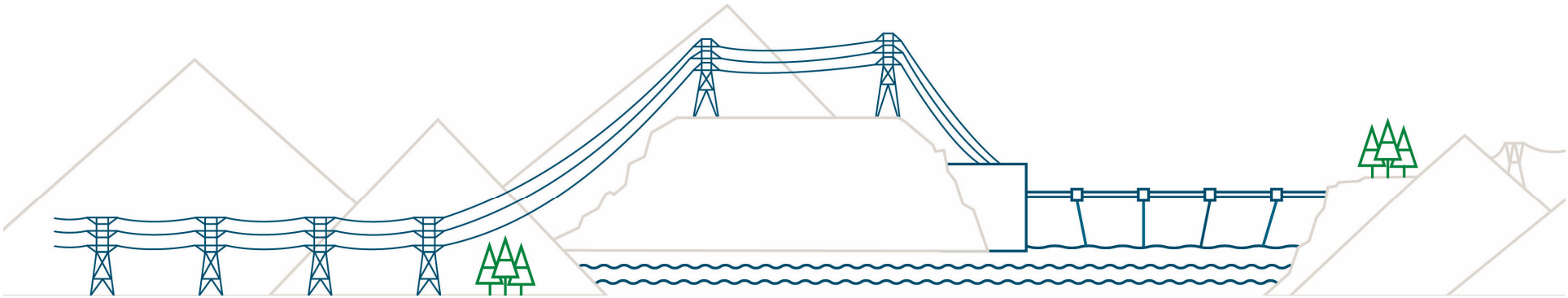
Resource Options Update Session



December 12, 2019

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Welcome & agenda

Anne Wilson, BC Hydro (Moderator)

Kathy Lee, BC Hydro

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Agenda

8:45	9:00 – 10:00			BREAK	10:10			11:20	11:40 – Noon
Context	Generation supply-side options			Demand-side management options			Grid management system	Next steps & close	
	Evolving	Existing	Emerging	Energy efficiency programs	Capacity focused programs	Rate options			
Kathy Lee	Alex Tu			Kristin Hanlon		Anthea Jubb	Cheong Siew	Anne Wilson	

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Purpose

To seek feedback on the update of BC Hydro's resource options inventory

- An inventory of potential resources to meet future customer demand
- This update will inform the development of BC Hydro's Integrated Resource Plan (IRP) next year
- The need for resources will be addressed in the IRP

We'd like to hear from you!

FILL OUT A FEEDBACK FORM

Are there additional resource options we should be considering?

Are there additional technical considerations when developing and characterizing resource options?

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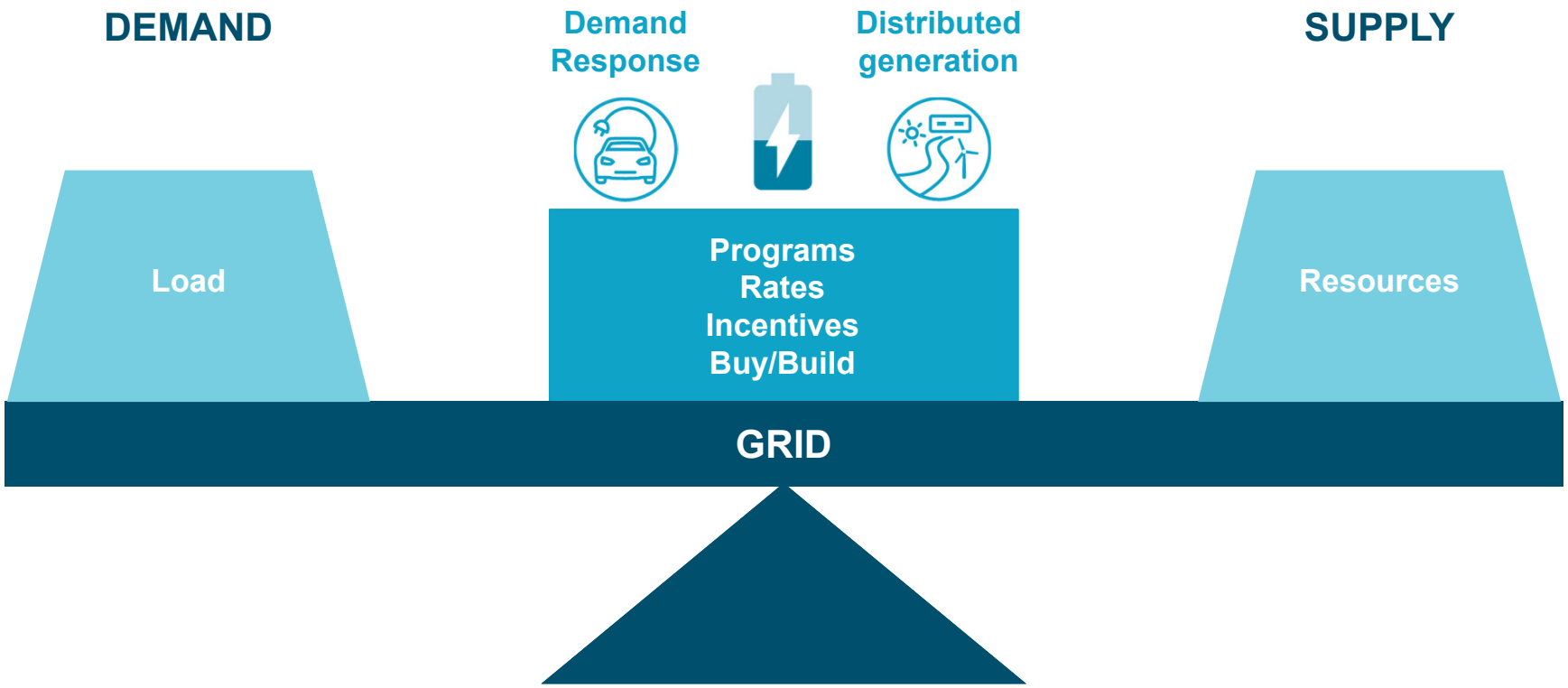
Resource options inventory

This update covers options from demand to supply side, and includes the trend towards smaller scale distributed options



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Approach for this update

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

Resource options characteristics

Both energy and capacity are needed to meet customer demand

- **Energy** – electricity produced over a period of time (MWh/month, GWh/year)
  - Intermittent resources such as wind provides energy, but not capacity
- **Capacity** – maximum electricity produced at a point in time (MW)
  - It can be relied upon whenever it is needed – particularly during winter peak periods
  - It can meet system capacity needs and/or regional capacity needs
- Along with additional attributes (e.g., cost, location, GHG emissions)

Generation supply-side options

Alex Tu, BC Hydro

We'd like to hear from you!

Are there additional resource options we should be considering?

Are there additional technical considerations when developing and characterizing resource options?

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Generation supply-side options

We've focused efforts on evolving resources and ensuring a breadth of coverage of resource options

Generation supply-side options		
Evolving	**Existing database**	**Emerging**
S / **W** / **B**	• Geothermal • Run-of-river hydro • Biomass • Municipal Solid Waste • Pumped storage • Natural gas • Marine • Off-shore wind • BC Hydro assets (expanding capability)	Next generation: • Solar or storage • Hydrogen • Customer distributed generation e.g., vehicle to grid
Solar • Utility and community scale • Customer scale Wind Batteries • Utility scale • Customer scale		

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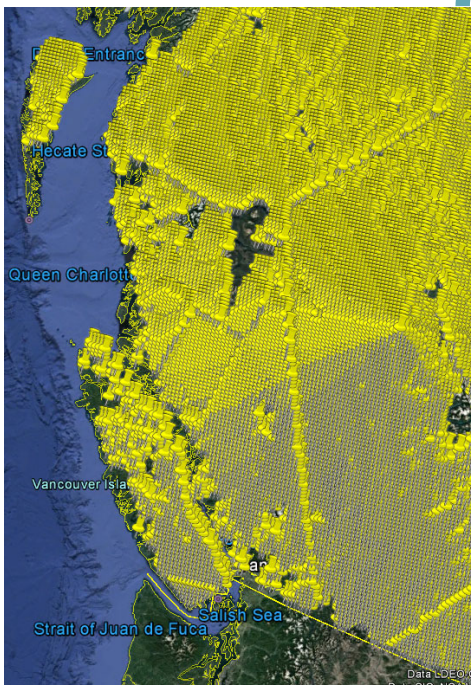
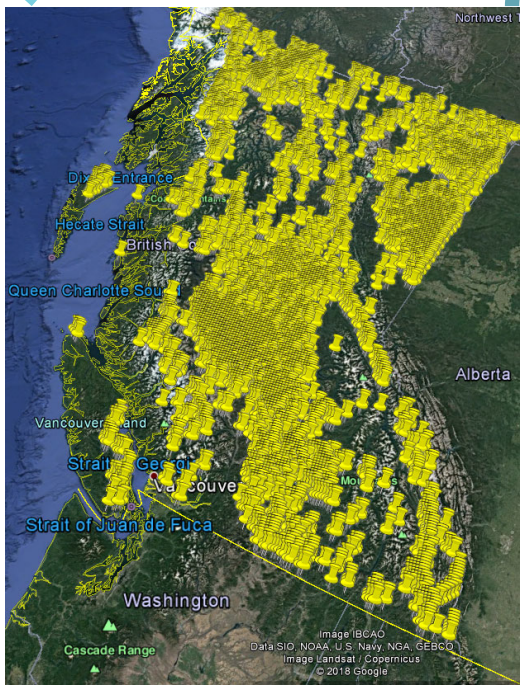
Generation supply-side options		
Evolving	Existing database	Emerging
S / W / B		

Solar resources – utility scale

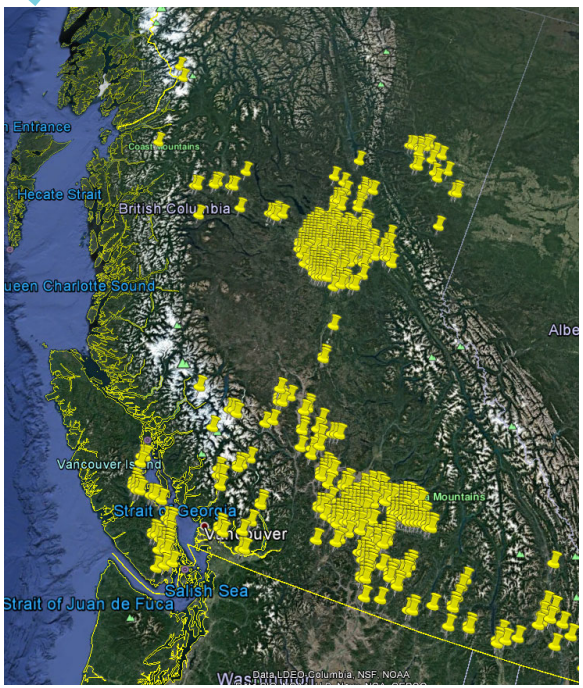
Technical resource limited by land use designation and distance from transmission



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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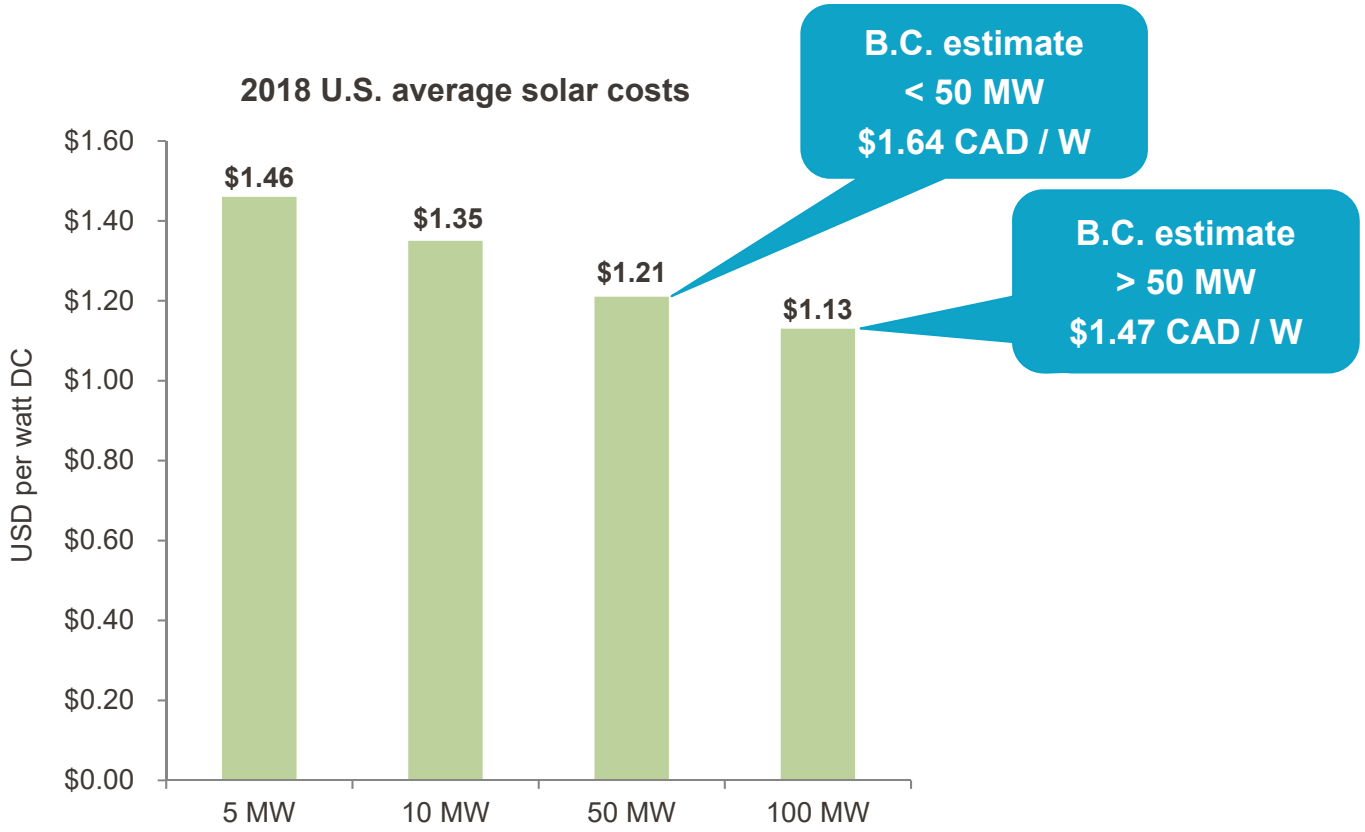
Solar resource – utility scale

Projected capital costs for B.C. solar resources is very similar to the average U.S. costs



Source: National Renewable Energy Laboratory – USD costs

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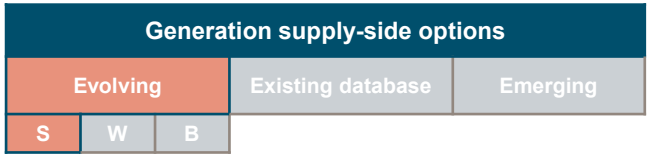


Solar resource – O&M costs

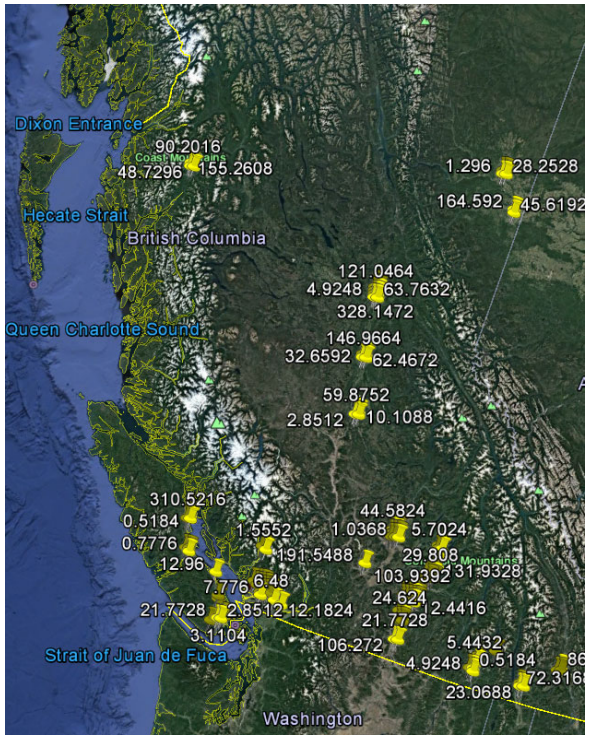
Operations and maintenance costs for utility and community scale solar is in line with U.S. averages, but property tax is specific to B.C.

Item	Solar
Operations & maintenance	$11 /kW-yr
Sustaining capital	$8 /kW-yr
Insurance	$2 /kW-yr
Property tax	$5 /kW-yr
Total	**$26 /kW-yr**

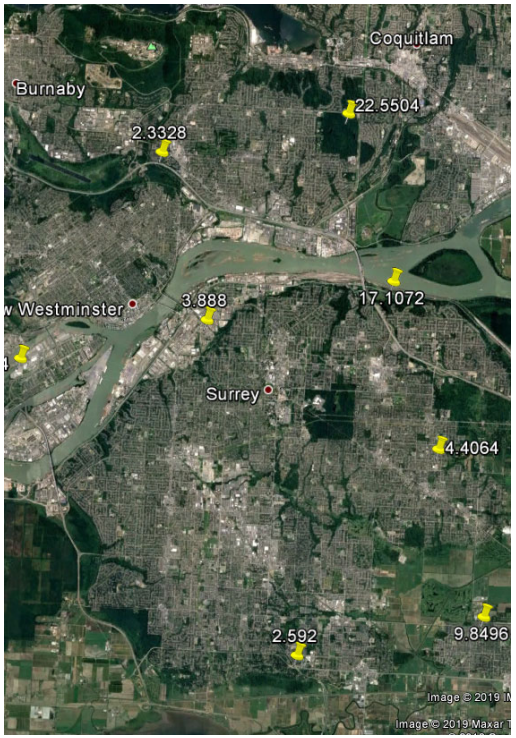
Generation supply-side options			
Evolving			Existing database	Emerging
S	W	B		

Solar resources – community scale

Community scale resources can be sited in available urban spaces and connected to local distribution system



Province-wide resources
(~100 potential resources)



Lower Mainland
resources

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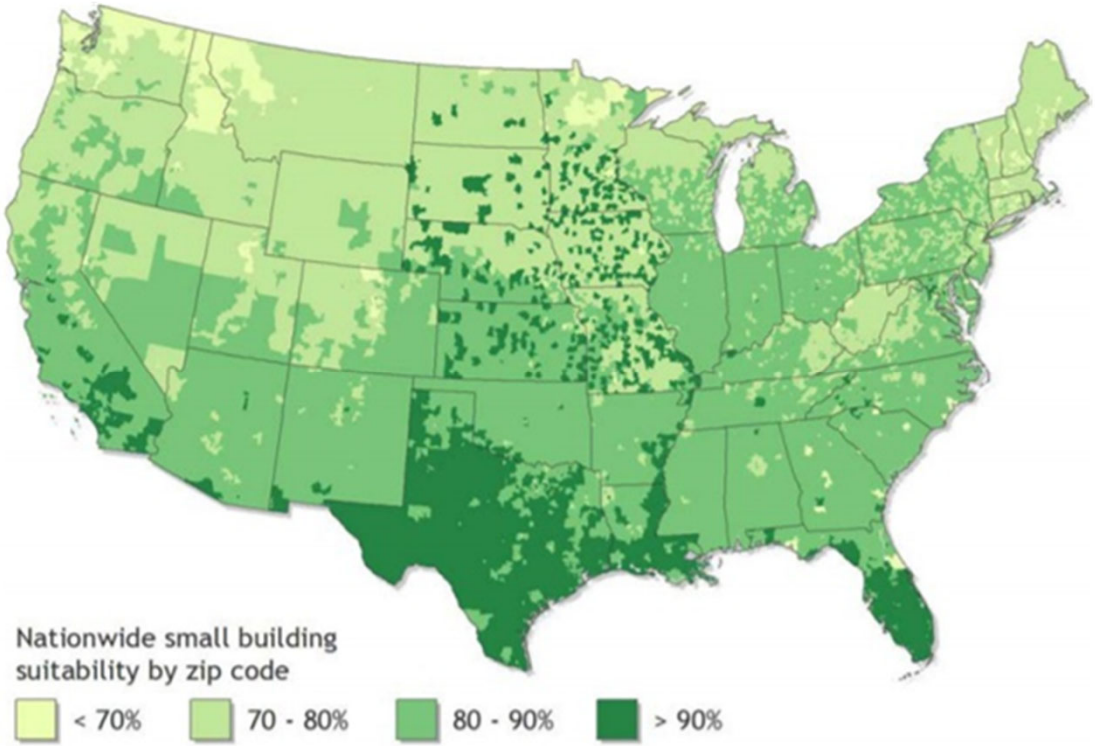
Generation supply-side options			
Evolving			Existing database	Emerging
S	W	B		

Customer scale – solar

The resource potential for rooftop solar is limited by available roof space, roof orientation, and shading



Gagnon, P. et al. (2016) Rooftop Solar Photovoltaic Technical Potential in the U.S.

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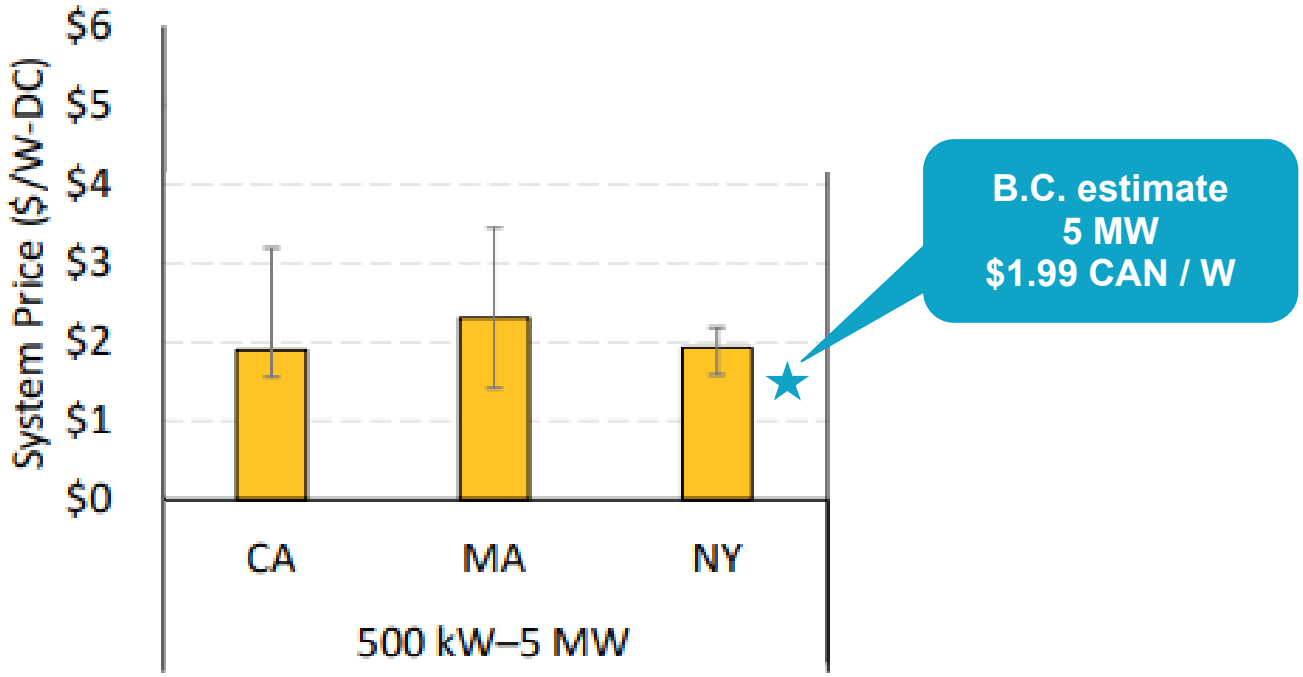
Generation supply-side options		
Evolving	Existing database	Emerging
S | W | B		

Solar resources – community scale

For ~ 5 MW resources, prices generally in line with high land cost jurisdictions



Source: NREL Q1/Q2 2019 Solar Industry Update

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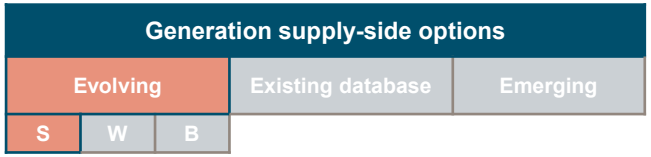

Customer scale – solar

Technical potential of rooftop solar in B.C. estimated based on generalizations developed in U.S. study to develop theoretical upper bound

Residential rooftops

- Limited to single family dwellings
- U.S. average for 'suitability' based on roof shape, shading, and orientation (79%)
- Limited to owner-occupied (76% of single family dwellings)
- Suitable houses could host (on average) ~6 kW system (~400 square feet roof space)

Total ~ 3.6 GW residential

(1.8 GW in Lower Mainland)

Commercial customer rooftops

- All small general service (SGS) customers included, e.g., restaurants, retail…
- Rooftop space based on average square foot by customer type
- 42% of all rooftop space is 'suitable' based on mid Navigant estimate
- Assume 67 square feet of 'suitable' rooftop space required per kW installed

Total ~ 2.5 GW SGS

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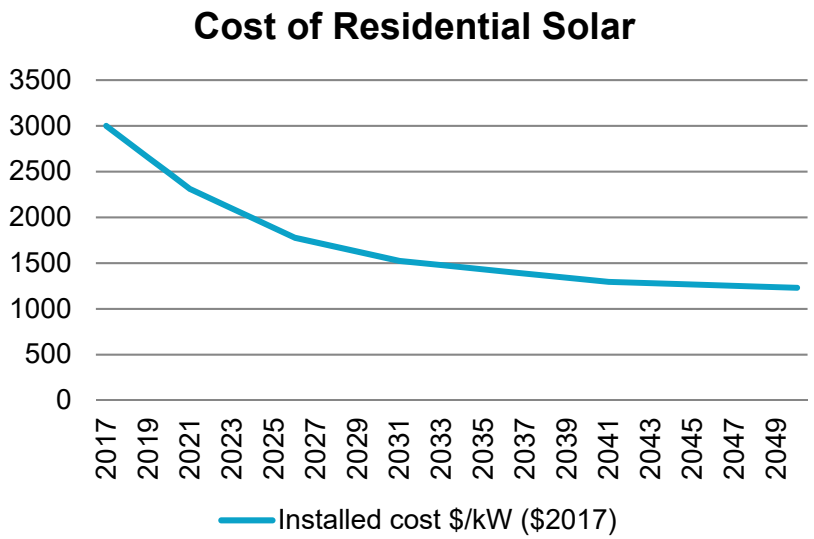
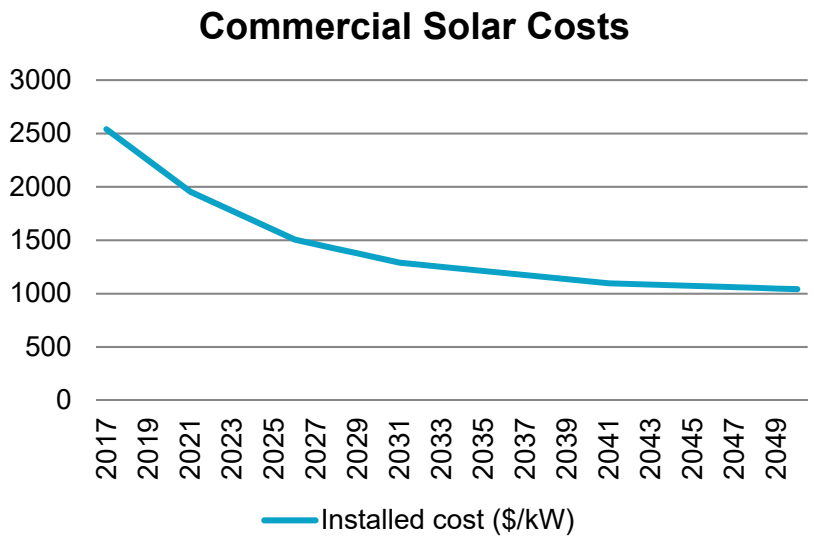
Generation supply-side options		
Evolving	Existing database	Emerging
S | W | B		

Customer scale – solar

Costs of rooftop solar in B.C. are coming down in the near term





Note: Cost declines based on National Renewable Energy Laboratory projections

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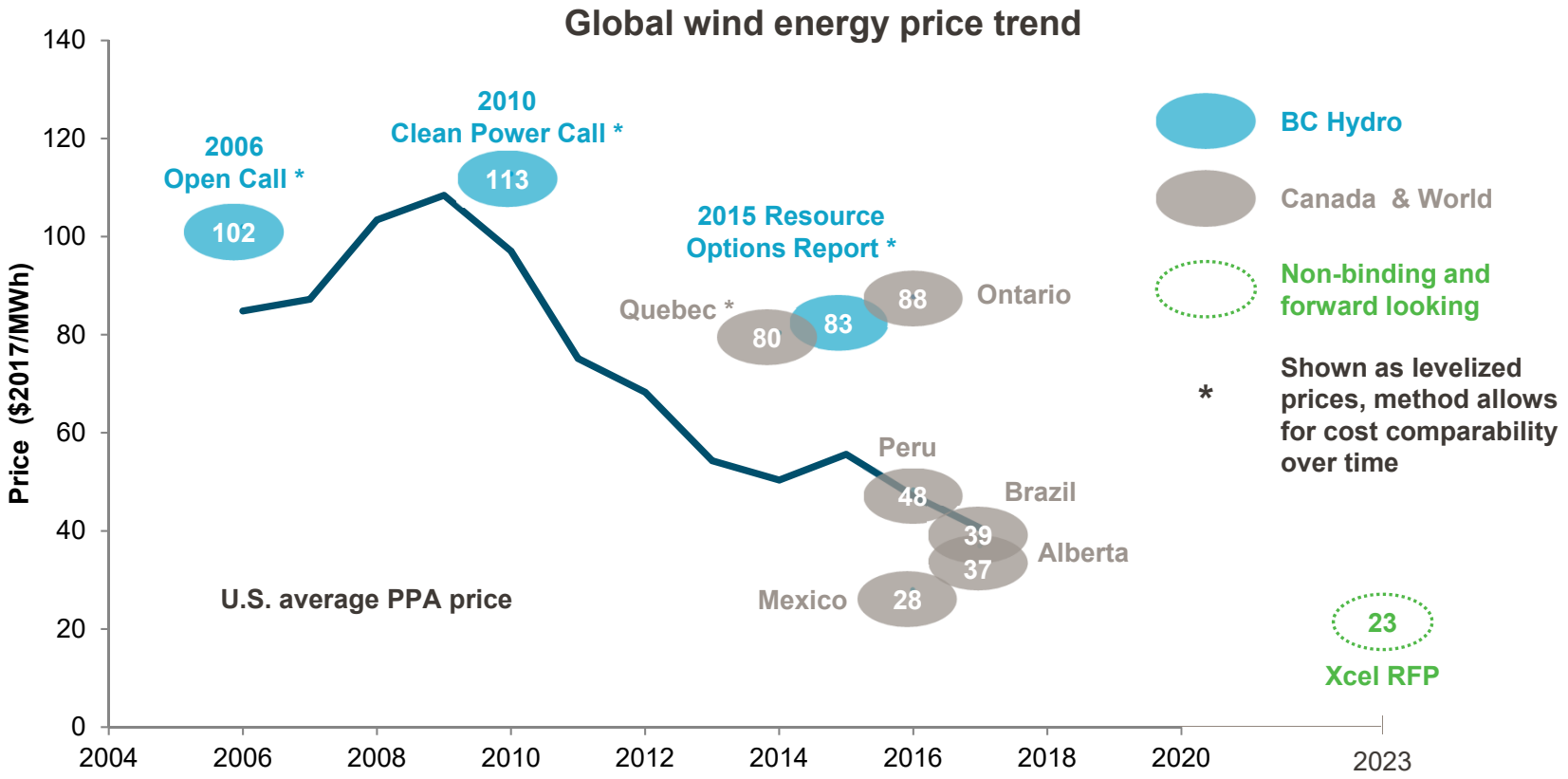
Generation supply-side options		
Evolving	Existing database	Emerging
S / W / B		

Wind resources

Dramatic price declines as technology and market conditions change



Source for U.S. data: 2016 Wind Technologies Market Report, U.S. Department of Energy

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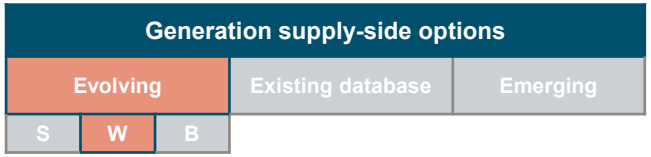

Wind resources – B.C. cost update

BC Hydro undertook a review of wind costs in 2018

- Hatch Wind Project Review (August 2018)
- 2017 Wind Technologies Market Report (August 2018)
- Review of costs of wind projects in Alberta (July 2018)
- IPP survey of costs (August 2018)

2018 costs for sample 150 MW wind farm in B.C.

Cost	Low	Mid	High
Capital Cost (2018)	$1,700 / kW	$2,110 / kW	$2,400 / kW
OMA Cost (2018)	$40 / kW-yr	$58 / kW-yr	$80 / kW-yr

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Energy storage resources

We are interested in long duration storage types that can be relied upon as alternative to supply-side capacity resource

Storage technology category	Duration at full power	Technologies
Long duration	4+ hours	• Compressed air energy storage • Flow battery • Sodium sulfur (NaS) battery • Lithium ion battery
Medium duration	2 hours	
Medium-short duration	1 hour	
Short duration	30 minutes	

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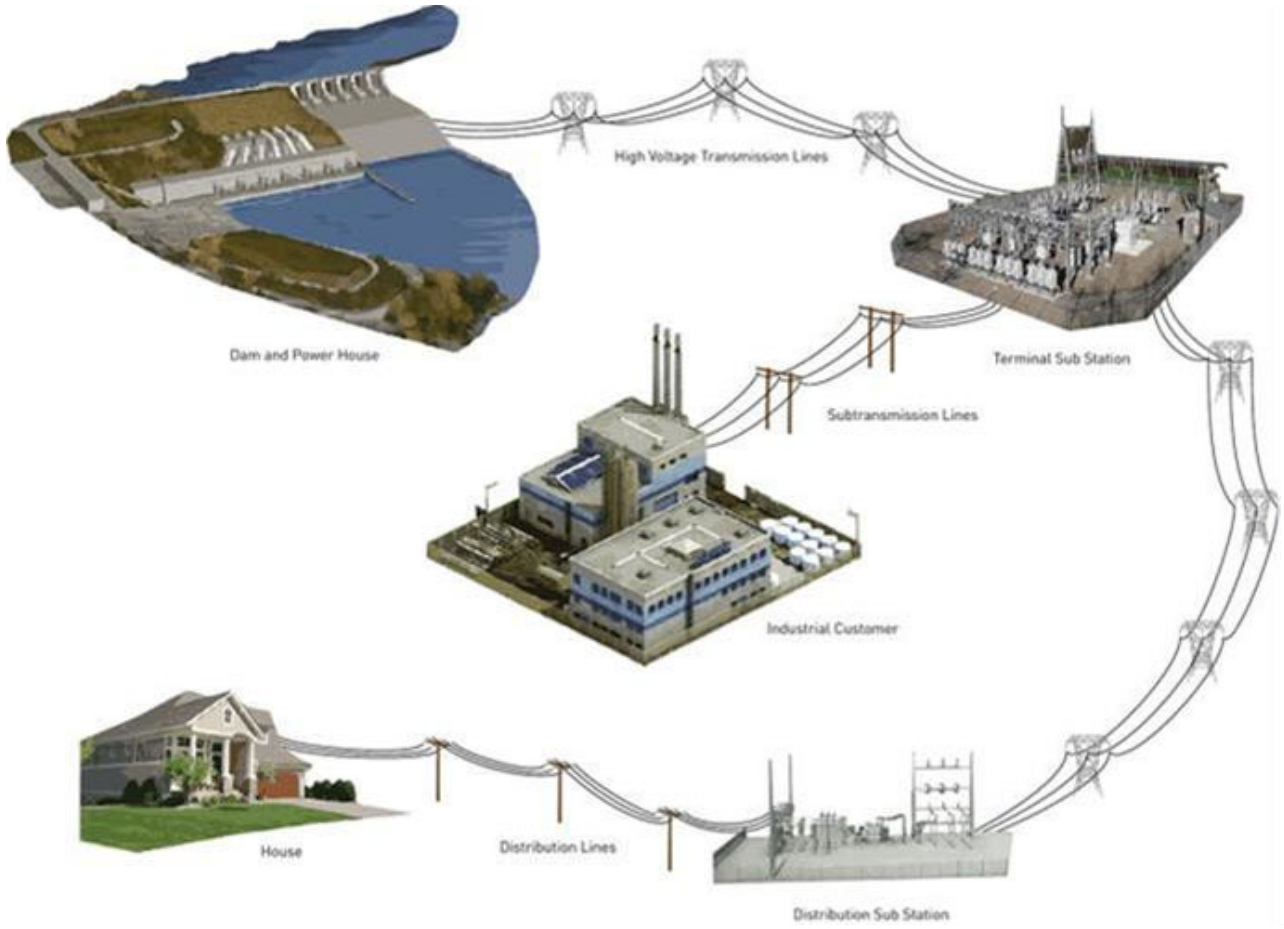
Generation supply-side options			
Evolving			Existing database	Emerging
S	W	B		

Energy storage resources

Long duration resources can be located at various grid locations, at different scales, costs and capabilities



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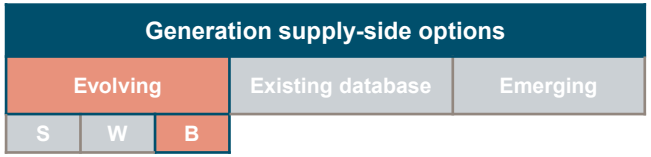

Energy storage resources

We'll estimate costs for each combination of technology type and grid location

Technology	Grid location	AC capacity	Modules ($/kWh)	Balance of plant ($/kW)	Installation ($/kW)	OMA (fixed variable)
CAES	Central / Bulk	100 MW				
CAES	Transmission	10 MW				
Li-Ion	Central/Bulk	100 MW				
Li-Ion	Transmission	10 MW				
Li-Ion	Distribution	2 MW				
etc.						

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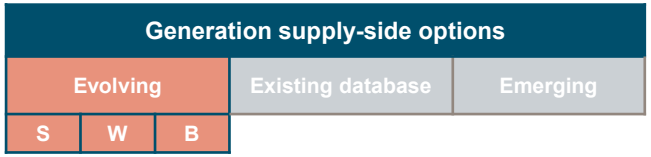
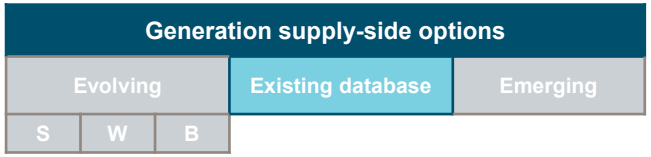


Summary – evolving category

The database will update installed costs & unit energy and unit capacity costs

Resource	Size	Representative size	Installed cost in 2020 ($/kW)	OMA
Solar – utility	>10 GW	50 MW	$1,469 - $1,640	$26 /kW-yr
Solar – community	<1 GW	10 MW	$1,989	$26 /kW-yr
Solar – DER	~5 GW	6 kW – 50 kW	$2,230 - $2,650	$10 – 20 /kW-yr
Wind onshore*	~17 GW	27 MW - 660 MW	$1,960 - $2,440	$58/kW-yr
Li-Ion batteries	N/A	2 MW – 100 MW	TBD	TBD
CAES	N/A	100 MW	TBD	TBD
Flow batteries	N/A	2 MW – 100 MW	TBD	TBD
DER – Li-Ion	N/A	10 kW – 10 MW	TBD	TBD

* preliminary estimates based on 2018



Summary – existing resources

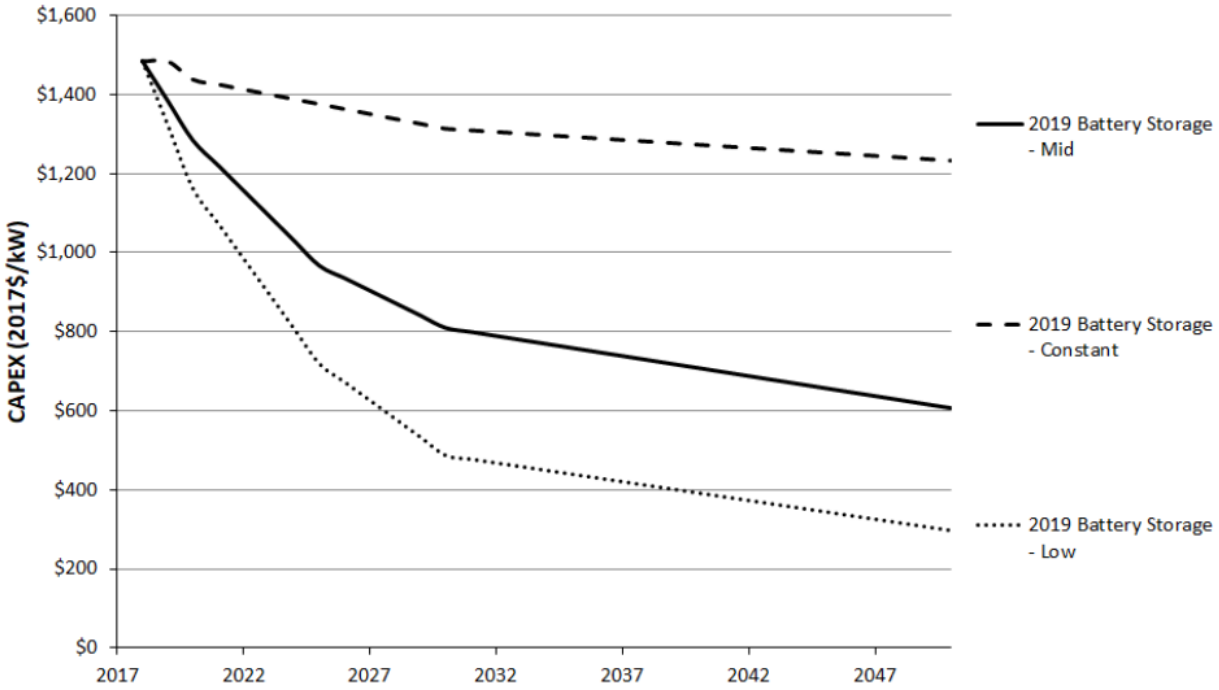
Update will result in installed costs, unit energy, and unit capacity costs

Resource	What was updated	Size	Representative size	Installed cost in 2020 ($/kW)	OMA ($/kW-yr)
Geothermal	Cost	~500 MW	30 MW	$5,700 – 14,000	$180-230
Run-of-river	Cost	>15 GW	5 MW	$2000 - $50,000	$120+
Small storage run-of-river	Resource	<1 GW	50 MW	$7,000 - $9,000	$350-450
Natural gas	Cost	N/A	100 MW	$1,000 - $1,700	$50-200
Pumped storage	Cost	>100 GW	1000 MW	$1,700 - $3,700	$16-75
Biomass	Resource & Cost	~460 MW	40 MW	$5,910	$146
MSW	Cost	~50 MW	12 – 25 MW	$1,550 – $2,290 / t	$78 - $87 / t
Marine – wave	Cost	~500 MW	50 MW	$13,000	$720
Marine – tidal	Cost	~500 MW	50 MW	$10,000	$580
Wind offshore	Resource & Cost	>10 GW	400 MW	TBD	TBD

Generation supply-side options			
Evolving			Existing database	Emerging
S	W	B		

Projecting cost declines

BC Hydro will use NREL annual technology baseline projections to estimate year over year cost reductions for all technologies



Battery Storage ATB cost projections

Source: National Renewable Energy Laboratory Annual Technology Baseline (2019), http://atb.nrel.gov

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Emerging – assessing new technologies

We're continuing to monitor an evergreen list of emerging technologies

- **Emerging solar**
  - Organic solar cells, floating solar, solar roads…
- **Hydrogen and fuel cells**
  - Molten carbonate fuel cells, solid-state hydrogen storage, power-to-gas…
- **Emerging storage**
  - Gravity storage, zinc-air batteries, advanced chemistries…
- **New customer side generation**
  - Micro-CHP, vehicle-to-home, vehicle-to-grid…
- **Next generation renewables**
  - Enhanced geothermal, zero-head hydro / hydrokinetic, floating offshore wind…

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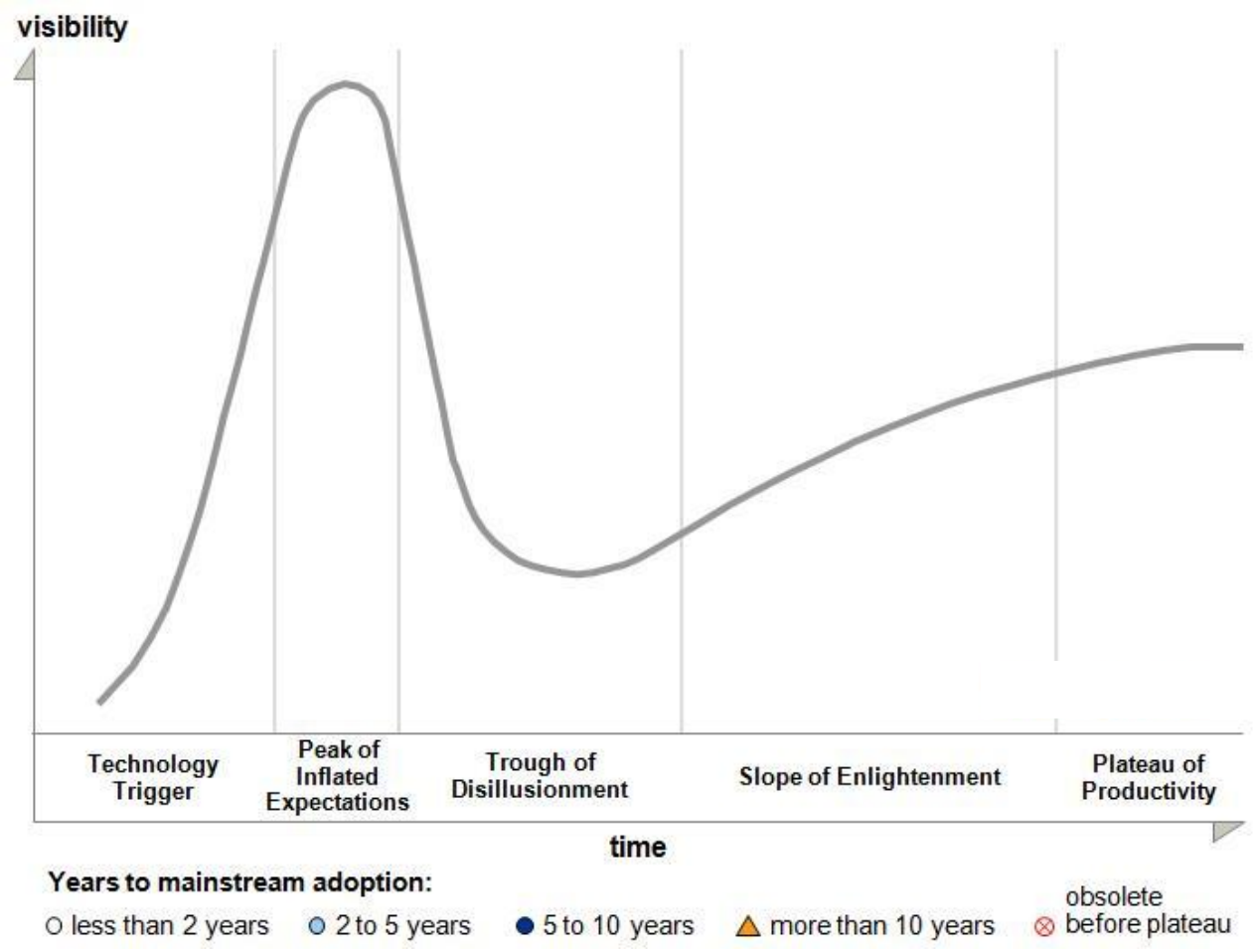
Generation supply-side options				
Evolving			Existing database	Emerging
S	W	B		

Emerging – assessing new technologies

Will use the Gartner Hype Cycle to assess new technologies in the B.C. context



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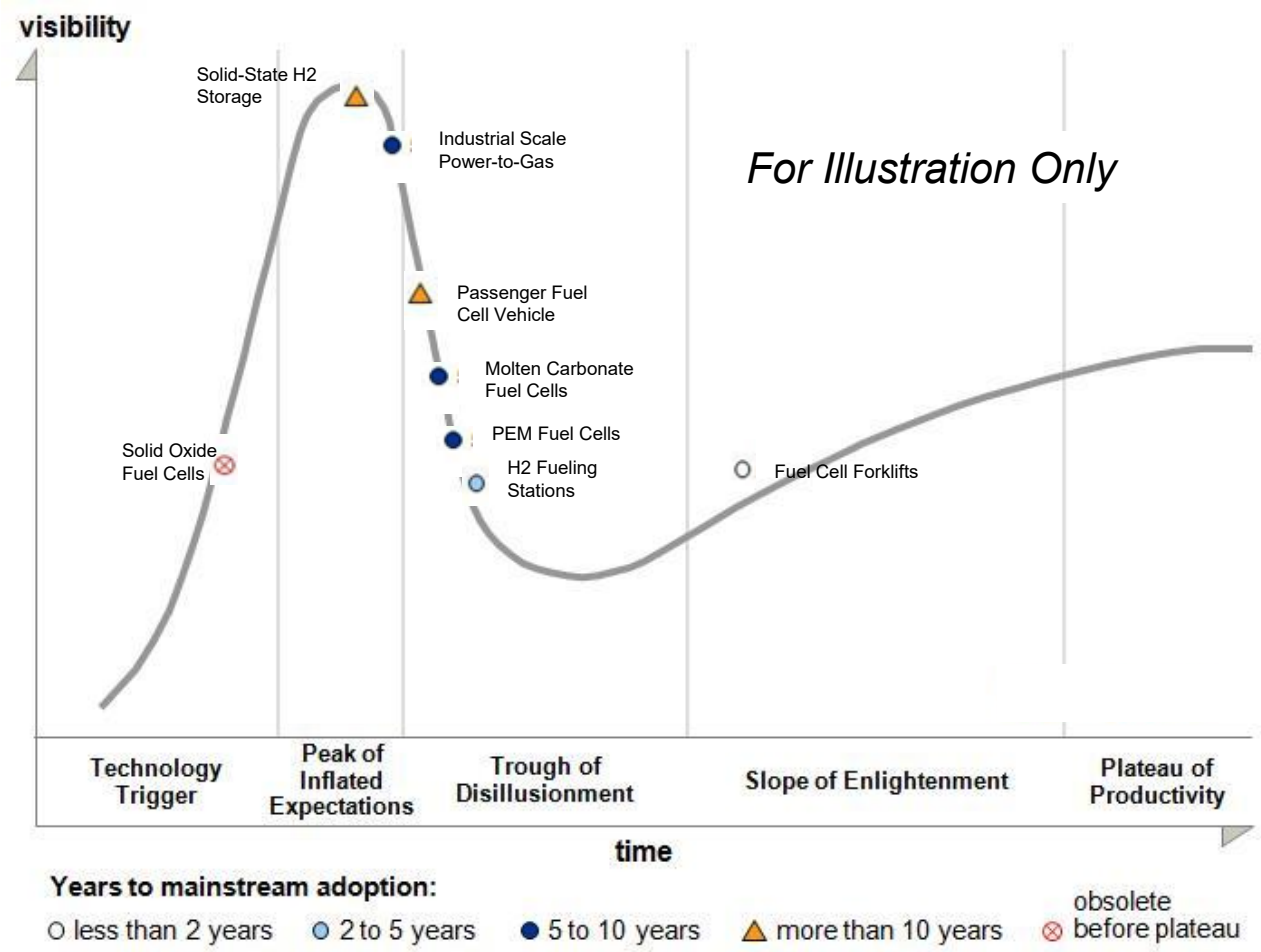
Generation supply-side options			
Evolving			Existing database	Emerging
S	W	B		

Emerging – assessing new technologies

An example of a hydrogen and fuel cell technology hype cycle



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Demand-side management options

Kristin Hanlon, BC Hydro

We'd like to hear from you!

Are there additional resource options we should be considering?

Are there additional technical considerations when developing and characterizing resource options?

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DSM resource options

Overview

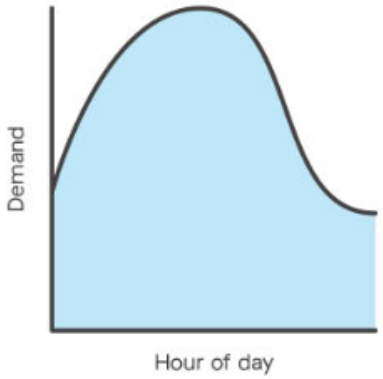
Demand-side management options		
Energy efficiency programs	Capacity focused programs	Rate options

Demand-side management options		
Energy efficiency programs	Capacity focused programs	Rate options

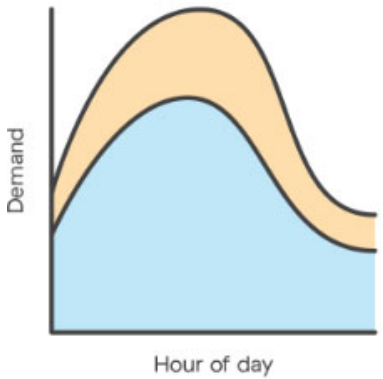
DSM resource options

Terminology

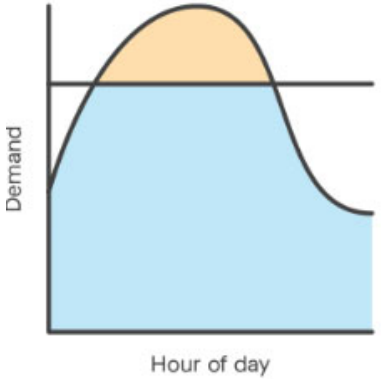
Base case



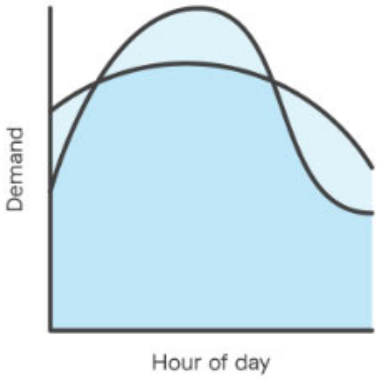
Energy efficiency



Peak shaving



Load shifting



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Demand-side management options		
Energy efficiency programs	Capacity focused programs	Rate options

Conservation potential review

Benefits of using a CPR for integrated planning

- What is a Conservation Potential Review (CPR)?
- The CPR integrates:
  - what is known about energy savings opportunities (i.e., costs and savings for energy efficiency measures); with
  - actual energy sales (how energy is used today); and
  - our load forecast (how energy is projected to be used into the future)
- Consistent with how many other jurisdictions conduct resource planning

Demand-side management options		
Energy efficiency programs	Capacity focused programs	Rate options

Conservation potential review

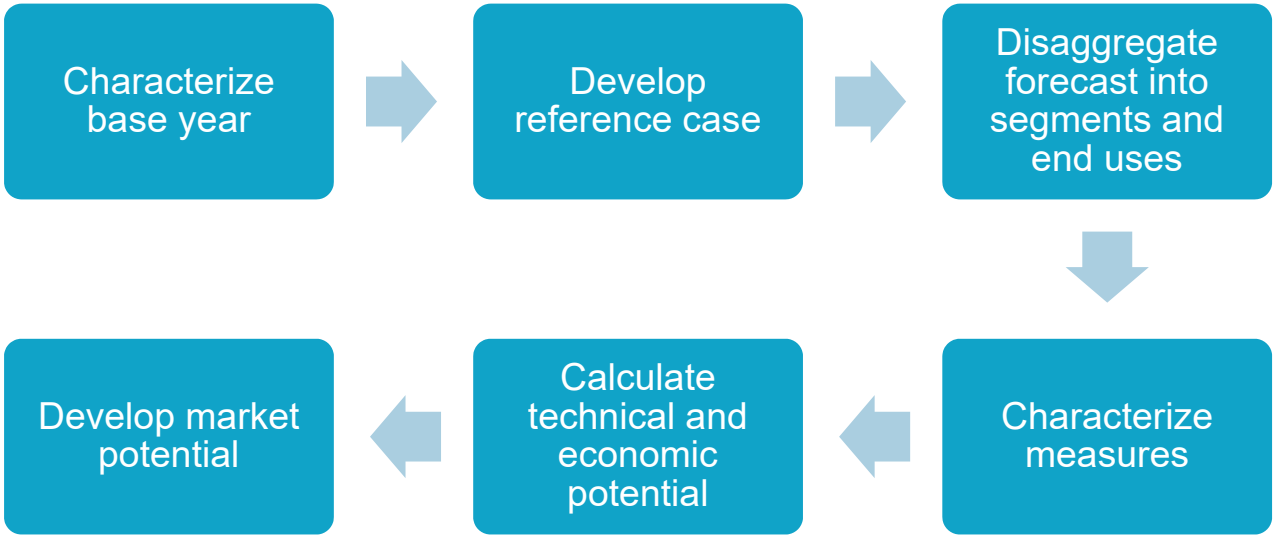
Building off what was done before

- In 2015, we worked with Fortis Gas, Fortis Electric, Pacific Northern Gas to conduct dual fuel, province wide CPR for the first time
- Navigant Consulting Ltd. chosen to perform modelling, with CleaResult subcontracted for the industrial sector
- Formed and engaged a Technical Advisory Committee to provide strategic advice into the study
- Estimated potential for energy efficiency (EE) and demand response (DR), and provided models for BC Hydro to use and update

Demand-side management options		
Energy efficiency programs	Capacity focused programs	Rate options

Conservation Potential Review

Steps to calculating potential



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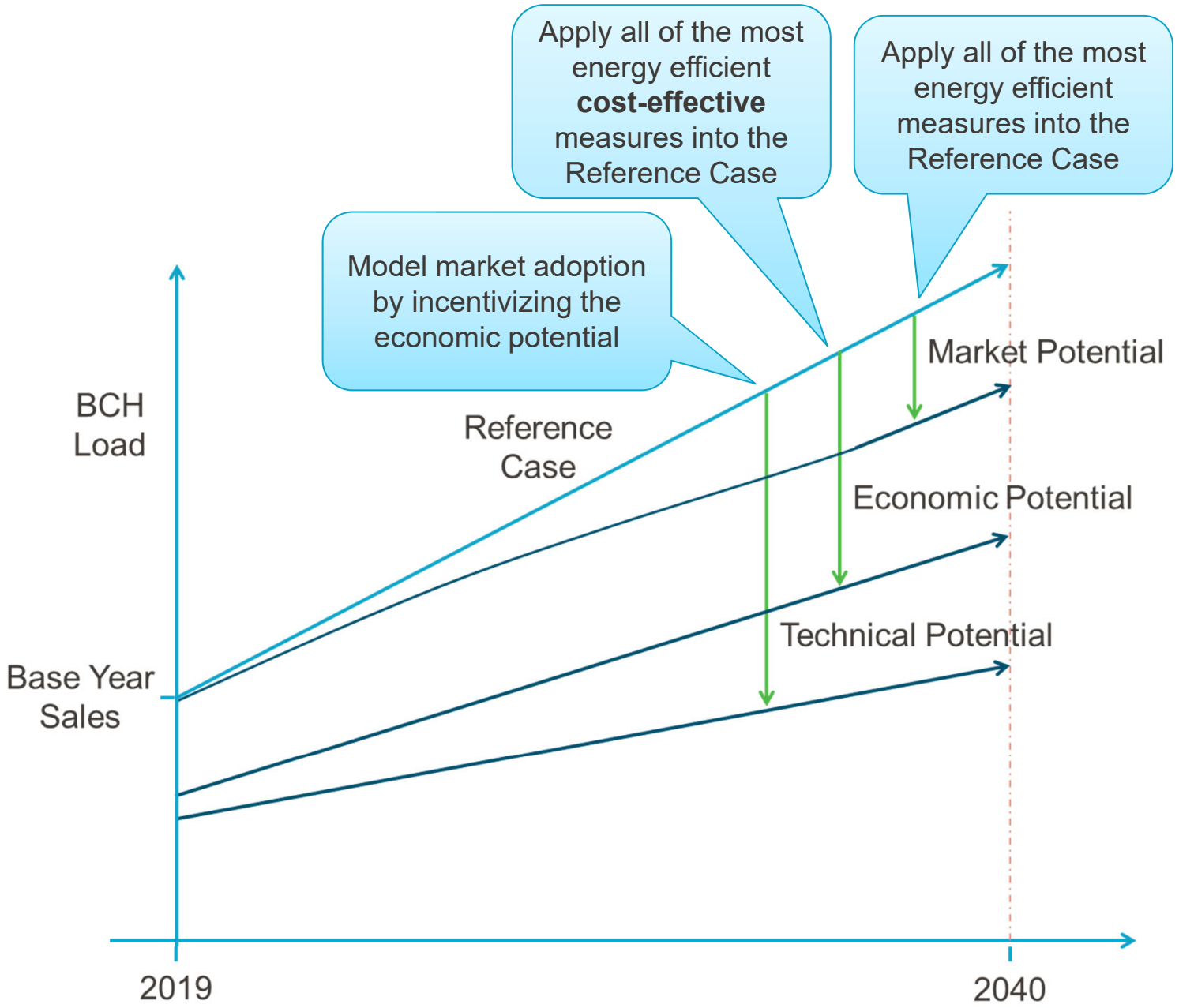

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Demand-side management options		
Energy efficiency programs	Capacity focused programs	Rate options

Conservation Potential Review (CPR)

Updating the conservation potential review is the first step in developing demand side management resource options

- Update CPR models to reflect more current information including:
  - Actual sales up to fiscal 2019, by customer class and end use
  - The updated load forecast
  - Limited update on measures
  - Global assumptions
- Conservation potential will likely be lower overall, due to the lower load forecast

Demand-side management options		
Energy efficiency programs	Capacity focused programs	Rate options

IRP resource options – energy efficiency

Approach to developing energy efficiency options

- Use the CPR market potential model
- Model incremental blocks of energy efficiency potential, over and above the current level of DSM

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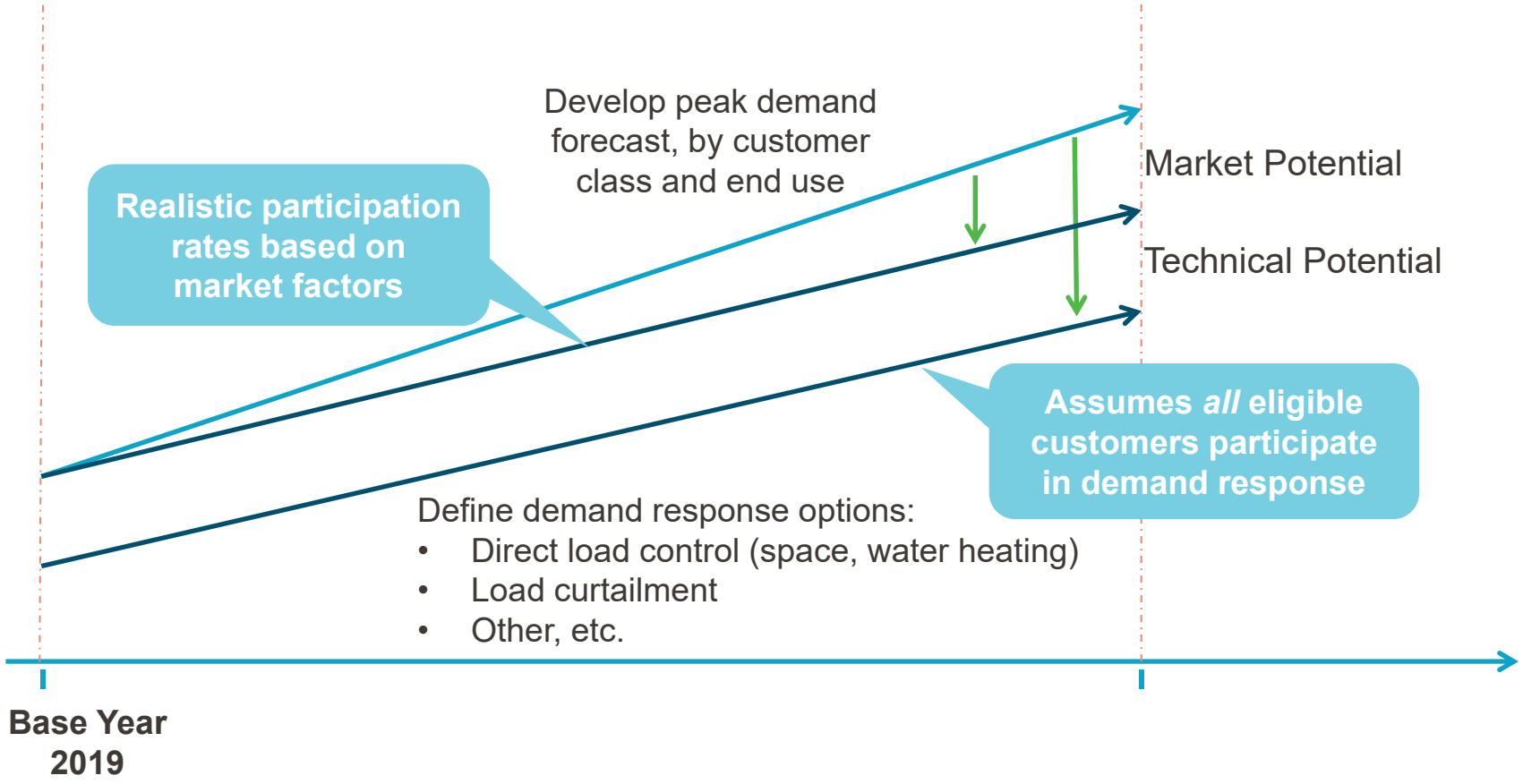
Demand-side management options		
Energy efficiency programs	**Capacity focused programs**	Rate options

IRP resource options – capacity

CPR demand response model



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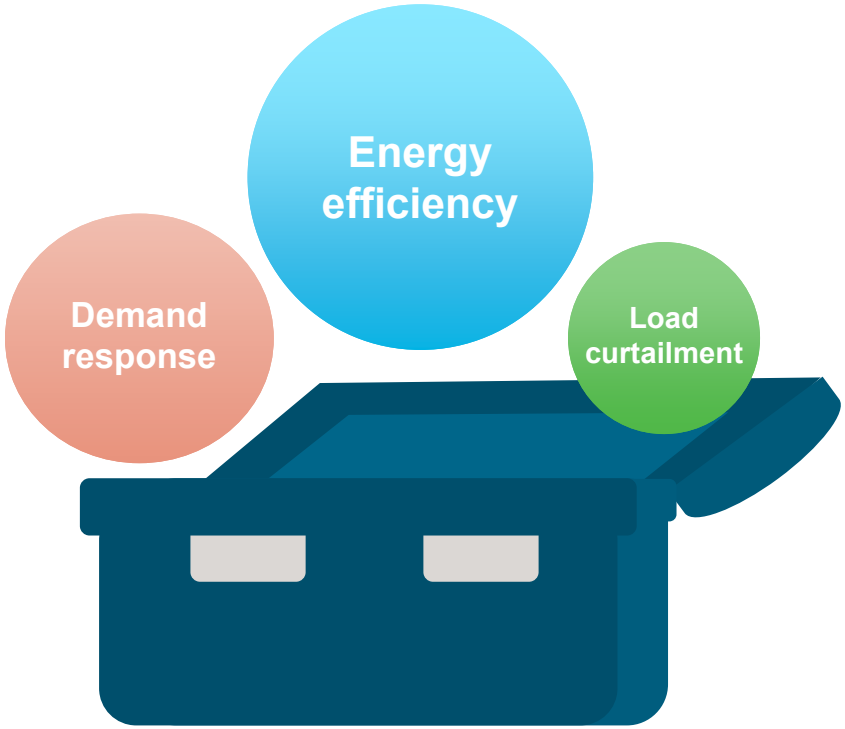
Demand-side management options		
Energy efficiency programs	**Capacity focused programs**	Rate options

IRP resource options – capacity

Approach to developing regional capacity resource options



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Demand-side management options		
Energy efficiency programs	**Capacity focused programs**	Rate options

IRP resource options – capacity

Learnings from our existing capacity pilots will inform the update

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Demand-side management options		
Energy efficiency programs	Capacity focused programs	Rate options

Capacity-focused rate design options

Price signals can be used to manage capacity

- **Scope:** Capacity focused rate designs that send a price signal to encourage peak shaving and load shifting
- **Topics:** Electricity pricing overview and jurisdiction scan of commonly used capacity focused rate designs

Demand-side management options		
Energy efficiency programs	Capacity focused programs	Rate options

Electricity pricing overview

The cost of providing electricity service is commonly classified as being energy, demand and customer related, and these cost are reflected in pricing

BC Hydro Residential Rate

(Rate Schedule 1101)

Basic Charge 60 days @ $0.2090 /day …….$12.54*

ENERGY CHARGES

Step 1: 1,332 kWh @ $0.0945 /kWh... …….$125.87*

Step 2: 106 kWh @ $0.1417 /kWh…...…….$15.02*

BC Hydro Medium General Service Rate

(Rate Schedule 1500)

Basic Charge 32 days @ $0.2673 /day ……$8.55*

ENERGY CHARGES

11,280 kWh @ $0.0968 /kWh……. ……$1,091.90*

DEMAND CHARGES

60 kW @ $5.4200 /kW……..... ……$325.20*

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Demand-side management options		
Energy efficiency programs	Capacity focused programs	Rate options

Common capacity-focused rate designs

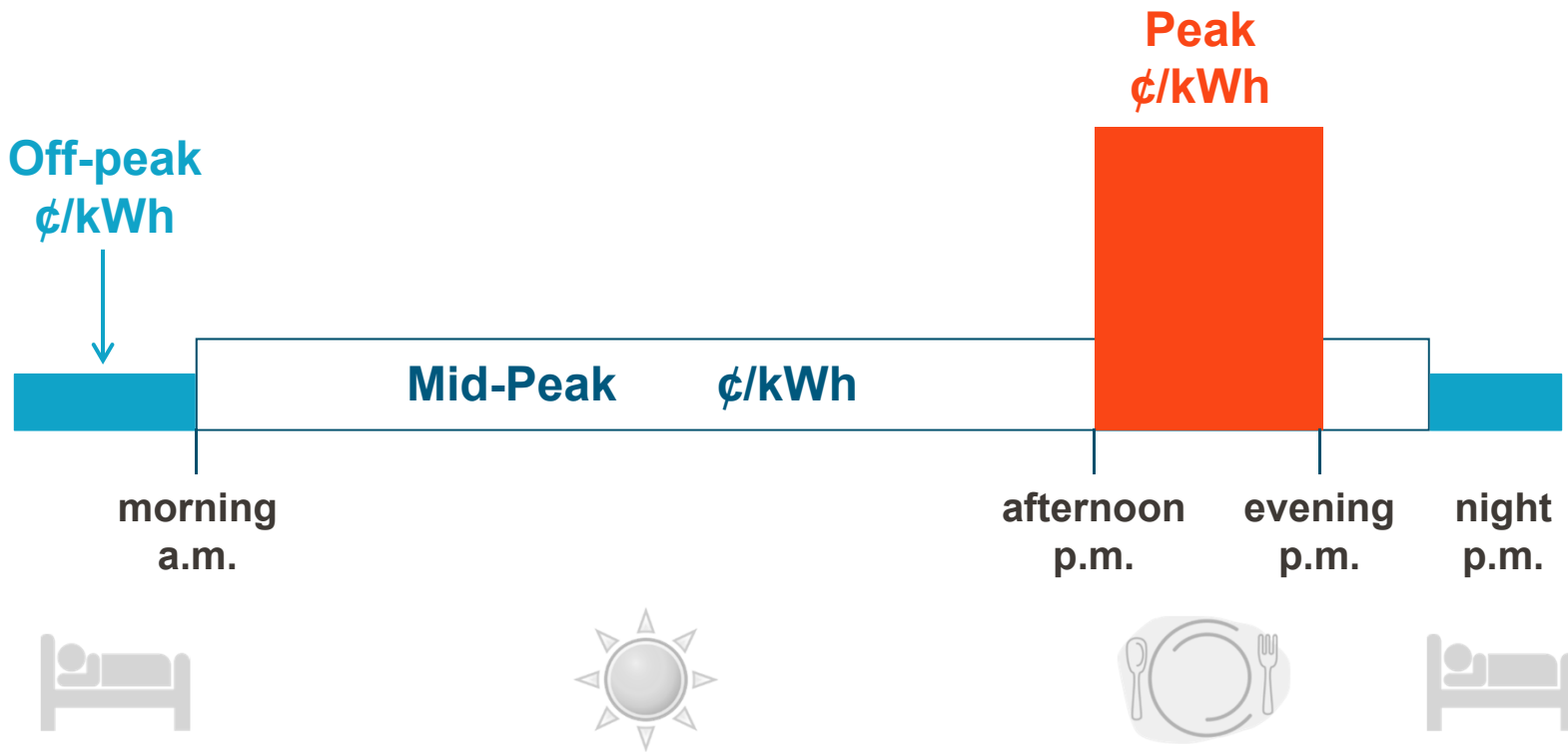
A jurisdictional review shows there are five common rate designs to encourage peak shaving and load shifting

Rate type	Encourages customers to...
Demand charges	reduce their peak demand
Time of use	use more electricity at certain, predefined times of the day, less electricity at other times
Peak time rebate	use less electricity during a limited number of critical periods
Critical peak pricing	use less electricity during a limited number of critical periods
Real time pricing	actively manage their demand in response to actual variations in its costs

Demand-side management options		
Energy efficiency programs	Capacity focused programs	Rate options

Time of use

Encourages load shifting by offering lower prices during off-peak, higher prices on peak. Simplified example adapted from Sacramento Municipal Utility District:



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Demand-side management options		
Energy efficiency programs	Capacity focused programs	Rate options

Peak time rebate

Encourages peak shaving at no risk to customer. Simplified example of pricing adapted from Portland General Electric:

Residential

Standard rate	
Basic charge	$11/month
Energy charge	12 c/kwh

Peak time rebate rate	
Basic charge	$11/month
Energy charge	12 c/kWh
Peak time rebate amount	100 c/kWh
Critical peak periods	Four consecutive hours per day, up to 20 days in a calendar year day ahead notice

Demand-side management options		
Energy efficiency programs	Capacity focused programs	Rate options

Critical Peak Pricing

Encourages peak shaving by sharing pricing risk and reward with customer

Simplified example adapted from Xcel Colorado:

General service

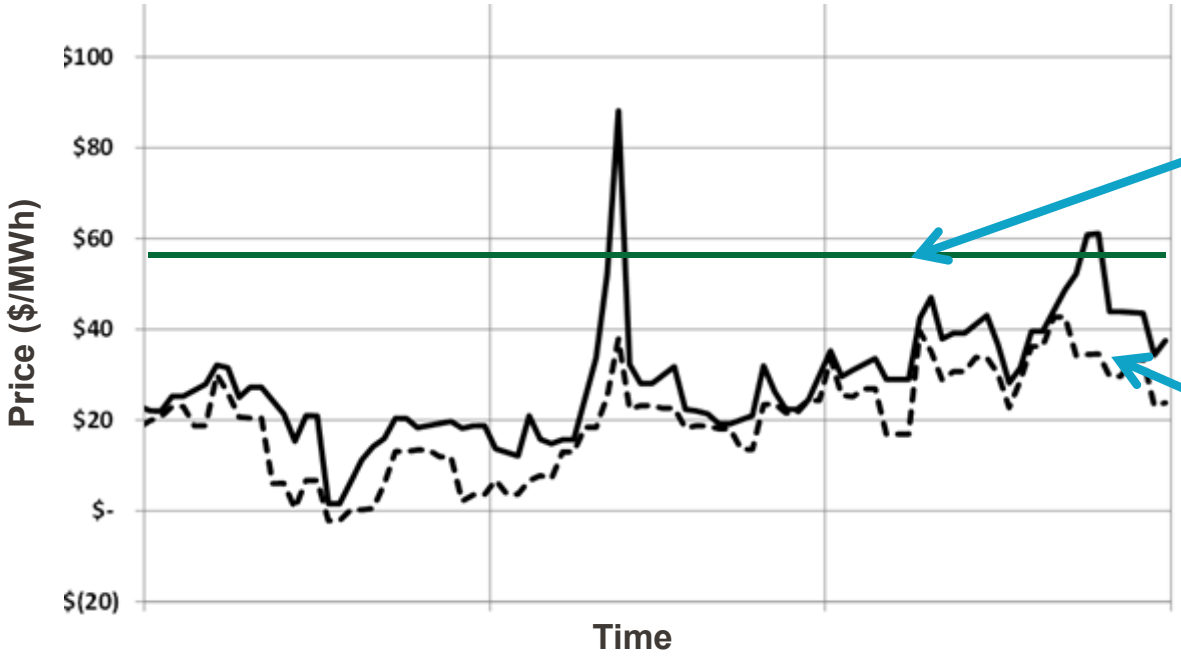
Standard rate	
Service & facilities charge	$300/month
Demand charge	$15/kW
Energy charge	$0.005/kwh

Critical peak pricing rate	
Service & facilities charge	$300/month
Demand charge	$11/kW
Energy charge	$0.005/kWh
Critical peak period energy rate	1.35 $/kWh
Critical peak periods	Up to four consecutive hours per day, up to 15 days in a calendar year day ahead notice

Demand-side management options		
Energy efficiency programs	Capacity focused programs	Rate options

Illustrative real time pricing rate design

Encourages active capacity management by passing on pricing risk and reward to customer. Simplified example adapted from Georgia Power:



Stable average price of standard bill component

Variable market prices (heavy and light load hours) of real time pricing bill component

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Grid management system

Cheong Siew, BC Hydro

BC Hydro
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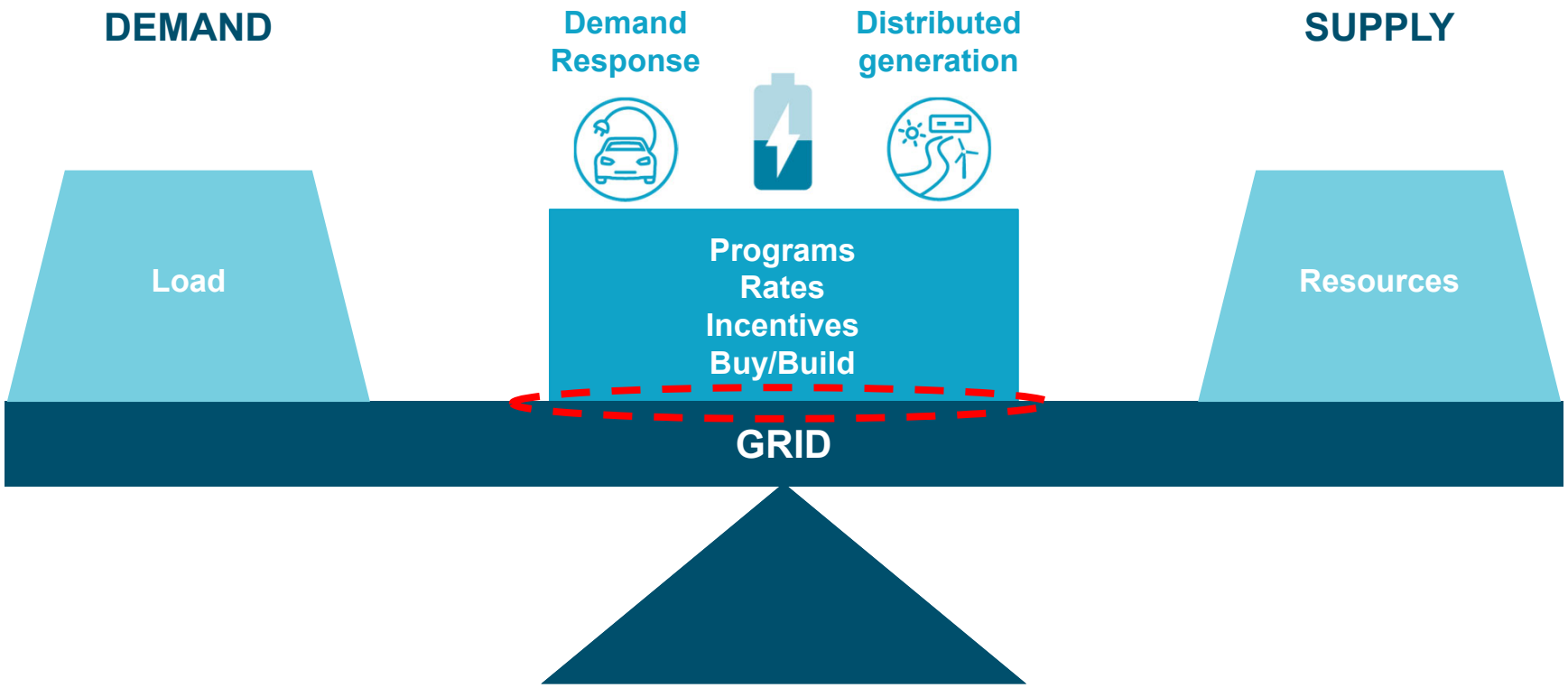
Grid management system

Grid management enables integration of increasing distributed resources



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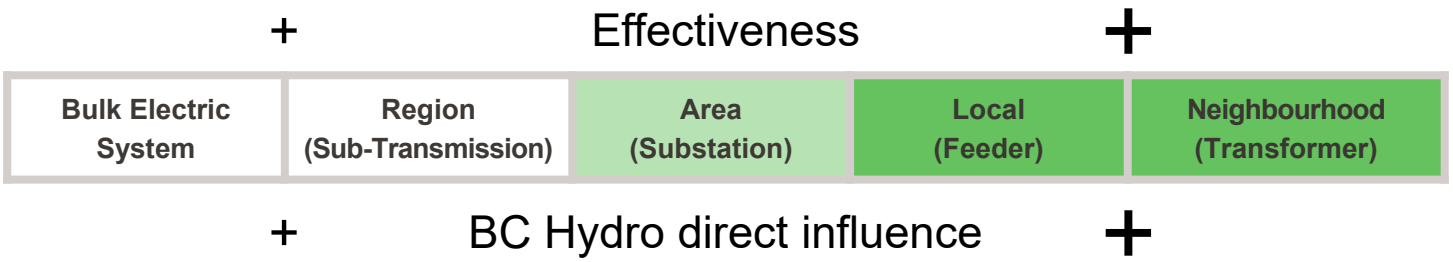
Grid management system

Maximizing benefits of distributed resources requires grid management

- Provides ability to forecast load requirements and resulting capacity constraints
- Provides ability to dispatch subscription based capacity-focused initiatives
- Results in increased benefits of some capacity focused initiatives by:
  - Reducing demand when there is insufficient capacity in the system
  - Coordinating the distributed resources with customer load requirements
- Greater visibility and influence at the local level allows effective management



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Next steps & session close

Anne Wilson, BC Hydro

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Next steps & thank you

We appreciate your interest and thank you for your participation in today's session

Your feedback is important to us

- Please leave your completed **feedback form** with us today
- Or, email your comments to us **by December 20**
  integrated.resource.planning@bchydro.com
- We will consider your input as we update our database

For information about resource options, visit our web page, www.bchydro.com/supplyoptions

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