaining our generation assets?
- What and when is the need for next new resources?
  - Generation (capacity)
  - Generation (energy)
  - Transmission
  - Imports in long term planning?

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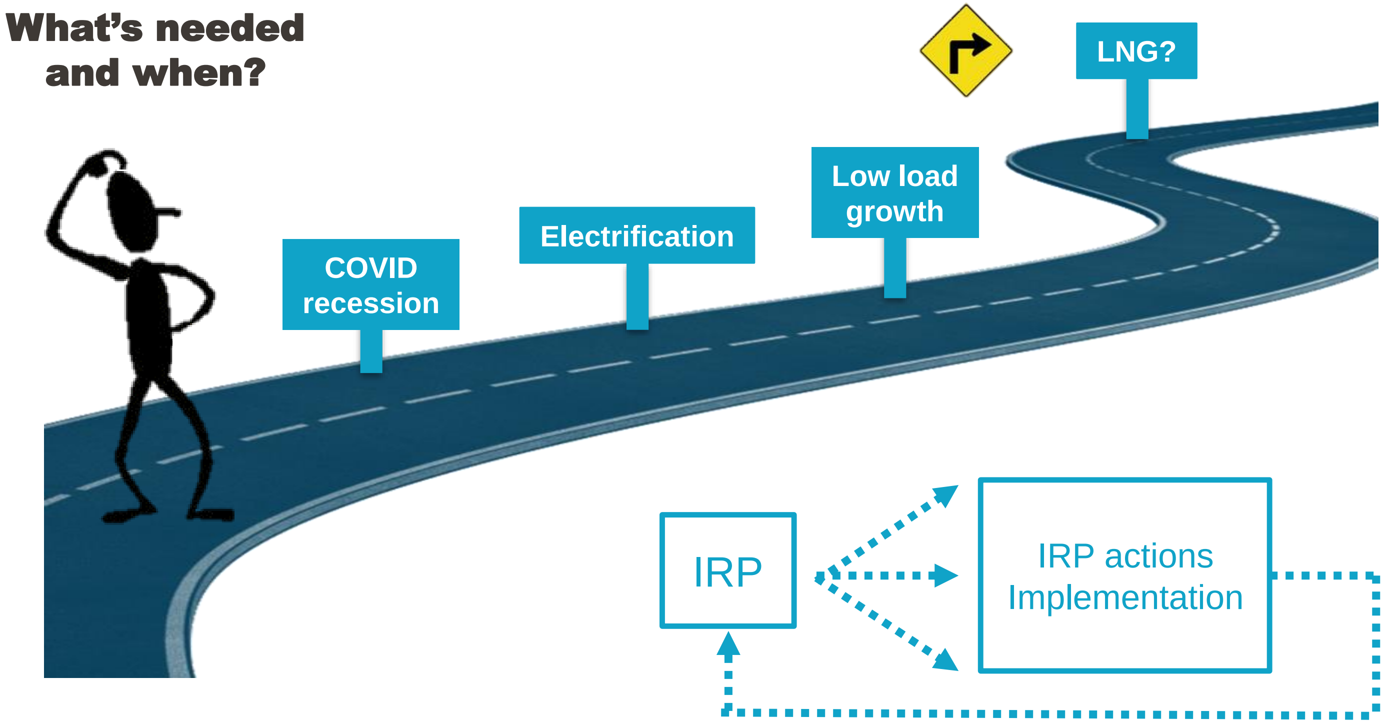
Biggest planning challenge is uncertainty

A successful IRP will accommodate a broad range of uncertainty



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Determining need for planned resources

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

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 resources beyond existing/committed that might be in our IRP:

- DSM programs
- Future EPA renewals
- Revelstoke 6

Need for planned resources

Observation based on June 2019 LRB – to be updated in September 2020

Reference case

- System: near term surplus; no pressing need for energy and capacity
- Regional: earlier need (capacity) for Lower Mainland/Vancouver Island (LM/VI)

Lower load

- System and regional needs further deferred

Higher load

- System and LM/VI needs advanced
- North Coast, Peace Region, Vancouver Island

New in 2021 IRP: Planning for Load Reductions?

What should BCH do from a power system planning perspective?

- COVID-19 has caused significant reductions in load
- BC Hydro is considering, for the first time, load reduction scenarios
- This raises numerous issues beyond power system planning (i.e. financial and operational issues)
- Nevertheless, some tools to address these reductions in load are power system planning options:
    - Level of DSM investment
    - Level of EPA renewals
    - Some discrete sustaining capital investment opportunities

Key questions

Interrelated questions solved simultaneously but four buckets for discussions

	Reference case – near term	Higher load OR Reference case longer term
System (energy & capacity)	Approach for: Demand side options, EPA renewals, Assets (by exceptions)	More? Plus: New resources? More?
Regional (capacity)	More? Greater focus in Lower Mainland Vancouver Island Region Plus: New resources later?	Greater focus in North Coast, Peace Region Plus: New resources?

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System – Reference Case – Near Term

The early planning horizon has us looking at choices with customer involvement options, EPA renewals and our existing heritage assets

- DSM energy efficiency
- Capacity focused DSM programs, e.g. load curtailment, demand response
- Rate options, e.g. time of use rate
- Net metering program
- EPA renewals
- Generation heritage assets:
  - Small plants strategy
  - Out of service plants

System – Reference Case – Near Term

Approach must balance near-term cost with the value of keeping options open

Considerations given sufficient resources in the first part of the planning horizon and load uncertainties:

- Insurance against rapid load growth?
- Lost opportunity to take advantage of low-cost resources?
- Now or never? Will the option disappear in the future if we decline today?
- Flexibility? Can our commitment to the option grow or wane in response to new conditions?

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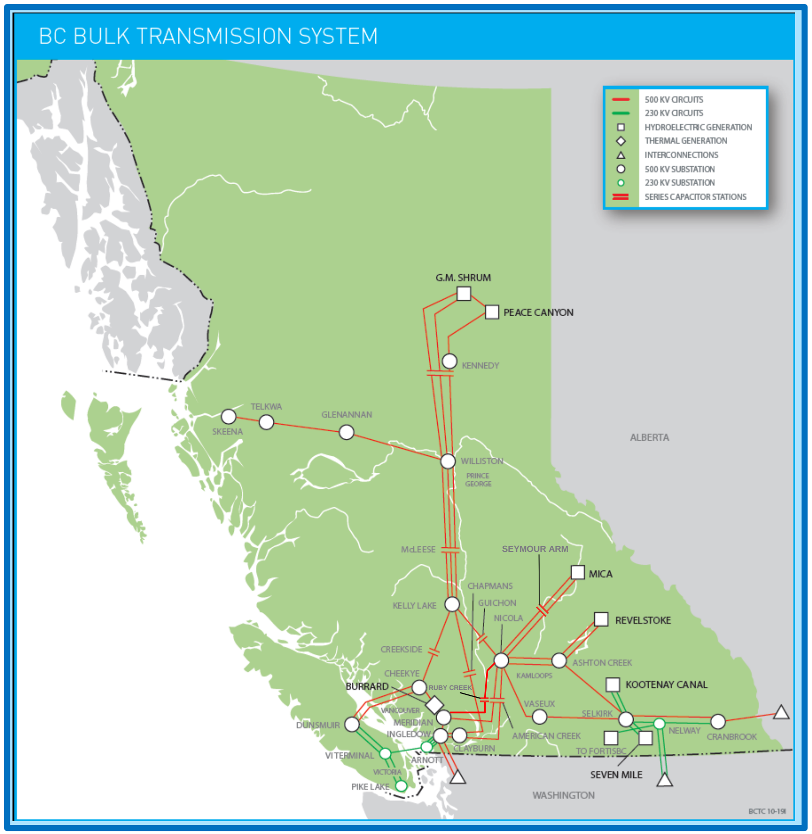
Regional – Reference Case – Near Term

Choices to serve Lower Mainland/Vancouver Island



In the near term:

Primarily a capacity question with greater regional focus? (e.g. more demand response in Lower Mainland?)

Then later…

Local generation (e.g. assets, batteries, pumped storage in Lower Mainland?)

<u>OR</u>

Remote generation with transmission
(e.g. Rev 6, transmission requirement from interior to Lower Mainland?)

Regional – Reference Case – Near Term

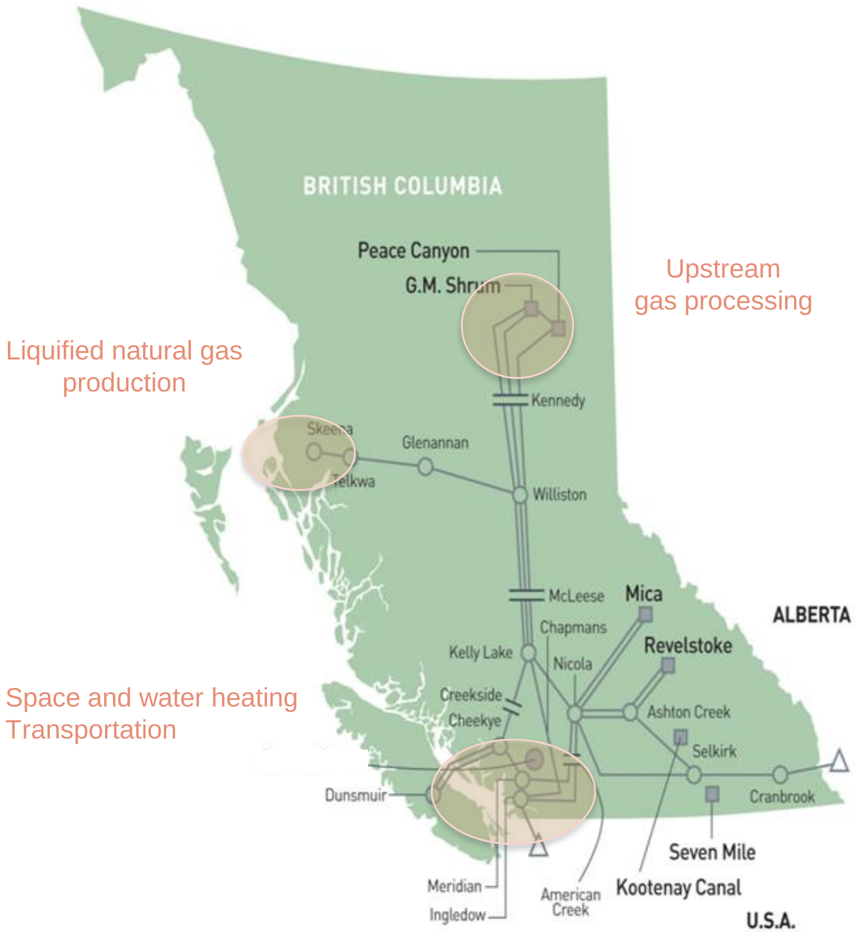
Key tradeoffs between local and remote options

Considerations:

- The amount of peak shifting possible considering the load shape
- Ability to secure transmission right of way
- Long lead time for transmission
- Future cost decline for batteries and the land requirement
- Pumped storage permitting and integration feasibility
- Rev 6 environmental assessment certificate
- Others?

Regional – Higher Load or Longer Term

North Coast & Peace Region also need special attention



North Coast & Peace Region:
uncertain potential large 'lumpy' loads

A question of transmission strategy:

- Proactive - build ahead to prepare but risk stranded assets
- Reactive – respond to customer requests

Options and considerations:

- What options can prepare us to serve but also minimize regrets? (imports, shorten lead time, risk sharing?)
- How proactive is prudent?
- Others?

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System – Higher Load or Longer Term

Approach should consider increased ability to serve while minimize regrets

- How much more of the “system – near term” approach is cost effective?
- Imports as bridging options to manage load uncertainty or resource delays?
- What new resources do we need and when do we pull the trigger?
  - What role does customer generation play?
  - Wind, solar, redevelopment of aging assets, Rev 6, batteries, pumped storage?
- Any additional preparation on the grid? e.g. distribution system supporting electric vehicles, technology to support demand response

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IRP objectives

Basil Stumborg, BC Hydro

IRP objectives

Roadmap to this topic

- Quick review and recap
- Link to modelling
- Preliminary list – work in progress
  - Some examples to make this concrete
- How will this list be used?
- Next steps
- Discussion

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Comparing options across multiple objectives

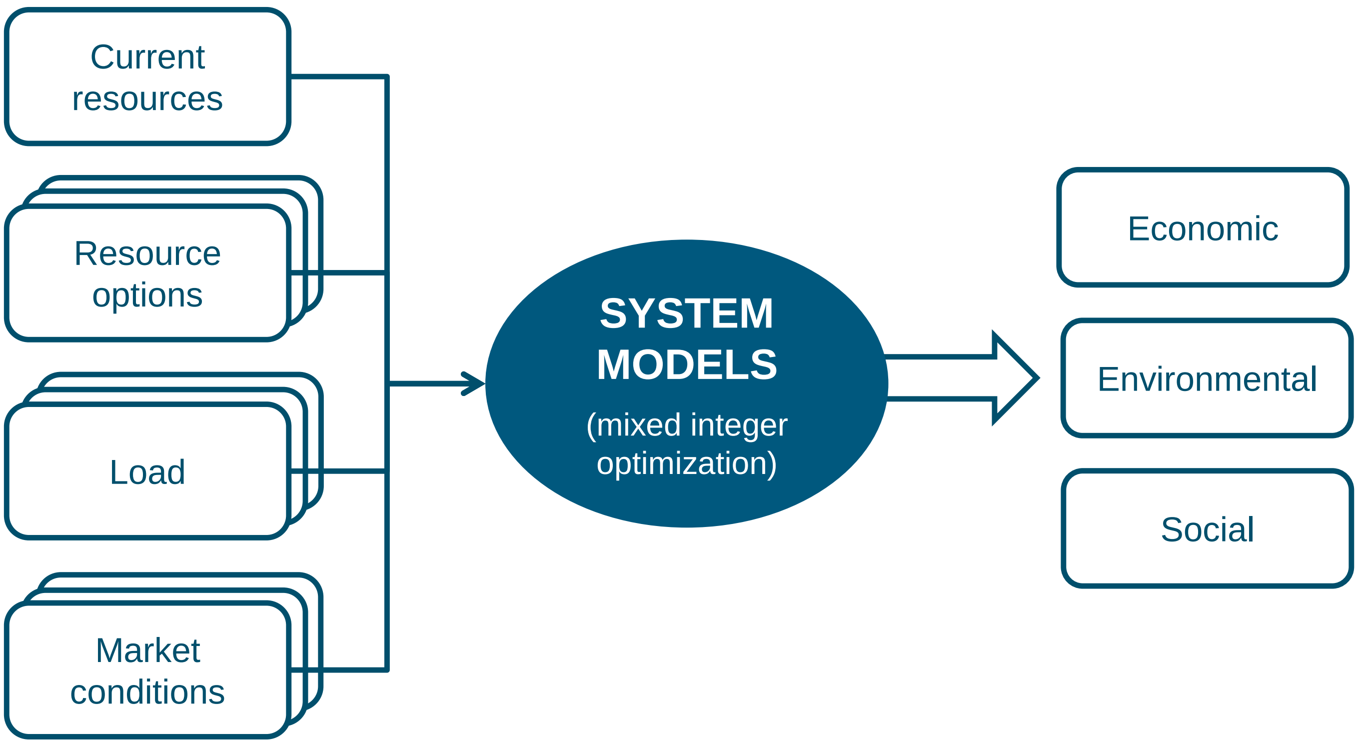
The “best” solution may depend on a balance of competing objectives

TAC was introduced briefly to the IRP decision framework in March 2020

- BC Hydro must consider multiple objectives when developing its IRP
- Some of these objectives may be in tension with others
- Some of these impacts are forecast with more certainty than others
- IRP analysis will estimate how different solutions make progress towards or away from these objectives

Comparing options across multiple objectives

Each portfolio will be a possible solution to system needs, characterized by these multiple objectives



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Comparing options across multiple objectives

"Decision objectives" are used for the comparison of options

Not all objectives are relevant for comparing options:

- Some objectives will be held as constraints
  - e.g. safety, reliability
- Some objectives are more about process
  - e.g. earlier and deeper consultation with Indigenous Nations
- Some objectives will factor into implementation

"Decision Objectives" for BC Hydro, are the 'things that matter' when comparing options

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Draft objectives – for comparing options within the IRP

This is a preliminary list and is open for discussion

Objectives	Sub-objectives	Measures	Comments
Minimize cost	Minimize cost to BC Hydro	NPV	For all comparisons
	Minimize cost at risk to BC Hydro	NPV	For valuing optionality
	Minimize rate impact	Relative %	For a few portfolios, including Base Resource Plan
	Minimize cost impact to customer type X	%	For 'DSM during surplus' considerations
Minimize environmental impacts	Minimize footprint	Ha	For options requiring new infrastructure
	Minimize footprint of type X	Ha (?)	Possible layers to identify cumulative impact considerations for post IRP implementation
	Maximize GHG avoided in B.C.	t C02e	For electrification analysis
Maximize economic development	Provincial GDP growth	Incremental change	For electrification analysis
	Maximize employment creation	FTEs	
	Maximize rural employment creation	Regional FTEs	For 'IPP renewal during surplus' considerations and for electrification analysis
	Maximize Indigenous employment creation	Sub-regional FTEs	

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Objectives in the IRP

What are the next steps?

- This is a draft list of decision objectives
  - Based on BC Hydro's past IRP experiences
  - Also based on the key questions in this IRP
- Depending on the question, this list may be smaller
- This list is also a preliminary one
- BC Hydro will consult on 'what matters' when comparing options
  - With Indigenous Nations
  - With the general public
- Will consider feedback on these objectives.
- In the fall, when portfolio modelling results are brought back to TAC, comparisons based on (subsets of these) multiple objectives will be presented.

Objectives in the IRP

To support multiple the comparisons of options

- Are there any questions from TAC at this point?
- Is there anything that BC Hydro has missed on this topic?
- Is there anything additional that BC Hydro needs to consider?

Key IRP uncertainties

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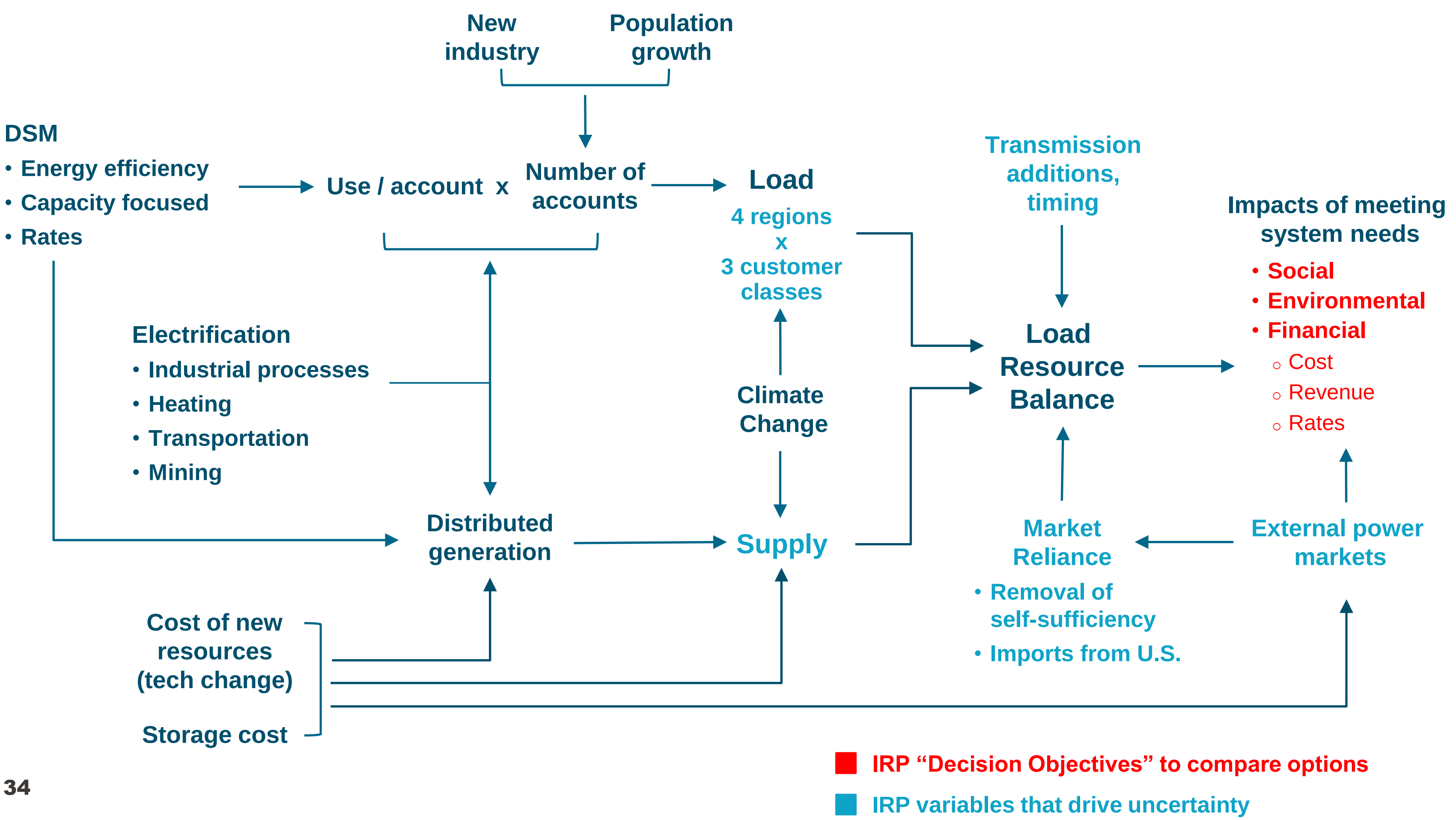
Key IRP uncertainties

Roadmap for this topic

- Recap / review
- Load uncertainties – examples
  - How will options be created and assessed?
- Other uncertainties – examples
  - How will these uncertainties be explored?
- Discussion

Types of uncertainties

Rough sketch of the interrelated uncertainties that impact this IRP



How will uncertainty be treated in this IRP?

Uncertainty can be treated in a number of ways

1. Think broadly – to counteract overconfidence
2. Include good estimates of uncertainty in forecasts
3. Take a cautious approach when setting standards (fixed value + margin for safety)
4. Create better (flexible) options
5. Carry out sensitivity analyses
6. Incorporate uncertainty into the consideration of tradeoffs
7. Monitor and react

- Following slides will focus on the following elements from this list:
  - #1 and #4 – for load sensitivities
  - #5 for other uncertainties

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Potential Lower Load Sensitivities

BC Hydro will consider loads falling below its Reference Load Forecast

Load Sensitivity	Details
Distributed Generation Defection	• COVID-19 triggers a long-lasting depression resulting multi-year GDP declines and load declines over the near-term forecast horizon. • Significant load declines across all sectors continue over the medium term with no recovery over the 20-year horizon. Rising BC Hydro rates, tech advances in solar and battery storage coupled with time-of-use rates and local retail access lead to substantial loss of load as BC Hydro customers (and FortisBC customers) turn to self generation.
COVID-19 Restructuring	• COVID-19 triggers a long-lasting depression resulting multi-year GDP declines and load declines over the near to medium term forecast horizon. • Long-term structural shifts occur between the commercial sector and residential sector, and the deep COVID-19 recession accelerates and deepens downward trajectory of forestry sector, leading to further load shrinkage in the medium to long term.
June 2020 COVID-19 Adjusted Low Sensitivity	• COVID-19 triggers short, sharp decline in system load in the near term. Load stays mostly flat over the moderate to long term with a number of large industrial customers closing permanently. Anemic economic growth and structural changes that further weaken the relationship between economic activity and electricity consumption keeps overall system load below pre-COVID-19 levels over the full forecast horizon.

Also to test robustness of Base Resource Plans

To prepare Contingency Plans for lower loads

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How will load sensitivities be used?

Different techniques for exploring load sensitivities

- System Optimizer will model portfolios of resources to meet system needs
- Comparing across loads gives insight into:
  - Volume
  - Timing
  - Additional considerations
- Currently, the IRP does not have a lot of ‘levers’ to address lower loads
  - Less DSM
  - Fewer EPA renewals
- Consequently, lower load sensitivities will not be a focus of the analysis
  - But will be pulled in when considering downside of ‘preparing for higher loads’ below

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Lower load sensitivities in the IRP

To support thinking broadly about load uncertainties

- Are there any questions from TAC at this point?
- Is there anything that BC Hydro has missed on this topic?
- Is there anything additional that BC Hydro needs to consider?

Potential Higher Load Sensitivities

The analysis will consider loads higher than the reference load forecast

Load sensitivity	Details
Navius 1 Electrification Scenario: Meeting BC GHG 2050 targets	• Electrification and other policy measures (e.g. renewable natural gas usage) ramped up to meet B.C. GHG reduction targets 2030 – 2050
Navius 2 Electrification Scenario: meeting B.C. GHG targets (lower battery cost sensitivity)	• Same as Navius 1 above, plus an assumption that battery costs decline at a faster rate than expected
Navius 3 Electrification Scenario: Meeting BC GHG targets (limited availability of biofuels)	• Same as Navius 1 above, plus alternative clean fuels (such as renewable natural gas and biodiesel) have limited availability and are higher cost
Mining + LNG 1 (North Coast)	• One (?) additional LNG facility and one (?) new mine
Mining & LNG 2 (North Coast)	• Incremental LNG and mining activity to LNG 1 (above)
Scenarios combining Navius Electrification & North Coast scenarios	• A few combined scenarios will be evaluated

Also to test robustness of Base Resource Plans

To prepare Contingency Plans for higher loads

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How will load sensitivities be used?

Different techniques for exploring load sensitivities

- System Optimizer will model portfolios of resources to meet system needs
- Comparing across loads gives insight into:
  - Volume
  - Timing
  - Additional considerations
- But the above comparison misses out on the role of uncertainty
- Following slide shows how to create and value options
  - How to consider ‘regret’ of choosing incorrectly

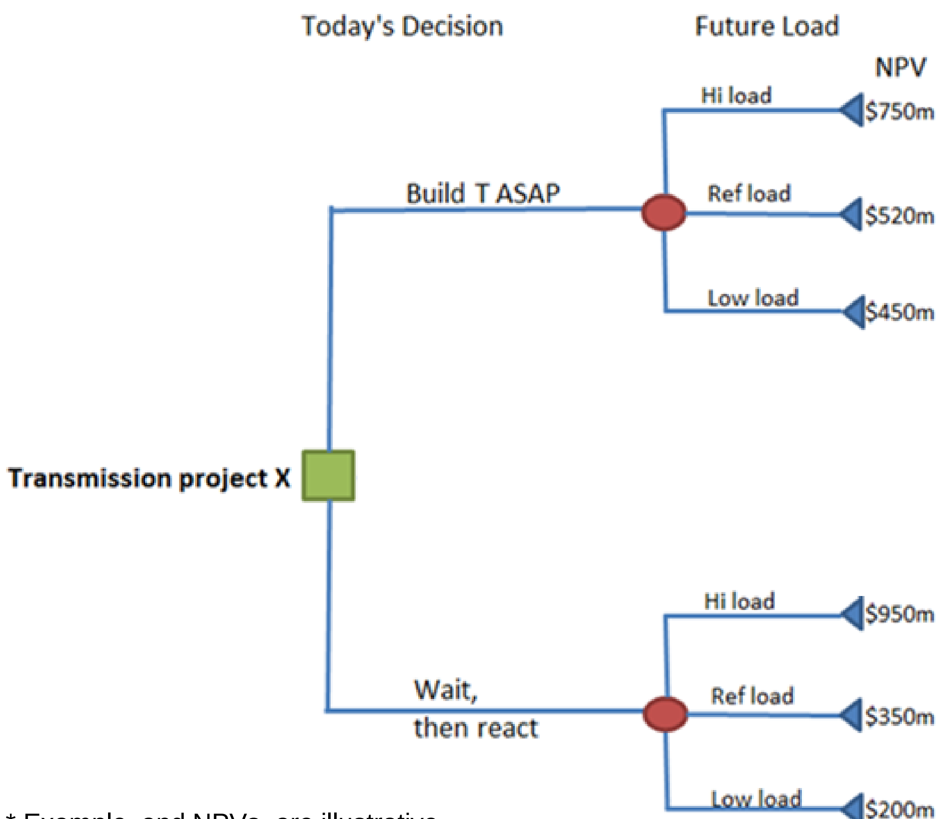
How to prepare for larger loads

…but avoid making investments we will regret

- Considering options will be a key part of this IRP
  - Considering their benefits (capturing upside)
  - But also their costs
- Likelihoods (probabilities) also important
  - This will be applied to transmission projects
  - But maybe to other topics as well
- This approach is time consuming
  - Can only be applied in a limited number of cases

Valuing Options in the IRP

Decision trees will play a role here



If our T schedules can't match customer timelines, then build in advance of need is not the only option.

* Example, and NPVs, are illustrative

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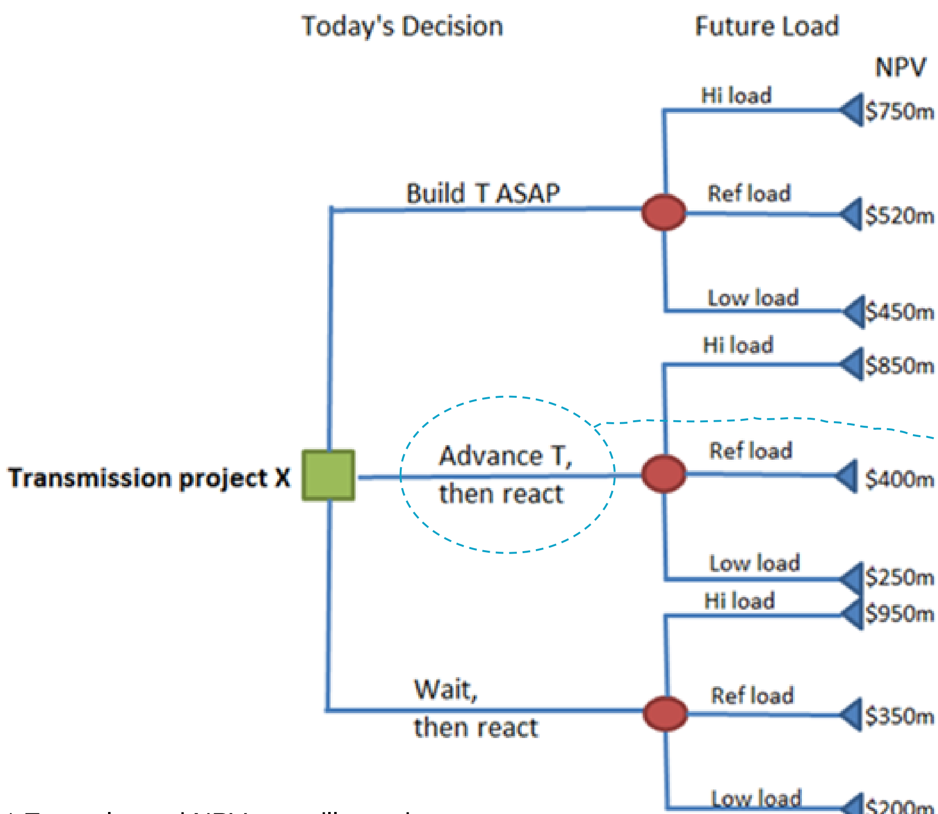
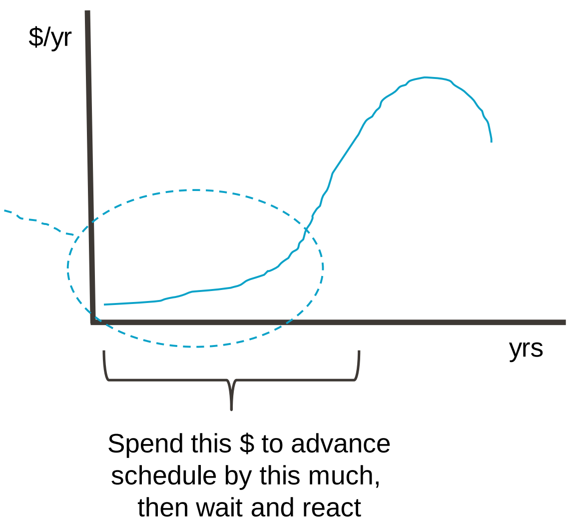
Valuing Options in the IRP

Decision trees will play a role here



If our T schedules can't match customer timelines, then build in advance of need is not the only option.

BCH can peel off "cheap" but lengthy planning/consultation/permitting sections.



* Example, and NPVs, are illustrative

Valuing options in the IRP

Decision trees will play a role here

- Probabilities will be important, but problematic
- But there are ways to work around this, and search for solutions that are robust across a wide range of likelihoods

Strategy Map

		Probability that High Load occurs									
		0%	5%	10%	15%	20%	25%	30%	35%	40%	45%
Probability	0%	Wait	Wait	Option	Option	Option	Option	Build	Build	Build	Build
That	5%	Wait	Wait	Wait	Option	Option	Option	Build	Build	Build	Build
Low Load	10%	Wait	Wait	Wait	Wait	Option	Option	Build	Build	Build	Build
Occurs	15%	Wait	Wait	Wait	Wait	Option	Option	Option	Build	Build	Build
	20%	Wait	Wait	Wait	Wait	Wait	Option	Option	Option	Build	Build
	25%	Wait	Wait	Wait	Wait	Wait	Option	Option	Option	Option	Build
	30%	Wait	Wait	Wait	Wait	Wait	Wait	Option	Option	Option	Option
	35%	Wait	Wait	Wait	Wait	Wait	Wait	Option	Option	Option	Option
	40%	Wait	Wait	Wait	Wait	Wait	Wait	Wait	Option	Option	Option
	45%	Wait	Wait	Wait	Wait	Wait	Wait	Wait	Wait	Option	Option

Higher load sensitivities in the IRP

To support thinking broadly about load uncertainty in the IRP

- Are there any questions from TAC at this point?
- Is there anything that BC Hydro has missed on this topic?
- Is there anything additional that BC Hydro needs to consider?

Additional parameter sensitivities

Selected where these may be a key assumption underlying a particular solution

Key Uncertainty	Details
Pumped storage availability	• Modelling can assess how cost, project schedule, or even feasibility would impact IRP actions.
Battery costs	• Considered in the DG Defection load sensitivity, but may also play a part when looking at Non-Wires Alternatives, e.g. Rev6+ILM vs local storage or Vancouver Island Transmission upgrades vs. local generation and storage.
Cost of renewable generation	• Can be considered when assessing Non-Wires Alternatives, e.g. Vancouver Island Transmission upgrades vs. local generation and storage.
Export market prices	• Can be part of any assessment that will leave BC Hydro more exposed to export markets, e.g. level of market reliance, role of ICG, ILM2 and PGTC upgrades, etc.
DSM deliverability uncertainty	• The level of reliance on DSM (including rates) energy and capacity savings, and the consequence of it not being available, can be assessed to see if BC Hydro is comfortable with the cost-effective level of DSM selected by least cost solution.
Transmission project cost and delivery	• These parameters can be varied to see whether BC Hydro needs to change solutions or build in a mitigation strategy to avoid or reduce the impacts of these uncertainties.
Climate change impacts	• BC Hydro will look at the potential impacts of climate change across all parts of its planning system (supply and demand) to see whether additional actions in the IRP need to be taken to mitigate these impacts.
Cost of capital differential	• The relative difference between IPP and BC Hydro cost of capital can be a key uncertainty that tips a portfolio between BC Hydro funded elements and those provided by the private sector.

To test robustness of Base Resource Plans

To prepare Contingency Plans if warranted

Additional parameter sensitivities

How will these be addressed in the IRP?

These additional uncertainties will be dealt with in one of two ways:

- It will be possible to re-run system optimization with different parameter values to see how this impacts to selected portfolio
  - e.g. how does the ‘wires vs non-wires’ solution differ as battery costs vary?
- It will also be possible to match these parameters with load sensitivities, where this can add additional insight
  - e.g. perhaps a low load sensitivity with ramped up DG could be paired with low export market costs (as DG costs in the U.S. drive market prices lower)

Additional sensitivities in the IRP

To support thinking broadly about uncertainties

- Are there any questions from TAC at this point?
- Is there anything that BC Hydro has missed on this topic?
- Is there anything additional that BC Hydro needs to consider?

How will uncertainty be treated in this IRP?

Note: detailed slide with additional information

Uncertainty can be treated in a number of ways

- Think broadly – to counteract overconfidence
  - This leans heavily on creative scenarios to give us:
    - Wide ranging LFs and load sensitivities
    - Wide ranging parameter values
- Include good estimates of uncertainty in forecasts
  - Means eliciting subjective probability distributions, to capture professional 'beliefs' on ranges of uncertainty
- Take a cautious approach when setting standards (fixed value + margin for safety)
  - When we feel uncomfortable to properly tackle uncertainty and also uncomfortable measuring benefits of reducing uncertainty
- Create better options
  - Even if these are inflexible, they can de-risk outcomes (at some cost)
  - Create flexible options – to allow us to wait and react
- Carry out sensitivity analyses
  - Tornado diagrams to discover uncertainties that 'move the needle'
  - Hi/Low ranges to test if decisions are robust to key uncertainties
- Incorporate uncertainty into the consideration of tradeoffs:
  - risk
  - option value and expected cost
  - risk preferences (aversion)
- Monitor and react
  - Identify signposts and conditional actions
  - trigger points, trigger values
  - on-ramps and off-ramps

Generation resource options

Alex Tu, BC Hydro

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Purpose and outline

We will summarizes the draft findings of our generation resource options update

This presentation includes:

- Scope and approach of the generation options update
- Findings from technical engagement workstreams to update evolving resources
- Findings from the targeted updates of existing database resources
- Summary of draft results
- Summary of feedback to date
- Summary of Resource Smart options
- Approach to EPA Renewals as a generation resource option
- Discussion questions

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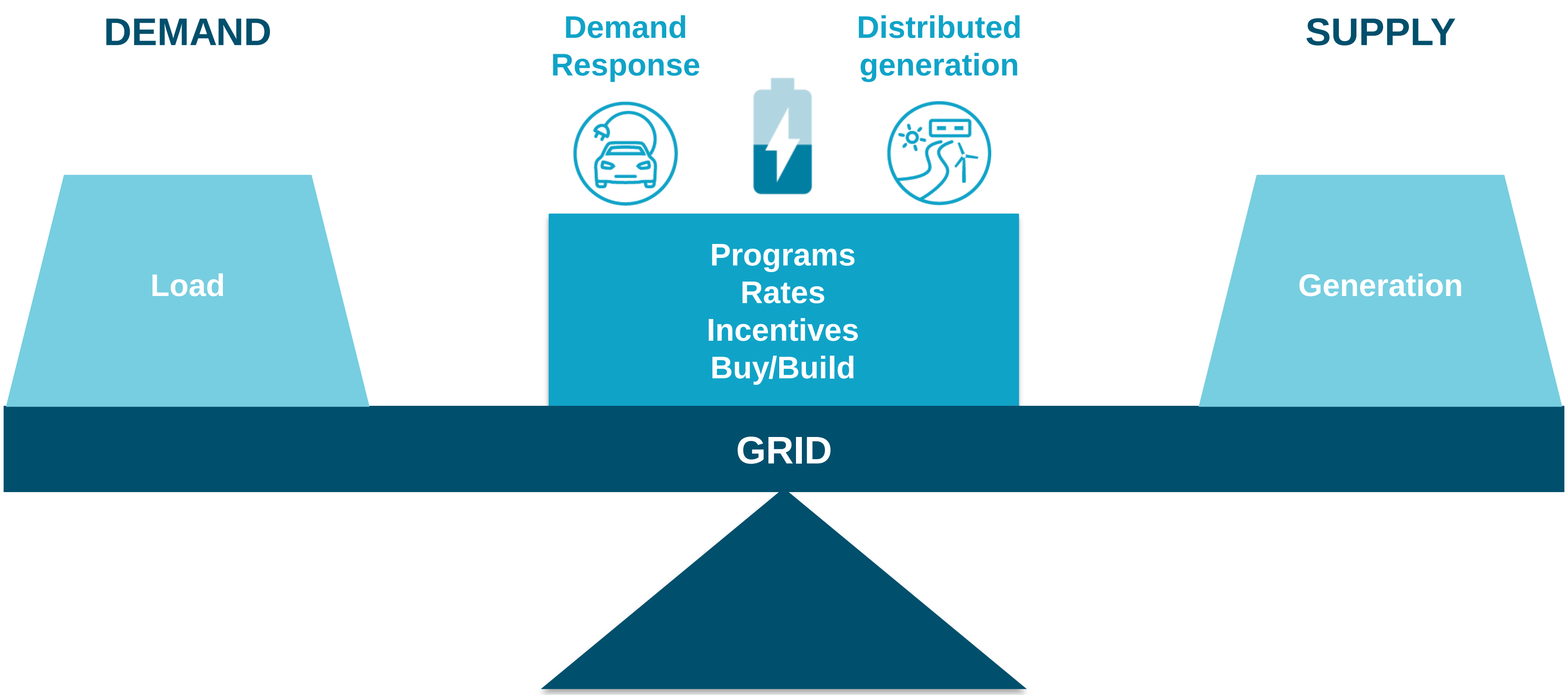
Resource options inventory

This presentation reports the update to Supply-Side Generation resources



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Characterizing resources

Attributes of resources at this stage are high-level and indicative

Attributes	
Technical	• Installed Capacity (MW AC), • Average Annual Energy (GWh/yr) • Dependable Capacity (MW)
Financial	• Unit Energy Cost ($/MWh) • Unit Capacity Cost ($/kw-yr)
Environmental	• Footprint (hectares)
Economic development	• Direct jobs (person-years)

- Financial measures at this stage represent the costs from the point of view of the developer, rather than the value from the point of view of the utility.
- These crude financial measures are a necessary input into Portfolio Analysis stage, where utility point of view on the relative value of resources will be developed

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Generation Resource Update - Approach

Focus on options that have evolved and watch out for new technologies

- Building on existing knowledge
- Focusing efforts on resource options that have seen the most changes and developments (e.g. wind, solar, batteries, etc.)
- Keeping watch on new technologies
- Collaborating with FortisBC on the update of generation supply-side options in the province

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Scope of Generation Resource Update

Our efforts focus on resources that have seen recent material changes (evolving) and ensure a breadth of coverage of resource options (emerging)

List of generation supply-side options that have been updated

Evolving			Existing database	Emerging
Solar	Wind	Batteries		

Evolving

Solar
- Utility & community scale
- Customer scale

Wind

Batteries
- Utility scale
- Customer scale

Existing database

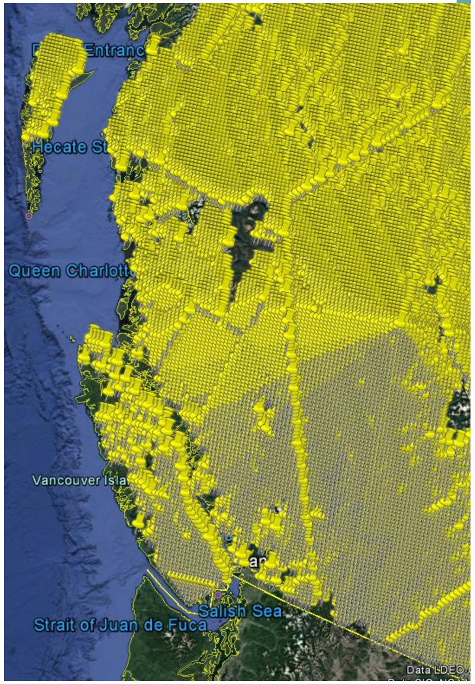
- Geothermal
- Run-of-river hydro
- Biomass
- Municipal solid waste
- Pumped storage
- Natural gas

Emerging

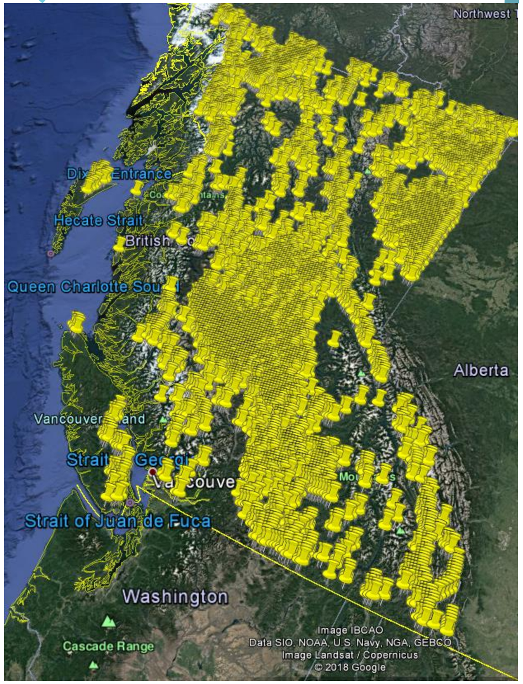
Next generation:
- New forms of Solar or Storage
- Pre-commercial Renewable Technologies e.g. Marine
- Emerging Customer distributed generation e.g. vehicle to grid

Solar Resources – Utility Scale

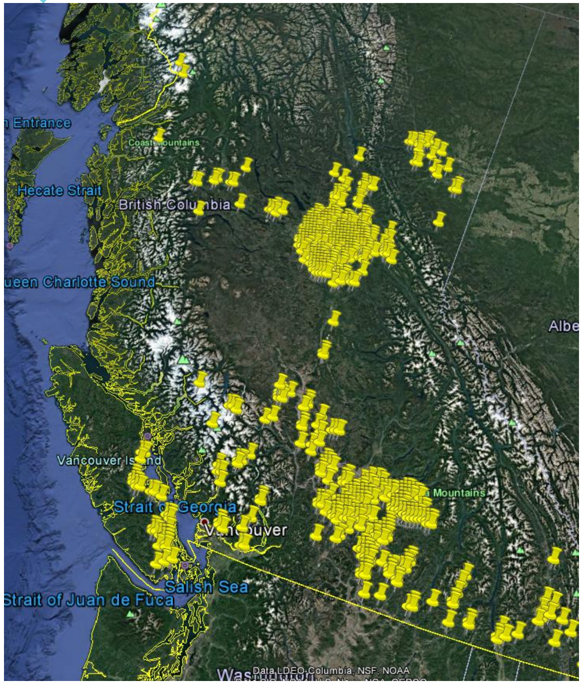
Technical resource limited by land use designation and distance from transmission



Unconstrained – exclude only water, parks and built areas



Less than 5% slope, not heavy forest



At least 15 MW, and within 25km of transmission

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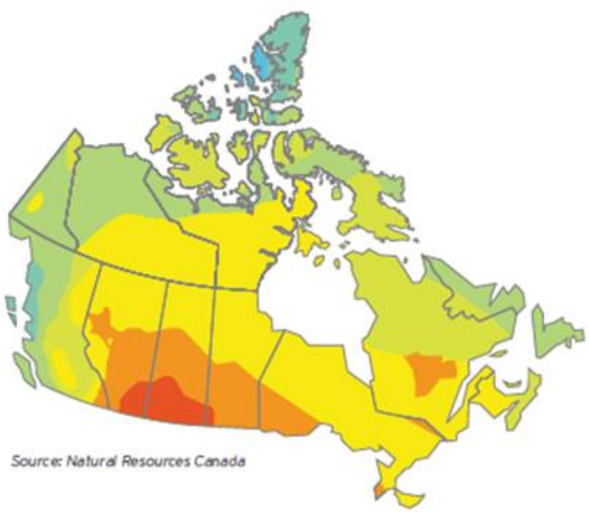
Solar Resources – Utility Scale

The quality of the solar resource varies across the province



kWh/kW 500-600 700-800 900-1000 1200-1300 1400+

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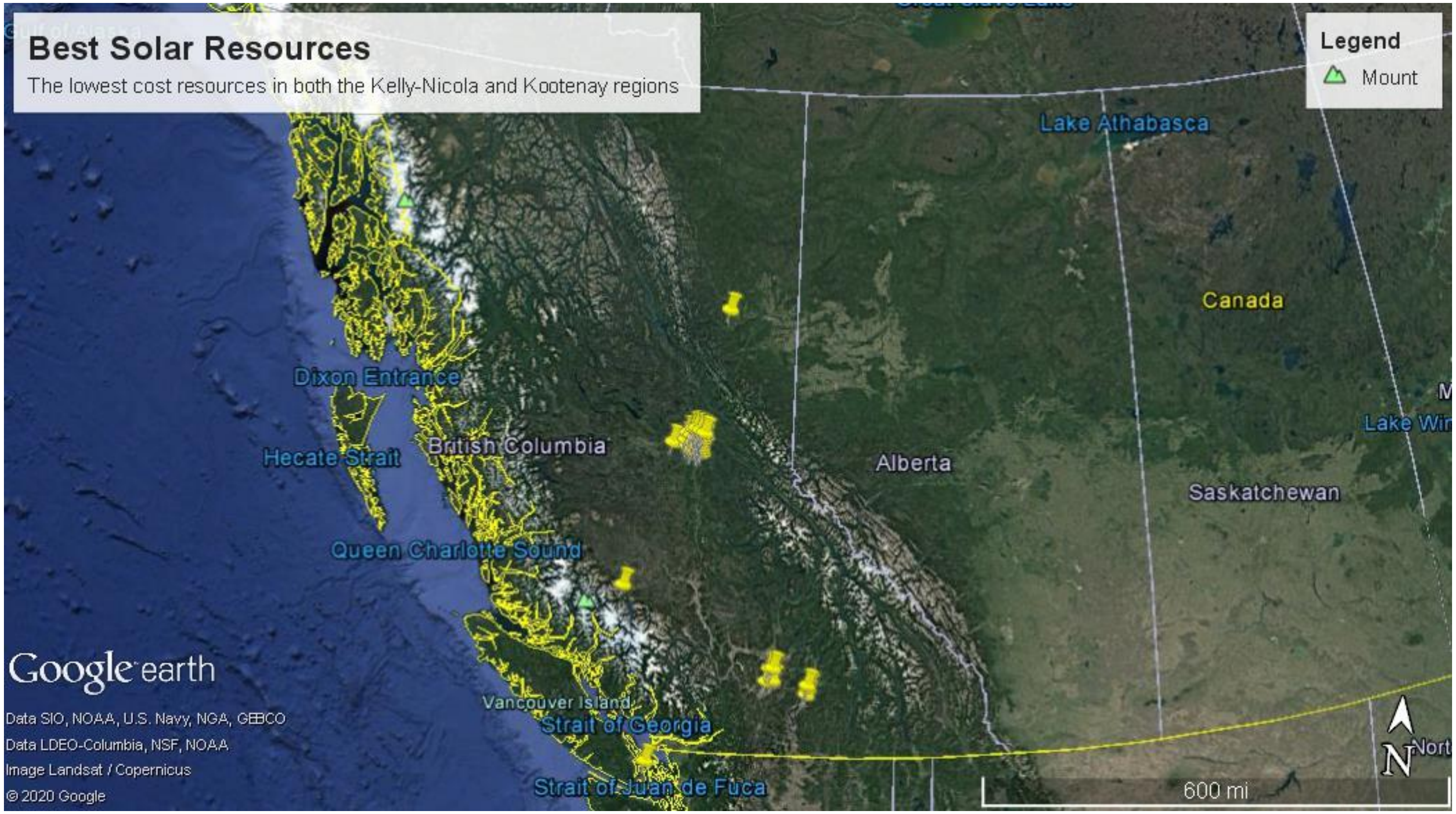
Solar Resources – Utility Scale

The lowest cost 30 solar resources based are clustered around Price George and Kelowna regions – not in the areas of the strongest solar resource



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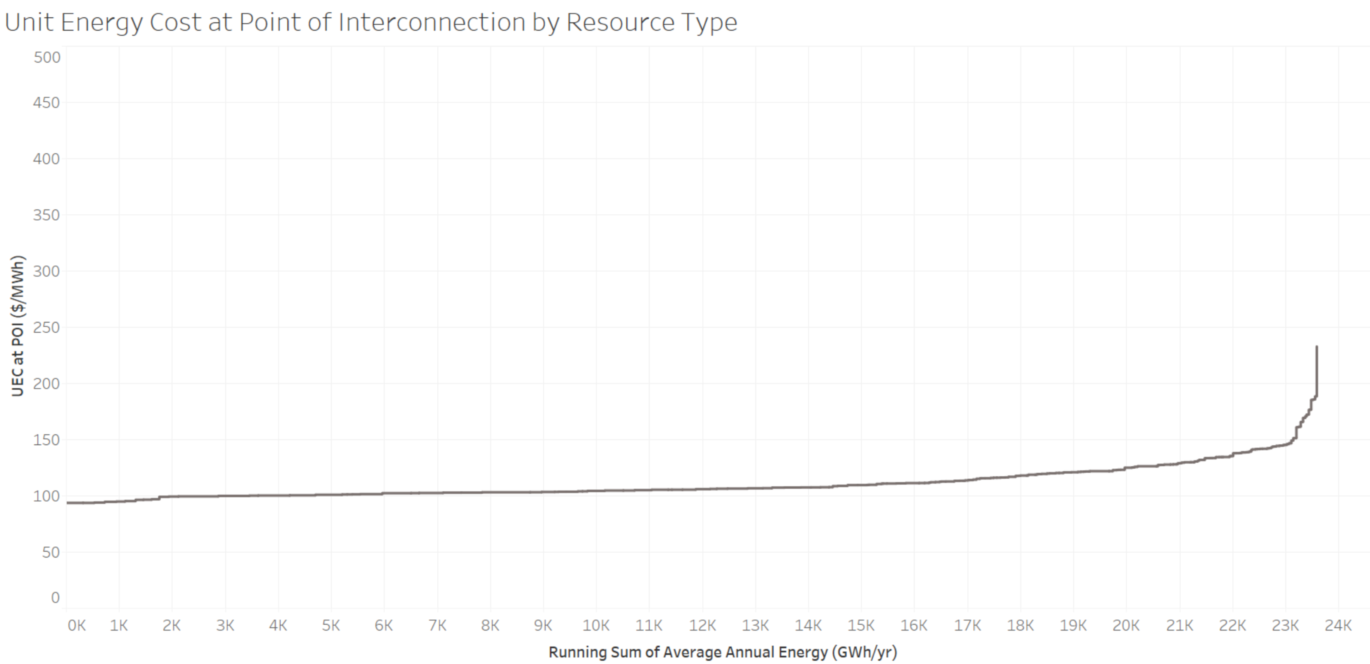
Solar Resources – Utility Scale

Abundant utility-scale solar resources (>20,000 GWh), most of which is available at between $95 – 120 / MWh if developed in 2020



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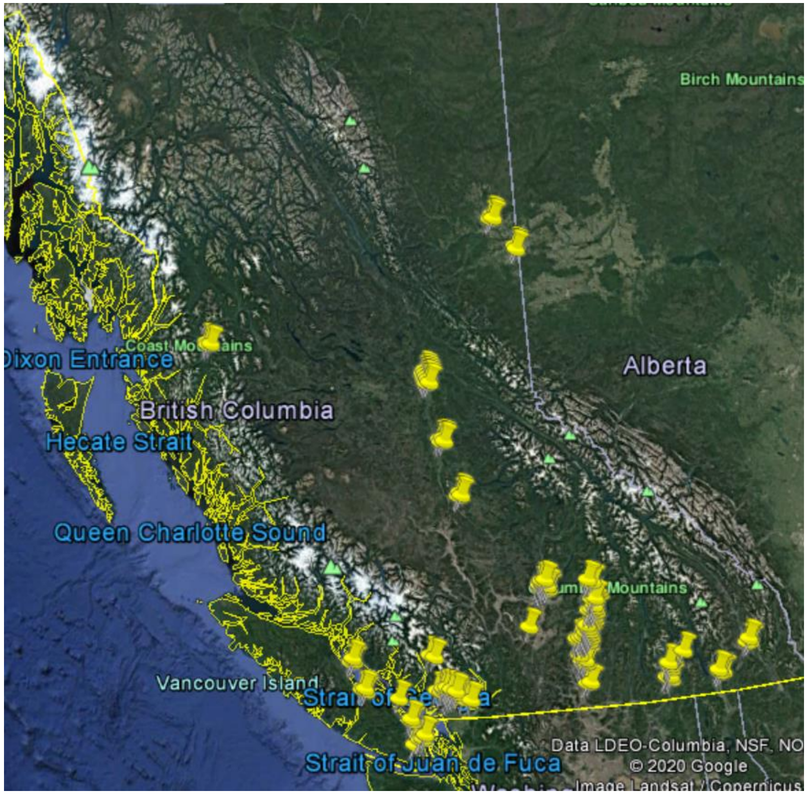
Solar Resources – Utility Scale

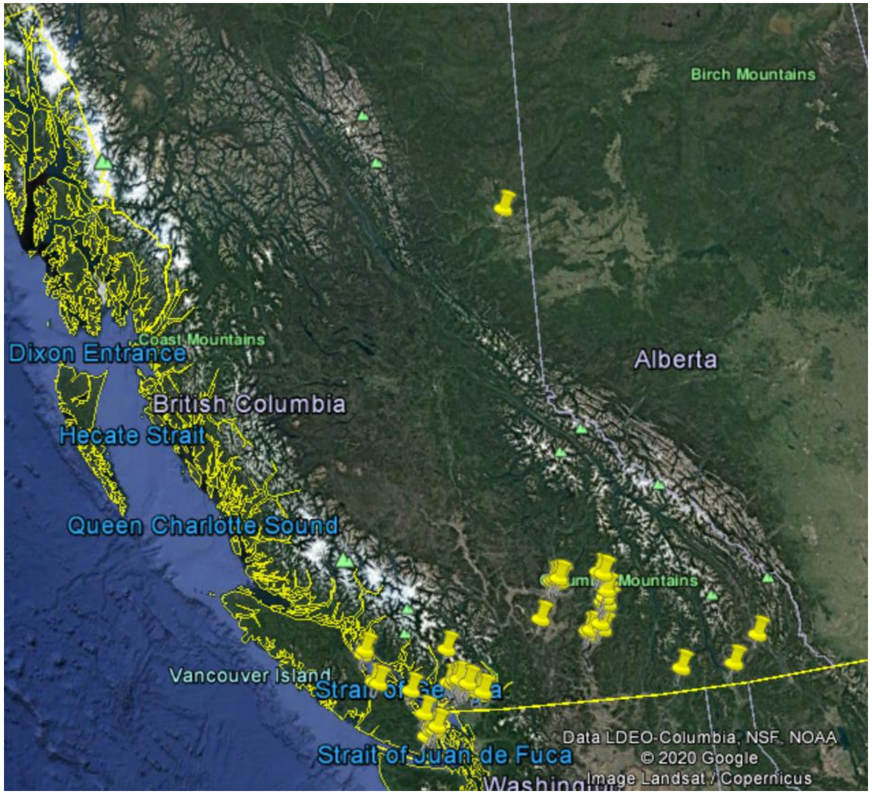
Summary of Feedback and considerations

- Not sufficient transparency into the Unit Energy Cost (UEC) calculation to follow the logic
  e.g. lifetime of system, financing assumptions, capacity factor etc.
- BC Hydro estimates of capital costs ($1,900 – 2,100 / kW AC) appear high relative to other jurisdictions, even after accounting for a premium for B.C.-based projects
- In general, utility scale estimates of UEC (as low as $93 / MWh) are reasonable

Solar Resources – Distributed Scale

Distributed solar resources are first screened based on available urban land and then based on carrying capacity of local distribution network





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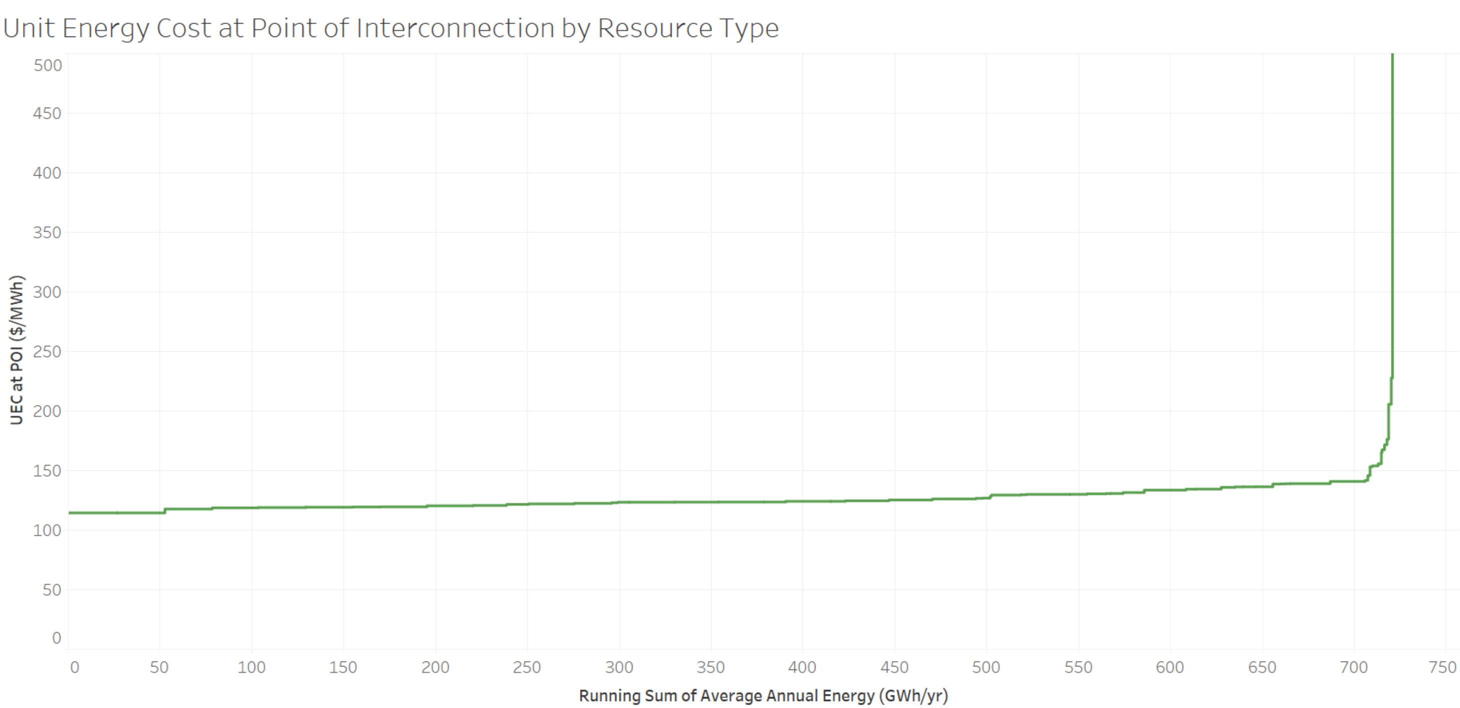
Solar Resources – Distributed Scale

Limited distributed scale resources (<700 GWh), most of which is available at a cost between $115 – 140 / MWh if developed in 2020



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Solar Resources – Distributed Scale

Summary of feedback and considerations

- These results are at-odds with distribution scale projects in Alberta in development today with costs between $45 to 70 / MWh
- Need more detail on how Distribution Connected Sites were identified
- How are customer-owned, behind the meter resources accounted for in the resource analysis?

Solar Resources – Financial Inputs

The key inputs below, and an assumed WACC of 6%, are the primary determinants of UEC

Scale	Capital Cost ($/kW)	OMA Cost ($/kW-yr)	Capacity Factor	Lifetime (years)	UEC @ POI
Utility	$1900 - $2100	$36	17 - 22%	30	$94 - 233
Distributed	$2590	$36	15 - 20%	30	$114 - 544
Customer (Com)	$3,000	$9	15%	15	$195
Customer (Res)	$3,400	$20	15%	15	$215

Wind – Onshore

Turbine costs and performance were updated

Methodology

- Analysis based on potential projects identified in the 2009 BC Hydro Wind Data Study and the 2009 BC Hydro Wind Data Study Update
- Installed capacity for each project was left unchanged, but average annual energy for each site was updated by developing generic power curves for leading edge turbines based on information from multiple turbine manufacturers

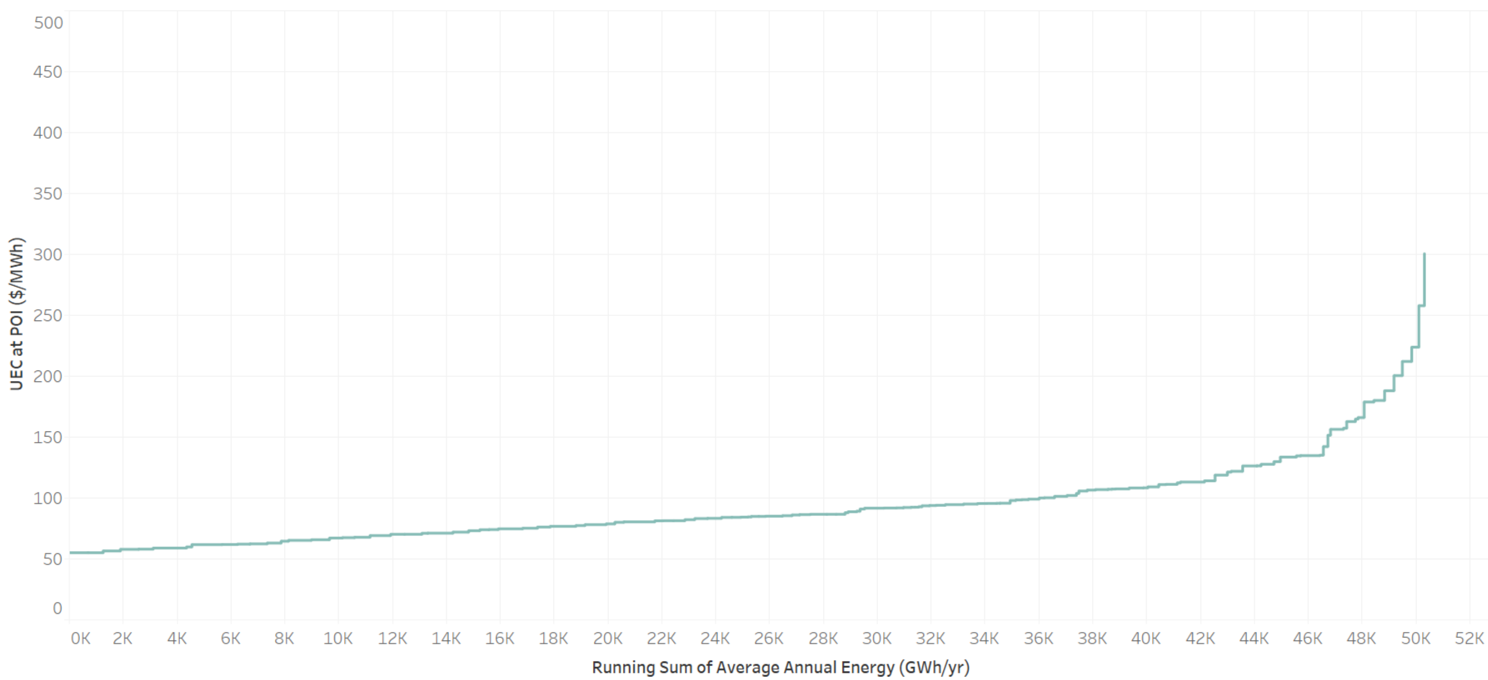
Key Assumptions

- In general, wind projects will utilize a series of 5 MW turbines with a 110 m hub height
- Capital and OMA cost information updated from 2015 based on
  - 2018 Hatch review of 2015 cost study
  - 2019 Wind Technology Market Report

Wind – Onshore

Abundant wind resources, but somewhat limited volume of low cost resources (<5000 GWh at less than $60/MWh) before climbing the cost curve

Unit Energy Cost at Point of Interconnection by Resource Type



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Wind – Onshore

Summary of feedback and considerations

- Not all the best sites for wind development were identified because analysis is based on wind data from 2009 and outdated turbine technologies
- Were environmental considerations related to caribou protected areas taken into account?

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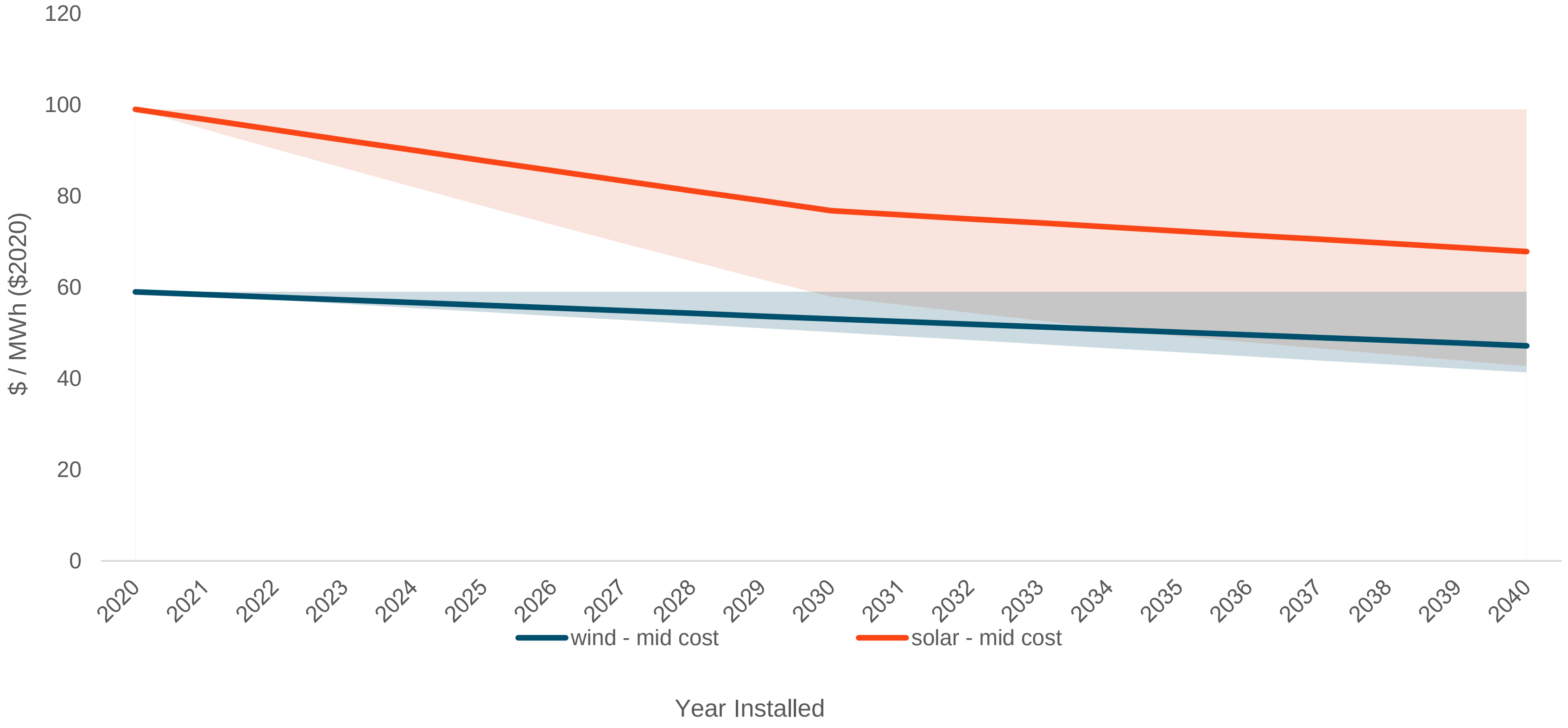
Wind Resources – Financial Inputs

The key inputs below, and an assumed WACC of 6%, are the primary determinants of UEC

Type	Capital Cost ($/kW)	OMA Cost ($/kW-yr)	Capacity Factor	Lifetime (years)	UEC @ POI
Onshore	$1,960 - 2,830	$60	26 - 54%	25	$55 - 301
Offshore	$3,800 - 4,760	$144	38 - 49%	25	$125 - 445

Future Costs of Wind and Solar

The future cost of solar has a wider uncertainty range, with the potential for larger cost reductions, than does wind



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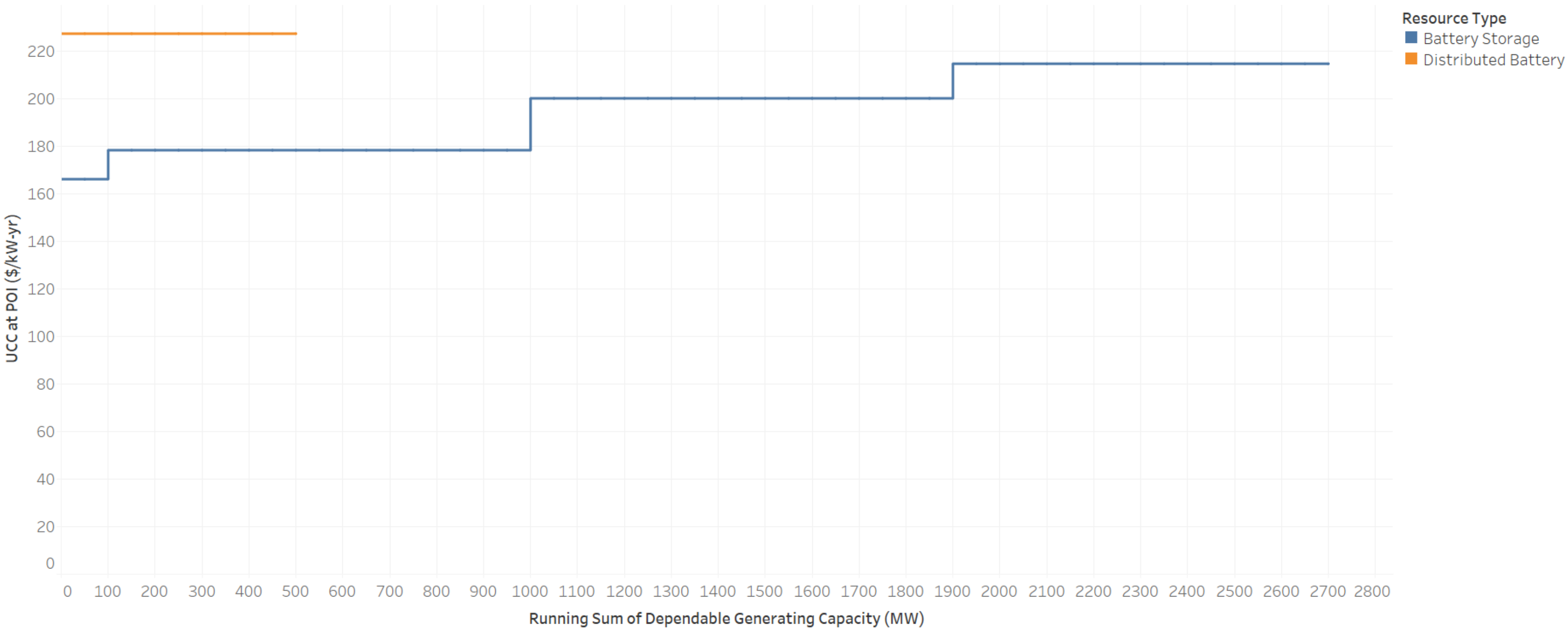
Battery Energy Storage

Batteries are generically defined as having a four-hour peak duration, and capable of providing dependable supply capacity during winter peak

- Relevant battery systems would most likely be located in one of these three grid locations:
    - Transmission connected at existing transmission substation infrastructure
    - Co-located with new transmission-connected renewable generation
    - Distribution connected at existing distribution substation infrastructure
- Both flow battery and lithium ion technology are viable alternatives, although lithium ion is currently more cost competitive
- Compressed air energy storage (CAES) has not yet been appropriately investigated for viability in the B.C. context

Battery Energy Storage

Co-located, Transmission-connected and Distributed Battery Storage systems have UCC between $165 - 230 / kW-yr



Battery Resources – Financial Inputs

The key inputs below, and an assumed WACC of 6%, are the primary determinants of UCC

Type	Capital Cost ($/kW)	OMA Cost ($/kW-yr)	Peak Duration*	Lifetime (yrs)	UCC @ POI
Co-located	$1,580	$52	4 hours	20	$166
Transmission	$1,700	$52	4 hours	20	$178 - 214
Distribution	$1,900	$55	4 hours	20	$230
Customer (Com/Ind)	$2,400	$10	2 hours	10	$310
Customer (Res)	$2,600	$10	2 hours	10	$340

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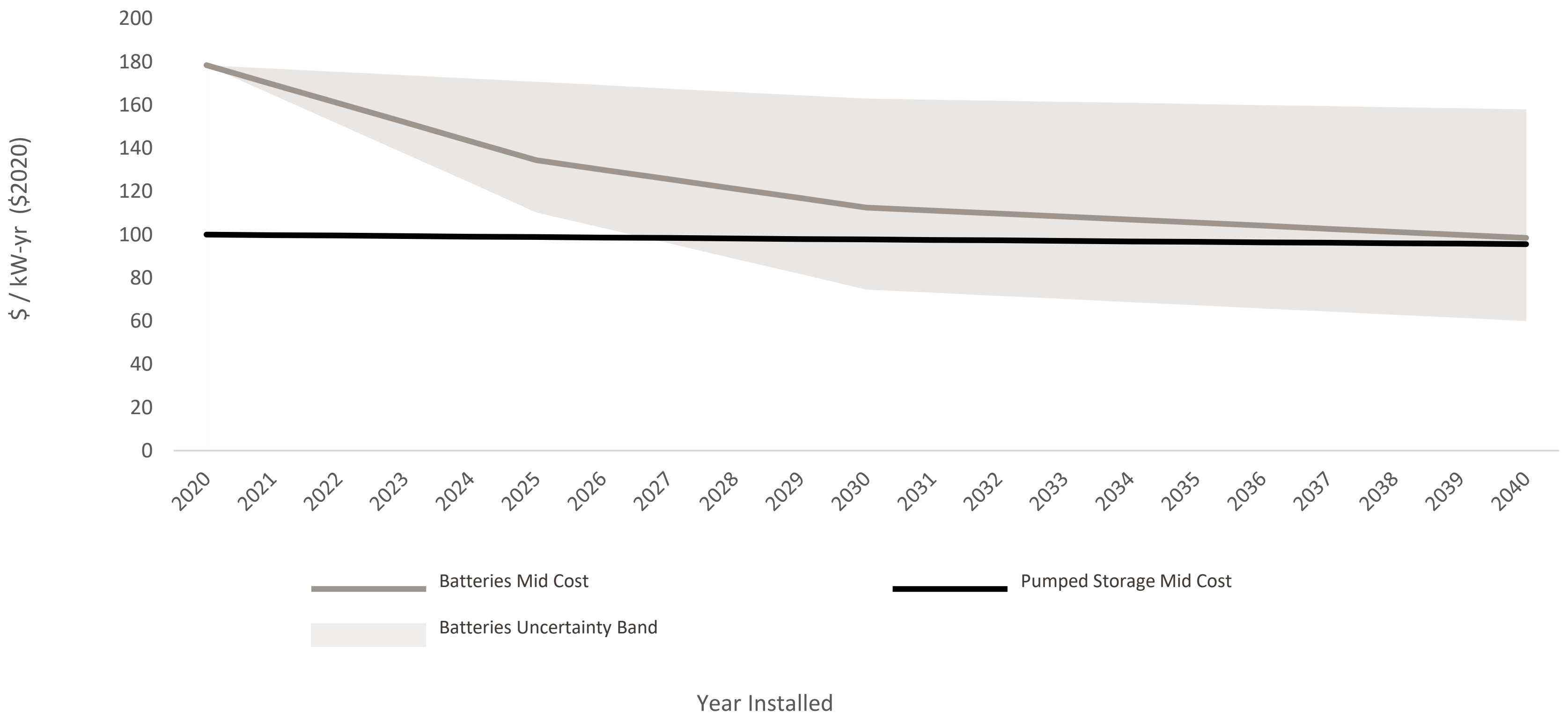
Future costs of Battery Energy Storage

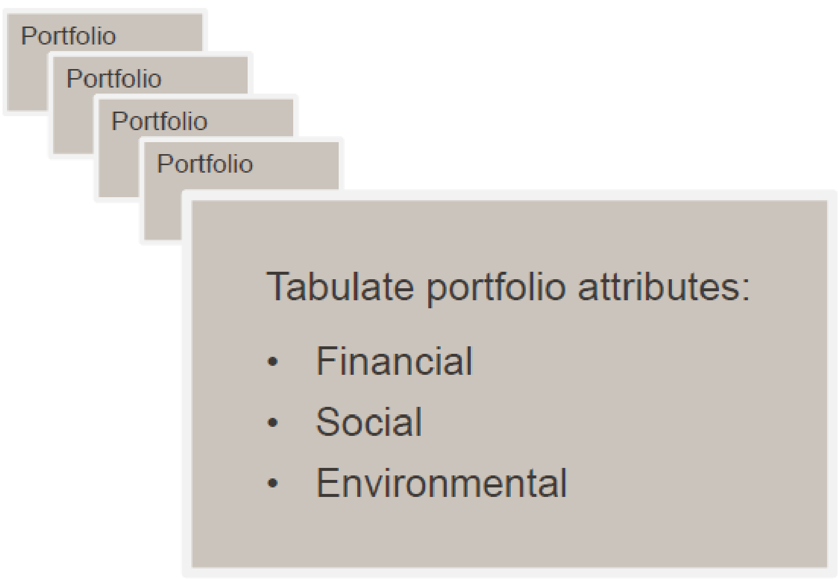
Relative to Pumped Storage, Battery Energy Storage may achieve cost parity based on UCC in the 2030 to 2040 timeframe



Non-financial attributes of additional resources

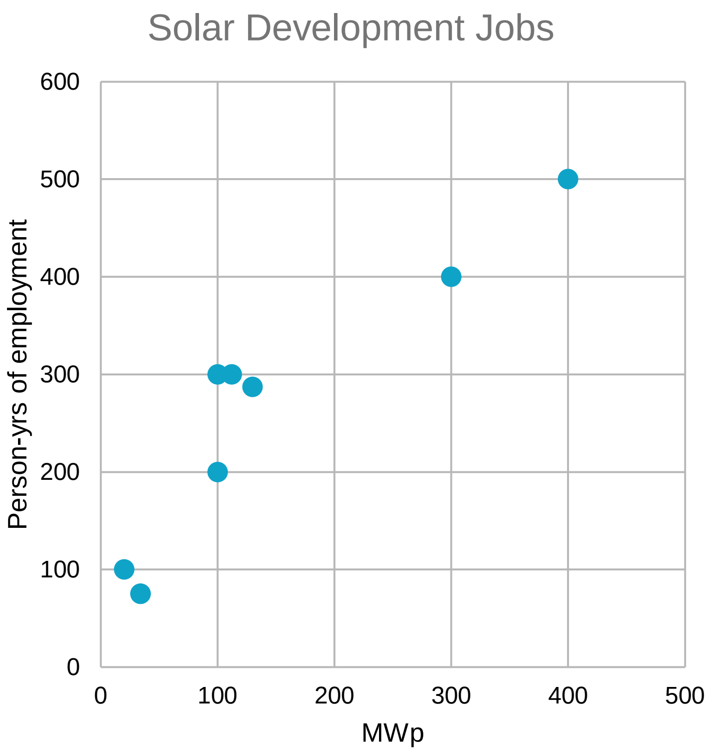
A quick reminder of multiple objective decision-making in the IRP

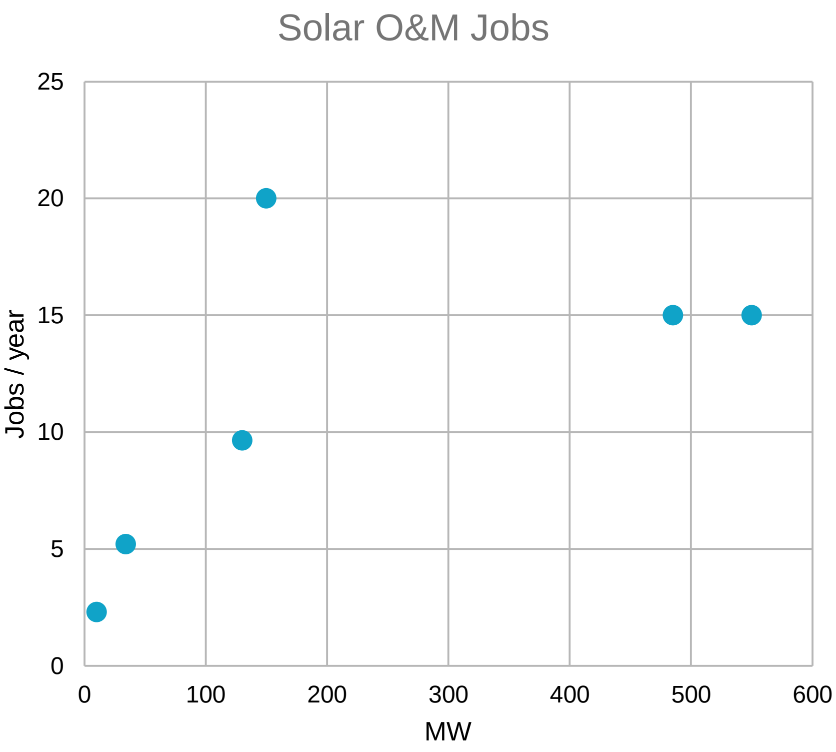
- The IRP will consider non-financial attributes when comparing options within the IRP
- This notion was introduced in our first meeting, and will be expanded on today



Economic Development Attributes

Regression analysis and 'best fit' real employment data to estimate construction and O&M jobs per MW for each resource type in B.C.





Environmental Impact Attributes

Each resource options type has a simple footprint measure and direct GHG emissions measure – will be refined after the Portfolio Modelling stage

- Terrestrial / Riparian footprint (hectares):
  - Based on plant footprint + new roads or interconnection equipment
  - For hydro resources, also includes intake area and penstock area
- GHG emissions:
  - Based only on direct emissions
  - Applicable only to fossil fuel combustion technologies, e.g. natural gas resources

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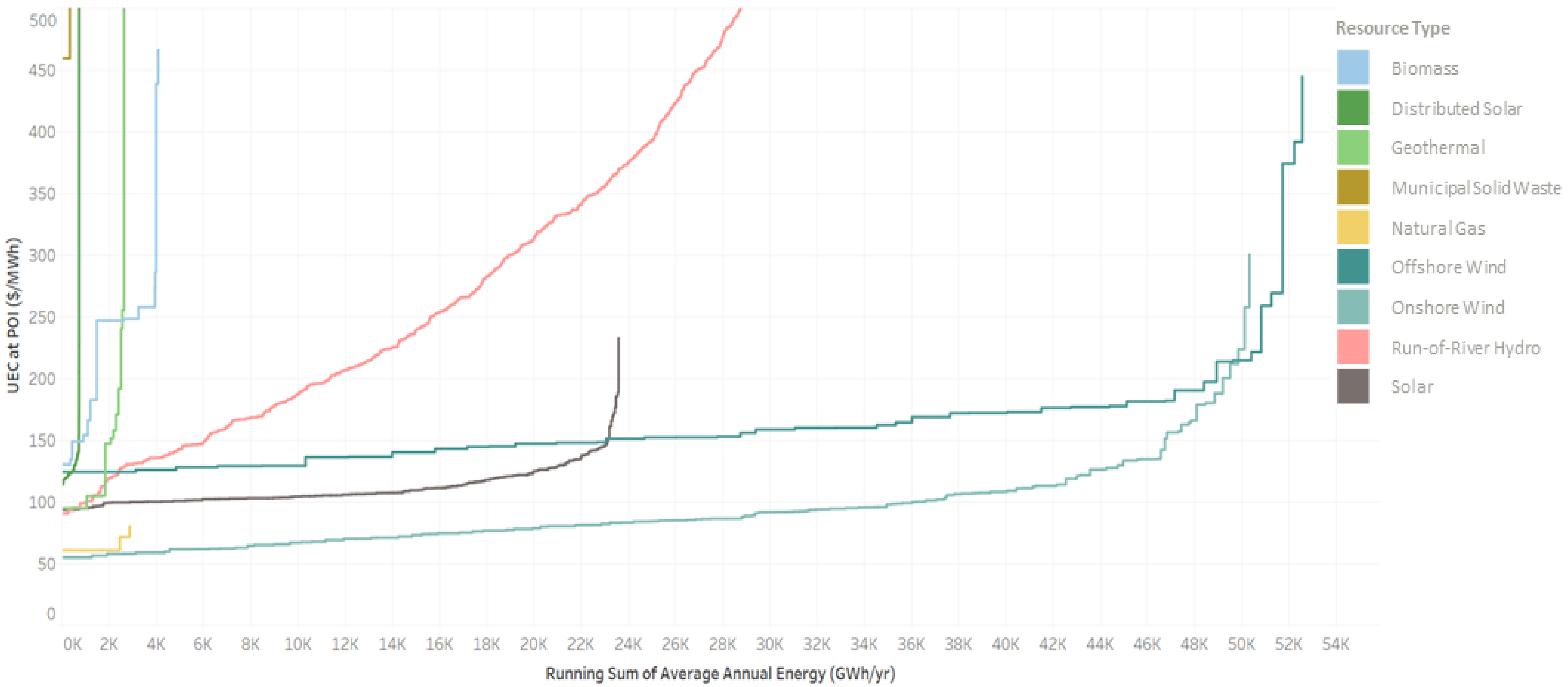
Summary of Energy Resources

Wind, Natural Gas CCGT* and Solar offer the lowest cost resources based on UEC



* Not inclusive of GHG taxes, which would add ~$18 / MWh to costs

Resource Smart

Expansion of existing BC Hydro generation assets is one potential source of additional capacity

- Some large expansions available to serve load growth

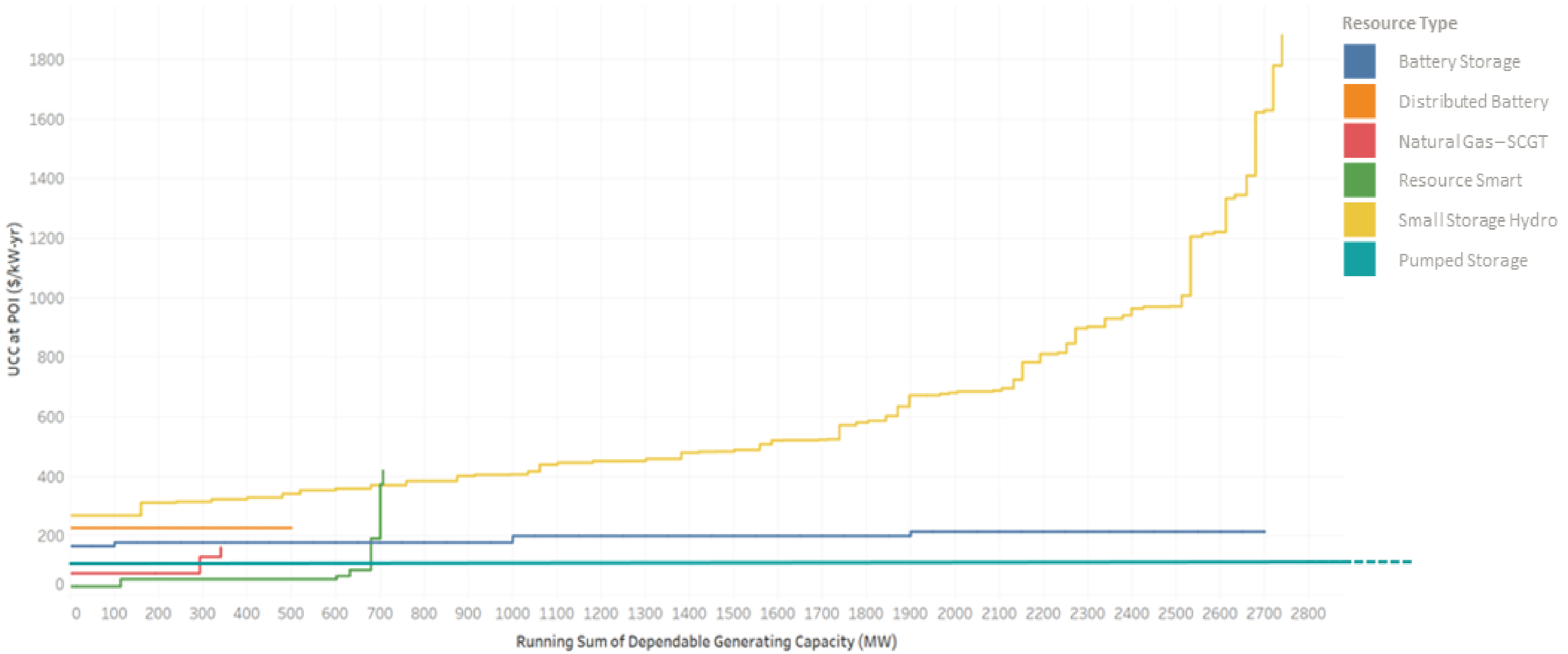
Resource Smart Option	Dependable Capacity (MW)	UCC ($/kW-year)
Revelstoke Unit 6	488	59
Revelstoke Unit 6 – deferred 5-year	488	60
Revelstoke Unit 6 – deferred 8-year	488	66
GM Shrum Units 1-5 capacity increase	100	49

- Some smaller expansions are a by-product of reliability-focused investments

Resource Smart Option	Dependable Capacity (MW)	UCC ($/kW-year)
Alouette redevelopment	21	333
Falls River redevelopment	24	414
Seven Mile turbines 1-3 upgrade	48	174
Wahleach turbine replacement	14	28

Summary of Capacity Resources

Limited amount of Resource Smart, Natural Gas SCGT, Pumped Hydro and Batteries offer lowest cost capacity resources based on UCC



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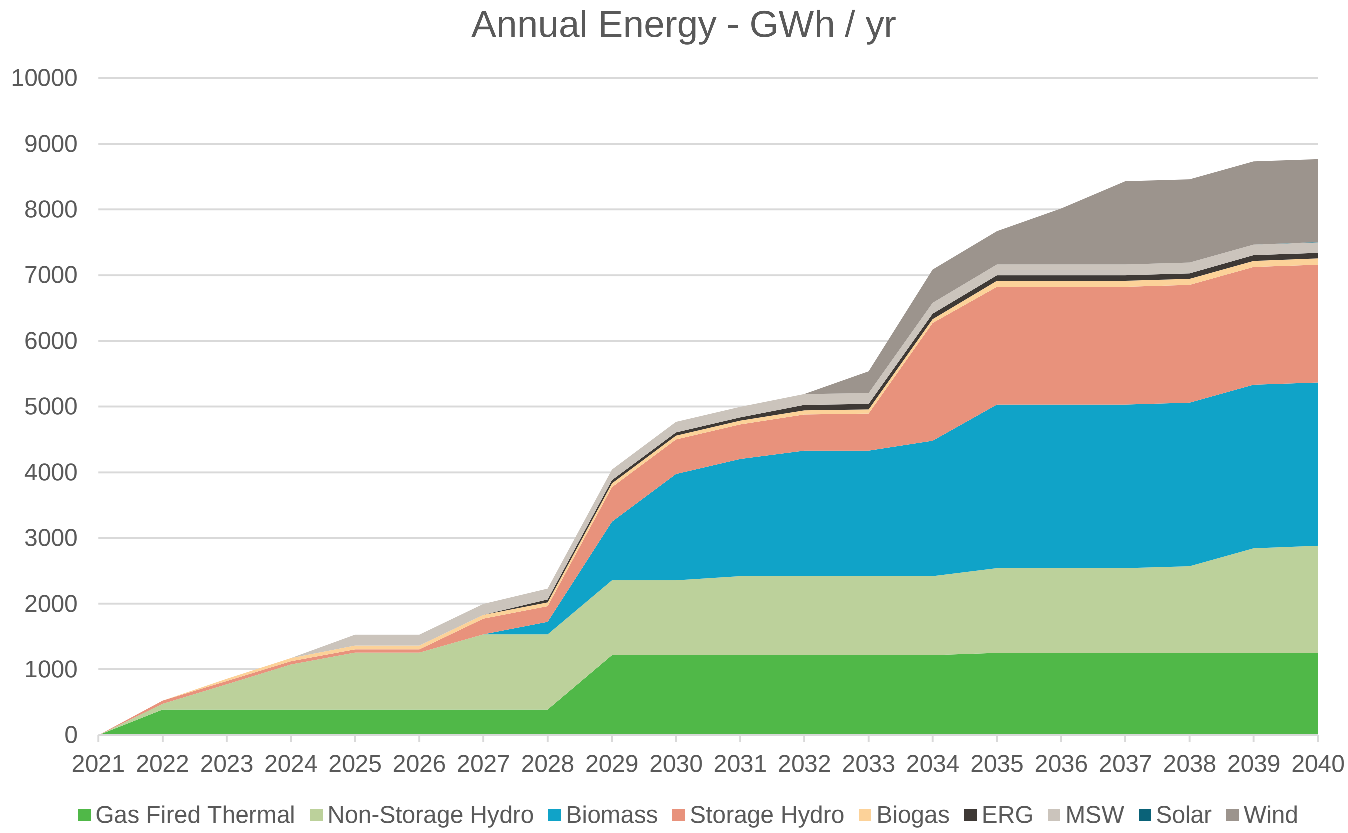
EPA Renewals – Energy Resource Potential

Almost 9,000 GWh of energy related to EPAs due to expire by 2040



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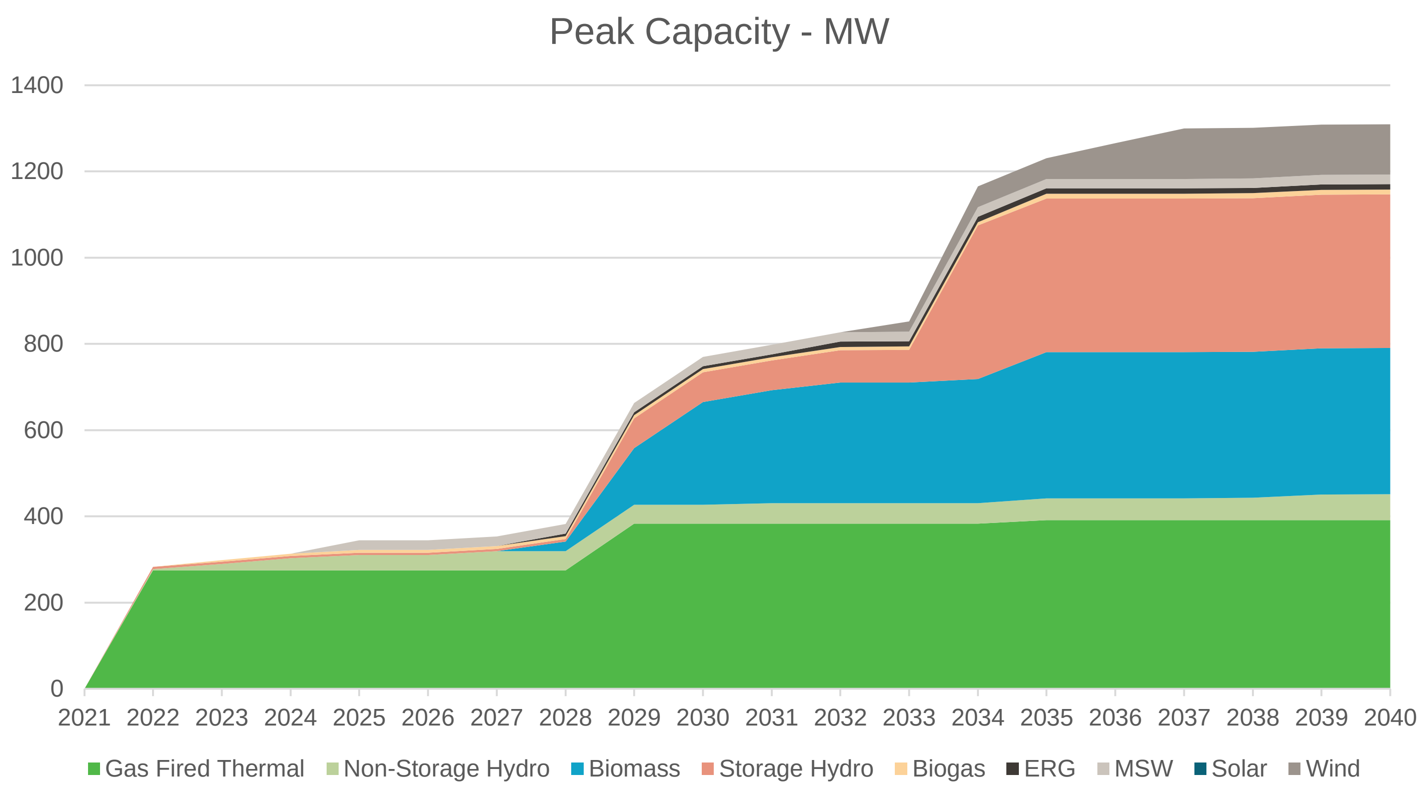
EPA Renewals – Capacity Resource Potential

Over 1,300 MW of dependable peak capacity is related to EPAs due to expire by 2040



EPA Renewal Options – Modelling and Renewal Strategy

Recognize high degree of uncertainty in characterizing options

- Each facility behind an EPA has unique characteristics and circumstances Broad generalizations based on resource type, age and size of facility are subject to high degree of uncertainty
- Portfolio modelling of each resource type allows us to gather insights about EPA renewal strategy, but cannot prescribe which specific EPAs to renew
- Ultimately, an EPA Renewal Strategy will include considerations of financial, technical, Indigenous Nations relations, environmental and economic development

EPA Renewal Options – Portfolio Modelling

As EPAs expire, BC Hydro may have several options

Expiring EPAs

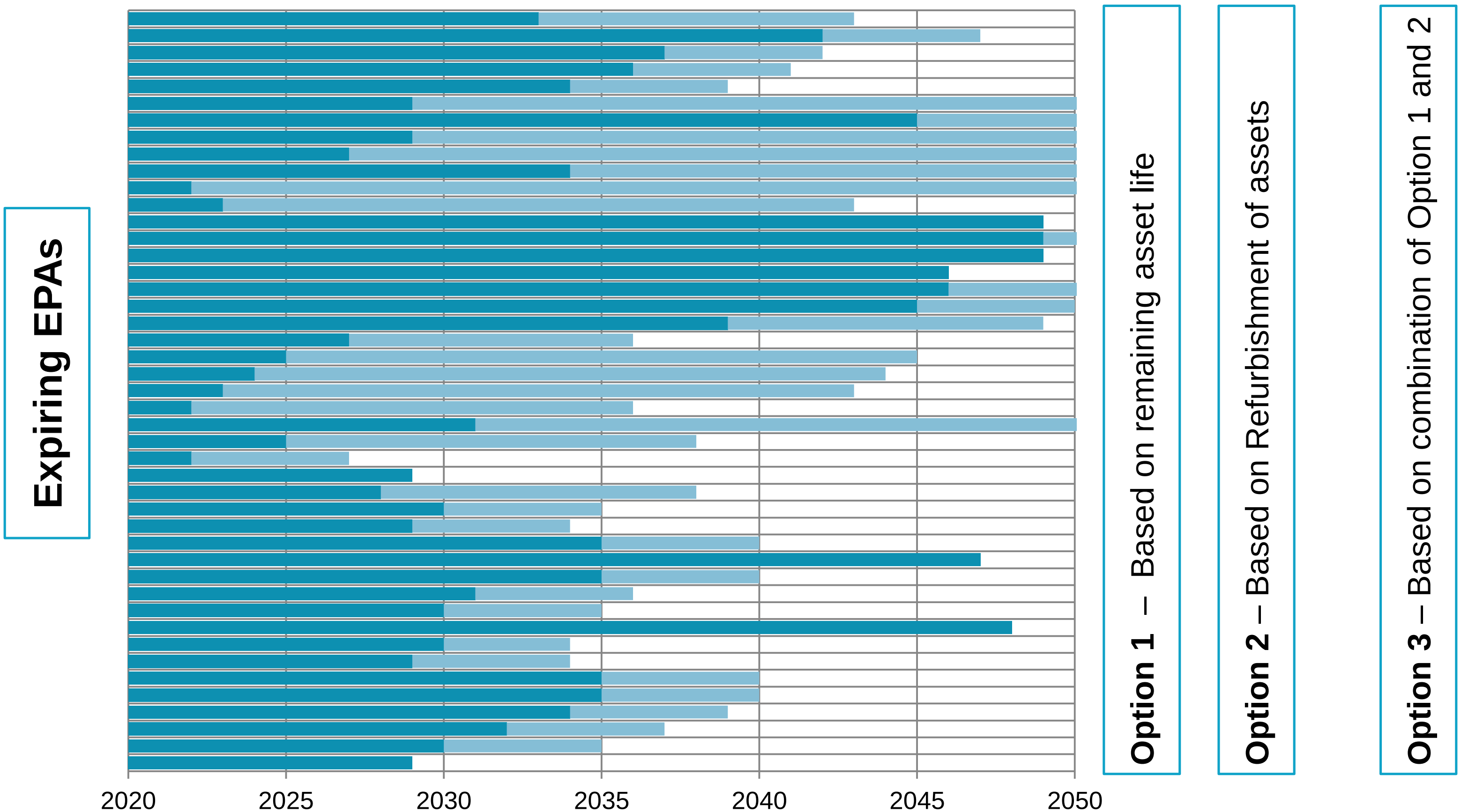
- Do Not Renew
- Agreement for remaining asset life
- Agreement for a renewed asset life

Later Options

- Do Not Renew
- Agreement for a renewed asset life

EPA Renewal Options – Portfolio Modelling

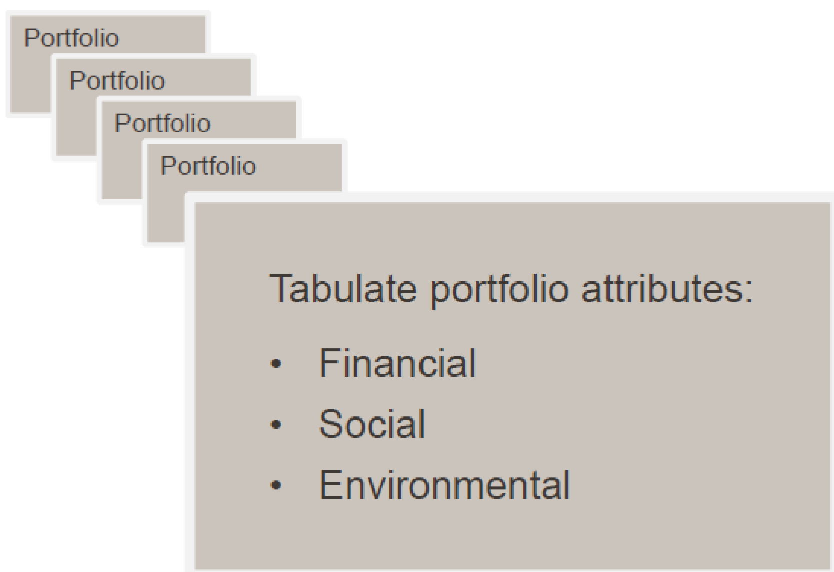
We'll investigate which options are selected under different scenarios



Non-financial attributes of EPA renewals

Similar to IPP acquisitions in terms of the dimensions of impacts considered

- Not renewing an EPA will have impacts if that IPP ceases production
- Portfolio modelling will estimate and aggregate those implications to add to option comparisons



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Discussion Questions

Feedback sought from TAC members

- Questions or comments on BC Hydro's proposed approach?
- Is BC Hydro missing some issues that need to be considered?
- Is there anything else that BC Hydro should be paying attention to when carrying out these analyses?

Distributed generation

Basil Stumborg, BC Hydro

Alex Tu, BC Hydro

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Distributed Generation (DG) in the IRP

To present how the topic of DG will be incorporated into the IRP analysis

Roadmap for this topic of discussion:

- Assumptions and methodology about Customer-DG adoption
- Conclusions
- Use in the IRP
  - How is this captured in the Reference Load Forecast?
  - How does this overlap with Demand Side Management (DSM) programs, electrification scenarios?
  - How will this be used in load sensitivities?

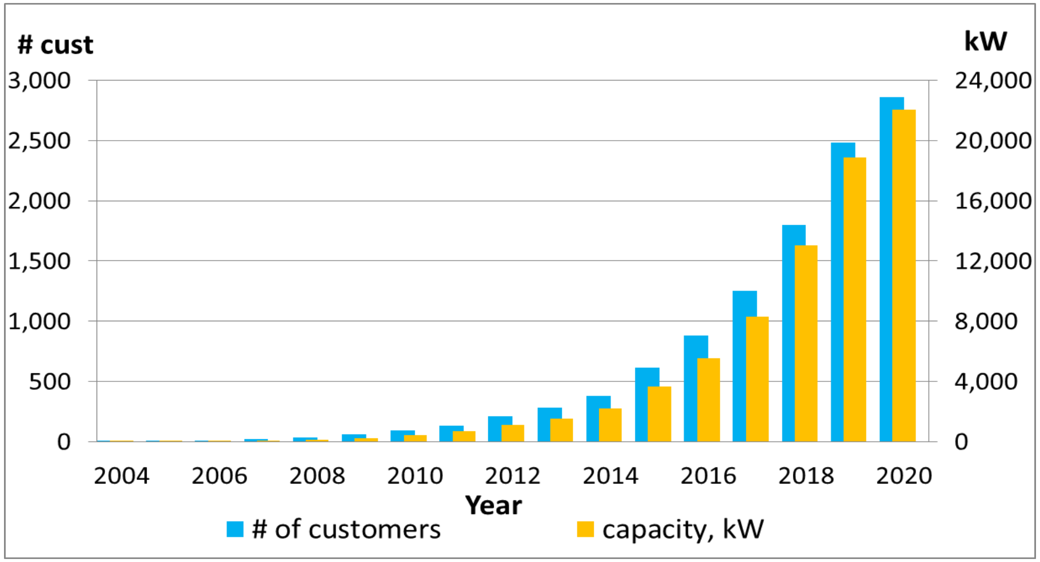
Distributed Generation in the IRP

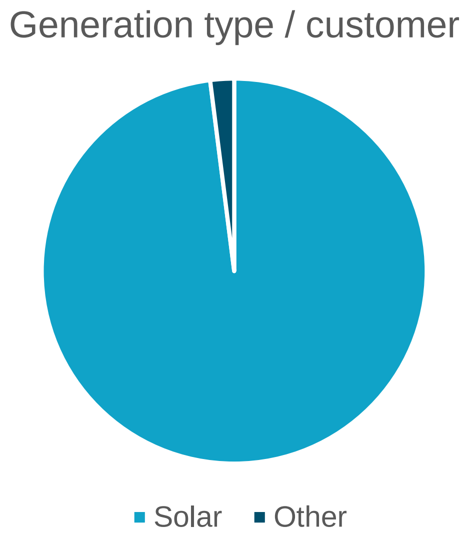
Assumptions and methodology

- Focus of Distributed Generation forecasts:
  - Customer owned rooftop solar
- Key drivers of uncertainty:
  - Solar costs
  - Customer attitudes
  - Economics of self-generation vs grid service
- Model constraints:
  - Net Metering Tariff structure
- For discussion – what has BC Hydro missed, or should look at differently?

Forecast of Customer Solar Adoption

At this time, DG growth is limited to customer solar through Net Metering Program





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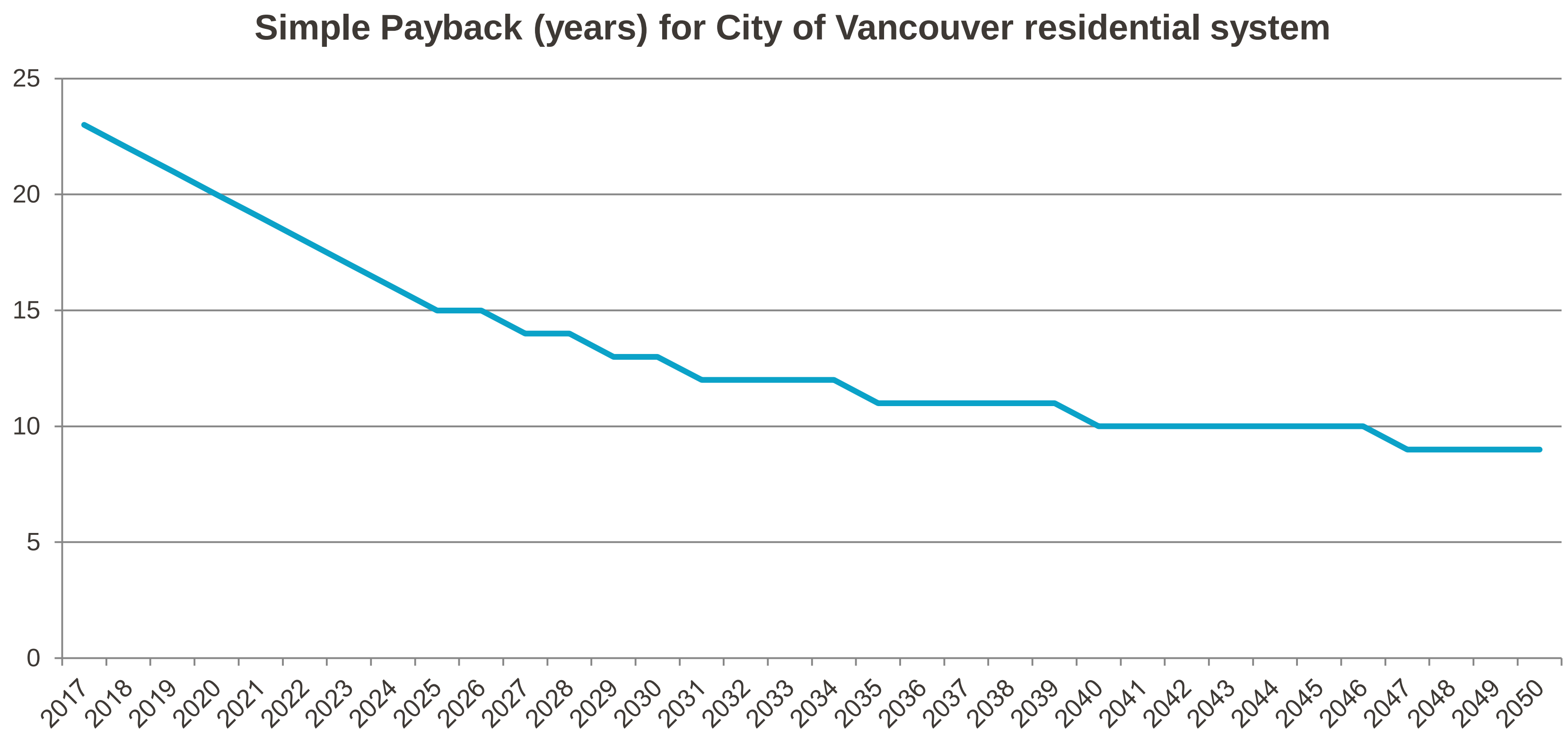
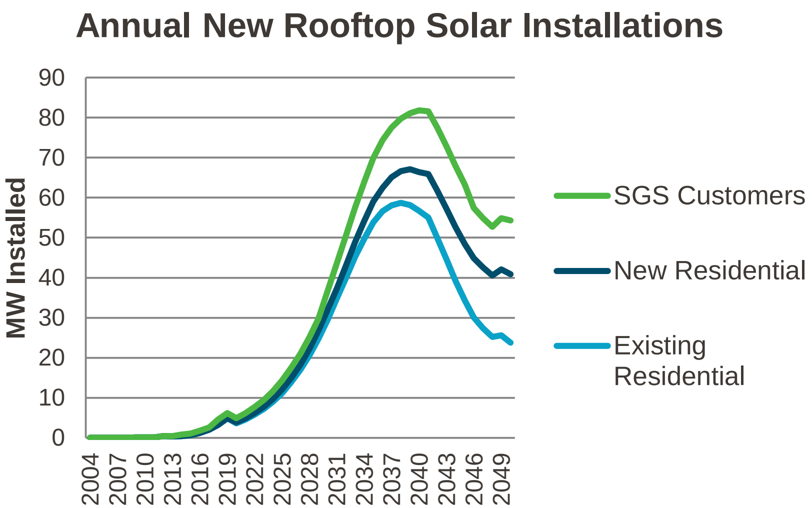
Forecast of Customer Solar Adoption

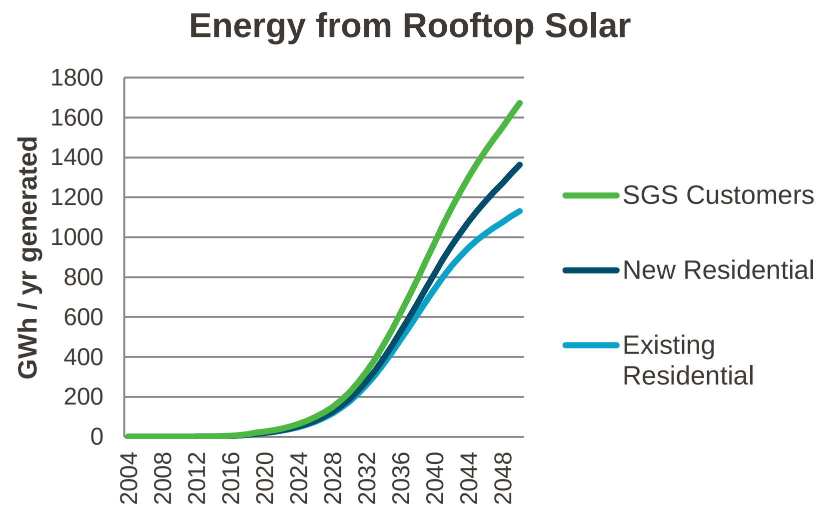
Economics of customer-driven solar is improving and driving uptake



Forecast of Customer Solar Adoption

Our best estimate of customer solar would see ~1600 GWh of generation in 2050





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Scenarios of Customer Solar Adoption

Adoption rates are sensitive to uncertainty of solar costs

Scenarios	Economic Assumptions	Customer Assumptions	GWh/yr in 2030*	GWh/yr in 2050
Reference Case "Our best estimate growth of solar"	Solar Costs: moderate decline Installed cost for residential customers falls from $2.63/W DC today to $2.03/W DC in 2030 BC Hydro Rates: 2.5% nominal annual increase until 2050 Net Metering Tariff: same as current	Price Sensitivity: same as U.S. average Customer Response to Solar: based on observed customer attitudes in Ontario from NREL survey	210 GWh/yr	1,600 GWh/yr ~15% of all residential customers have solar
Low Cost Solar "Massive growth of solar around the world, with new low-cost solar technology available"	Solar Costs: steep decline Installed cost for residential customers falls from $2.63/W DC today to $1.50/W DC in 2030		260 GWh/yr	2,000 GWh/yr ~18% of all residential customers have solar
High Cost Solar "Solar growth stalls around the world as incentives disappear and barriers to imported solar panels go up"	Solar Costs: no decline Installed costs remain at $2.63/W in nominal dollars		100 GWh/yr	250 GWh/yr ~2% of all residential customers have solar

Scenarios of Customer Solar Adoption

Adoption rates are moderately sensitive to Net Metering surplus energy rates and assumptions about customer attitudes

Scenarios	Economic Assumptions	Customer Assumptions	GWh/yr in 2030*	GWh/yr in 2050
Net Metering Rate Re-Design “BC Hydro levels the playing field, charging net metering customers for their use of the grid as a battery to store their surplus generation”	Net Metering Tariff: Elimination of under recovery of fixed infrastructure costs through establishment of fixed charge, demand charge or other mechanism		170 GWh/yr	1,100 GWh/yr ~10% of all residential customers have solar
Enthusiastic Customer Base “B.C. population eagerly adopts solar despite the poor economics to demonstrate energy self-sufficiency”		Customer Response to Solar: set to same as observed for electric vehicle uptake in Canada	670 GWh/yr	1,900 GWh/yr ~17% of all residential customers have solar

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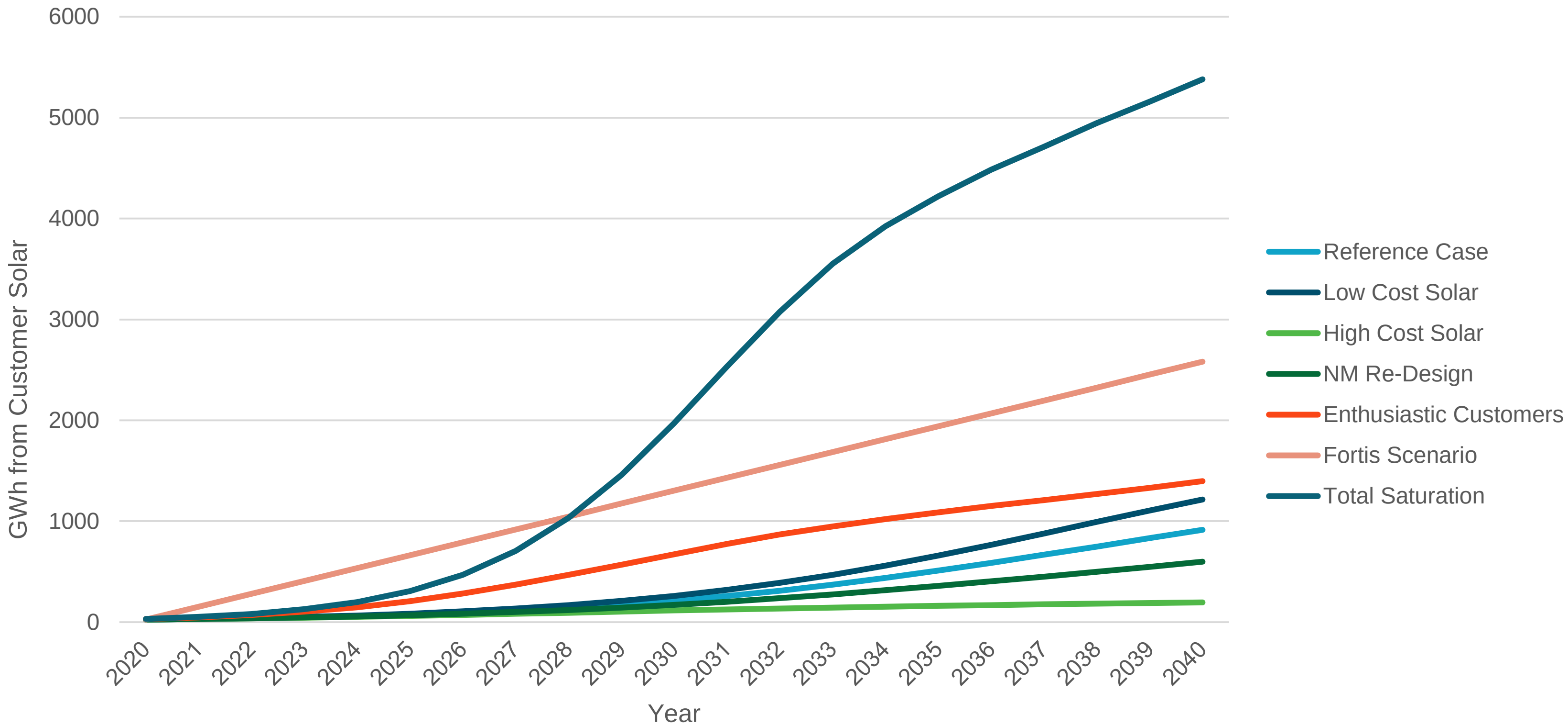
Scenarios of Customer Solar Adoption

Adoption rates are moderately sensitive to Net Metering surplus energy rates and assumptions about customer attitudes

Scenarios	Economic Assumptions	Customer Assumptions	GWh/yr in 2030*	GWh/yr in 2050
Aggressive Scenario considered by FortisBC "Combination of Customer Solar + Storage is an economically viable alternative to grid supply"	Straight-line annual growth, with 1/3 of residential and 1/2 of commercial customers adopting solar by 2040		1,300 GWh/yr Note: this scenario would also include a capacity contribution as storage grows, which has not been quantified	~4,000 GWh/yr ~40% of all residential customers have solar
A Solar Panel On Every Viable Rooftop This scenario shows the assumptions necessary to achieve 100% adoption of solar by customers with viable roofs by 2050	Solar Costs: steep declines as described in the low cost solar scenario BC Hydro Customer Rates: doubling by 2030	Customer Response to Solar: set to same as observed for electric vehicle uptake in Canada	2,000 GWh/yr	7,000 GWh/yr Every viable rooftop in the province has solar 60% of all residential customers have solar

Scenarios of Customer Solar Adoption

Reference Case solar growth is in the ‘middle of the pack’



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Scenarios of Customer Solar Adoption

High-level conclusions from customer solar forecast

- General takeaways are that:
  - DG growth is likely manageable
  - Range of potential uptake does not warrant system-level concerns/investment in the near term
  - Potentially some local effects could require local investment in grid
  - Opportunities may exist for co-ordination of customer resources – solar, solar + storage, and/or customer demand response – to provide some local system benefits

- Questions / discussion

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Distributed Generation in the IRP

How does distributed generation appear in the IRP analyses?

- In the Load Resource Balance
  - Reference Case load impact will be incorporated into the LRB
  - All customer-side resources assumed to have no peak energy contributions – customer-owned small hydro resources assumed negligible in the LRB context
- As a Demand-Side Resource Option
  - A notional customer solar incentive program has been defined to accelerate adoption of solar resources beyond Reference Case
  - This option will be tested as part of the Portfolio Analysis, with no commitment to pursue at this time
- As a strategic considerations
  - Assess the role of Net Metering in Resource Planning
  - Assess viability of DG as a Non-Wire Alternative to conventional distribution infrastructure
  - Assess prudent grid modernization investments to deal with or realize benefits from DG
- Questions / discussion

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Distributed Generation in the IRP

How does distributed generation appear in the load sensitivities?

- General push in this IRP to think broadly about future uncertainties
  - DG is one driver that may erode load growth
  - This factor may evolve in surprising ways in the future
- BC Hydro will consider a low load scenario with accelerated and widespread DG uptake as a driver of load erosion
  - Could be in combination with:
    - Extended and deep COVID impacts
    - Flat to negative load trajectory
    - Low market prices (as DG accelerates in our export markets)
- Multiple variations on low load scenarios will not be pursued

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Next steps

Basil Stumborg, BC Hydro

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Next TAC Meetings

As outlined in the work plan discussion

- The project team will be modelling over the rest of the summer
- Preliminary results will be available in early September
  - The load resource balances will be presented
  - Some final inputs will also be available for discussion (planning criteria, market price forecasts).
- Some modelled portfolio results will be available towards the end of September
- The project team will be reaching out soon to secure dates on your calendar.

Pulse check regarding the work plan

Opportunity for TAC to provide feedback

- Several questions that the BC Hydro IRP team is interested in hearing from you about:
  - Full day meetings vs split up (two half-day meetings)?
  - How to balance information transfer and group discussion:
    - Model 1 – TAC does more pre-reading and meetings jump more quickly to discussions
    - Model 2 – BC Hydro dedicates more meeting time to detailed explanations, which leaves less work for TAC, but gives less time for discussion.
  - Two meetings in September achievable?
- Other comments, questions, or concerns?

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