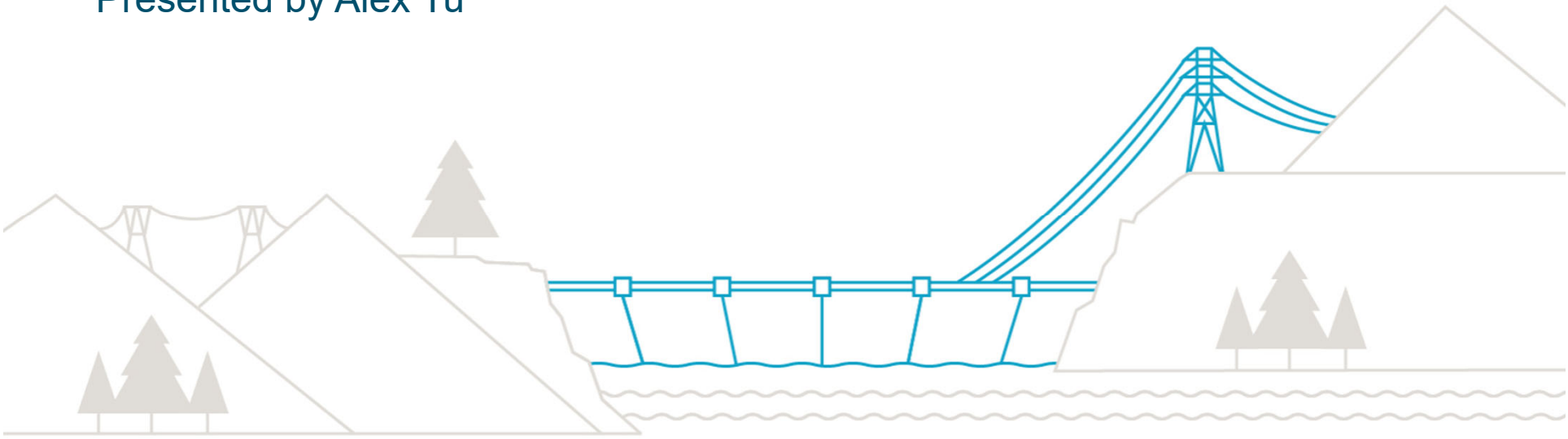
Resource Options Engagement
Solar Financial Estimates

Presented by Alex Tu



November 20, 2019

BC Hydro
Power smart

Purpose and Agenda

Receive input from technical experts on the assumptions that underpin BC Hydro's view of solar resource costs in BC

1. Quick recap of input from last week
2. What costs are included in the assessment
3. Draft assumptions to estimate total capital and OMA costs of solar resources in BC
    - Utility Scale (~50 MW, transmission connected)
    - Urban Scale (~5 MW, distribution connected)
    - Customer Scale (residential and commercial rooftop)
4. Summary of input assumptions for discussion

Input on Technical Assumptions

Excellent feedback received and generally accepted

Feedback	BC Hydro's consideration of feedback
Viable utility scale resources should be limited to within 20 miles of existing transmission infrastructure	BC Hydro will update the restriction to reflect this feedback
Forested land is too simplistic of a limitation to screen viable land uses	BC Hydro will expand the land uses restrictions to reflect a more granular view
Develop a map of current solar development in BC	This is beyond the scope of the Resource Options Update
Stakeholders suggested monocrystalline panels are moving toward the default assumption	BC Hydro will change assumption to use monocrystalline panels
The utility and urban scale resource estimate likely overstates the total resource available after practical considerations of competing land uses and land availability	Agreed – this estimate reflects a higher bound 'technically achievable' resource inventory and may be further refined in future to better reflect this additional considerations
For commercial and residential systems, both are likely to have 1.3: 1 overbuild ratios	BC Hydro will adopt these assumptions
For commercial and residential systems, 10 degree fixed tilt for commercial and 20 degree fixed tilt for residential are reasonable assumptions	BC Hydro will adopt these assumptions

What are relevant costs to account for?

Capital and operating costs are unique to each resource, but financing and taxes are applied generically to all resources in BC

Unique costs for each resource

- Capex
  - Equipment, including generating plant, balance of systems, and step-up transformer
  - Land, site prep, studies & public engagement, Engineering Procurement & Construction (EPC), sales tax, other developer costs including net profits
- O&M
  - Fixed O&M: regular maintenance, property tax, insurance cost, annualized cost of sustaining capital
  - Variable O&M: fuel costs or other costs than vary with output

Unique resource parameters

- Planned life (# of years)
- Development timeline (# of years)

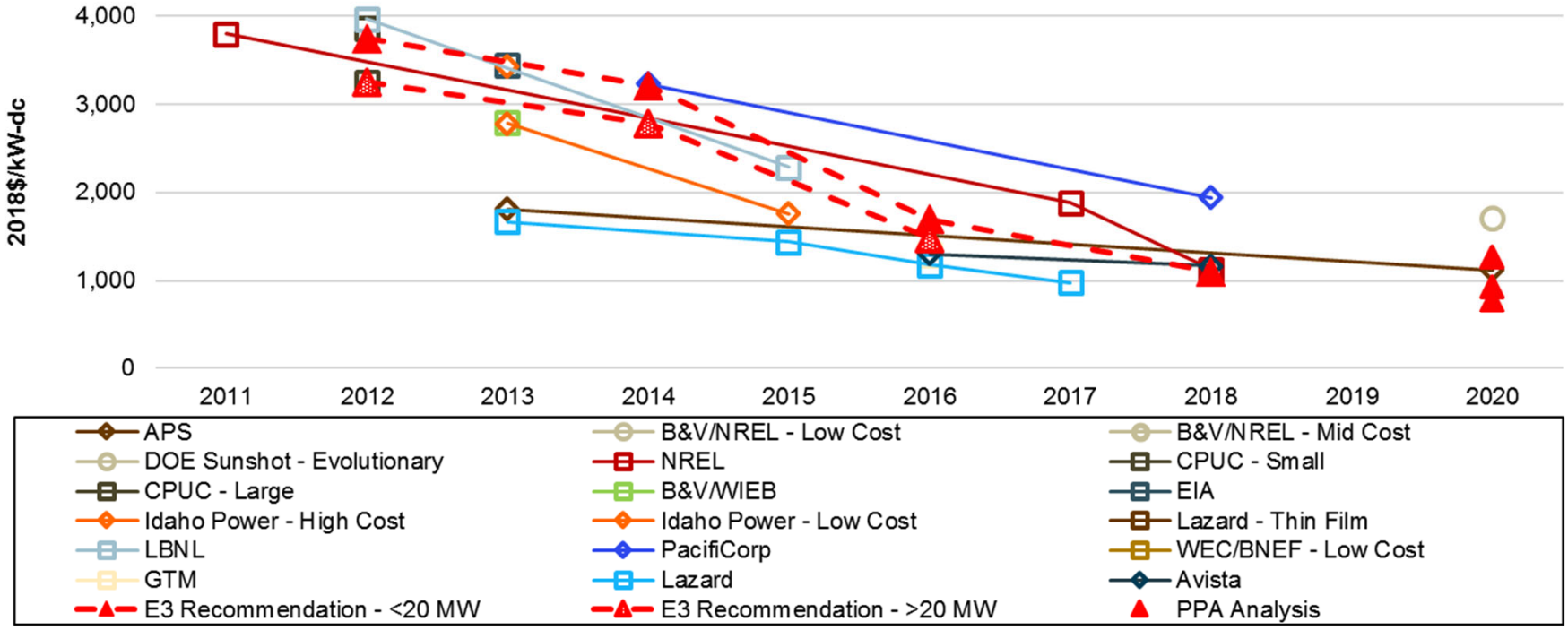
Generic resource parameters

- Financing costs and structures
- Corporate Taxes
- Tx interconnection cost to POI, Road Construction, and Tx station and Network upgrades

Utility Scale Capital Costs

Published literature – detailing US experience – varies widely with assumptions

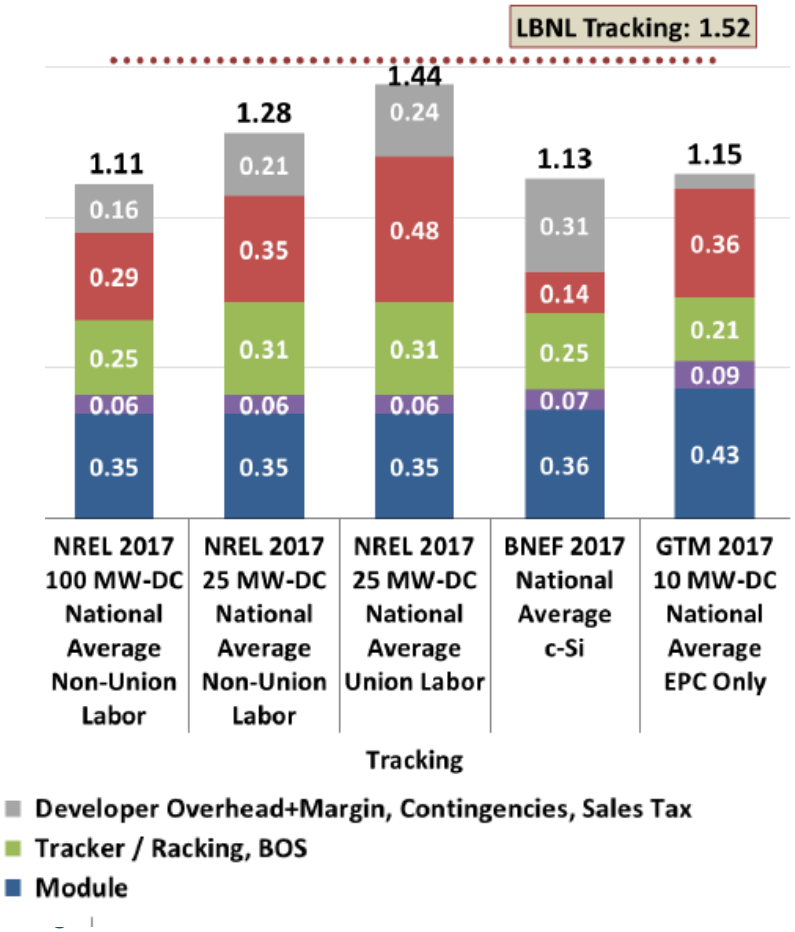
Capital Cost Estimate by Source



BC Hydro
Power smart

Utility Scale Costs

Capital Costs are in this range for the US – are they transferable to BC for 2020?



Category	Low ($CAN)	Mid ($CAN)	High ($CAN)
Modules	$0.45	$0.50	$0.55
Inverter	$0.08	$0.10	$0.12
Tracking / BOS	$0.27	$0.34	$0.40
EPC, Land…	$0.18	$0.40	$0.62
Developer costs	$0.20	$0.30	$0.40
Total	$1.18 / W DC ($CAN)	$1.64 / W DC ($CAN)	$2.09 / W DC ($CAN)

Utility Scale Costs

OMA costs are in this range for the US – are they transferable to BC for the year 2020?

US solar O&M costs by category (2018)

	Residential	Commercial	Utility-scale (fixed-tilt)	Utility-scale (tracking)
Module cleaning & vegetation management	$0.80	$2.70	$3.30	$3.30
System inspection & monitoring	$2.72	$4.97	$1.79	$2.43
Component parts replacement	$4.55	$0.93	$0.55	$0.87
Module replacement	$0.82	$0.82	$0.91	$0.91
Inverter replacement	$10.00	$5.54	$3.77	$3.77
Operations administration	$2.60	$2.57	$2.50	$2.86

Source: National Renewable Energy Laboratory.

Category	Low	Mid	High
Daily Mainten-ance	$8	$11	$15
Sustaining Capital	?	$8	?
Insurance	?	?	?
Property Taxes	?	?	?
Total	$25 / kW-yr (AC)	$38 / kW – yr (AC)	??

Low and HIgh cost bases on conversations with O&M vendors
Mid Costs based on US data, assuming maintenance and sustaining capital are 50% of total O&M

Discussion on Utility Scale Approach

BC Hydro
Power smart

Costs of Urban scale

US experience suggests negligible economies of scale

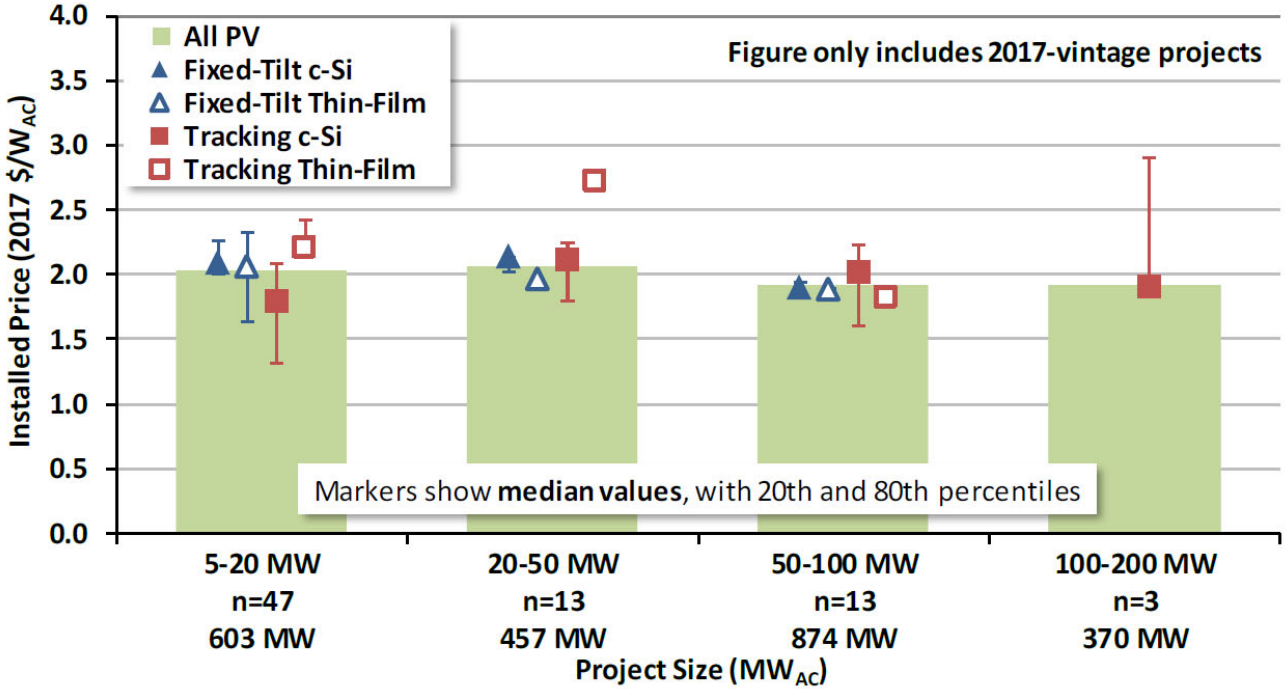


Figure 11. Installed Price of 2017 PV Projects by Size, Module Technology, and Mounting Type

BC Hydro
Power smart

Costs of Urban Scale

Some simple ways of cost differentiating urban from utility scale

Adjustments for urban-scale capital costs

- Increased cost of modules ($0.05 / kW)
- Increased cost of land ($0.10 / kW) ??
- Increased developer costs (eg permitting, stakeholder engagement, land acquisition) $(0.10 / kW) ??
- Lower Interconnection costs (calculated elsewhere)
- Total cost premium for urban scale solar (1-15 MW) ~ $0.25 / kW DC

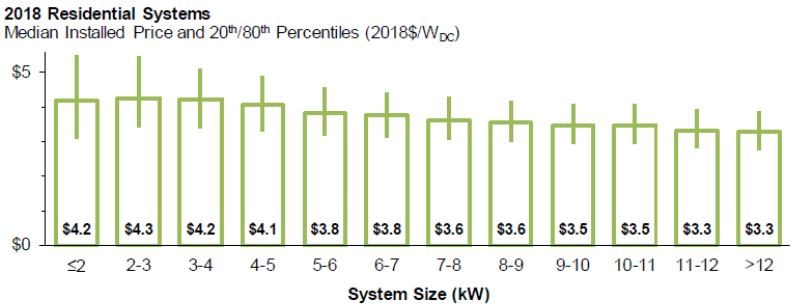
Discussion on Urban Scale Approach

BC Hydro
Power smart

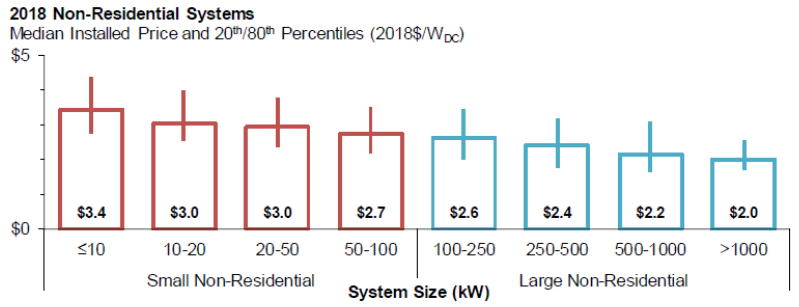
Costs of Customer Scale

Some clear economies of scale

Residential Systems



Non-Residential Systems

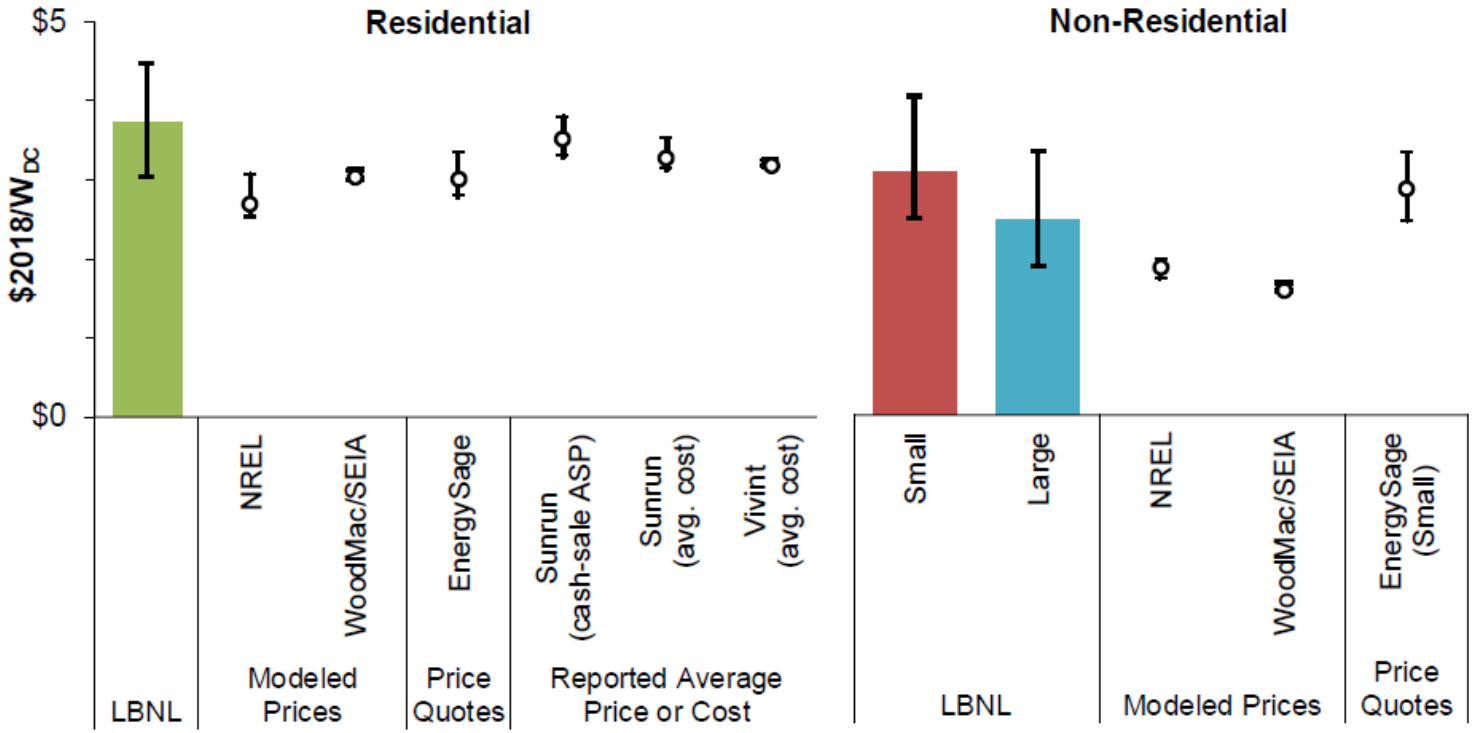


- Among residential systems installed in 2018, median prices were roughly $1/W lower for the largest (>12 kW) systems compared to the smallest (≤2 kW) systems

BC Hydro
Power smart

Costs of Customer Scale

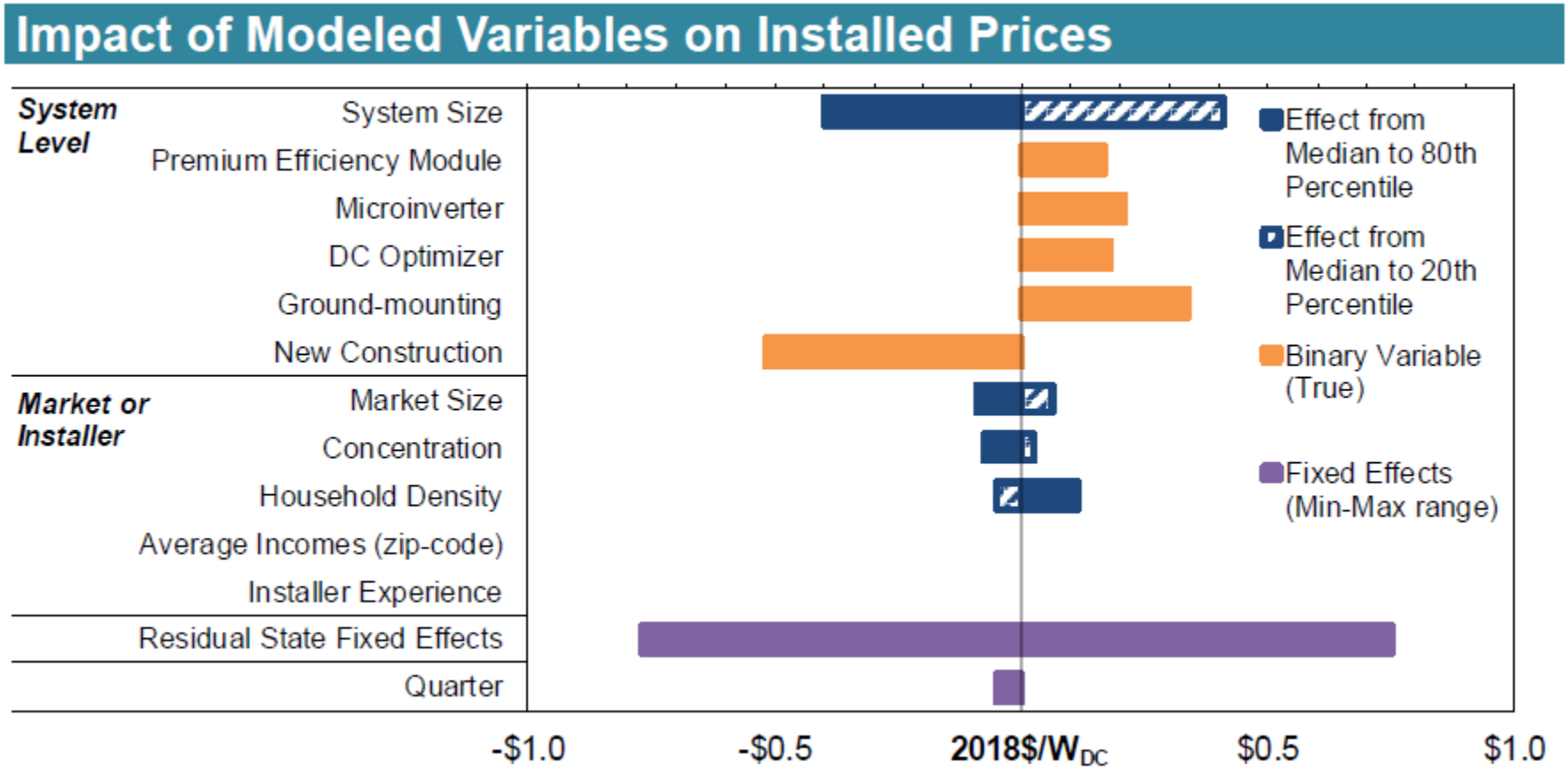
Wide range of modelled and reported costs



BC Hydro
Power smart

Costs of Customer Scale

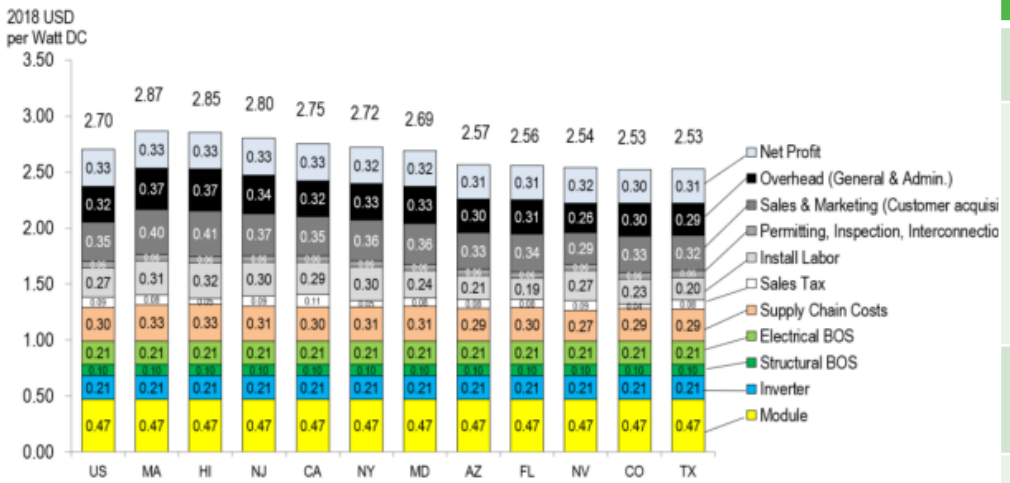
Regression analysis of costs in US point to major determinants of cost variance



BC Hydro
Power smart

Costs of Customer Scale

Residential 6 kW systems – Are typical US costs applicable to BC?



Category	Low	Mid	High
Equipment	$1.74	$1.77	$1.80
Permit, Install, inspect, inter-connect	$0.34	$0.41	$0.48
Developer costs	$1.14	$1.29	$1.44
Total	$3.22 / W DC ($CAN)	$3.47 / W DC ($CAN)	$3.72/ W DC ($CAN)

Source: NREL

BC Hydro
Power smart

Customer Scale Costs

OMA costs for Residential– are they transferable to BC?

US solar O&M costs by category (2018)

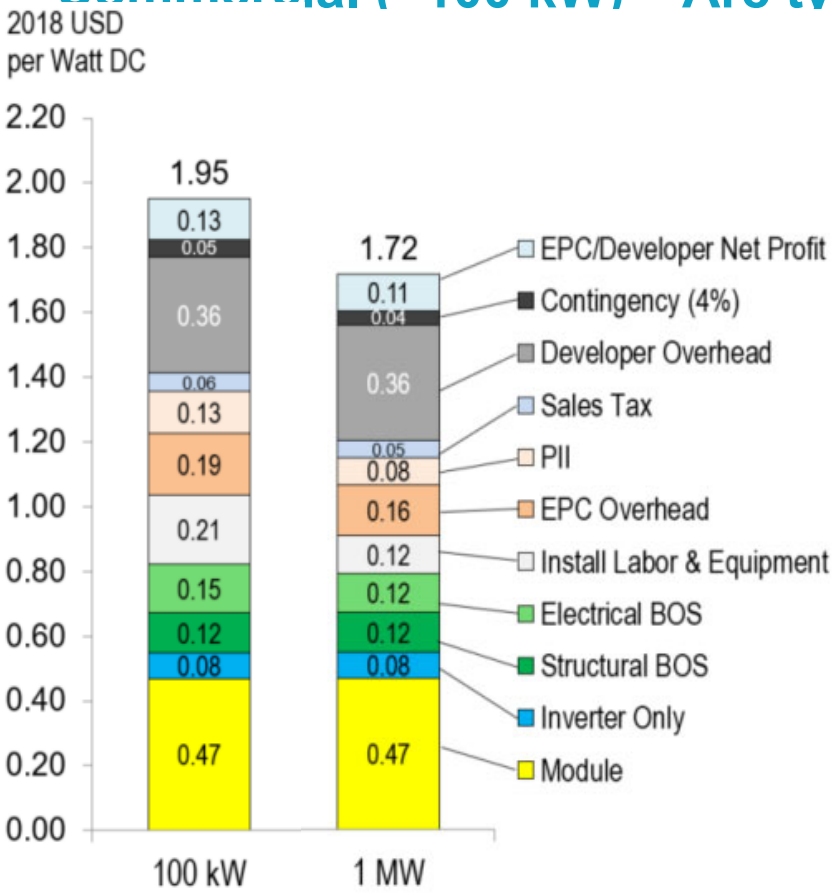
	Residential	Commercial	Utility-scale (fixed-tilt)	Utility-scale (tracking)
Module cleaning & vegetation management	$0.80	$2.70	$3.30	$3.30
System inspection & monitoring	$2.72	$4.97	$1.79	$2.43
Component parts replacement	$4.55	$0.93	$0.55	$0.87
Module replacement	$0.82	$0.82	$0.91	$0.91
Inverter replacement	$10.00	$5.54	$3.77	$3.77
Operations administration	$2.60	$2.57	$2.50	$2.86

Source: National Renewable Energy Laboratory.

Category	Low	Mid	High
Daily Mainten-ance	?	$8	?
Sustaining Capital	?	$20	?
Insurance	?	?	?
Property Taxes	?	?	?
Total		$28 / kW-yr (AC)	

Customer Scale Costs

Commercial (~100 kW) – Are typical US costs applicable to BC?



Source: NREL

Category	Low	Mid	High
Equipment	$1.10	$1.18	$1.27
Permit, Install, inspect, inter-connect	$0.48	$0.57	$0.65
Developer costs	$0.69	$0.79	$0.89
Total	$2.27 / W DC ($CAN)	$2.54 / W DC ($CAN)	$2.81/ W DC ($CAN)

BC Hydro
Power smart

CustomerScale Costs

OMA costs for commercial customers for the US – are they transferable to BC for the year 2020?

US solar O&M costs by category (2018)

	Residential	Commercial	Utility-scale (fixed-tilt)	Utility-scale (tracking)
Module cleaning & vegetation management	$0.80	$2.70	$3.30	$3.30
System inspection & monitoring	$2.72	$4.97	$1.79	$2.43
Component parts replacement	$4.55	$0.93	$0.55	$0.87
Module replacement	$0.82	$0.82	$0.91	$0.91
Inverter replacement	$10.00	$5.54	$3.77	$3.77
Operations administration	$2.60	$2.57	$2.50	$2.86

Source: National Renewable Energy Laboratory.

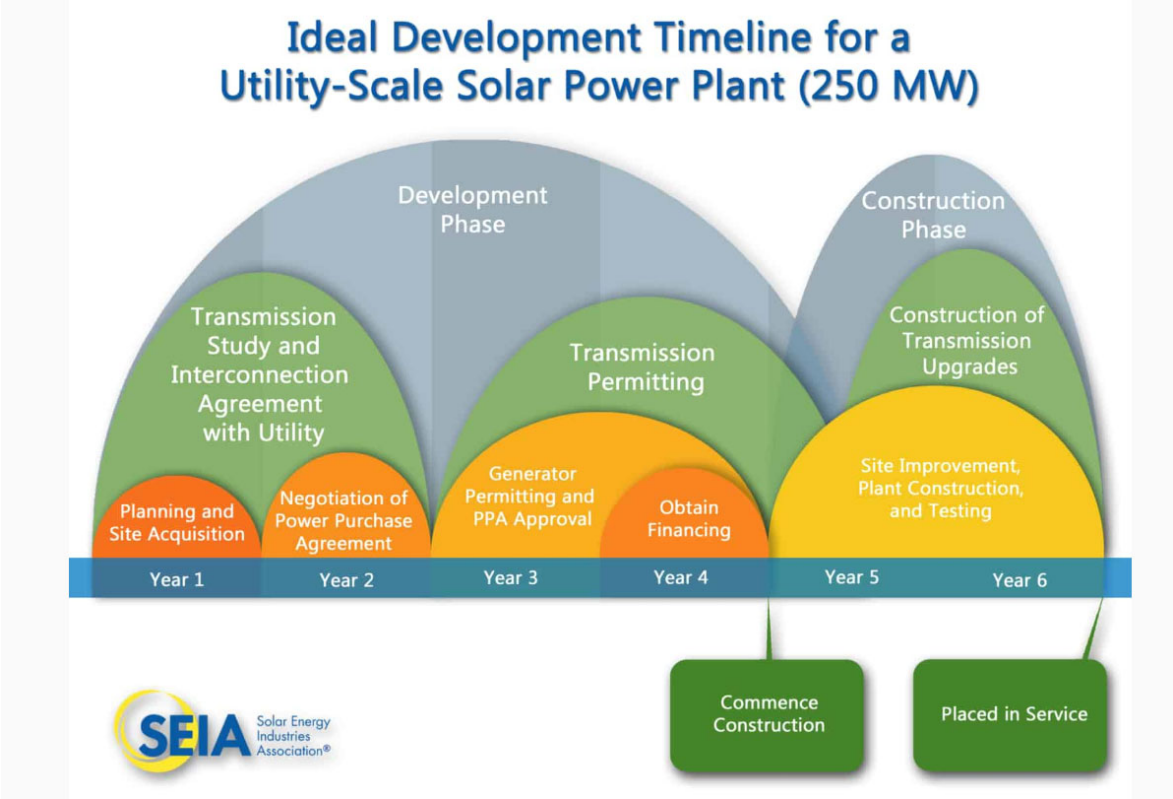
Category	Low	Mid	High
Daily Mainten-ance	?	$13	?
Sustaining Capital	?	$9	?
Insurance	?	?	?
Property Taxes	?	?	?
Total		$22 / kW – yr (AC)	

Discussion on Customer Scale Approach

BC Hydro
Power smart

Development timelines for solar

What are reasonable development and construction phase durations?



BC Hydro
Power smart


BC Hydro
Power smart