INTEGRATED RESOURCE PLAN TECHNICAL ADVISORY COMMITTEE MEETING #4

April 5 & 6, 2011

BC hydro

FOR GENERATIONS

AGENDA – DAY 1

BC hydro FOR GENERATIONS

Time	Agenda Item	Presenter
9:00 – 9:30	**Review Agenda & Meeting Objective**	Anne Wilson
9:30 – 10:30	**Context to Portfolio Analysis and Evaluation**	Kathy Lee
10:30 – 10:45	Break	
10:45 – 12:15	**Context to Portfolio Analysis and Evaluation** (continued)	Kathy Lee Basil Stumborg
12:15 – 1:00	Lunch	
1:00 – 1:30	**Context to Portfolio Analysis and Evaluation** (continued)	Basil Stumborg
1:30 – 2:00	**Demand-Side Management**	Kathy Lee
2:00 – 2:15	Break	
2:15 – 3:15	**Demand-Side Management** (continued)	Kathy Lee Basil Stumborg
3:15 – 4:15	**Role of Thermal** (time dependant)	Kathy Lee
4:30 – 5:00	**Roundtable/Preparation for Day 2**	Anne Wilson / All

AGENDA – DAY 2

BC hydro FOR GENERATIONS

Time	Agenda Item	Presenter
9:00 – 9:15	**Welcome & Agenda Review**	Anne Wilson
9:15 – 10:45	**Resource Acquisitions Analysis**	Kathy Lee
10:45 – 11:00	Break	
11:00 – 12:00	**Role of Thermal** (possibility of moving to Day 1)	Kathy
12:00 – 1:00	Lunch	
1:00 – 2:30	**Capacity Analysis**	Kathy Lee Lindsay Fane Basil Stumborg
2:30 – 2:45	Break	
2:45 – 4:00	**IRP Inputs – Additional Q&A**	All
4:00 – 4:30	**Roundtable and Next Steps**	Anne Wilson / All

INTRODUCTION TO TAC MEETING #4

BC hydro FOR GENERATIONS

- Purpose of April 5/6 (TAC Meeting #4)
  - Seek TAC member's input on draft analysis
    - Is it understandable?
    - Is it adequate?
    - Is there anything missing?

- Portfolio analysis is continuing through to end of April

- The remaining draft analysis is to be discussed on April 27/28 (TAC Meeting #5)

PLANNING CONTEXT

KATHY LEE AND BASIL STUMBORG

FOR GENERATIONS

IRP PROCESS OVERVIEW

BChydro FOR GENERATIONS

Risk Framework

INPUTS

NEED

RESOURCE OPTIONS

MARKET CONTEXT

5 KEY ISSUES

DSM

ELECTRIFICATION

RESOURCE ACQUISITION

TRANSMISSION

EXPORTS

Analysis

PORTFOLIOS
20 year
30 year

OTHER ISSUES
US T needs
Role of Gas
Reliability
Wind Integration
Export
Expenditures

COMBINING LOAD AND MARKET PRICE UNCERTAINTIES

BC hydro
FOR GENERATIONS

Load Uncertainty

- Simplified to a Large/Mid/Small gap

Market Price Uncertainties

- Simplified to five combinations of variables (A to E)

These can be combined through a probability tree

Application of this

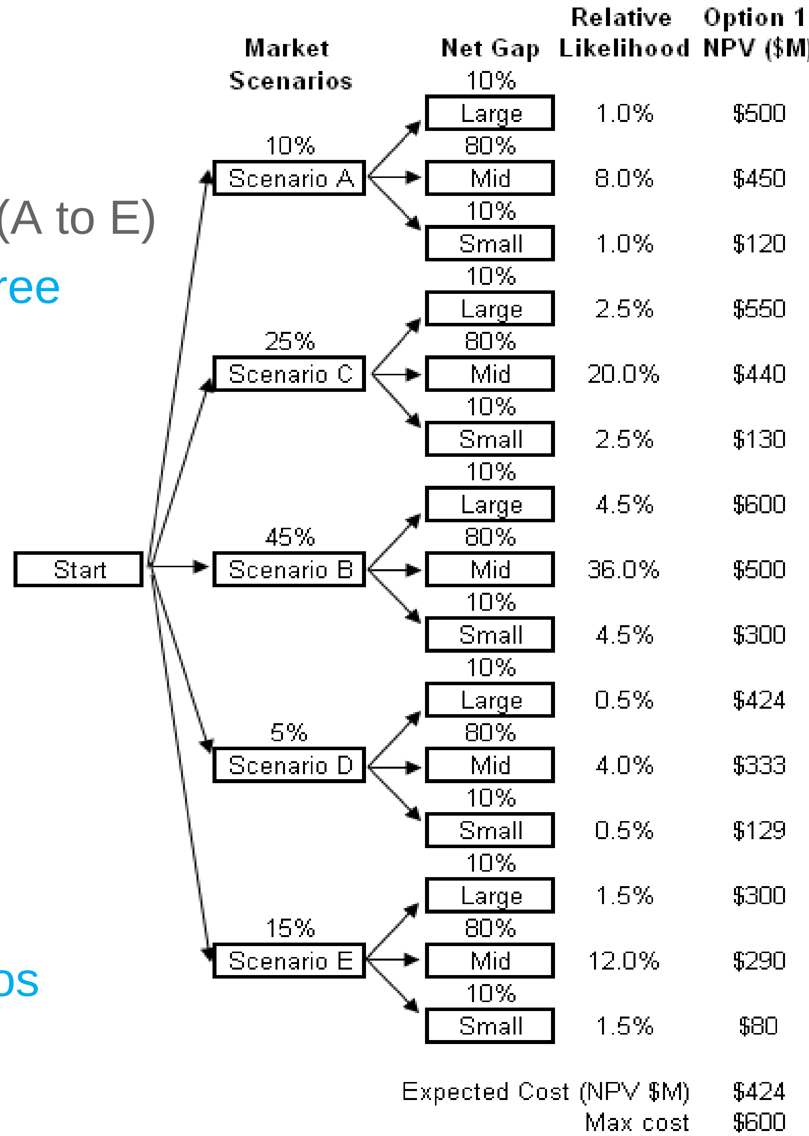
- Tailored to each question
- Full tree may not be used to conserve
  - modelling resources

Probabilities and combination

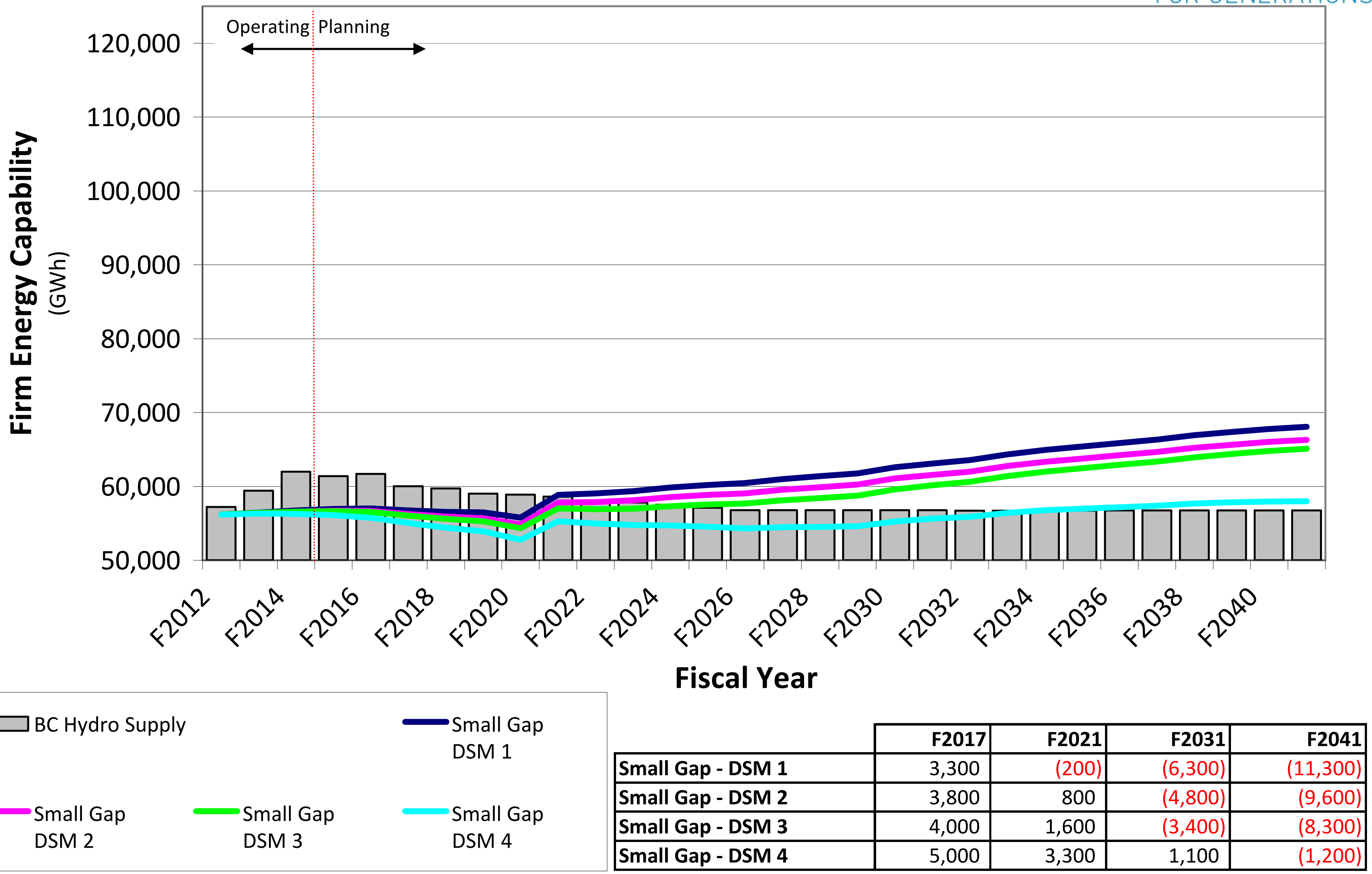
- A “best effort”, not exact/complete
- Sensitivity analysis may be performed
  - For key questions
  - if time permits

Probability estimation for Market Price Scenarios

- in forthcoming report



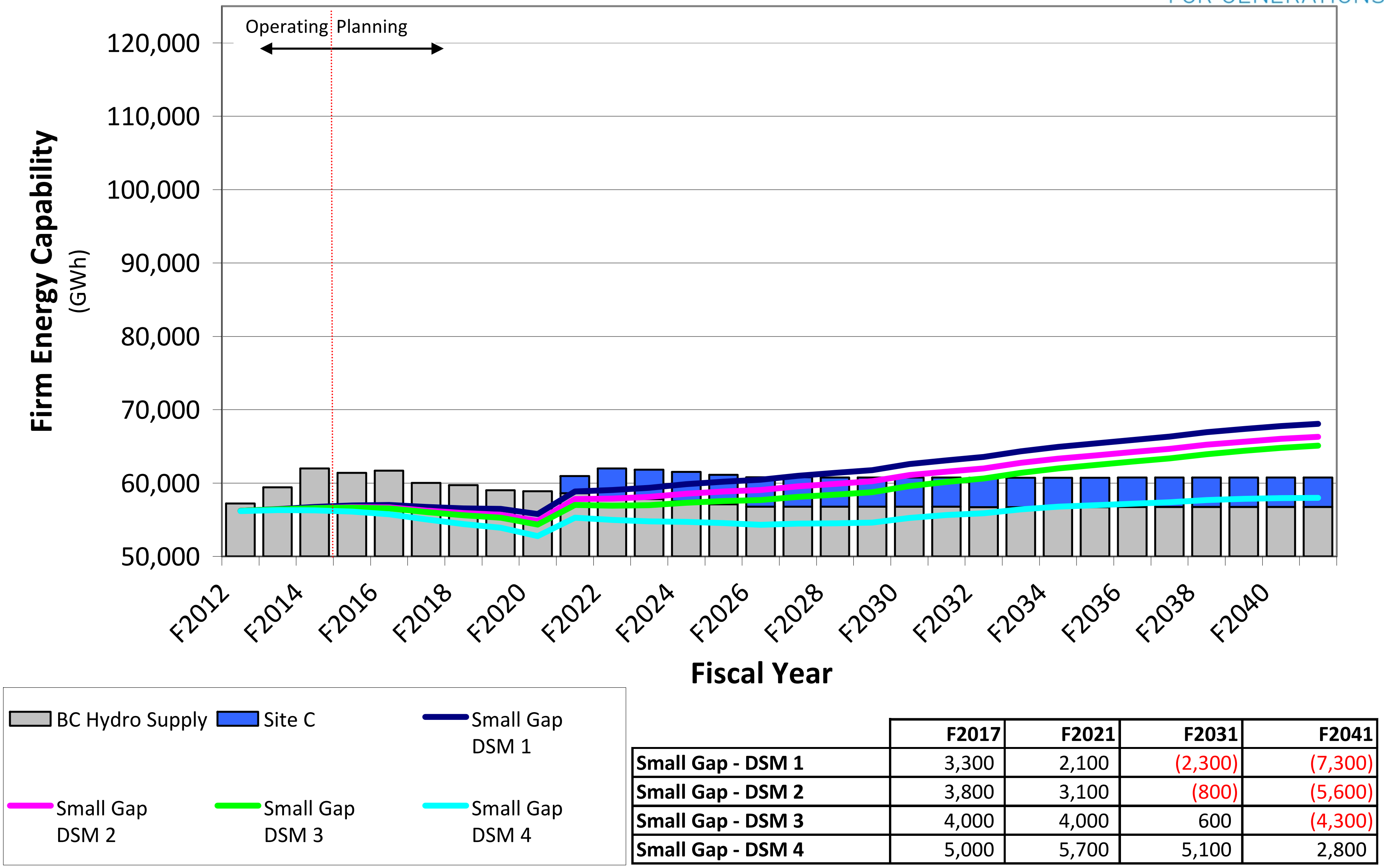
ENERGY: SMALL GAP



	F2017	F2021	F2031	F2041
Small Gap - DSM 1	3,300	(200)	(6,300)	(11,300)
Small Gap - DSM 2	3,800	800	(4,800)	(9,600)
Small Gap - DSM 3	4,000	1,600	(3,400)	(8,300)
Small Gap - DSM 4	5,000	3,300	1,100	(1,200)

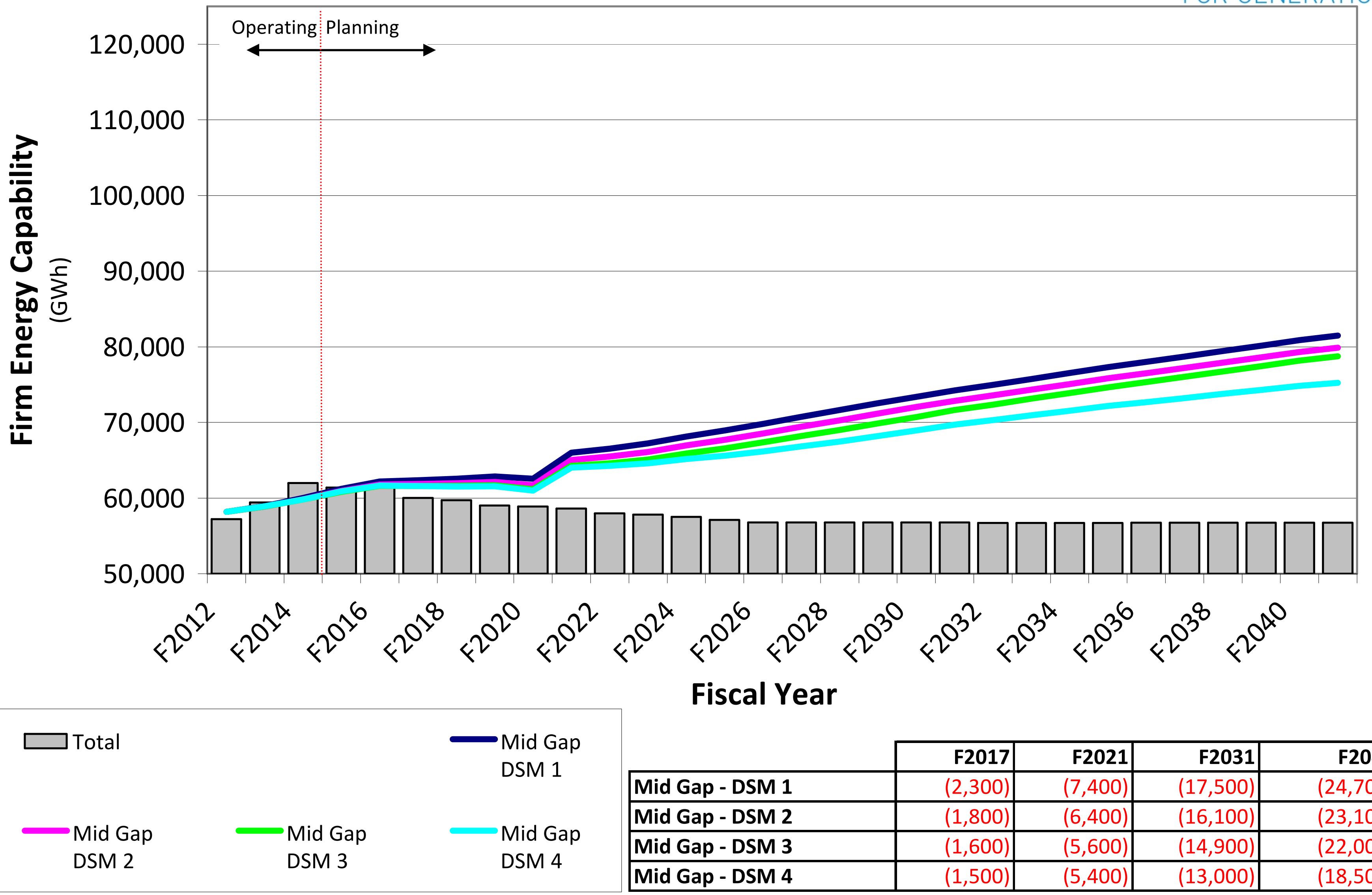
ENERGY: SMALL GAP WITH SITE C

BC hydro FOR GENERATIONS



	F2017	F2021	F2031	F2041
Small Gap - DSM 1	3,300	2,100	(2,300)	(7,300)
Small Gap - DSM 2	3,800	3,100	(800)	(5,600)
Small Gap - DSM 3	4,000	4,000	600	(4,300)
Small Gap - DSM 4	5,000	5,700	5,100	2,800

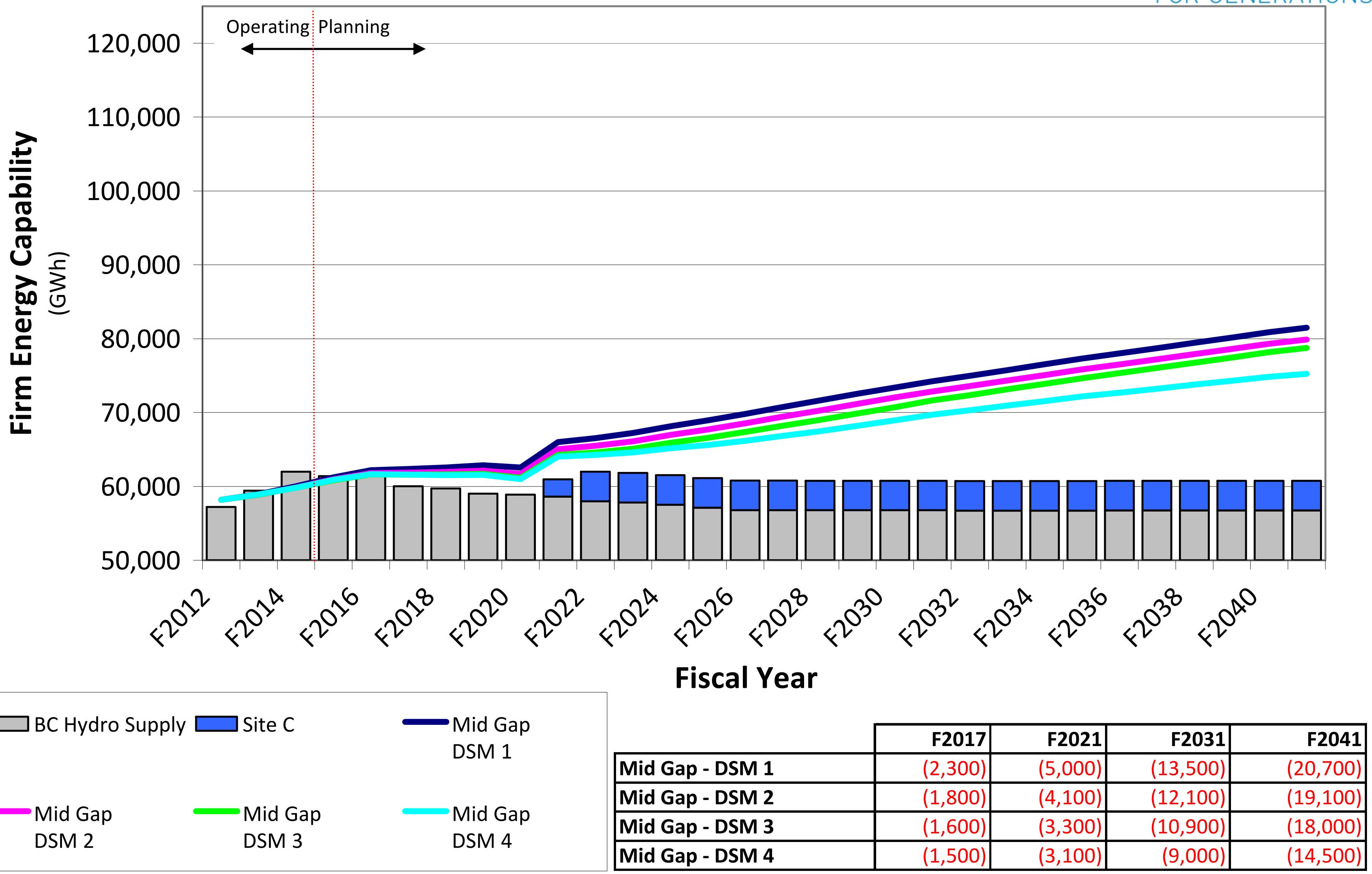
ENERGY: MID GAP



	F2017	F2021	F2031	F2041
Mid Gap - DSM 1	(2,300)	(7,400)	(17,500)	(24,700)
Mid Gap - DSM 2	(1,800)	(6,400)	(16,100)	(23,100)
Mid Gap - DSM 3	(1,600)	(5,600)	(14,900)	(22,000)
Mid Gap - DSM 4	(1,500)	(5,400)	(13,000)	(18,500)

ENERGY: MID GAP WITH SITE C

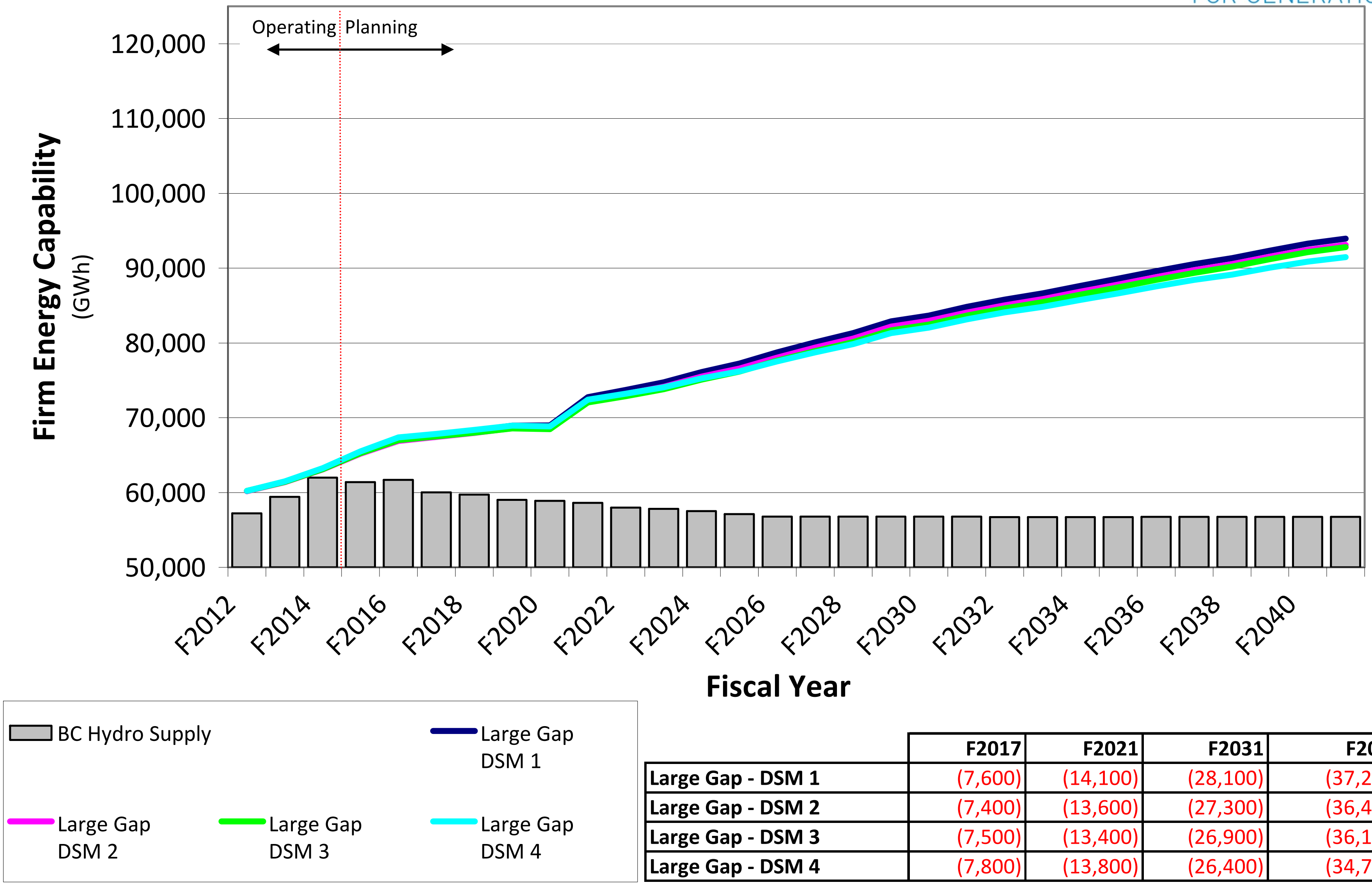
BC hydro FOR GENERATIONS



	F2017	F2021	F2031	F2041
Mid Gap - DSM 1	(2,300)	(5,000)	(13,500)	(20,700)
Mid Gap - DSM 2	(1,800)	(4,100)	(12,100)	(19,100)
Mid Gap - DSM 3	(1,600)	(3,300)	(10,900)	(18,000)
Mid Gap - DSM 4	(1,500)	(3,100)	(9,000)	(14,500)

ENERGY: LARGE GAP

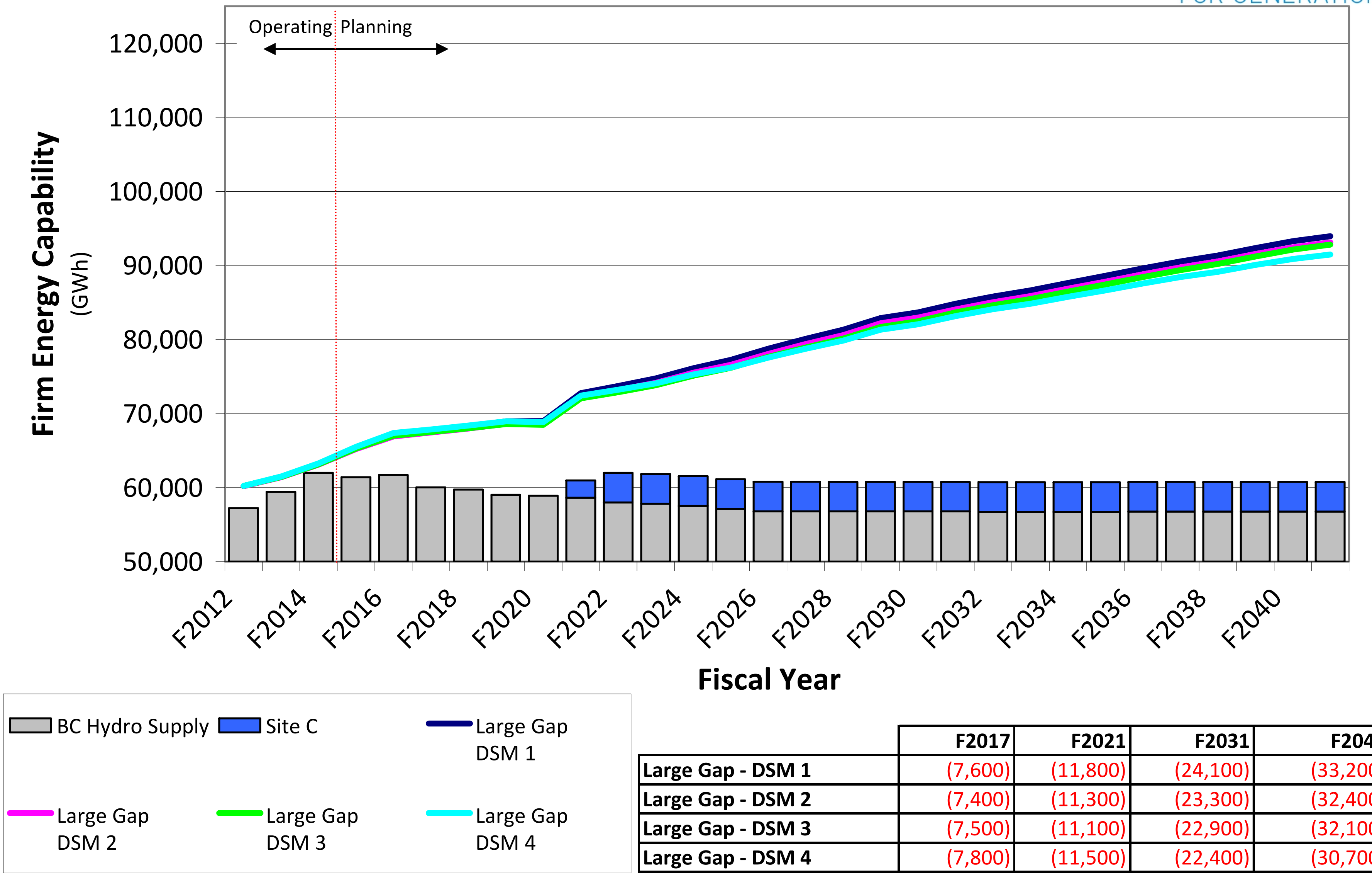
BChydro FOR GENERATIONS



	F2017	F2021	F2031	F2041
Large Gap - DSM 1	(7,600)	(14,100)	(28,100)	(37,200)
Large Gap - DSM 2	(7,400)	(13,600)	(27,300)	(36,400)
Large Gap - DSM 3	(7,500)	(13,400)	(26,900)	(36,100)
Large Gap - DSM 4	(7,800)	(13,800)	(26,400)	(34,700)

ENERGY: LARGE GAP WITH SITE C

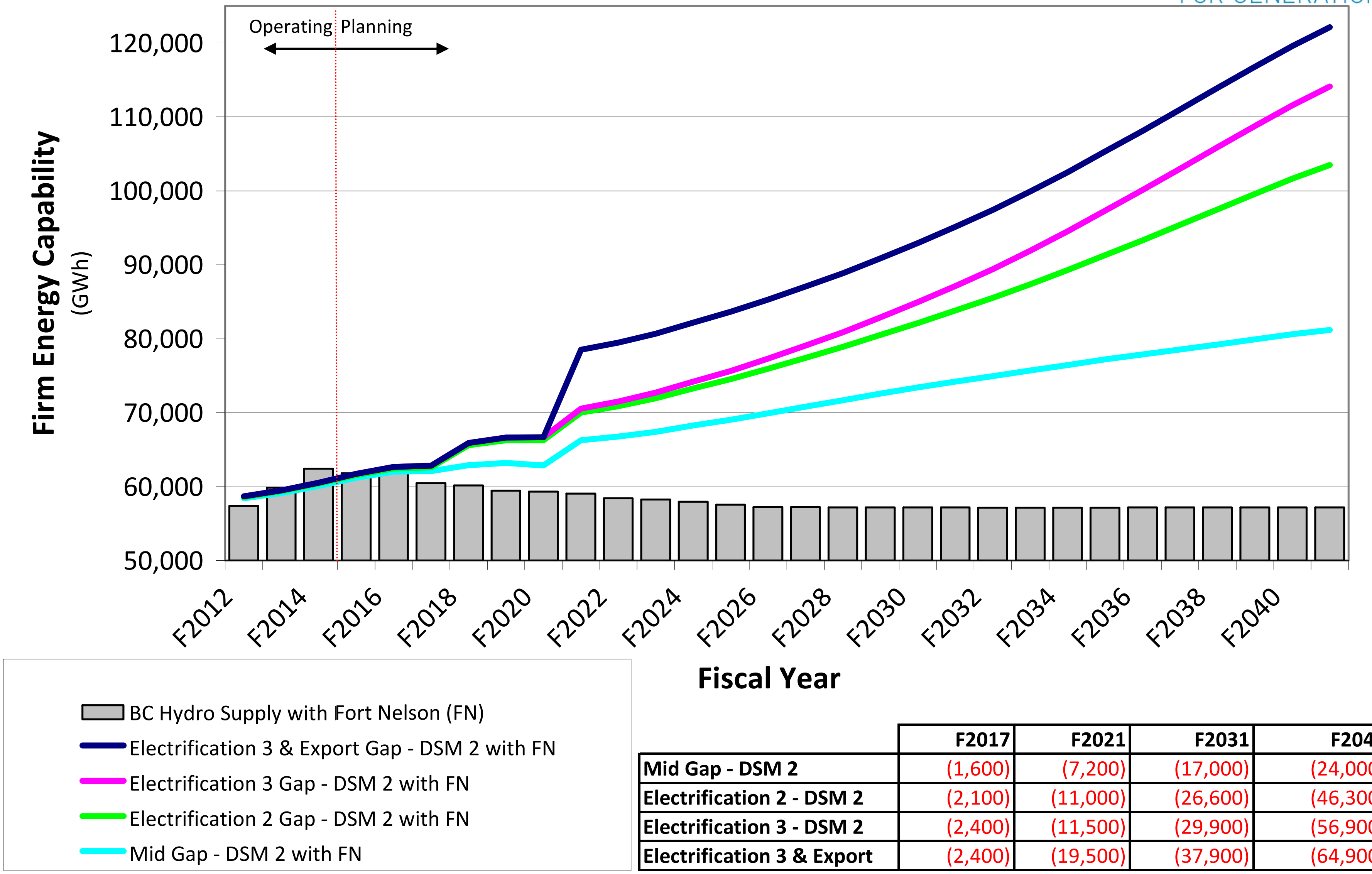
BChydro
FOR GENERATIONS



	F2017	F2021	F2031	F2041
Large Gap - DSM 1	(7,600)	(11,800)	(24,100)	(33,200)
Large Gap - DSM 2	(7,400)	(11,300)	(23,300)	(32,400)
Large Gap - DSM 3	(7,500)	(11,100)	(22,900)	(32,100)
Large Gap - DSM 4	(7,800)	(11,500)	(22,400)	(30,700)

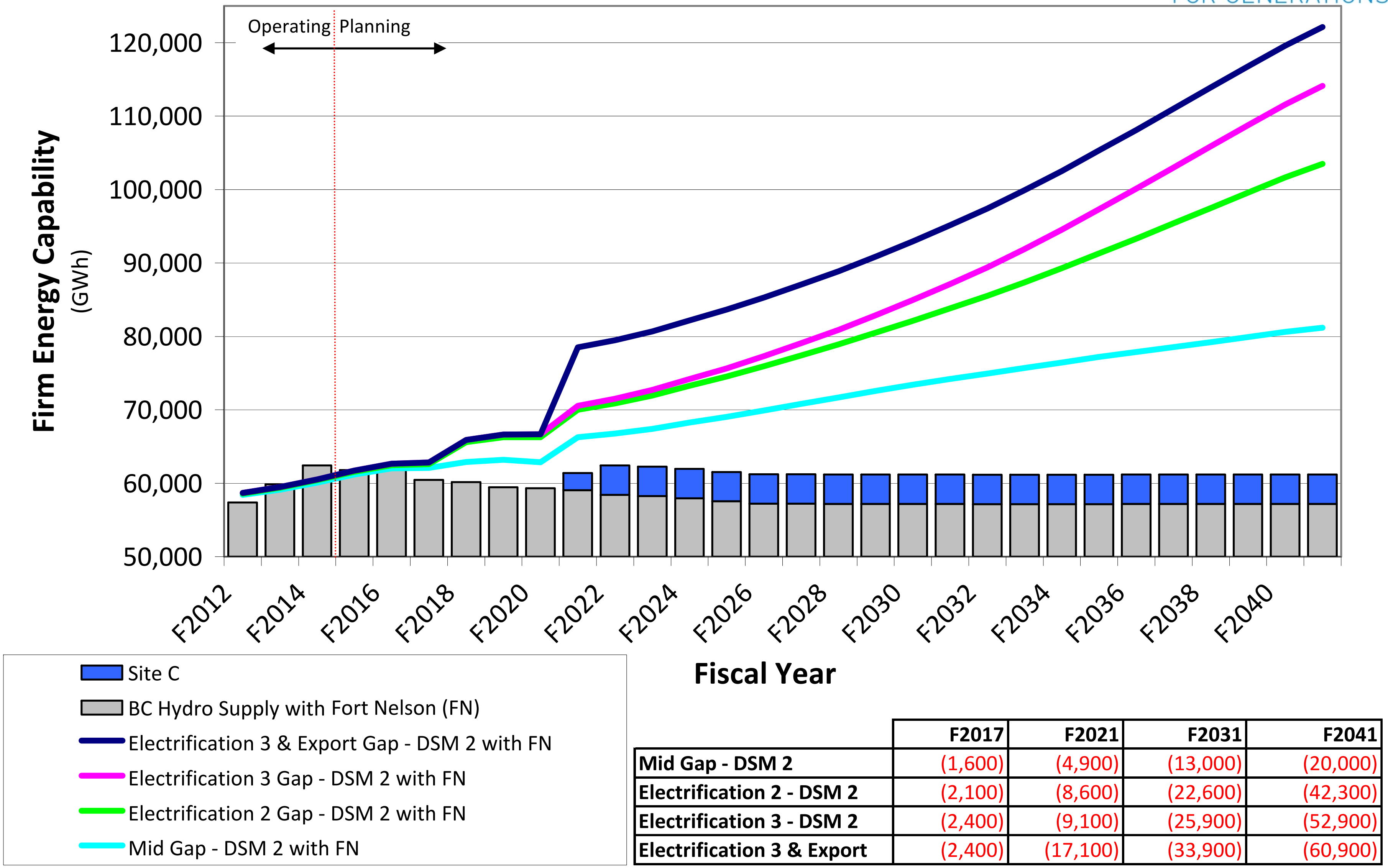
ENERGY: LOAD SENSITIVITIES

BChydro FOR GENERATIONS



	F2017	F2021	F2031	F2041
Mid Gap - DSM 2	(1,600)	(7,200)	(17,000)	(24,000)
Electrification 2 - DSM 2	(2,100)	(11,000)	(26,600)	(46,300)
Electrification 3 - DSM 2	(2,400)	(11,500)	(29,900)	(56,900)
Electrification 3 & Export	(2,400)	(19,500)	(37,900)	(64,900)

ENERGY: LOAD SENSITIVITIES WITH SITE C



	F2017	F2021	F2031	F2041
Mid Gap - DSM 2	(1,600)	(4,900)	(13,000)	(20,000)
Electrification 2 - DSM 2	(2,100)	(8,600)	(22,600)	(42,300)
Electrification 3 - DSM 2	(2,400)	(9,100)	(25,900)	(52,900)
Electrification 3 & Export	(2,400)	(17,100)	(33,900)	(60,900)

PLANNING CONTEXT

BChydro FOR GENERATIONS

Self Sufficiency Requirement

- Long position (energy surplus of about 8000 GWh/yr under average water conditions to over 14,000 GWh/yr with high water condition)
- Sufficient transmission (to external markets as well as internal to BC) together with shaping capacity (generation/pumping) is critical to the optimization of the value of surplus

Demand-Side Measures

- Take demand-side measures and conservation that reduce expected increase in demand in 2020 by at least 66%

Clean Electricity

- Requirement to pursue actions to meet required 93% clean or renewable target

Climate Change

- Actions or responses that assist in meeting the *Greenhouse Gas Reduction Targets Act*

Export

- Potential to export clean electricity, and actions in support of exports

PORTFOLIO ANALYSIS

BC hydro
FOR GENERATIONS

INPUTS

NEED

RESOURCE OPTIONS

MARKET CONTEXT

PARAMETERS

TIMEFRAME (20/30 yrs)

POLICY REQUIREMENTS

RELIABILITY CRITERIA

FINANCIAL ASSUMPTIONS

→

PORTFOLIO EVALUATION

SYSTEM OPTIMIZER
To determine the optimal resource mix (type, location, timing, capacity, minimal cost)

HYSIM
System simulation model to evaluate portfolio under variable inflow conditions

MAPA
(Multi-Attribute Portfolio Analysis)
to output portfolio attributes (e.g. environmental, economic development attributes)

→

OUTPUTS

Portfolio for scenario Xi

RESOURCE MIX (includes T):
location, timing, capacity

PORTFOLIO NET COST:
cost of resources,
trade volume and revenue,
present value of net cost

ENVIRONMENTAL

ECONOMIC DEVELOPMENT

RATE IMPACT
(for a few selected portfolios)

MODELLING ASSUMPTIONS FOR TODAY'S DISCUSSIONS

BC hydro FOR GENERATIONS

Resource Options

- Base Options: Run of River Hydro, Wind, Wood-based Biomass etc.
  - Monthly energy profile
  - Intermittency (wind integration cost of $10/MWh)
- Gas
  - Not considered as an option (will be discussed in "Role of Gas")
- Excludes: emerging technologies, geothermal, standing timber biomass
  - Will consider emerging technologies in 30 year runs
- Site C
  - Initial views with and without Site C as option
  - Modelled at 6.6 Billion $ estimate ($85/MWh real levelized unit cost)
    - Under review

MODELLING ASSUMPTIONS FOR TODAY'S DISCUSSIONS

BC hydro FOR GENERATIONS

Capacity Options

- Rev 6
- Pumped Storage in LM/VI (modelled as capacity proxy)
- Gas (SCGT)
  - Considered as an option only in the "Role of Gas" analysis
- Capacity proxy could be replaced by other capacity options outside modelling analysis (to be discussed)

SAMPLE PORTFOLIO

Key input variables:

(1) Gap: Mid Gap (i.e. mid load and DSM option 2 mid saving)

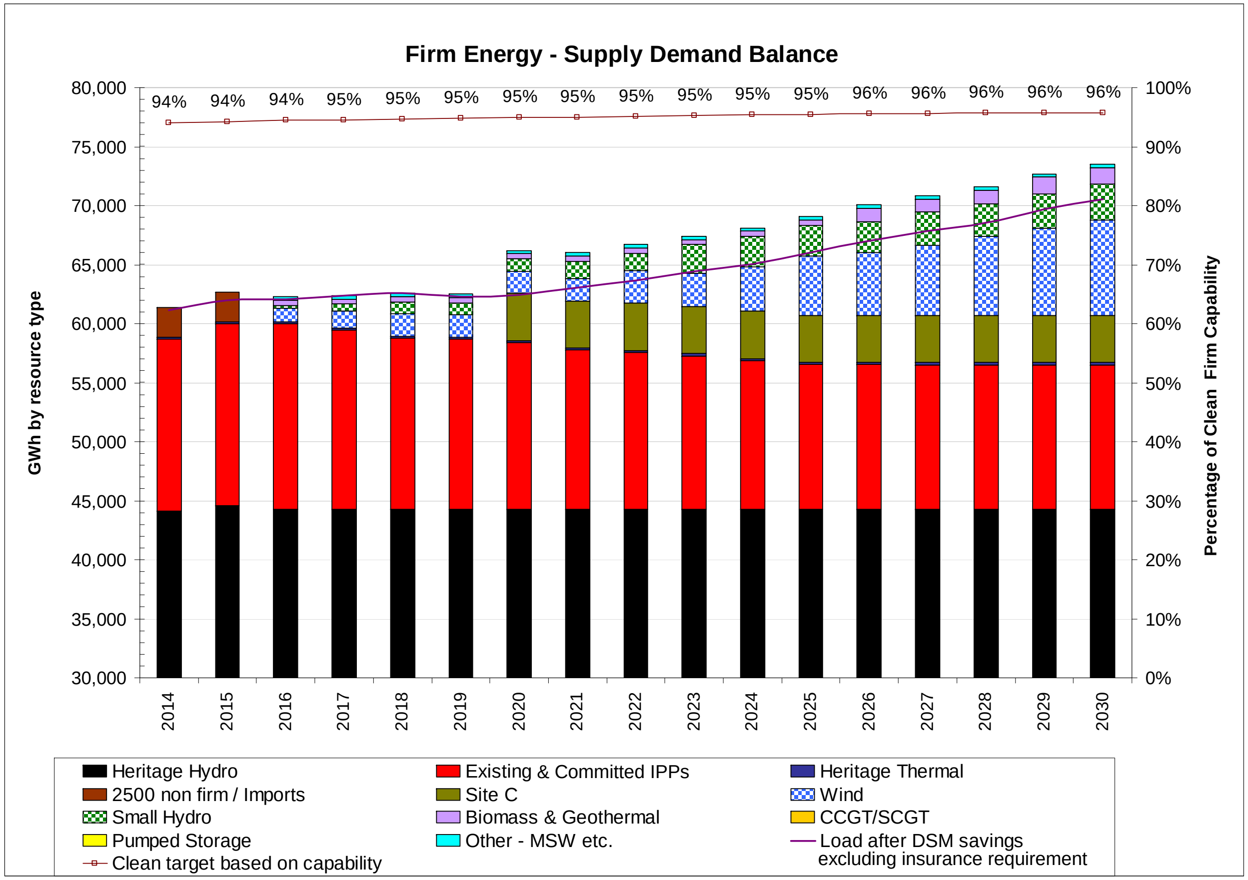
(2) Market Scenario: B (mid prices)

(3) Site C as an option

SAMPLE PORTFOLIO

BC hydro FOR GENERATIONS

Filling the Firm Energy resource gap



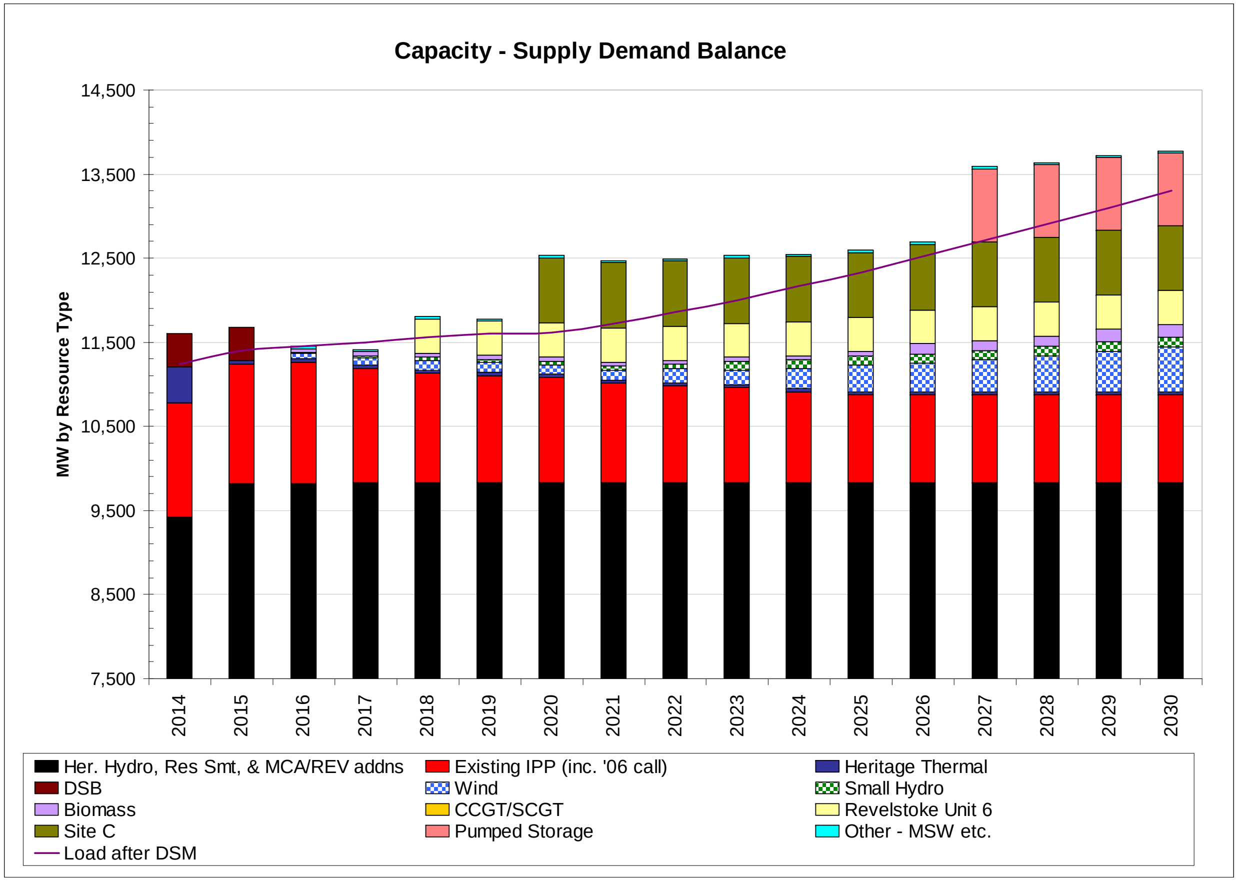
Resources Selected

Year	Zone	Resource
2016	BCH_PR	Wind_PC20
2016	BCH_PR	Wind_PC28
2016	BCH_VI	WBBio_VI
2016	BCH_LM	MSW2_LM
2016	BCH_LM	ROR_T1R1_60-80_LM
2017	BCH_PR	Wind_PC21
2017	BCH_VI	ROR_T1R1_80-90_VI
2018	BCH_PR	Wind_PC13
2018	BCH_LM	ROR_T1R1_80-90_LM
2018	BCH_REV	Revelstoke Unit 6

SAMPLE PORTFOLIO

BC hydro FOR GENERATIONS

Filling the dependable capacity resource gap



Resources Selected

Year	Zone	Resource
2016	BCH_PR	Wind_PC20
2016	BCH_PR	Wind_PC28
2016	BCH_VI	WBBio_VI
2016	BCH_LM	MSW2_LM
2016	BCH_LM	ROR_T1R1_60-80_LM
2017	BCH_PR	Wind_PC21
2017	BCH_VI	ROR_T1R1_80-90_VI
2018	BCH_PR	Wind_PC13
2018	BCH_LM	ROR_T1R1_80-90_LM
2018	BCH_REV	Revelstoke Unit 6

Transmission Expansion

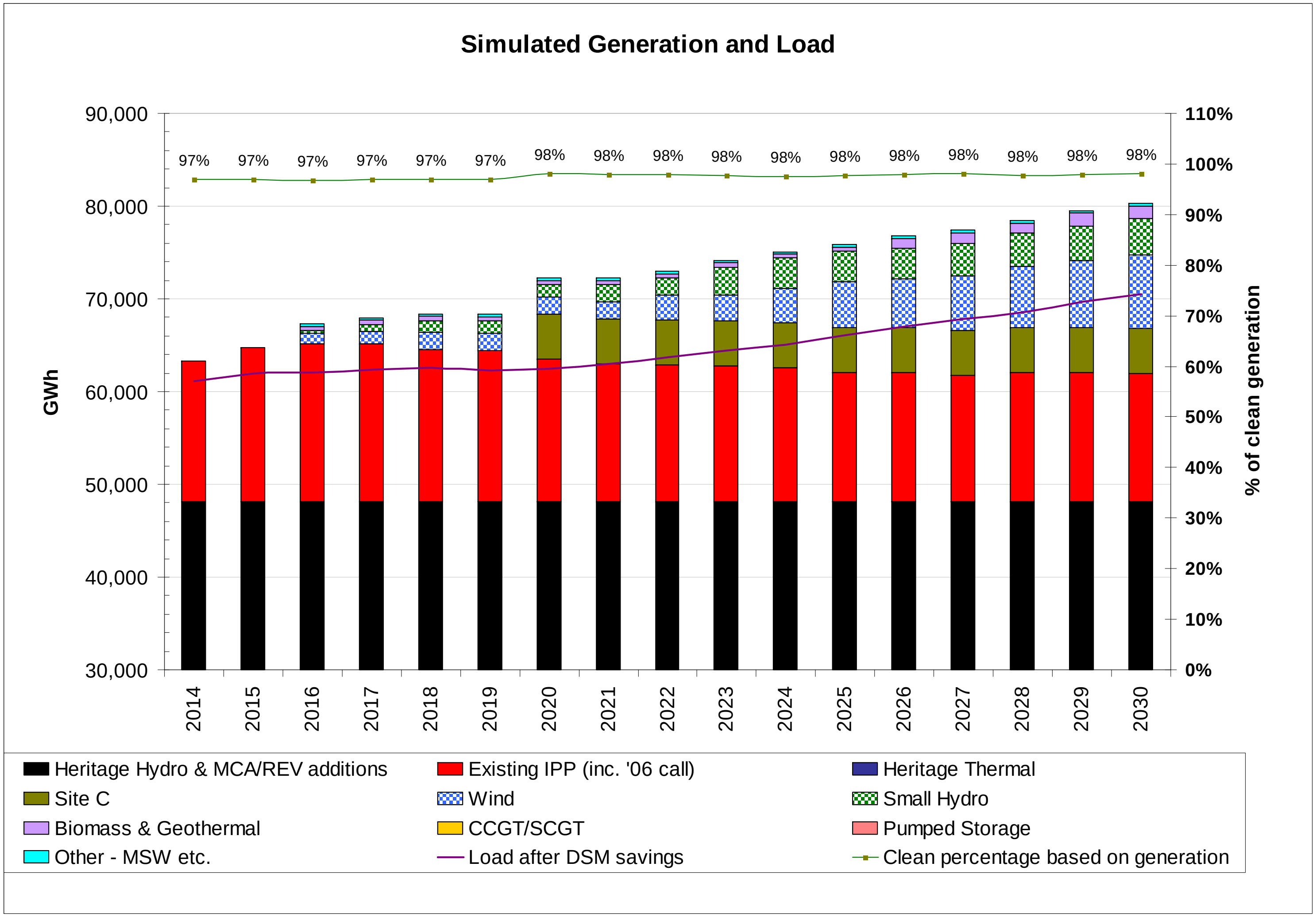
Year	Project Description
2018	BCH_SE to KN_Series compensation of 5L91 and 5L98
2018	BCH_SE to KN_Series compensation of 5L76, 5L79 and 5L96

Present Value (PV) Generation & Transmission Resource Cost

SAMPLE PORTFOLIO

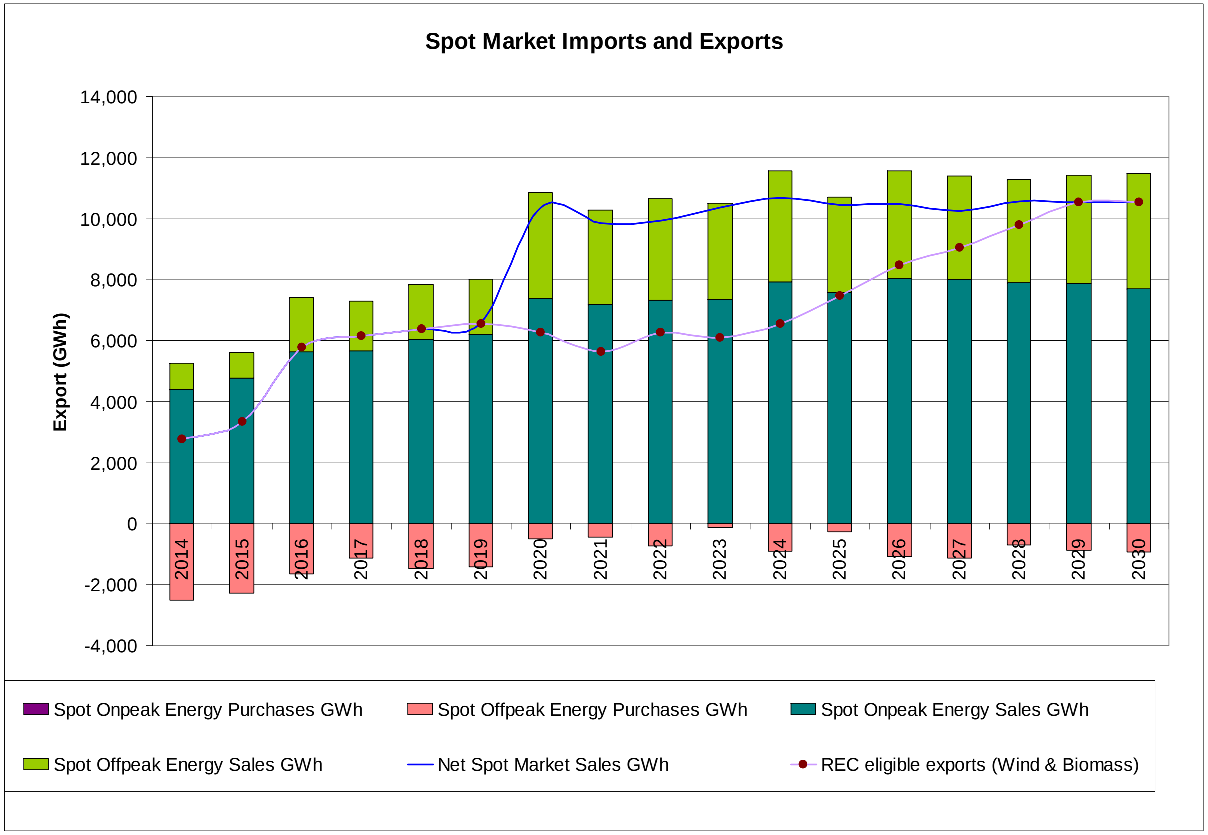
BC hydro FOR GENERATIONS

Average Energy



SAMPLE PORTFOLIO

Trade



Present Value of Generation & Transmission Resource Cost $ millions	8,560
Present Value of Trade Revenue $ millions	-6,590
Present Value of DSM Option Cost $millions	3,356
Present Value of Total Portfolio Cost $millions	**5,327**

MODELLING MAP

HL ML LL — Gap: High Load (HL), Mid Load (ML), Low Load (LL)

D1 D2 D3 D4 — DSM Option: Option #1 (D1) — Option #4 (D4)

SA SB SC SD SE — Market Scenario: Scenario A (SA) — Scenario E (SE)

SC SN — Site C: Yes (SC) / No (SN) – considered as an option

TY TN — Thermal: Yes (TY) / No (TN) – considered as an option

W5 W10 W15 — Wind Integration Cost: $5, $10, $15 / MWh

GAP & MARKET SCENARIOS SENSITIVITIES

BC hydro FOR GENERATIONS

	DSM Option 2				
GAP	Sc A	Sc B	Sc C	Sc D	Sc E
Large	13.2 to 14.1 B				
Mid	4.9 to 6.2 B				
Small	-2.8 to 0.4 B				

	Scenario B			
GAP	DSM Option1	DSM Option2	DSM Option3	DSM Option4
Large	12.4 to 13.9 B			
Mid	5.2 to 6.4 B			
Small	0.1 to 0.3 B			

COMPARING OPTIONS WITHIN THE 5 IRP QUESTIONS

BC Hydro has committed to considering a broad range of criteria when comparing options within the IRP

These criteria are derived from:

- The Clean Energy Act
- Planning consistent with good utility practice
- Interests expressed through discussions with First Nations, stakeholders, and the general public

Wherever possible, these comparisons will be summarized in a consequence table

- For areas of information where there are data gaps, this will not be possible
- BC Hydro will apply professional judgment to draw conclusions from consequence tables

This portion of the meeting will address the general approach to calculating:

- Environmental impacts
- Economic development impacts
- Financial impacts

COMPARING OPTIONS
ENVIRONMENTAL ATTRIBUTES

BC hydro FOR GENERATIONS

Some general context for the following discussion:

- Resource Options data is site specific
- Options within portfolio modelling is somewhat more aggregated, e.g., bundles of projects, not individual projects
- But a call for power may not result in these projects, bundles
- IRP portfolio modelling is not about picking IPP projects
- Therefore, we should not try to be too precise with these measures
- Measures and data are to be generally indicative
- BC Hydro would be interested in TAC's opinion regarding what lessons can (and can't) be drawn from this data, given limitations

Modelling specific context:

- Bulk transmission impacts not yet included
- Data is preliminary, still under review internally

COMPARING OPTIONS ENVIRONMENTAL ATTRIBUTES

These are modelling snapshots, not all real IRP questions

Purpose is to "test drive" these measures

- understand the story they are telling
- discuss how to interpret these
- goal is to boil down information to capture key comparisons
- this will require reducing down # of measures

Method

- if two measures are capturing a key tradeoff, highlight these
- If two measures are "telling the same story" reduce to one measure

COMPARING OPTIONS ENVIRONMENTAL ATTRIBUTES

BC hydro FOR GENERATIONS

Method for reviewing measures

- Will present a few portfolio comparisons:
  - large vs. mid gap size
  - Option 2 vs. Option 4 DSM
  - Site C in vs. Site C out

Next slides

- Land impacts
- Freshwater impacts
- Marine Impacts
- Atmosphere impacts
- Financial impacts

COMPARING OPTIONS
ENVIRONMENTAL ATTRIBUTES (LAND)

BC hydro FOR GENERATIONS

Land Impacts

- 2006 IEP looked at footprint on land
  - at the time, the question was raised regarding different types of land classes
- for IRP, subdivided into the following sub and sub-sub categories of footprint affected
  - Relative Net Primary Productivity of land impacted
  - Linear Density of land impacted
  - High Priority Species (# per ha)

Land	Relative Net Primary Productivity (NPP) (ha per class, gC/m²/year)	Low (0 to <69)
		Med (69 to <369)
		High (>369)
		Weighted total
	Linear Density (ha per class, km/km2)	Wilderness (<0.2)
		Remote (0.2 to <0.66)
		Rural (0.66 to 2.2)
		Urban (>2.2)
		Weighted total
	High Priority Species (ha per class, percentile)	0 to <20
		20 to <40
		40 to 60
		60 to 80
		>80
		Weighted total

ENVIRONMENTAL – LAND IMPACTS

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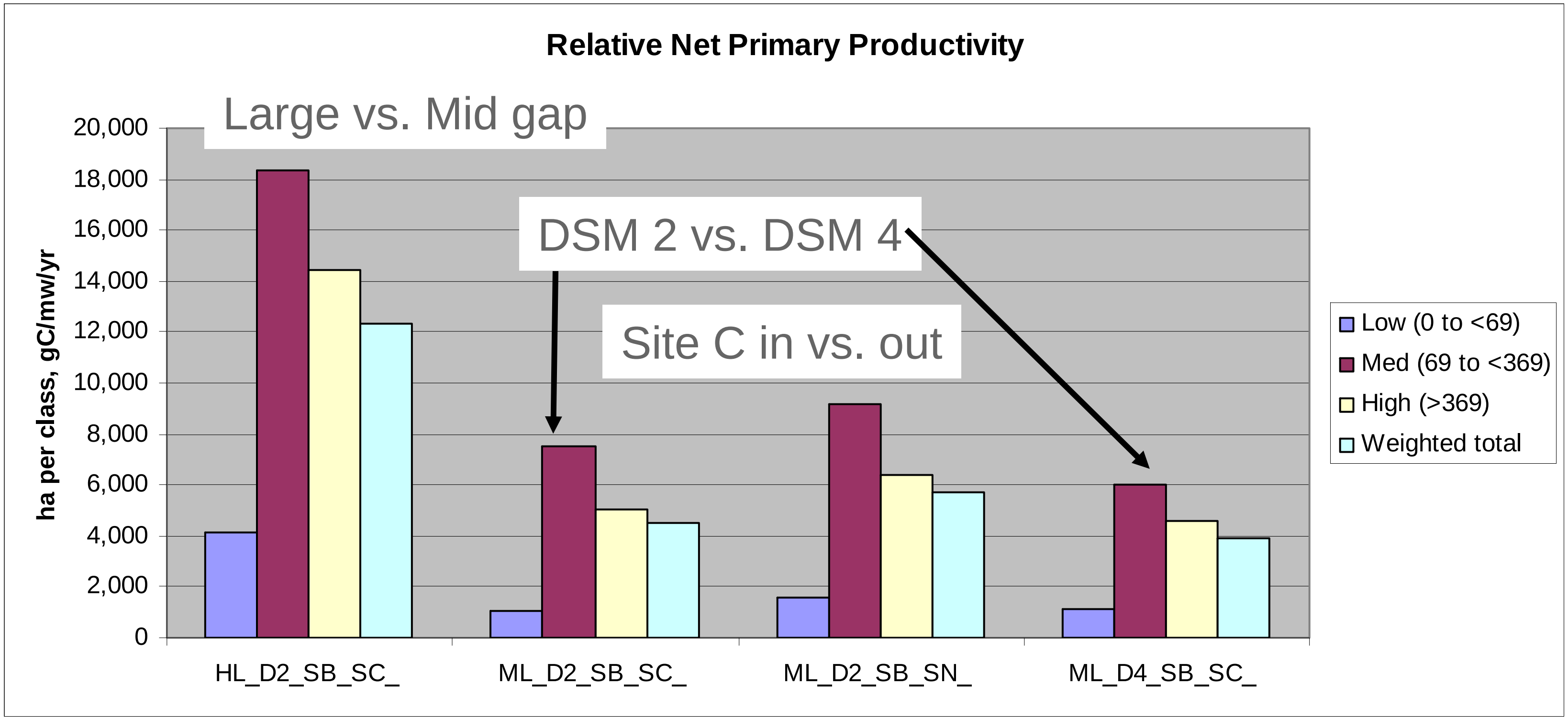
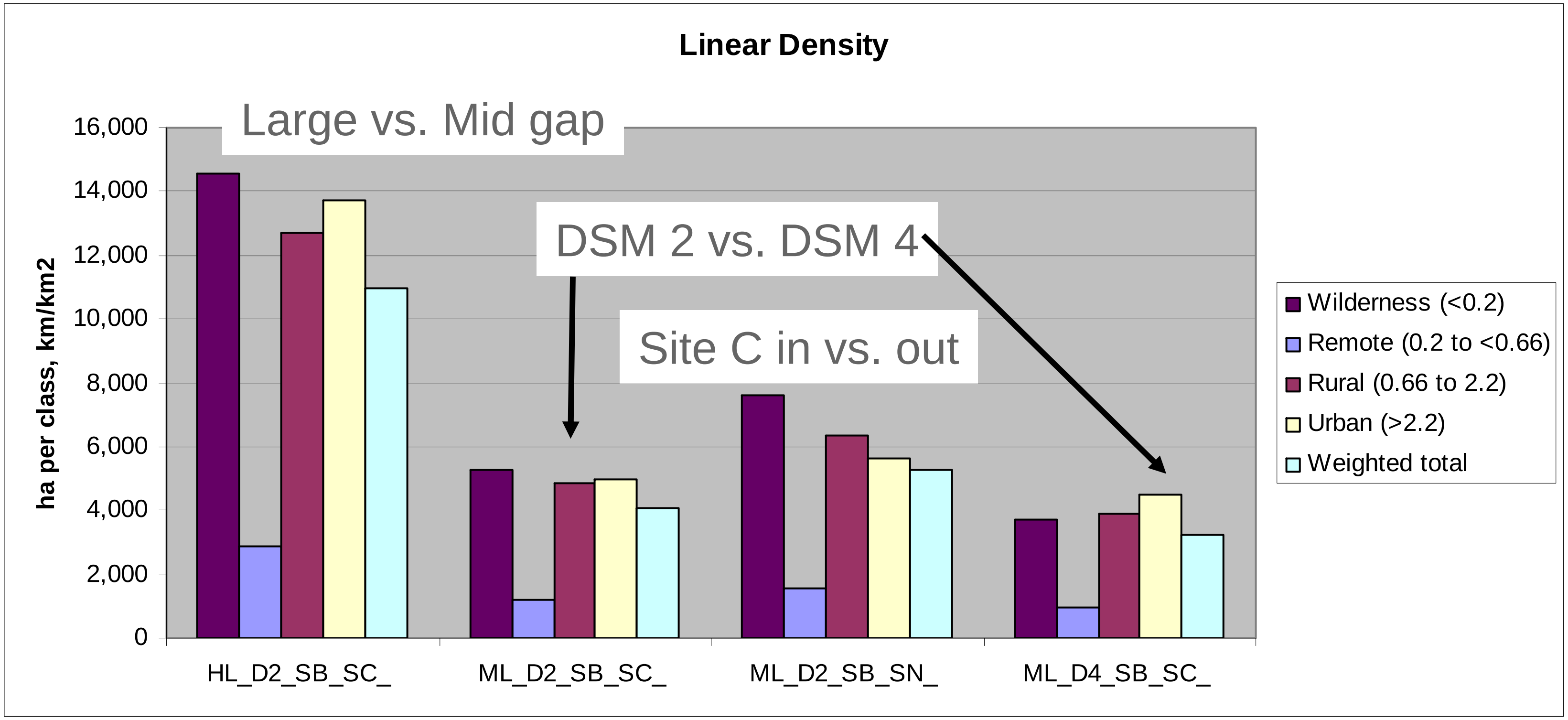


Preliminary Conclusions

- Similar pattern with no tradeoffs suggests a proxy measure is appropriate

ENVIRONMENTAL – LAND IMPACTS

BC hydro FOR GENERATIONS

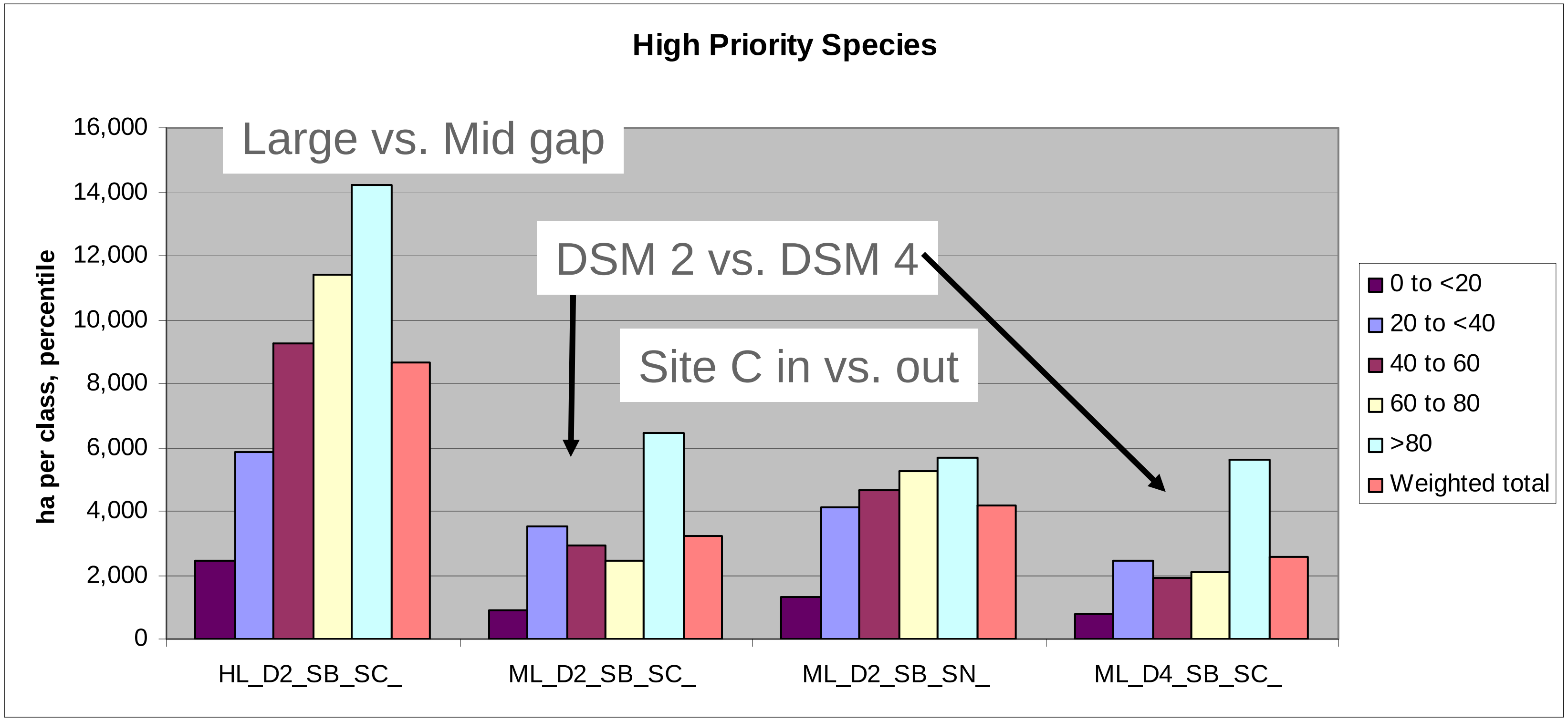


Preliminary Conclusions

- Similar pattern with no tradeoffs suggests a proxy measure is appropriate

ENVIRONMENTAL – LAND IMPACTS

BC hydro FOR GENERATIONS



Preliminary Conclusions

- Similar pattern with no tradeoffs suggests a proxy measure is appropriate
- Site C comparison will need further review re “>80” category

ENVIRONMENTAL – FRESHWATER IMPACTS

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FOR GENERATIONS

Freshwater Impacts arising from

- inundating rivers
- diverting streams
- building across streams (e.g., roads, transmission lines, etc.)

Freshwater	Fisheries Priority Species (ha per class of No. of priority species per watershed)	No Priority Species (0)
		Low Species Diversity (1 to 12)
		Moderate Species Diversity (13 to 23)
		High Species Diversity (24 to 38)
		Weighted total
	Riparian Area (ha per stream order)	Stream Order 1
		Stream Order 2
		Stream Order 3
		Stream Order 4
		Stream Order 5
		Stream Order ≥ 6
		Weighted total
	Reservoir Aquatic Area (ha)	
	Affected Stream Length (km)	

ENVIRONMENTAL – FRESHWATER IMPACTS

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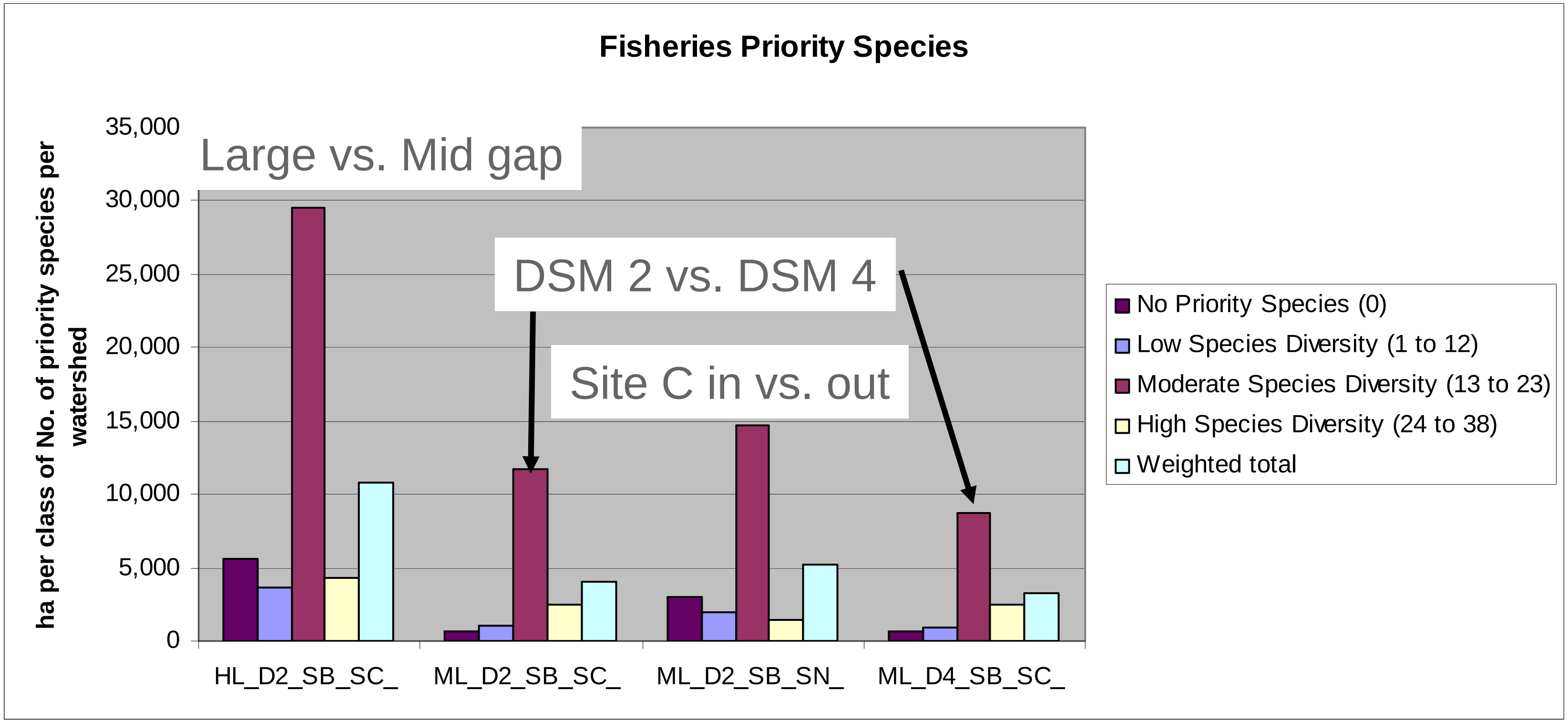
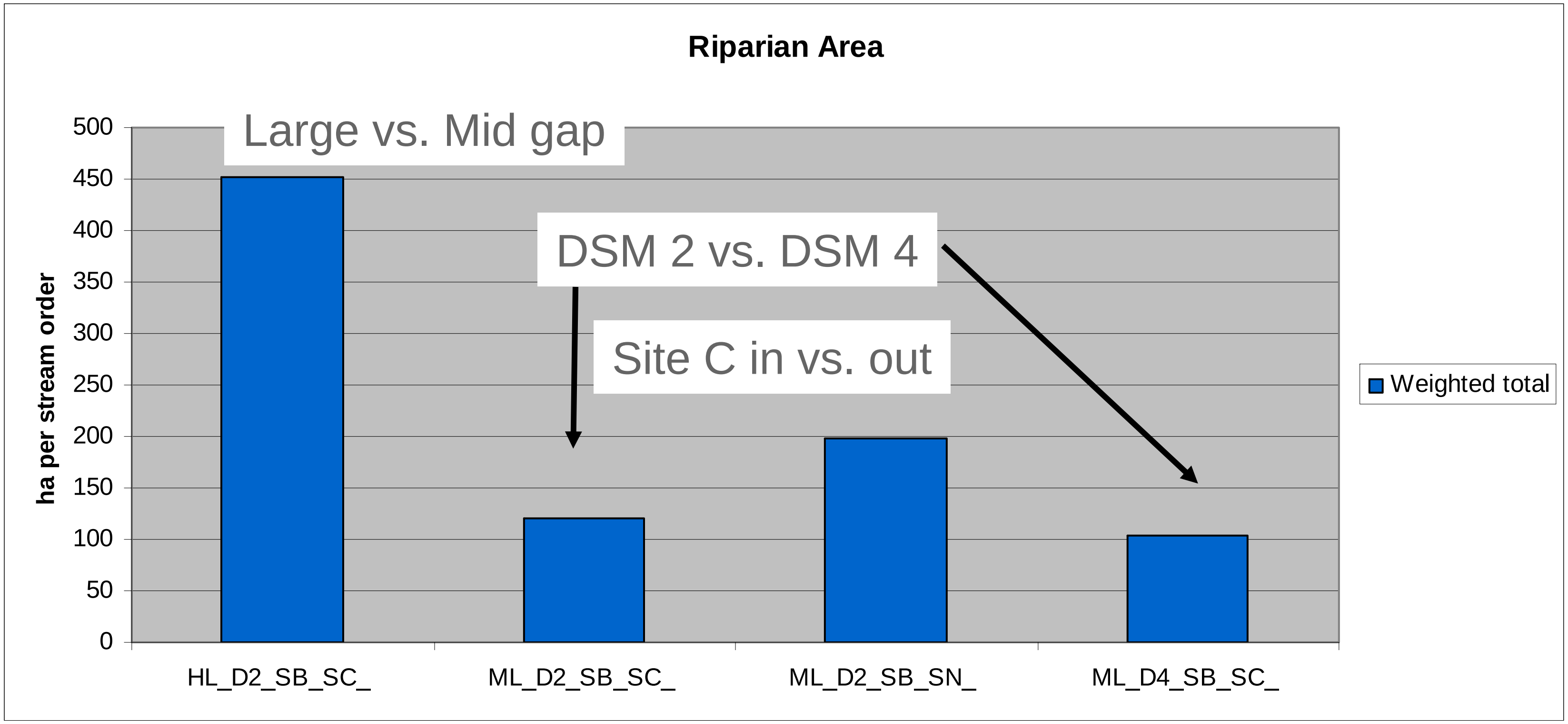


Preliminary Conclusions

- Similar pattern with no tradeoffs suggests a proxy measure is appropriate

ENVIRONMENTAL – FRESHWATER IMPACTS

BC hydro FOR GENERATIONS



Preliminary Conclusions

- Similar pattern with no tradeoffs suggests a proxy measure is appropriate

ENVIRONMENTAL – REMAINING WATER MEASURES

BC hydro FOR GENERATIONS

Two measures still in development

- Reservoir aquatic area
- Affected stream length

One set of measures not impacted to so far (in 20 yr analysis)

no resource options impacting these areas are being picked up

Marine	Bathymetry (ha per class)	Photic (0 to 20 m)
		Shallow (20 to 200m)
		Deep (200 to 1000m)
		Abyssal (>1000 m)
		Weighted total
	Valued Ecological Features (ha per class)	None (0)
		Low (1 to 2)
		Medium (3 to 5)
		High (>5)
		Weighted total
	Key Commercial Fishing Areas (ha per class)	no bottom fisheries
		1 bottom fishery
		2 to 3 bottom fisheries
		> 3 bottom fisheries
		Weighted total

ENVIRONMENTAL – ATMOSPHERIC IMPACTS

BC hydro
FOR GENERATIONS

Atmospheric Impacts

- also tracked for the 2006 IEP
  - resource options then included coal, natural gas, biomass, Burrard, etc

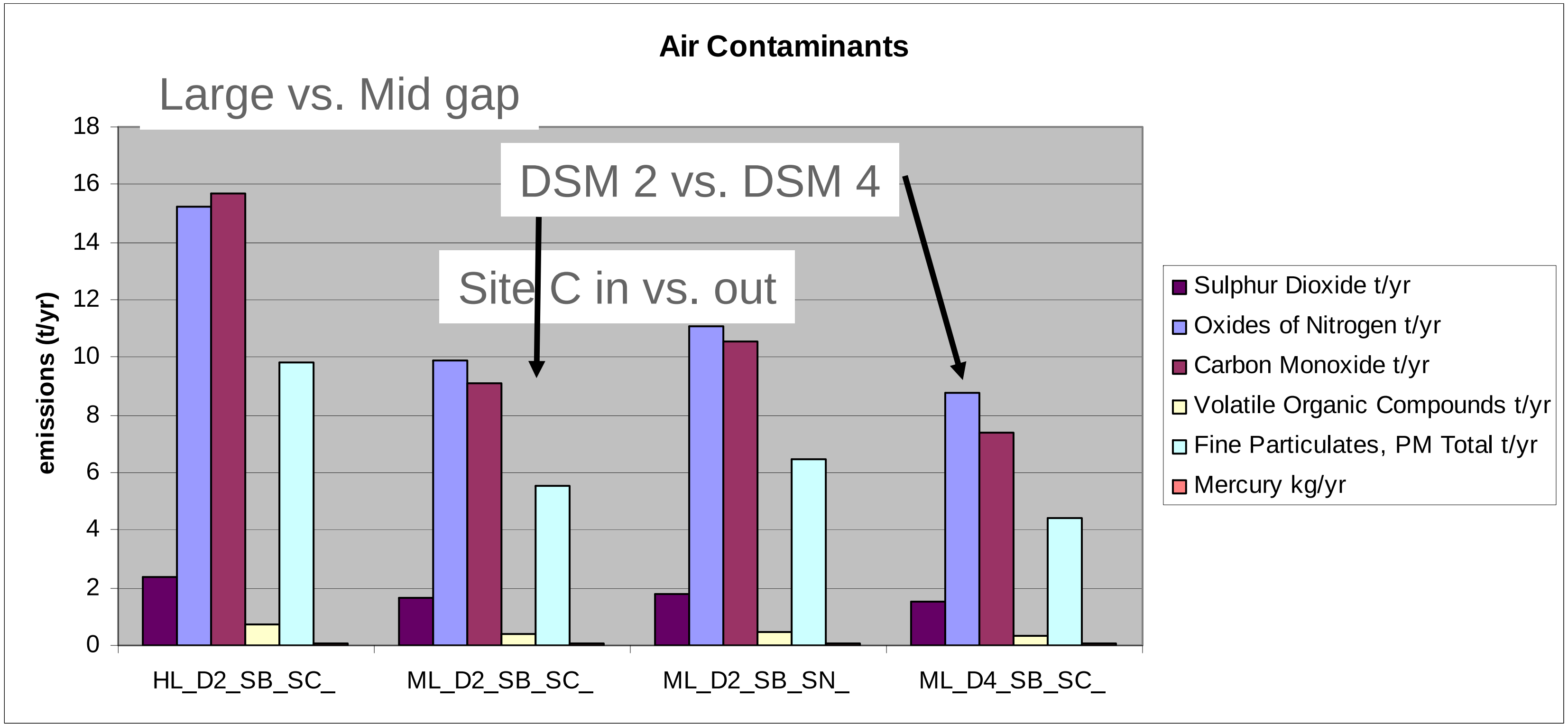
For this IRP

- scope limited to role of gas question (up to 93% clean)

Atmosphere	GHG Equivalent Emissions	Emissions - (tonnes of CO2e per year)
	Air Contaminants	**Sulphur Dioxide** t/yr
		Oxides of Nitrogen t/yr
		Carbon Monoxide t/yr
		Volatile Organic Compounds t/yr
		Fine Particulates, PM Total t/yr
		Mercury kg/yr

ENVIRONMENTAL - ATMOSPHERIC IMPACTS

BC hydro FOR GENERATIONS



Preliminary Conclusions

- Measures tell the same story
- Summing these is not appropriate
- Delay judgment until “role of gas” runs are completed.

ECONOMIC DEVELOPMENT MEASURES

New area of measurement for electricity planning in B.C.

Measures are a first cut

- Track
- GDP
- Employment
- Government Revenue

Impacts arise from

- direct spending
- indirect spending
- induced spending

These have been subdivided into

- construction
- operations

ECONOMIC DEVELOPMENT MEASURES

Some caveats are in order

- These measures are a direct function of spending
- As a result, they directly track costs of providing new activities (but not total portfolio costs, which also include trade revenues)
- DSM values are not included yet

For full list of assumptions, see summary brief from IRP TAC #2

ECONOMIC DEVELOPMENT

BC hydro FOR GENERATIONS

Total list is quite long (18 items)

Recommendation is to aggregate

As with environmental measures

- desire to see location-specific
- impacts
- not possible for IRP

GDP (NPV M$)	Construction	Direct
		Indirect
		Induced
		Construction GDP Sub Total
	Operations	Direct
		Indirect
		Induced
		Operations GDP Sub Total
		GDP Total
Employment (person-year)	Construction	Direct
		Indirect
		Induced
		Sub Total
	Operations	Direct
		Indirect
		Induced
		Sub Total
		Total
Government Revenue (NPV M$)	Construction	Direct
		Indirect
		Induced
		Sub Total
	Operations	Direct
		Indirect
		Induced
		Sub Total
		Total

ECONOMIC DEVELOPMENT – TOTAL GDP

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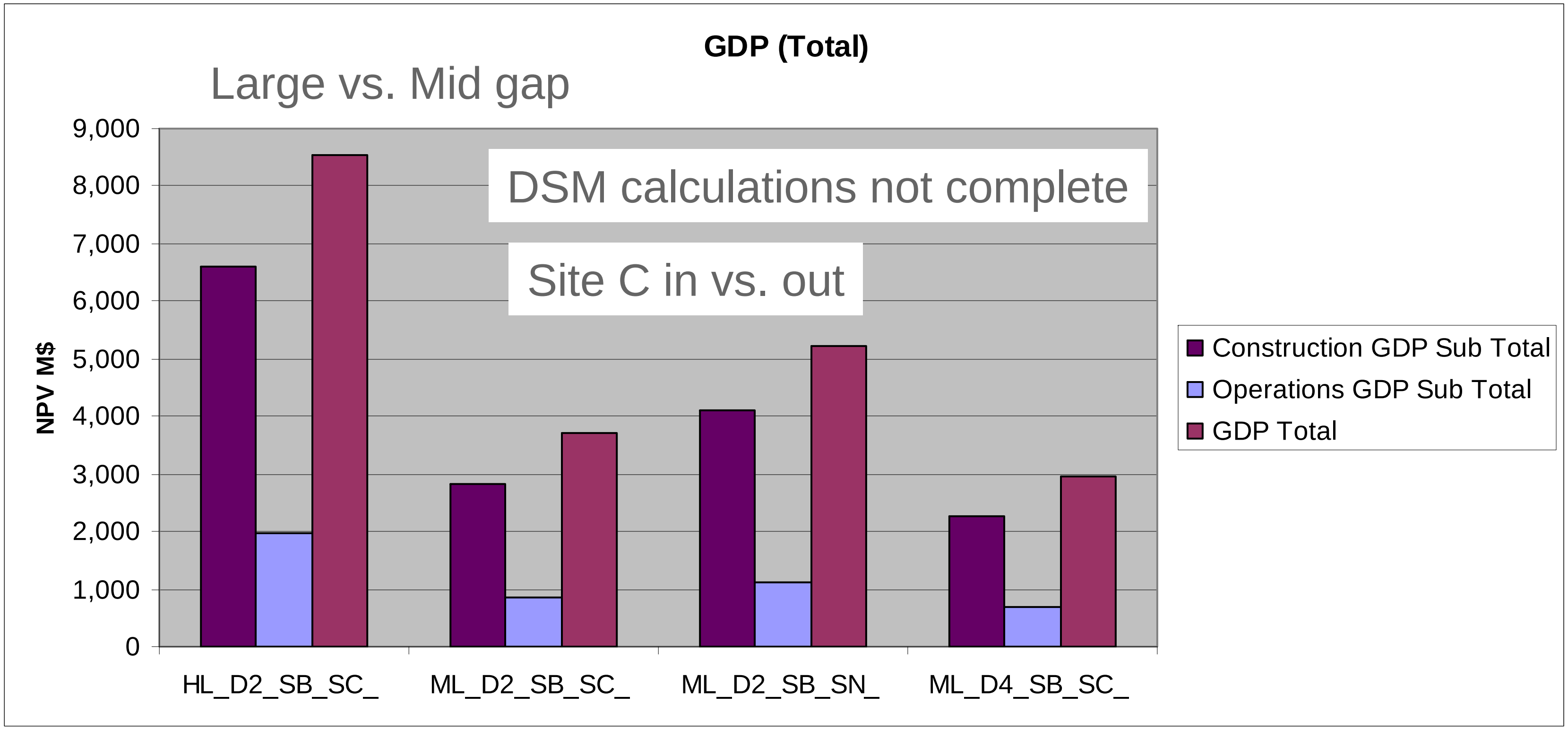
FOR GENERATIONS

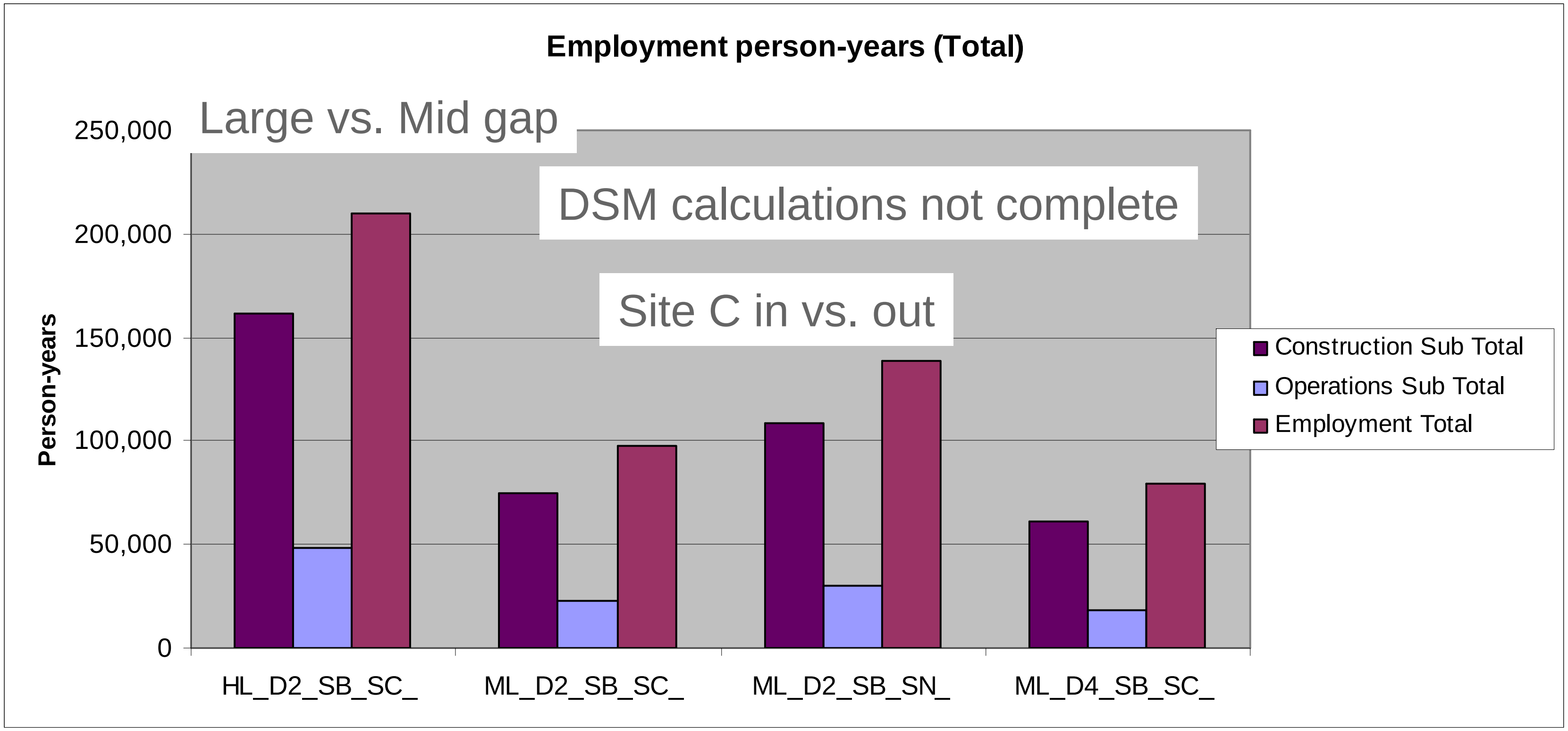


Preliminary Conclusions

- Measures tell the same story
- BC Hydro will sum these for reporting purposes

ECONOMIC DEVELOPMENT

BC hydro FOR GENERATIONS

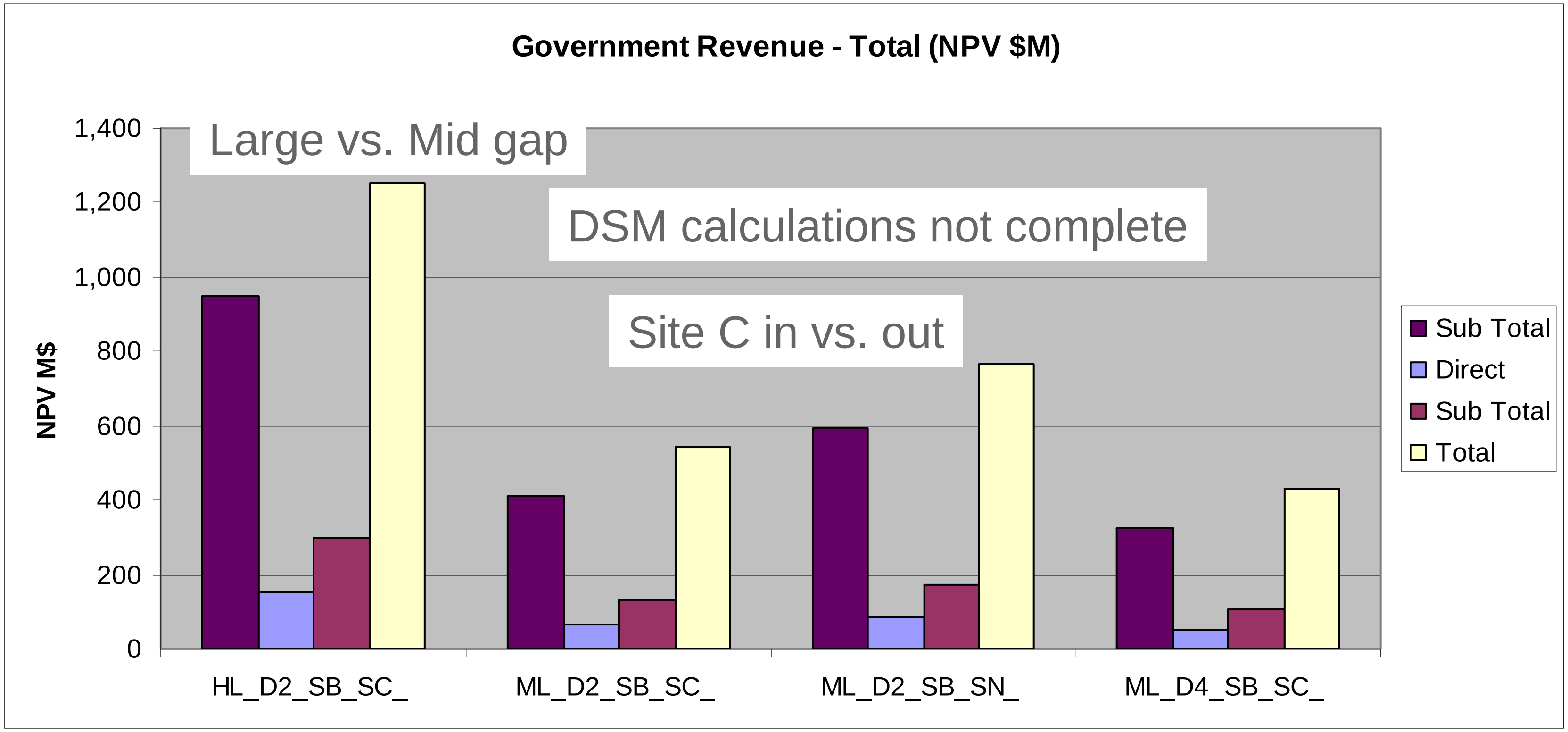


Preliminary Conclusions

- Measures tell the same story
- BC Hydro will sum these for reporting purposes

ECONOMIC DEVELOPMENT

BC hydro FOR GENERATIONS



Preliminary Conclusions

- Measures tell the same story
- BC Hydro will sum these for reporting purposes

ECONOMIC DEVELOPMENT

BChydro FOR GENERATIONS

Respending and rate impacts

- A caveat with these measures is that they are derived from spending
- As a result, portfolios with more building look better on economic development measures
- What is missing is that these more expensive options have to be paid for
  - This means that, at some point, other spending will be cut back as rates rise, or
  - Cheaper options allow more spending in other parts of the economy
- Two methods to capture this:
  - include rate impacts' downward pressure on economic development measures (discussed in following section)
  - include lower portfolio costs' upward pressure on economic development
  - latter called "respending effect", and calculations are underway

FINANCIAL MEASURES

BC Hydro will be tracking a number of financial measures to compare options

- Generation and Transmission Resource Cost
- Trade Revenue
- Total portfolio costs (including range across all relevant scenarios)
- Total expected (probability weighted) portfolio cost
- Cost Risk
- Rate Impact

First four items touched in on the description of modelling

These last two items will be explained in more detail in the following slides

COMBINING LOAD AND MARKET PRICE UNCERTAINTIES TO ESTIMATE COST RISK

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Uses of the 15 branch tree

- Range of financial outcomes
- Expected value (probability weighted)
- Measure of cost risk

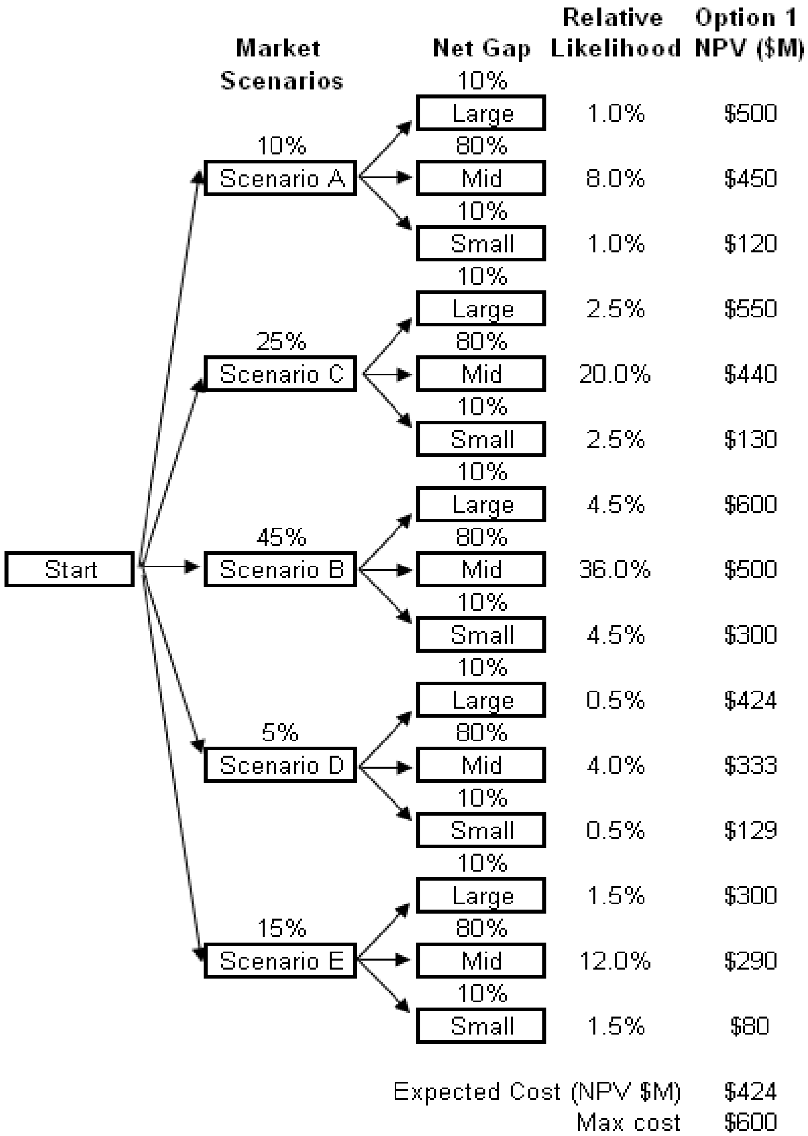
In this example

- Option 1's costs range from $80 - $600M
- Option 1's expected cost is $424M
- Option 1's extreme cost is $600M

More sophisticated cost risk measures could be used

- e.g., 95%ile cost
- Var95 cost
- etc.

If needed, sensitivity analysis could be employed to see if conclusions turn on probability tree's construction



RATE ANALYSIS APPROACH

TAC input from last meeting:

- Requested for rate impact analysis for all portfolios tested

Proposed approach – model relative impacts for a range of portfolios:

- To provide indication of various options impacts on rates
- Results will show rate incremental to a base portfolio
- Base portfolio assumes: Mid Gap (mid load with DSM Option 2 mid savings), Market Scenario B, With Site C, no Gas

Portfolios suggested:

- Test Mid gap for all DSM options
- Test Large, Mid, Small gaps for DSM Option 2
- Test with and without Site C (Mid gap with DSM Option 2)
- Test the 2 electrification load sensitivities
- Test 2 Market Scenarios

Updated rate forecast will be done for the base resource plan

DSM PLANNING LEVEL ANALYSIS

BASIL STUMBORG

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INTRODUCTION

Planning Level Analysis

- Complex
- Many levels of information
- Requires a balance across different energy planning objectives

Progression of analysis to be looked at:

- Cost
  - Average
  - Incremental
  - Portfolio
- Other Cost impacts
  - Savings uncertainty
  - Cost risk
- Non-Cost Impacts
  - Environmental Impacts, Economic Development

INTRODUCTION

BC hydro FOR GENERATIONS

Quantitative Analysis

- in progress but not complete
- tells some of the story, but maybe not all
- some progress made in uncertainty analysis since LTAP
- still some important gaps remaining to be filled

Qualitative Analysis

- jurisdictional review still in progress
- balance across different planning objectives

BC Hydro will take all the information gathered and apply its professional judgment to arrive at :

- a recommended level of DSM; and
- DSM activities to pursue

Like the portfolio analysis for supply-side resources

- is guided by, but does fall directly out of portfolio modelling

Today's discussion is not about choosing a level of DSM

- BC Hydro is looking for advice regarding comparison, risk management

PORTFOLIO RESULTS: DSM

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Five DSM portfolio options were presented in TAC Meeting #2

First cut of portfolio analysis for Options 1 through 4 are complete for:

- Three gap levels
  - Small Gap: Low load (20% likelihood) and high DSM (20% likelihood)
  - Mid Gap: Mid load (60% likelihood) and mid DSM (60% likelihood)
  - Large Gap: High load (20% likelihood) and low DSM (20% likelihood)
- One market scenario
  - Scenario B - mid gas, electric and GHG market prices
- Site C scenarios
  - Site C as an option available to System Optimizer for selection
  - Site C not available as an option

BC Hydro acknowledged that the original Option 5

- provided some insight, but did not represent a realistic, implementable option
- should be reviewed

BC Hydro is considering how to characterize this reworked option

- Only Options 1 - 4 shown here

REVIEW: DSM OPTIONS IN KEY YEARS

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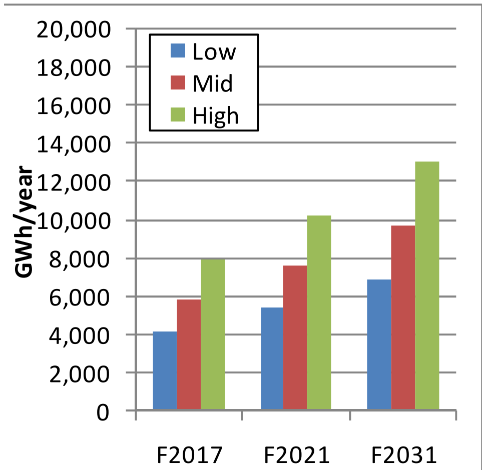
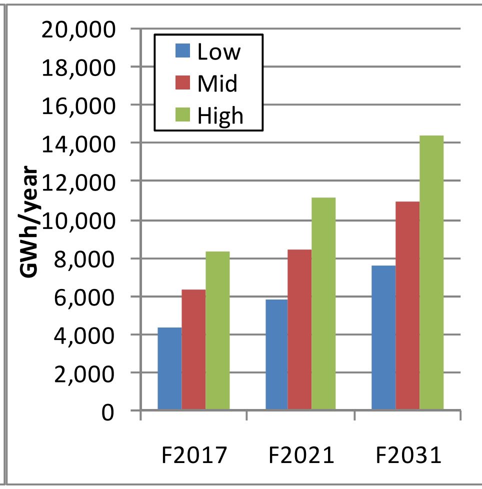
- A comparison of the energy savings for DSM Options 1 to 4 are provided below
- Each of the DSM options involves a significant amount of uncertainty, and the uncertainty increases over time
- The magnitude of the uncertainty increases with each DSM option
- The effects are similar with peak demand savings

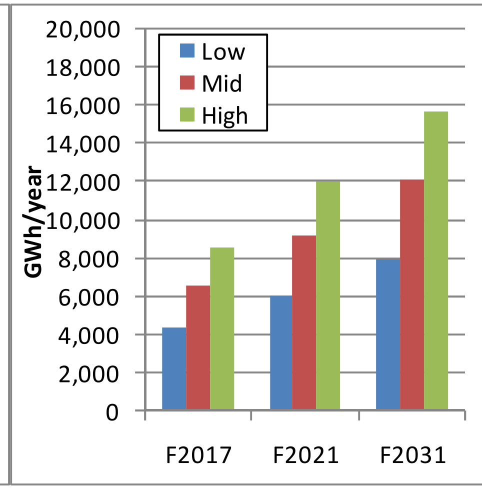
Option 1



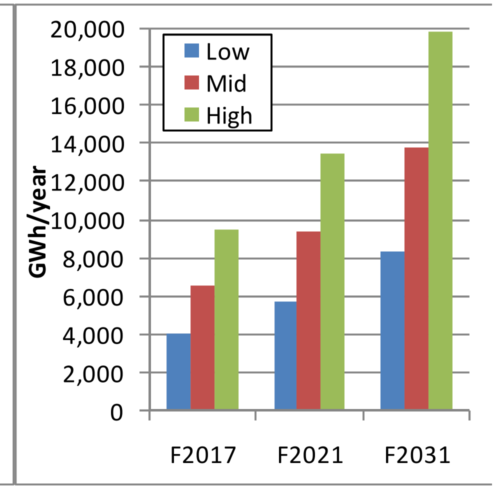
Option 2



Option 3



Option 4



REVIEW: DSM UNCERTAINTY BANDS

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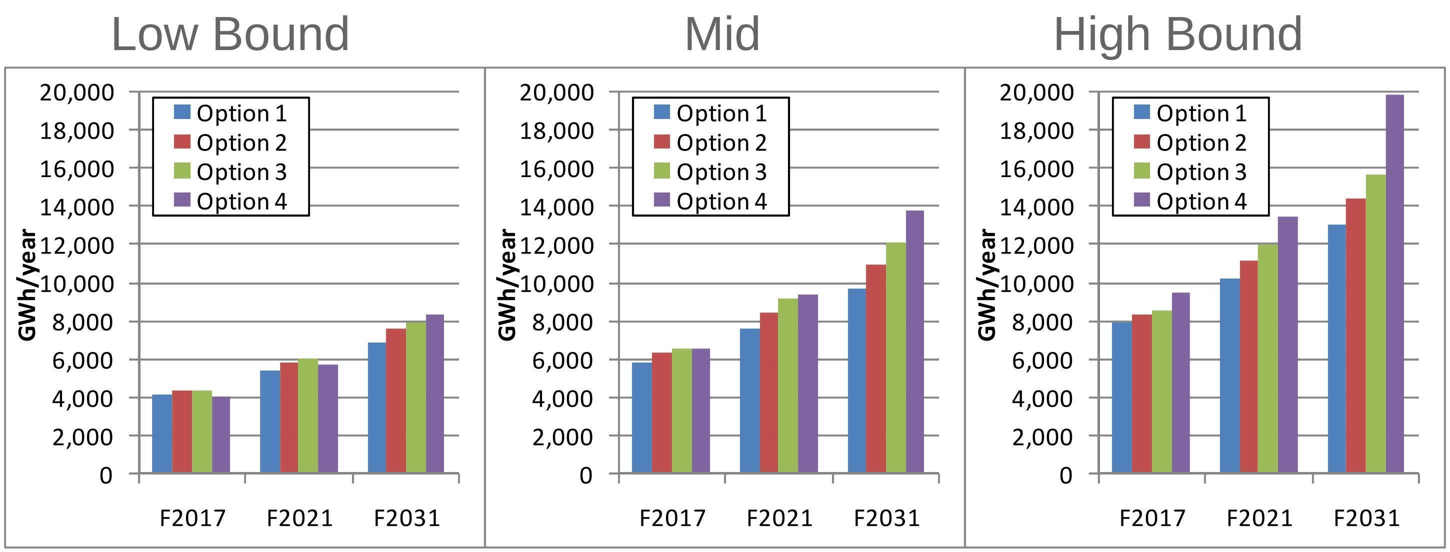
- The Low DSM bound (20% likelihood) results in very little difference in acquired DSM for any of the portfolios
  - In the early years, Options 2 and 3 are stronger than Options 1 and 4
  - In later years, the trend of increasing DSM starts to present itself
- The Mid DSM (60% likelihood) results in a relatively consistent progression from Option 1 through Option 4
- The High DSM bound (20% likelihood) shows the potential for Option 4 to provide much more savings than the other options



MODELLING MAP – DSM

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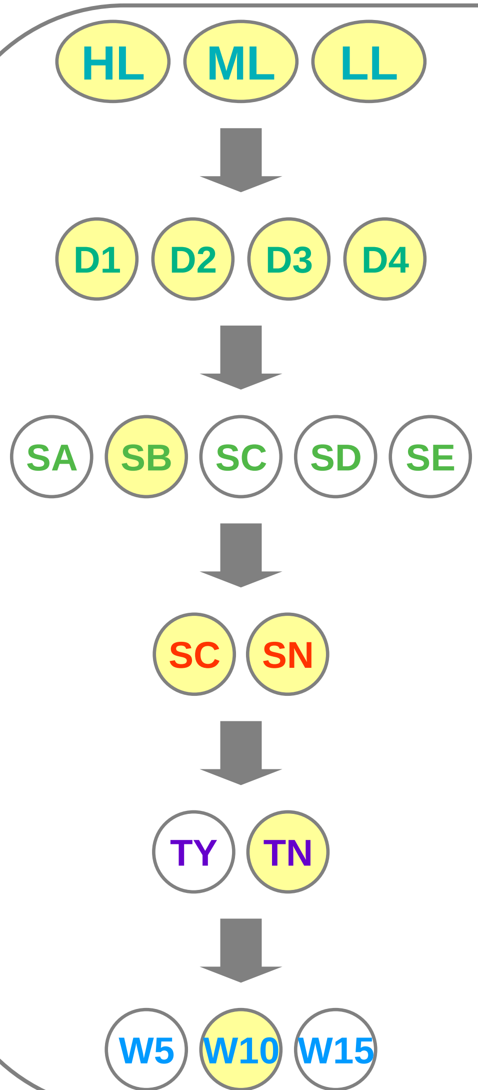

Gap: High Load (HL), Mid Load (ML), Low Load (LL)

DSM Option: Option #1 (D1) — Option #4 (D4)

Market Scenario: Scenario A (SA) — Scenario E (SE)

Site C: Yes (SC) / No (SN) – considered as an option

Thermal: Yes (TY) / No (TN) – considered as an option

Wind Integration Cost: $5, $10, $15 / MWh

COST PROFILE OF BASE PORTFOLIOS

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The base portfolios for DSM analysis include:

- Market Scenario B
- Site C
- Large, Mid and Small Gaps

Cost categories:

- Generation and Transmission
- Trade
- DSM
- Total Cost

	Base Portfolio Results PV $M			
	Large Gap			
	DSM 1	DSM 2	DSM 3	DSM 4
G&T	17,496	16,905	16,658	16,725
Trade	(7,241)	(7,174)	(7,164)	(7,174)
DSM	2,410	2,741	3,111	3,524
Total	12,666	12,472	12,605	13,074
	Mid Gap			
	DSM 1	DSM 2	DSM 3	DSM 4
G&T	9,475	8,560	7,910	7,328
Trade	(6,629)	(6,590)	(6,611)	(6,589)
DSM	2,883	3,356	3,933	4,680
Total	5,729	5,327	5,232	5,419
	Small Gap			
	DSM 1	DSM 2	DSM 3	DSM 4
G&T	4,087	3,215	2,829	2,299
Trade	(7,293)	(7,093)	(7,234)	(7,914)
DSM	3,446	3,987	4,656	5,958
Total	240	109	251	343

DSM PORTFOLIO RESULTS

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Table at left provides the following present value numbers, by DSM option analyzed

- Likelihood of scenario (%)
- Total portfolio cost ($M)
- DSM costs (portion of total) ($M)
- DSM energy savings (GWh)
- DSM savings (average and expected $/MWh)

Total Portfolio PV cost

- Mid Gap case is lowest with DSM Option 3
- Large Gap and Small Gap cases are lowest with DSM Option 2

In each case, the average cost per MWh of DSM:

- Range from $36/MWh to $63/MWh
- Increases from one DSM option to the next, expected values increasing from 40 $/MWh to 51 $/MWh
- Decreases for any DSM option with increasing success of the option (high DSM is the lowest cost with low DSM being the highest, in all cases)

DSM	Gap	%	Portfolio PV $M	PV of DSM cost $M	PV of Energy Savings GWh	PV DSM Average Cost ($/MWh)	PV Expected DSM Average Cost ($/MWh)
Option 1							
Low	Large	10%	12,666	2,410	51,406	47	
Mid	Mid	80%	5,729	2,883	71,952	40	40
High	Small	10%	240	3,446	96,396	36	
Option 2							
Low	Large	10%	12,472	2,741	55,468	49	
Mid	Mid	80%	5,327	3,356	79,917	42	42
High	Small	10%	109	3,987	104,988	38	
Option 3							
Low	Large	10%	12,605	3,111	57,179	54	
Mid	Mid	80%	5,232	3,933	86,323	46	46
High	Small	10%	251	4,656	111,902	42	
Option 4							
Low	Large	10%	13,074	3,524	55,767	63	
Mid	Mid	80%	5,419	4,680	91,194	51	51
High	Small	10%	343	5,958	130,375	46	

DSM INCREMENTAL COSTS

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Incremental DSM cost analysis provides a comparison of the increment in cost and energy saving of going from one DSM option to another

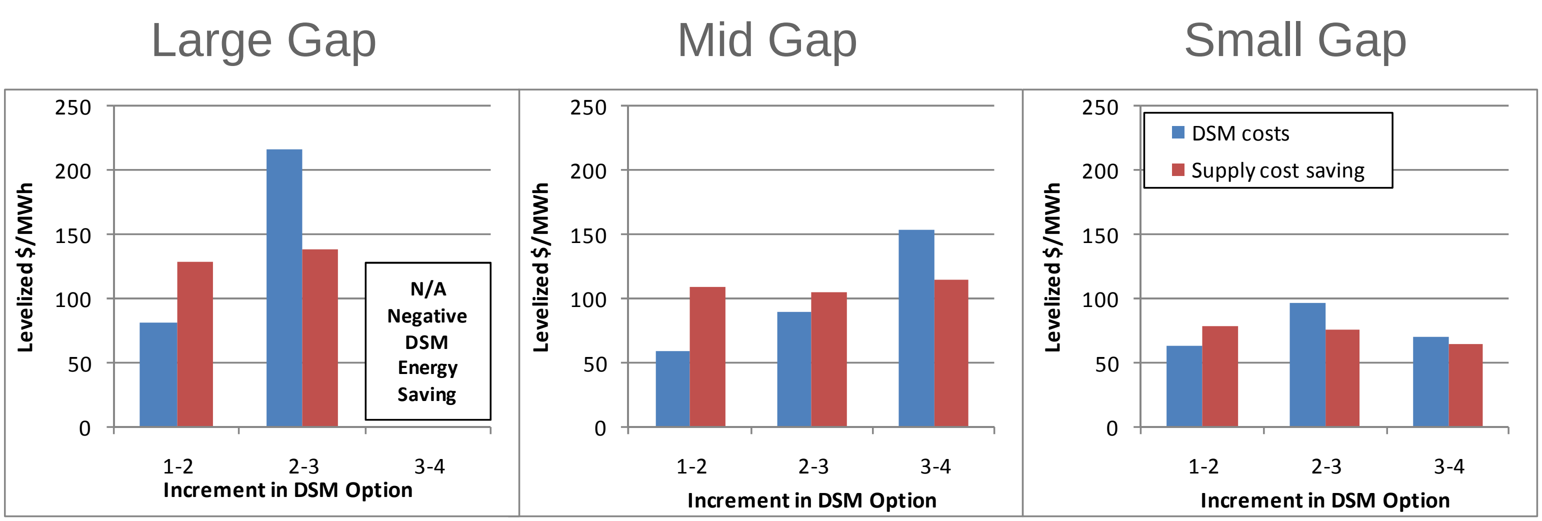
- Marginal DSM costs rise moving with each step
  - 61 $/MWh from Option 1 to 2
  - 137 $/MWh from Option 3 to 4
- Marginal supply-side cost savings decline with each step in DSM
  - 107 $/MWh from Option 1 to 2
  - 100 $/MWh from Option 3 to 4

DSM	Gap	%	PV of DSM cost $M	PV of Supply Portfolio Cost $M	PV of Energy Savings GWh	PV Expected DSM Incremental Cost ($/MWh)	PV Expected Supply Incremental Savings ($/MWh)
From Option 1 to 2							
Low	Large	10%	331	-525	4062		
Mid	Mid	80%	473	-876	7965	61	107
High	Small	10%	542	-672	8592		
From Option 2 to 3							
Low	Large	10%	369	-237	1712		
Mid	Mid	80%	577	-671	6406	94	102
High	Small	10%	668	-527	6914		
From Option 3 to 4							
Low	Large	10%	413	56	-1413		
Mid	Mid	80%	746	-559	4871	137	100
High	Small	10%	1302	-1210	18473		

DSM ECONOMIC COST / BENEFIT

The following graphics present the incremental cost of DSM against the marginal supply-side cost reduction for each gap for the base portfolios. This provides additional granularity behind the expected values in the tables.

- Moving from Option 1 to Option 2, incremental cost of DSM is lower than supply-side
- Moving from Option 2 to 3, DSM is lower cost than supply-side in the mid scenario, but higher in both the high and low scenarios
- Moving from Option 3 to 4, DSM is never lower cost than supply-side



PORTFOLIO COMPARISON OF DSM

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Preliminary Results at the portfolio level include, including both portfolios with and without Site C:

- Site C selected in all cases except Option 4, Small Gap (lowest load level net of DSM)
- Site C always selected for its earliest in-service date (2020) in Mid and Large Gap scenarios
- Site C in-service dates in the Small Gap scenarios were
  - DSM Option 1: 2021
  - DSM Option 2: 2029
  - DSM Option 3: 2029
  - DSM Option 4: not selected

		PV ($M)		
		With Site C	Without Site C	Site C ISD
Large Gap				
Option 1	10%	12,666	13,451	2020
Option 2	10%	12,472	13,274	2020
Option 3	10%	12,605	13,410	2020
Option 4	10%	13,074	13,867	2020

Mid Gap		PV ($M)		
		With Site C	Without Site C	Site C ISD
Mid Gap				
Option 1	80%	5,729	6,405	2020
Option 2	80%	5,327	5,964	2020
Option 3	80%	5,232	5,879	2020
Option 4	80%	5,419	6,022	2020

Expected	PV ($M)	
	With Site C	Without Site C
Expected Value		
Option 1	7,021	7,779
Option 2	6,586	7,305
Option 3	6,519	7,247
Option 4	6,762	7,444

Low Gap		PV ($M)		
		With Site C	Without Site C	Site C ISD
Small Gap				
Option 1	10%	240	283	2021
Option 2	10%	109	133	2029
Option 3	10%	251	259	2029
Option 4	10%	343	343	N/A

PORTFOLIO VALUES ACROSS DSM OPTIONS

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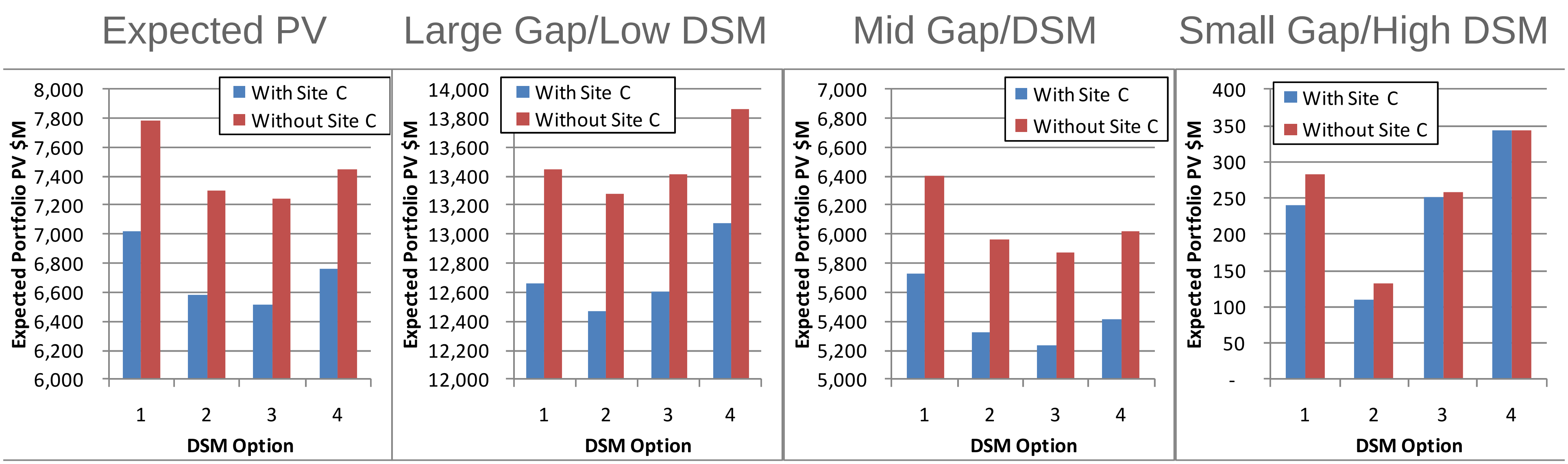
A cost profile appears across the range of portfolio results

- The lowest cost point is between DSM Option 2 and Option 3
- The expected result and the mid gap DSM are lowest near DSM Option 3
- The results at the high and low end of DSM delivery (Small and Large Gap) would indicate that the lowest cost would be near DSM Option 2



SUMMARY OF COST OBSERVATIONS

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Economic Analysis

- On an expected basis, DSM Option 3 is somewhat more economic than DSM Option 2
- There are risks that the economic value of DSM Option 3 will be less economic than DSM Option 2
  - Both the high and low bounds of DSM deliverability show Option 3 would provide lower economic value than Option 2
- DSM Option 4 never produced more economic value than DSM Options 2 or 3
- Remaining work for this IRP
  - Some positive impacts of DSM not yet included in analysis
    - e.g., transmission analysis is still to come
  - Predicting regional impacts of DSM is still a work in progress
    - Difficult due to uncertainty around site specific impacts

OTHER COST IMPACTS OF DSM

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Current DSM plans meet roughly 80% of incremental load growth through conservation

BC Hydro is has been clear that DSM savings uncertainty is a key issue in its planning considerations

A full consideration of cost risk needs to address:

- What is the planning uncertainty around DSM?
  - Particularly in short term when time to ability to react is limited
  - Currently addressed by DSM uncertainty assessments
- What are the risk management strategies?
  - Changing the DSM/supply-side mix (risk avoidance)
  - Reacting to being wrong (risk mitigation)
  - Reducing uncertainty (through learning)
- What are the consequences of:
  - Being wrong (and needing to adapt quickly)?
  - Adopting risk management strategies?

DSM NEAR-TERM UNCERTAINTY

What happens if we plan based on our “mid” DSM assumptions

- And we are surprised (by either “hi” or “low” DSM delivery outcome)?

Focus on near term is appropriate as:

- Less ability to react to being “wrong” in planning assumptions
- Legislative obligation to be self sufficient by 2016

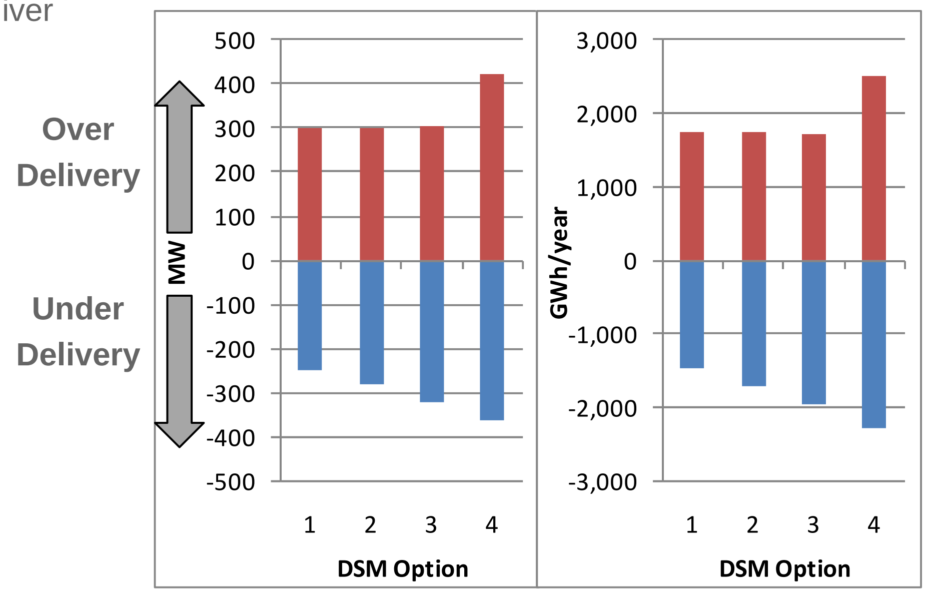
If we base our Base Resource Plan on “mid” DSM levels

- How wrong could we be 4 years out (from a F2013 starting point to F2017)?

Actual DSM 4 years out (F2017) could deliver

- 250 MW to 365 MW less than expected
- 300 MW to 420 MW more than expected

- 1,500 MW to 2,300 GWh/yr less than expected
- 1,700 MW to 2,500 GWh/yr more than expected



DSM NEAR-TERM UNCERTAINTY

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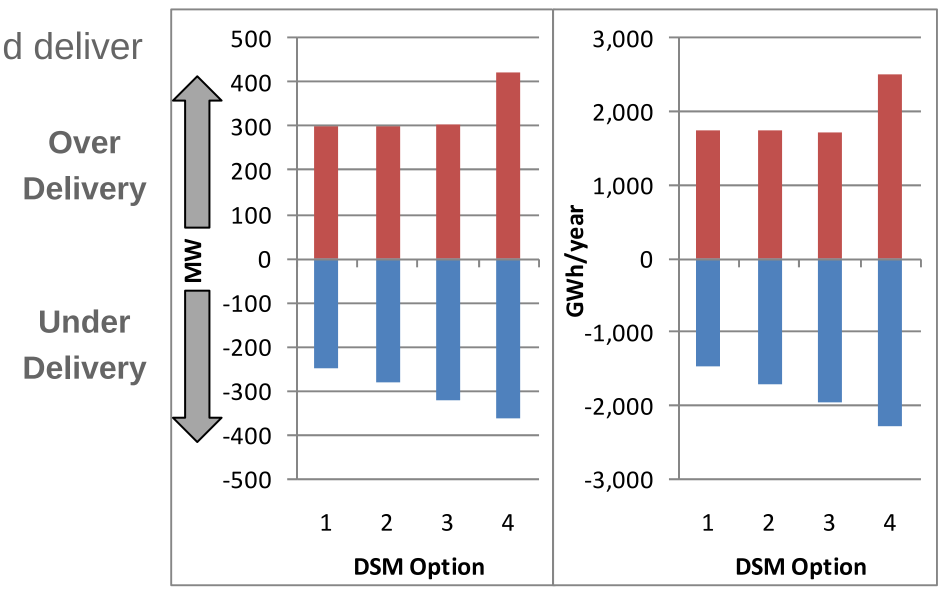
Preliminary observations

- Being long and short may both pose challenges
  - Surplus – must be moved through transmission, then sold
  - Deficit – must be purchased
- Material uncertainty across all options
- Increasing uncertainty with moves to more DSM
  - No “cliff edge”, only marginal increases

Actual DSM 4 years out (F2017) could deliver

- 250 MW to 365 MW less than expected
- 300 MW to 420 MW more than expected

- 1,500 MW to 2,300 GWh/yr less than expected
- 1,700 MW to 2,500 GWh/yr more than expected



RISK MANAGEMENT TO ADDRESS DELIVERABILITY RISK

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Currently, BC Hydro is assessing risk management strategies:

1 - Changing the DSM/supply-side mix (risk avoidance)

- To some extent, addressed by comparing levels of DSM through portfolio analysis
- Other choices – count on less DSM from each option
  - Reduces downside uncertainty
  - Increases costs ($/GWh)
  - Increase size of surplus

2 - Reacting to being wrong (risk mitigation)

- Currently under consideration:
  - What energy and capacity resources can be shelf ready?
  - With what lead times?
  - At what additional cost?

3 - Reducing uncertainty (through learning)

- What activities can BC Hydro undertake to reduce uncertainty in a cost effective, timely way?

CONSEQUENCES OF BEING WRONG WITH DSM PLANNING ASSUMPTIONS

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Supply/Demand Gap risk analysis issue

- Described here with respect to DSM, but concept holds for any resource acquisition decisions
- Distinction with DSM is the reliance and corresponding magnitude, and thus consequence of being wrong

What are the consequences of:

- Being wrong (and needing to adapt quickly)?
- Adopting risk management strategies?

BC Hydro must be reasonably confident of achieving self sufficiency.

If BC Hydro is surprised by a gap before 2016, 2020

- Difficult to ramp up DSM further in a short period
- Alternative is short lead time IPP resources

What resources are available, at what cost, what timeframe

- Under consideration
- Helps fill out consequences of “being wrong”

NON-COST IMPACTS OF DSM

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Environmental

- As addressed in earlier discussion
- Note that bulk transmission impacts still to be incorporated into analysis
- Increasing DSM will always avoid footprint impacts of adding new supply

Economic Development

- Data still being assembled
- In moving from Option 2 to 3, not clear a priori whether more DSM or more supply-side resources add more employment, economic development benefits
- Nature and location of impacts likely to be very different
- Cost, avoided cost, and rate/respending effects further complicate the picture as total portfolio costs decrease, flatten, then rise with increasing DSM

ROLE OF NATURAL GAS-FIRED GENERATION

KATHY LEE

ROLE OF NATURAL GAS-FIRED GENERATION

BC hydro FOR GENERATIONS

Natural gas-fired generation is impacted by Clean Energy Act and Greenhouse Gas Reduction Targets Act

- 93% clean or renewable generation target
- GHG emissions reduction targets

The proposed role of natural gas-fired generation in the IRP, and underlying analysis, is:

- Rely on existing thermal generation to their firm energy and dependable capacity capabilities;
- Retain some room within the 7% allowed thermal supply for:
  - Simple cycle gas turbines (SCGTs) in the contingency options for the Contingency Resource Plans and Transmission Contingency Plans;
  - Resource options for non-integrated areas such as Fort Nelson

93% CLEAN REQUIREMENT

BC Hydro required to meet the 93% clean or renewable target

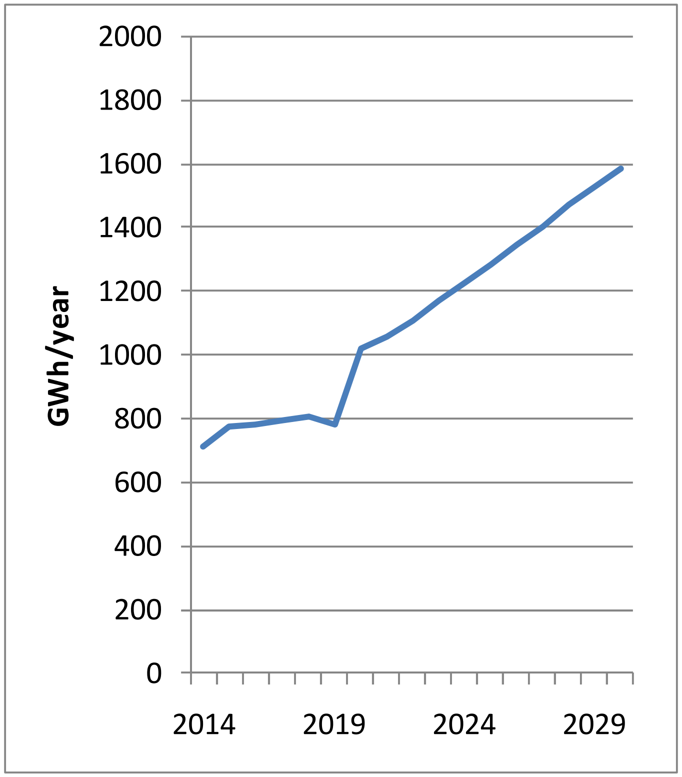
- 19 (1) To facilitate the achievement of British Columbia's energy objective set out in section 2 (c), a person to whom this subsection applies … must pursue actions to meet the prescribed targets in relation to clean or renewable resources …

BC Hydro existing gas-fired generation includes ICG, McMahon, Prince Rupert and Fort Nelson

- Results in approximately 3,550 GWh/year of thermal firm energy commitment, absent serving new load in the Horn River Basin
- Currently results in 94% clean energy, increases to approximately 95.75% under the mid load scenario by 2030

Leaves space for 700 to 1,600 GWh/year (1% to 2.75%) additional firm energy commitment from natural gas-fired generation

Remaining Space for Gas-fired Energy in Mid Load Scenario



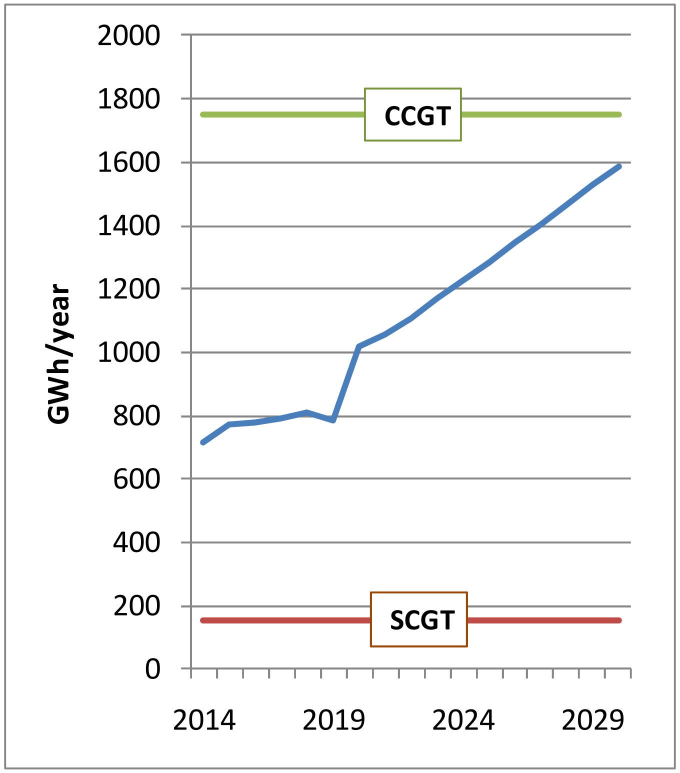
ROOM FOR SCGT PEAKING CAPACITY

BC hydro FOR GENERATIONS

The remaining 700 to 1,600 GWh of space that could be allocated to thermal generation

- Would allow for additional 100 MW SCGT peaking capacity
  - Assumed to have a capacity factor of 17.5% for firm energy capability and production
  - Space for approximately 4 to 12 units over the planning horizon
- Not sufficient space for any new 250 MW base load CCGTs

Relative Impact of one CCGT or one SCGT on Clean Target



USE OF GAS FOR SPECIFIC PURPOSES

Natural gas-fired generation continues to hold value for special situations:

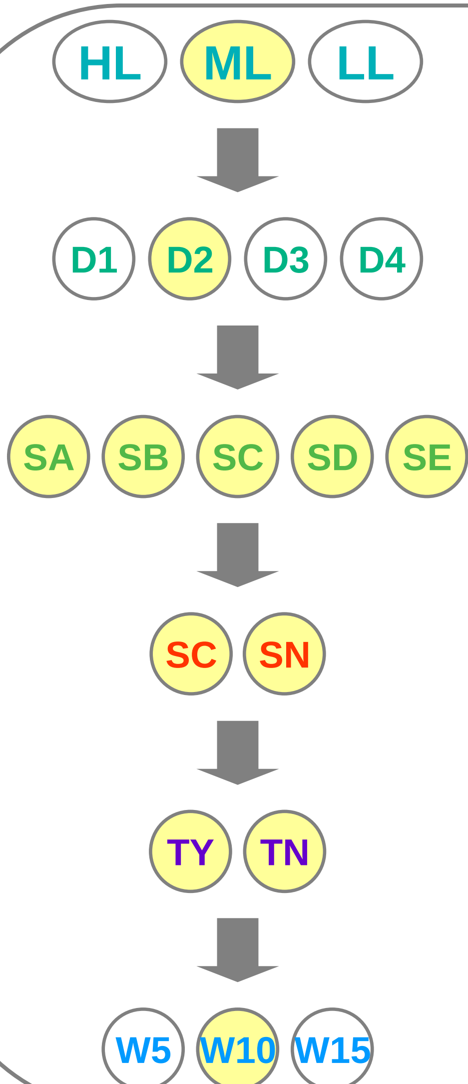
- Remote or non-interconnected locations, such as Fort Nelson
- Contingency Resource Plans
- Transmission contingency backup

Example based on BC Hydro supplying increased load in the Fort Nelson and Horn River Basin (HRB) area with natural gas generation

- Absent any BC Hydro commitment to the Horn River Basin (HRB), the available space remains approximately 12 units by 2030 (previous slide)
- If BC Hydro's commitment to the HRB equalled its mid load forecast, there would only be space for 2 SCGTs on the interconnected system by 2020
- If the Fort Nelson high forecast were to occur, but still the mid HRB forecast, there would be no remaining space for the interconnected system in 2022
- Using gas generation to meet the HRB high load scenario would far exceed the space available while meeting the 93% clean or renewable target

MODELLING MAP – THERMAL

BC hydro FOR GENERATIONS



Gap: High Load (HL), Mid Load (ML), Low Load (LL)

DSM Option: Option #1 (D1) — Option #4 (D4)

Market Scenario: Scenario A (SA) — Scenario E (SE)

Site C: Yes (SC) / No (SN) – considered as an option

Thermal: Yes (TY) / No (TN) – considered as an option

Wind Integration Cost: $5, $10, $15 / MWh

PORTFOLIO RESULTS FOR THERMAL ENERGY

BC hydro FOR GENERATIONS

SCGT comparison analysis across the 5 market scenarios based on portfolios with the mid load scenario and DSM option 2, both with and without Site C

- Thermal cases allowed 100 MW SCGTs to be installed at Kelly Lake
- Cases compared against portfolios that excluded SCGTs as an option

Results

- With Site C, SCGTs selected in 4 of 5 scenarios, earliest selection date was 2026
  - SCGTs provided small benefit in all cases
  - There was room within 93% for more SCGTs in all cases (much below 12 units selected)
- Without Site C, SCGTs selected in at least 4 of the 5 scenarios [A not done yet]
  - SCGTs provide larger benefit, earliest ISD was 2022
  - Full space available for SCGT's was used in Scenario B and D (12 units)

	With Site C					Without Site C				
Market Scenario	PV with No SCGTs	PV SCGTs allowed	PV Change $M	Number of SCGTs	Earliest ISD	PV with No SCGTs	PV SCGTs allowed	PV Change $M	Number of SCGTs	Earliest ISD
A	4,053	4,053	-	-		4991	4965	26	3 units	2029
B	5,406	5,371	35	5 units	2026	6,021	5,838	183	12 units	2022
C	5,918	5,887	31	3 units	2026	5,991	5,810	181	11 units	2023
D	4,138	4,115	23	5 units	2026	4,996	4,874	122	12 units	2022
E	6,247	6,232	14	2 units	2027	6,303	6,193	110	9 units	2023

RESOURCE ACQUISITION ANALYSIS

KATHY LEE

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RESOURCE ACQUISITION ANALYSIS

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- Size and timing
- Model runs:
  - 15 runs: 3 gaps and 5 market scenarios without Site C
  - 3 runs: 3 wind integration costs, mid gap with Scenario B, with Site C
- Analyzes:
  - Sensitivity to gap sizes and market scenarios
  - Influence of REC on resource selection
  - Wind integration
    - Sensitivity to wind integration costs
    - Wind integration limit
- Resource sensitivities (To be discussed end of April):
  - Geothermal
  - Emerging resources e.g. Coal CCS, wave etc

MODELLING MAP – ACQUISITION

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FOR GENERATIONS

HL ML LL — Gap: High Load (HL), Mid Load (ML), Low Load (LL)

D1 D2 D3 D4 — DSM Option: Option #1 (D1) — Option #4 (D4)

SA SB SC SD SE — Market Scenario: Scenario A (SA) — Scenario E (SE)

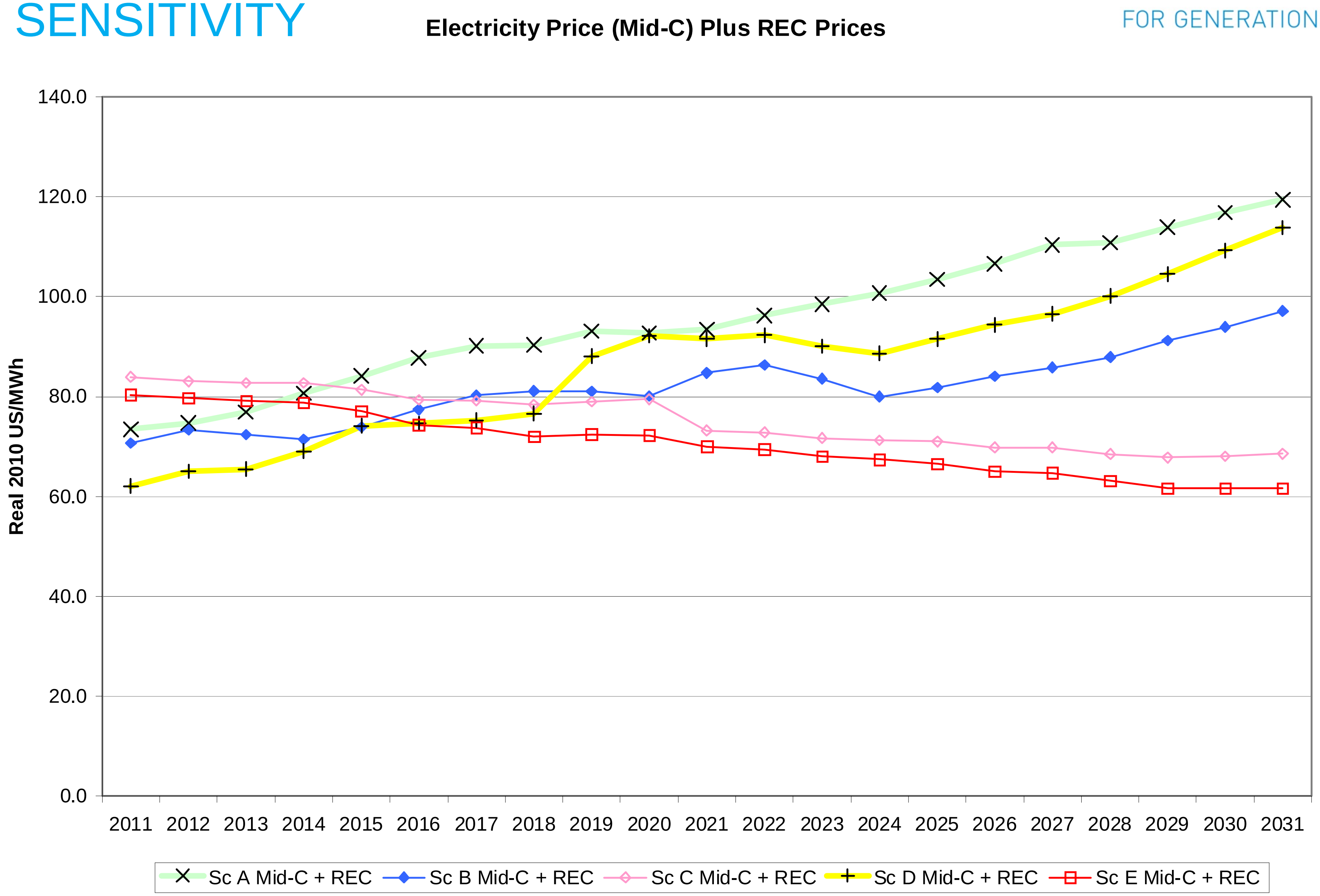
SC SN — Site C: Yes (SC) / No (SN) – considered as an option

TY TN — Thermal: Yes (TY) / No (TN) – considered as an option

W5 W10 W15 — Wind Integration Cost: $5, $10, $15 / MWh

ACQUISITION: MARKET SCENARIOS SENSITIVITY

BChydro FOR GENERATIONS



ACQUISITION

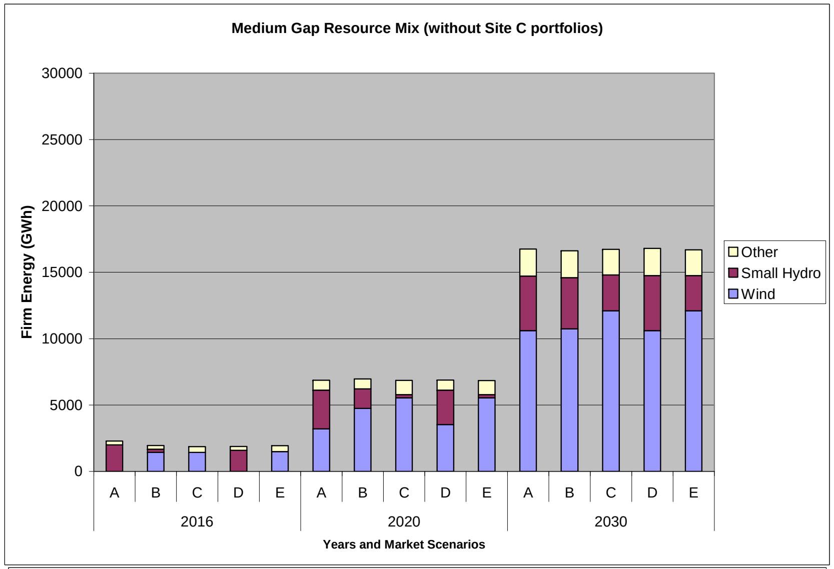
BC hydro FOR GENERATIONS

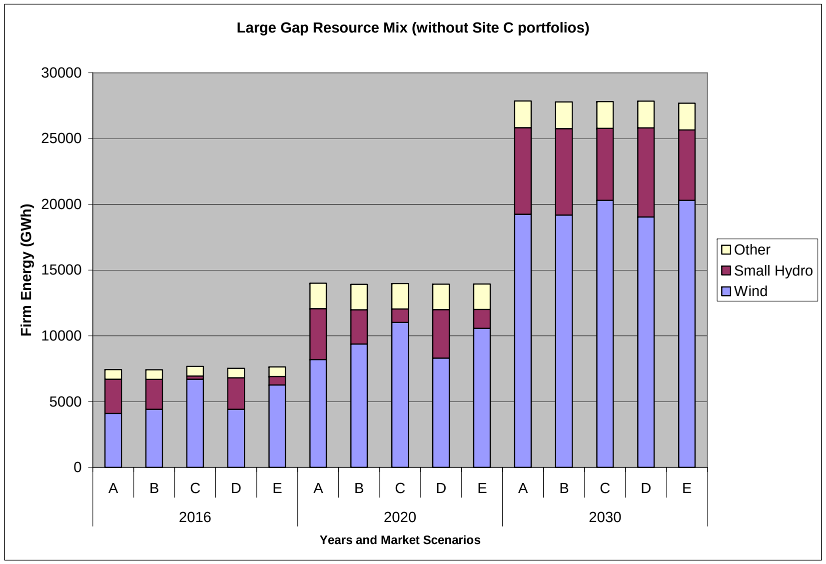
- Present value sensitivity to gap size and market scenarios

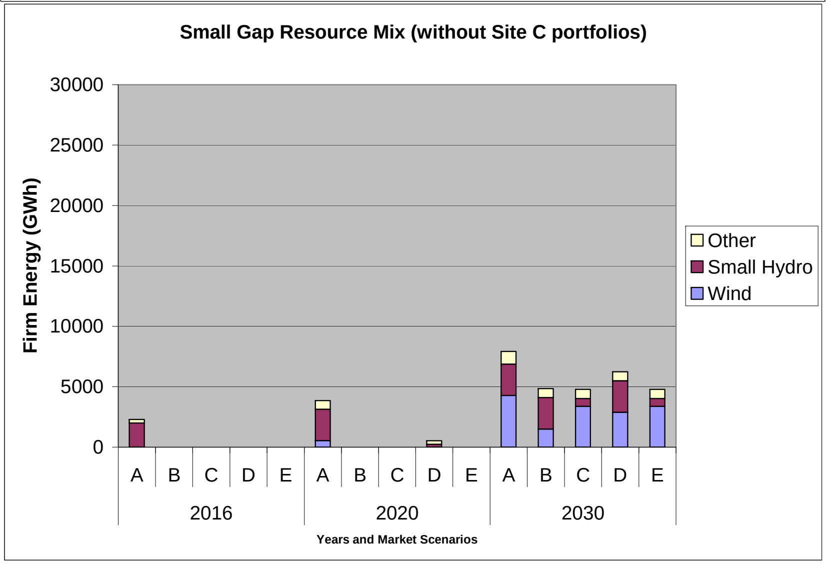
		Without Site C			
		PV (Millions$) 2011 real $, discounted to 2011			
		Large Gap	**Medium Gap**	**Small Gap**	**Weighted Average across gap**
Market Scenarios	**Likelihood**	10%	80%	10%	
A	**10%**	14,144	5,026	(2,793)	5,286
B	**45%**	13,274	5,964	133	6,260
C	**25%**	13,306	5,914	61	6,222
D	**5%**	13,996	4,934	(2,744)	5,211
E	**15%**	13,632	6,236	426	6,553
Weighted Average across market scenarios		13,459	5,847	(278)	**6144**

ACQUISITION: GAP SIZE AND MARKET SCENARIOS SENSITIVITY

BC hydro FOR GENERATIONS





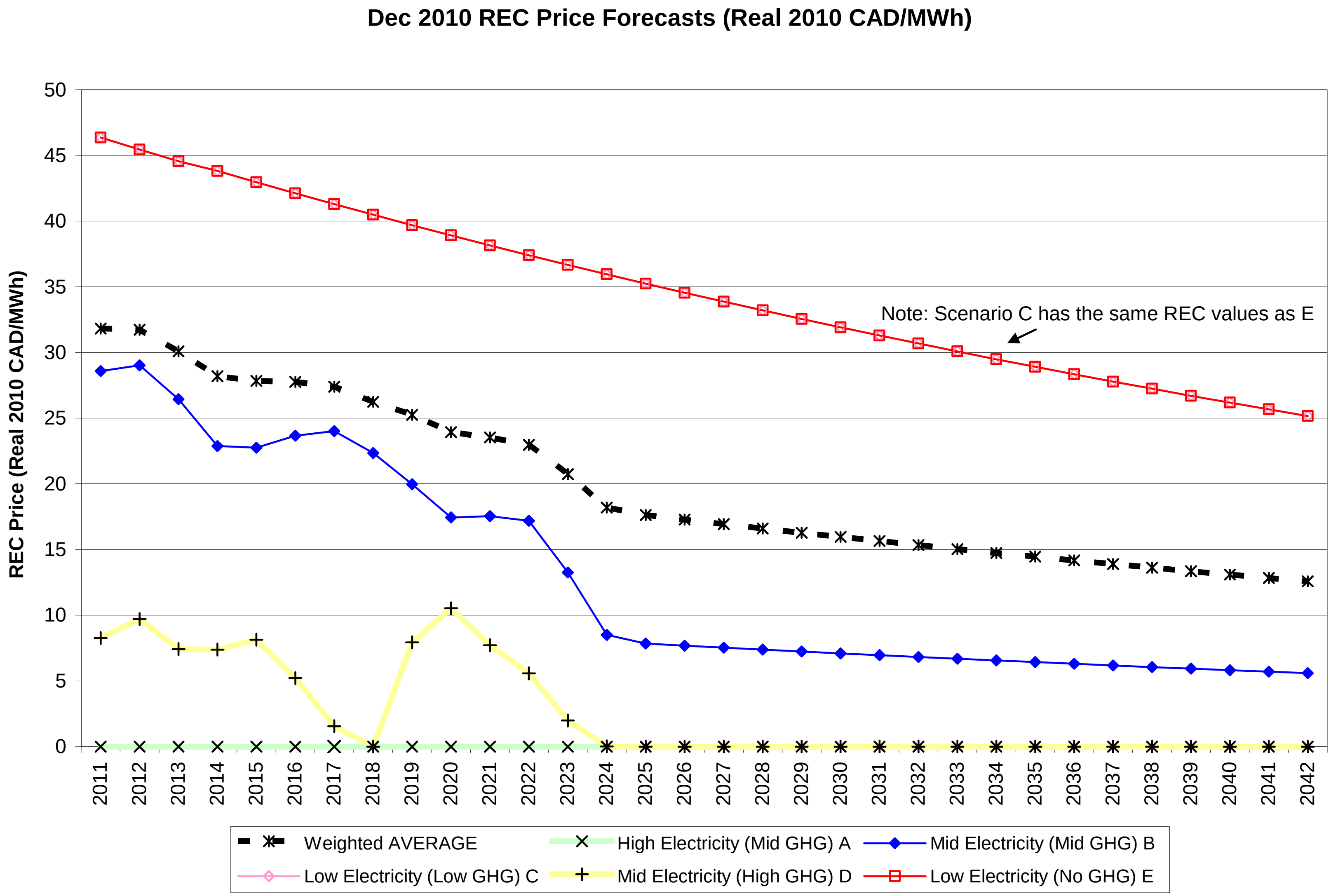


Model builds to fill gap/meet needs.

In the small gap case, economic build opportunity for market scenarios with high electricity prices.

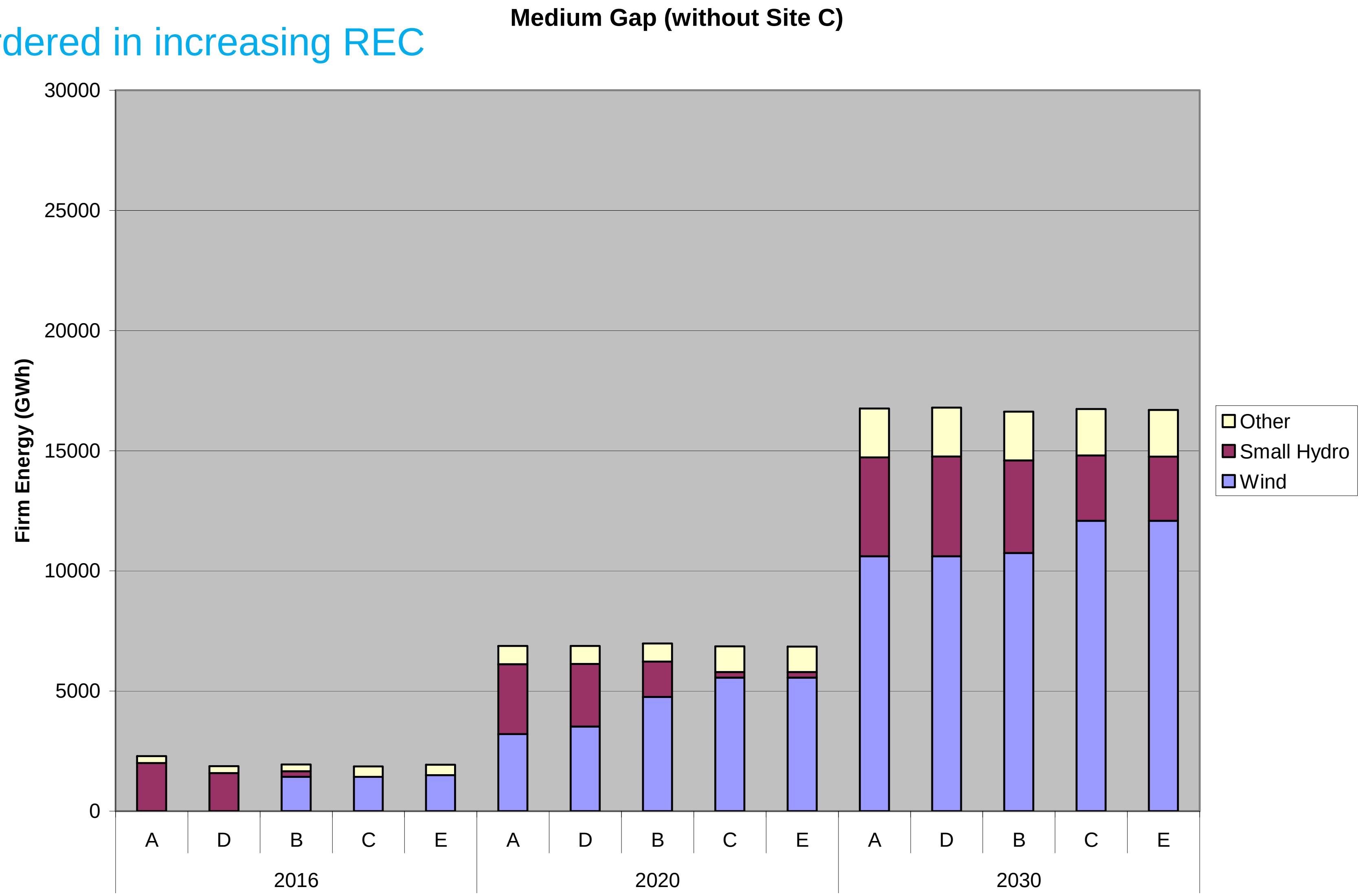
ACQUISITION: REC INFLUENCE

BC hydro
FOR GENERATIONS

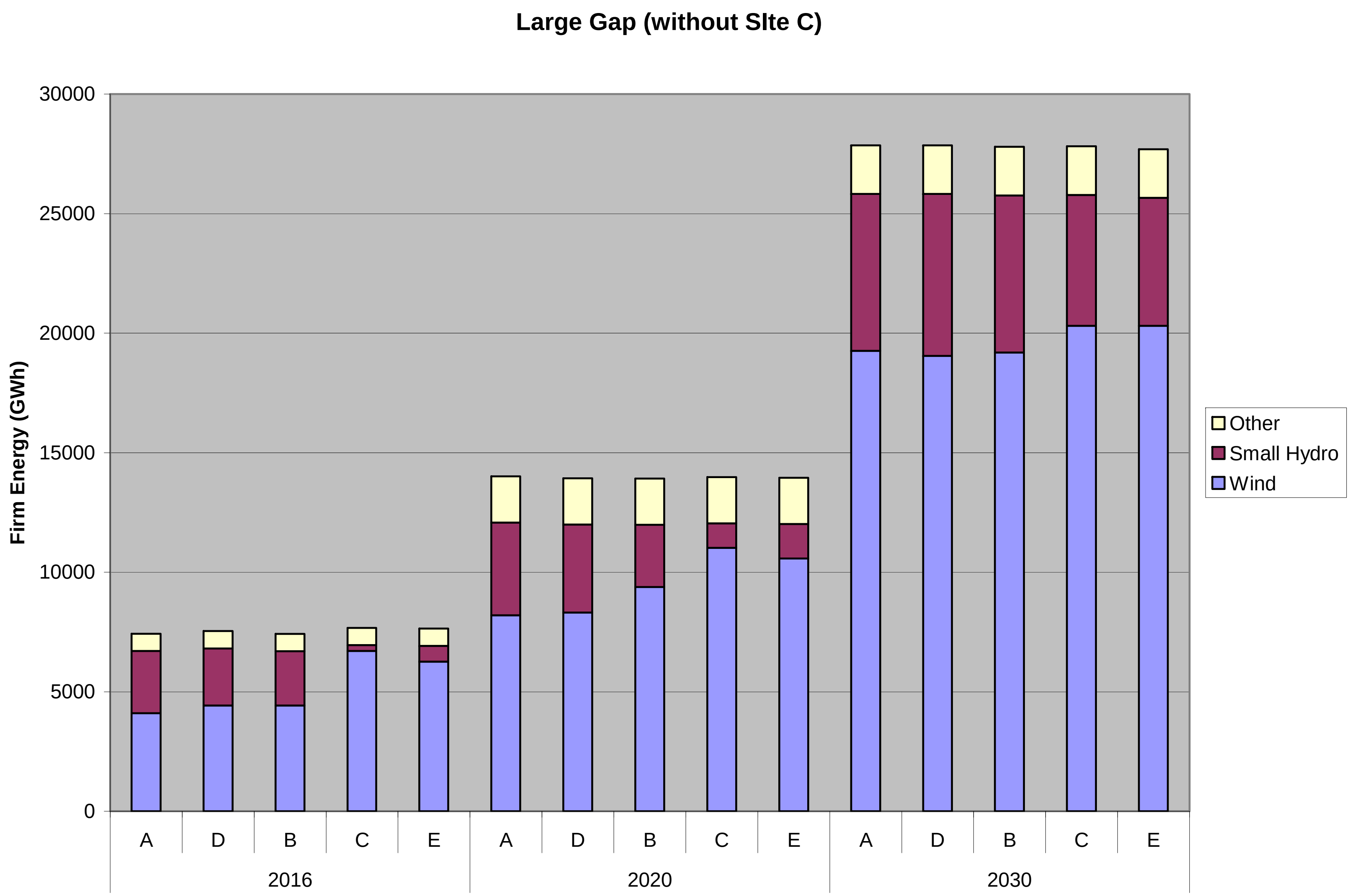


ACQUISITION: REC INFLUENCE

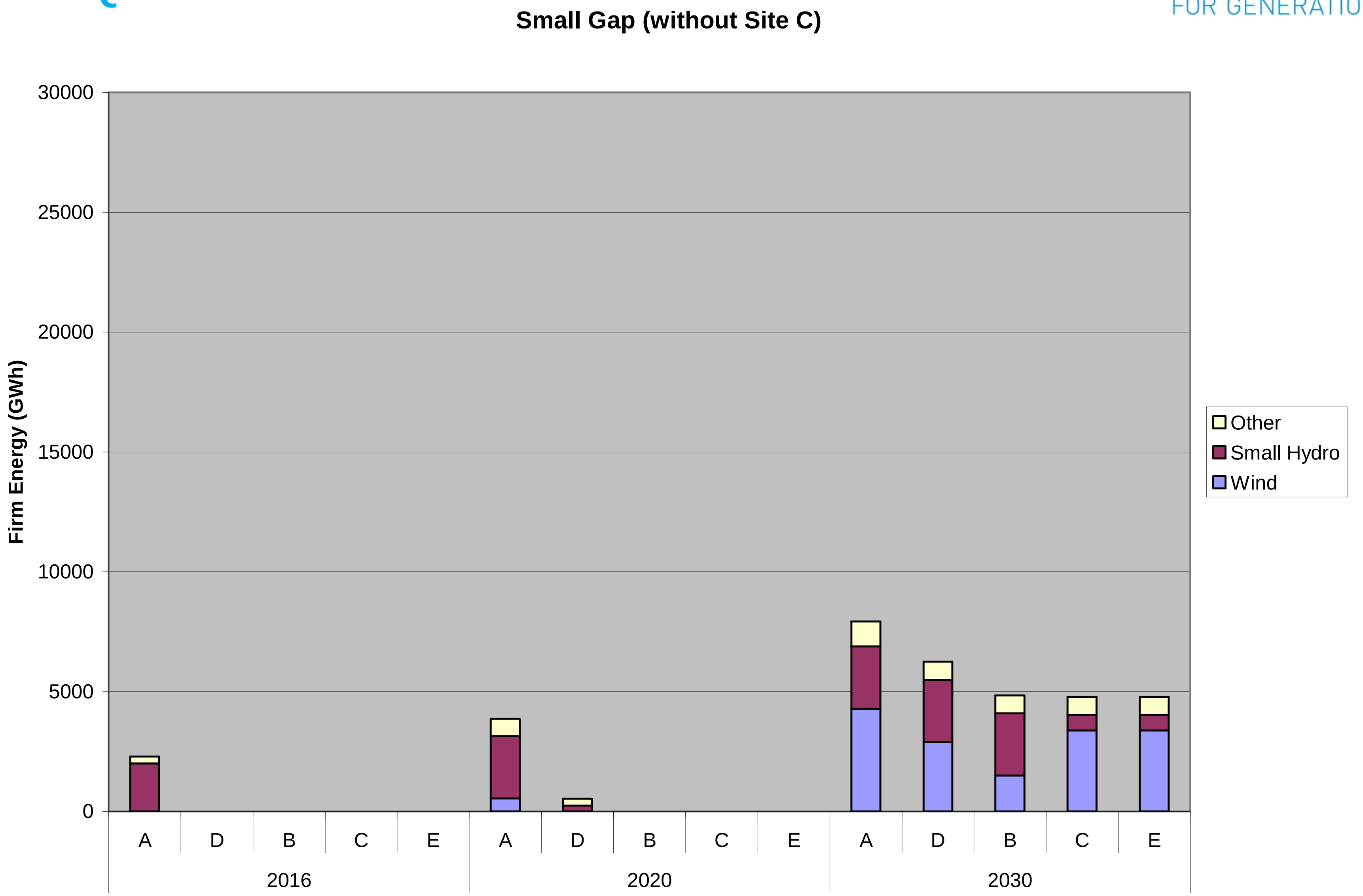
Ordered in increasing REC



ACQUISITION: REC INFLUENCE



ACQUISITION: REC INFLUENCE



SUMMARY OF PORTFOLIO COSTS
MID GAP

BC hydro FOR GENERATIONS

Discounted to Beginning of 2011

	Scenario A	Scenario B	Scenario C	Scenario D	Scenario E
G& T Resource cost	9,188	8,927	8,294	10,127	8,316
Trade Revenue	(7,526)	(6,320)	(5,738)	(8,460)	(5,447)
DSM Cost	3,356	3,356	3,356	3,356	3,356
Total Portfolio Cost	5,019	5,964	5,912	5,024	6,225

SUMMARY OF PORTFOLIO COSTS
LARGE GAP

BC hydro FOR GENERATIONS

Discounted to Beginning of 2011

	Scenario A	Scenario B	Scenario C	Scenario D	Scenario E
G& T Resource cost	17,753	17,625	17,150	18,609	17,017
Trade Revenue	(7,635)	(7,092)	(7,968)	(8,639)	(7,292)
DSM Cost	3,987	2,741	3,987	3,987	3,987
Total Portfolio Cost	14,106	13,274	13,170	13,957	13,712

SUMMARY OF PORTFOLIO COSTS SMALL GAP

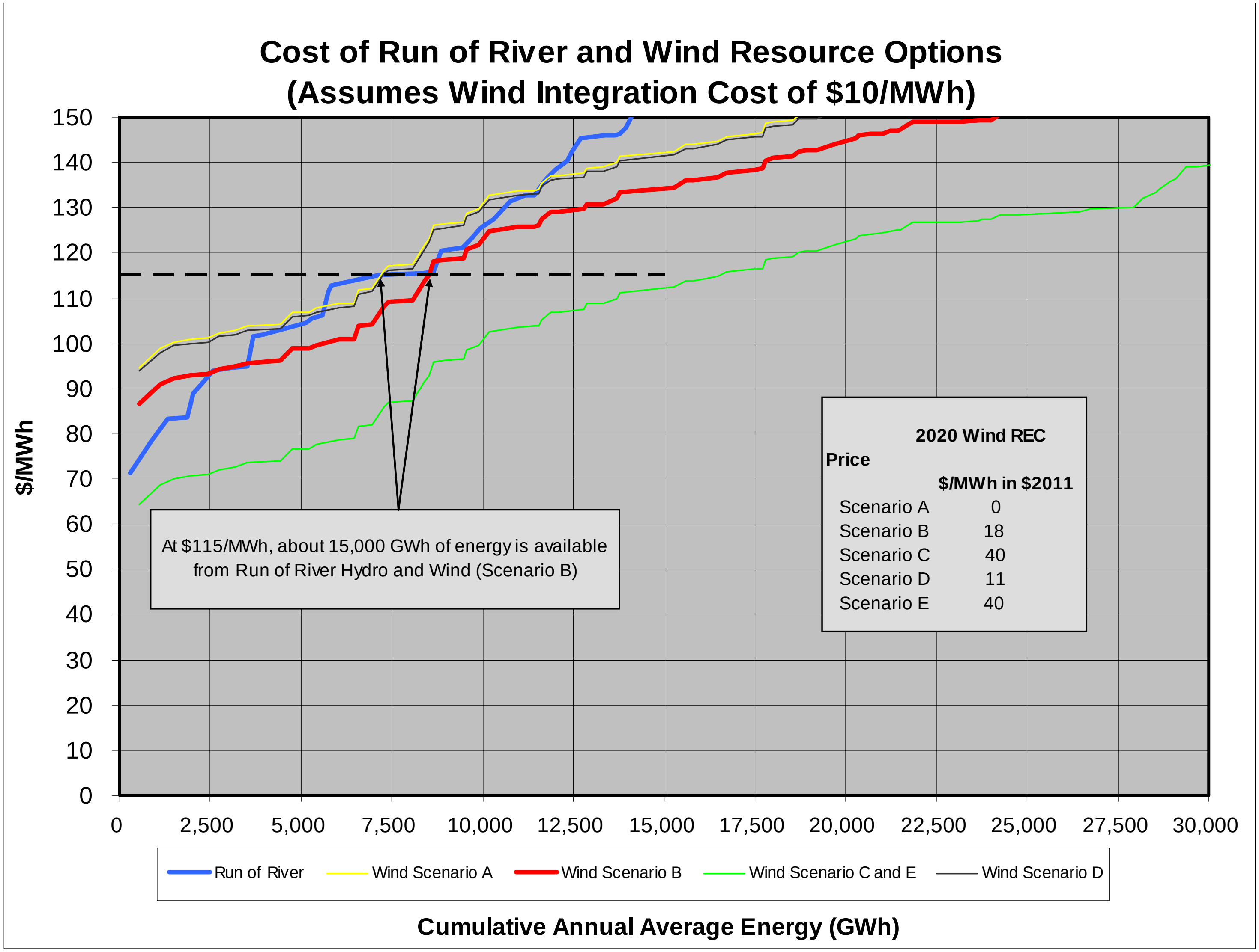
BC hydro FOR GENERATIONS

Discounted to Beginning of 2011

	Scenario A	Scenario B	Scenario C	Scenario D	Scenario E
G& T Resource cost	4,638	3,086	3,085	4,132	3,228
Trade Revenue	(10,041)	(6,941)	(5,639)	(9,488)	(5,413)
DSM Cost	2,741	3,987	2,741	2,741	2,741
Total Portfolio Cost	(2,662)	133	186	(2,616)	557

ACQUISITION: REC INFLUENCE

BC hydro FOR GENERATIONS



ACQUISITION: REC INFLUENCE

BChydro FOR GENERATIONS

Observations/Conclusions

- REC values: generally higher in the near term
  - Trending down as electricity prices increase with GHG costs
  - Combined electricity prices and REC reflects value
- Cost effectiveness of RPS eligible resources may be advanced given REC
- Higher REC cases show preference for more RPS eligible resources
  - especially in the near term
- However, high REC does not result in portfolios with only RPS eligible resources
- Resource selection depends on REC as well as relative cost competitiveness between resource options
- REC is an important evaluation factor for acquisition

ACQUISITION: WIND INTEGRATION COST

BC hydro FOR GENERATIONS

Wind Integration Cost includes:

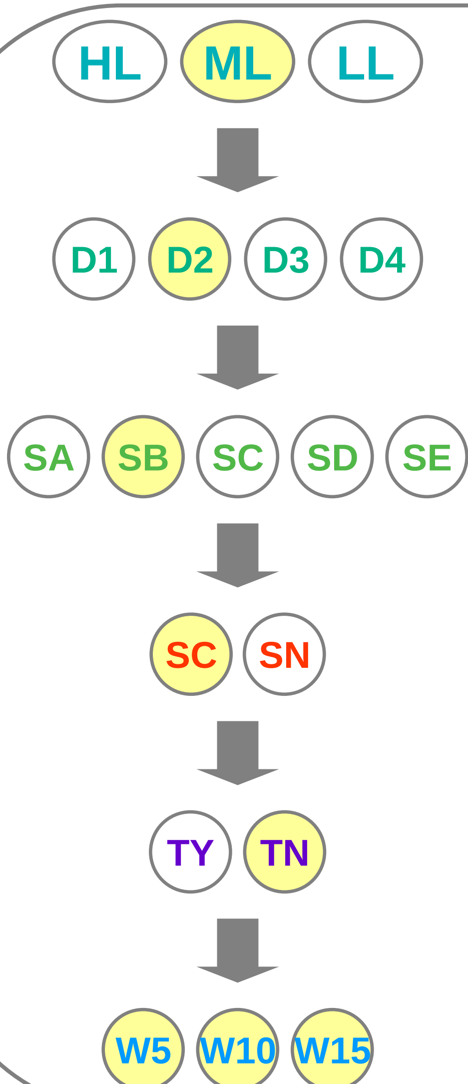
- Cost of incremental with-in hour reserves required to support intermittency of wind generation
- Cost associated with operating the system to accommodate wind forecast errors

ACQUISITION: WIND INTEGRATION COST

Reserve Cost + Day-Ahead Opportunity*	2010/11 Study Year		2020/21 Study Year	
	per MWh of wind energy	per kW installed wind capacity per month	per MWh of wind energy	per kW installed wind capacity per month
Economic Dispatch, CAPEX 15% (1,500 MW)	$10.79	$2.84	$12.79	$3.36
Economic Dispatch, CAPEX 25% (2,500 MW)	$15.58	$4.09	$19.41	$5.10
Economic Dispatch, CAPEX 35% (3,500 MW)	$13.57	$3.37	$16.57	$4.11
High Diversity, 15% (1,500 MW)	$5.39	$1.14	$6.04	$1.28
High Diversity, 25% (2,500 MW)	$6.36	$1.35	$7.31	$1.55
High Diversity, 35% (3,500 MW)	$7.64	$1.62	$8.51	$1.80

- Base assumption in IRP analysis: $10/MWh wind integration cost
- Tested wind integration cost sensitivities: $5/MWh and $15/MWh (approximate the low and high values in the study associated with diversity and higher levels of wind penetration)

MODELLING MAP – WIND



Load Gap: High Load (HL), Mid Load (ML), Low Load (LL)

DSM Option: Option #1 (D1) — Option #4 (D4)

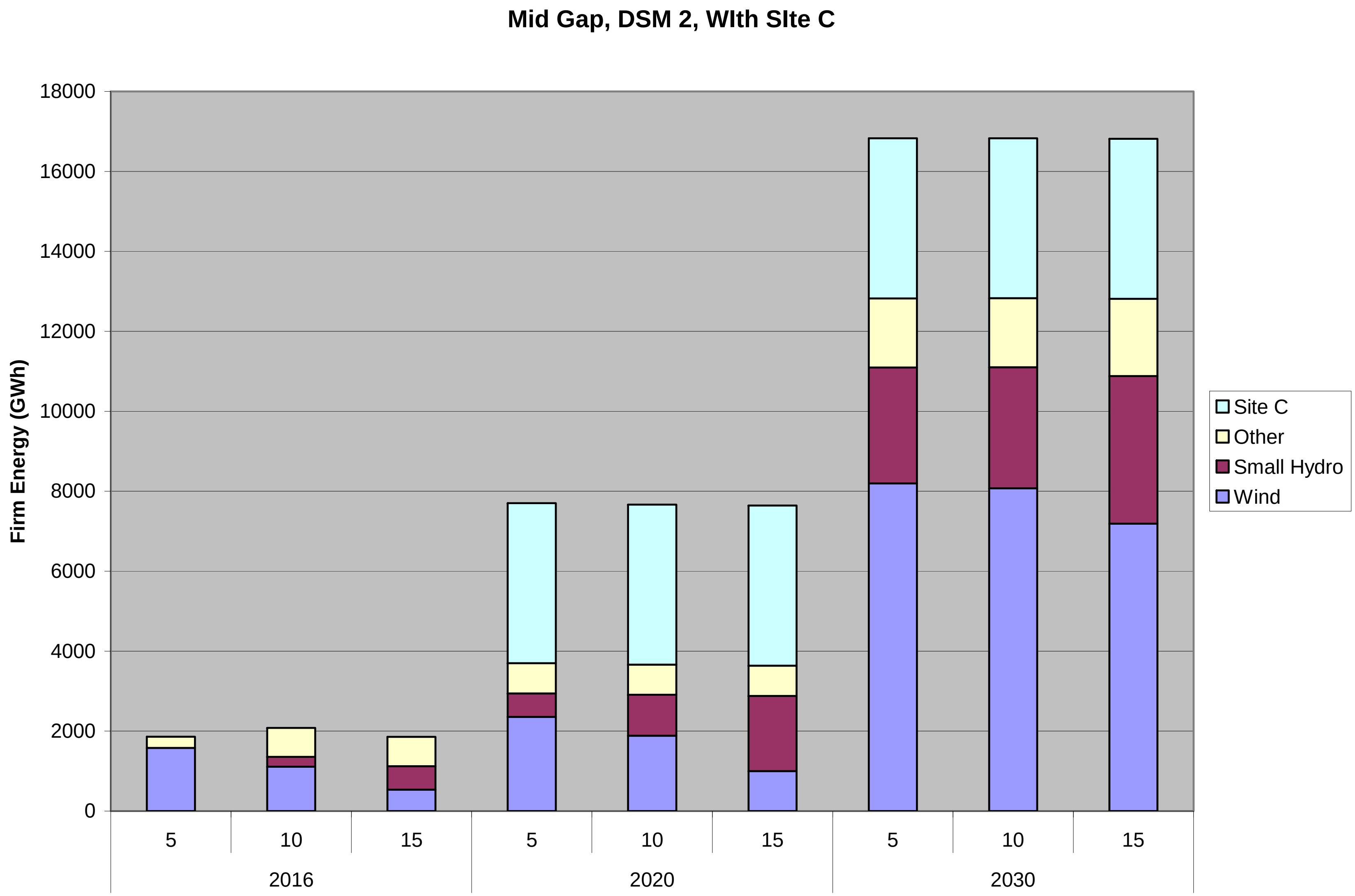
Market Scenario: Scenario A (SA) — Scenario E (SE)

Site C: Yes (SC) / No (SN) – considered as an option

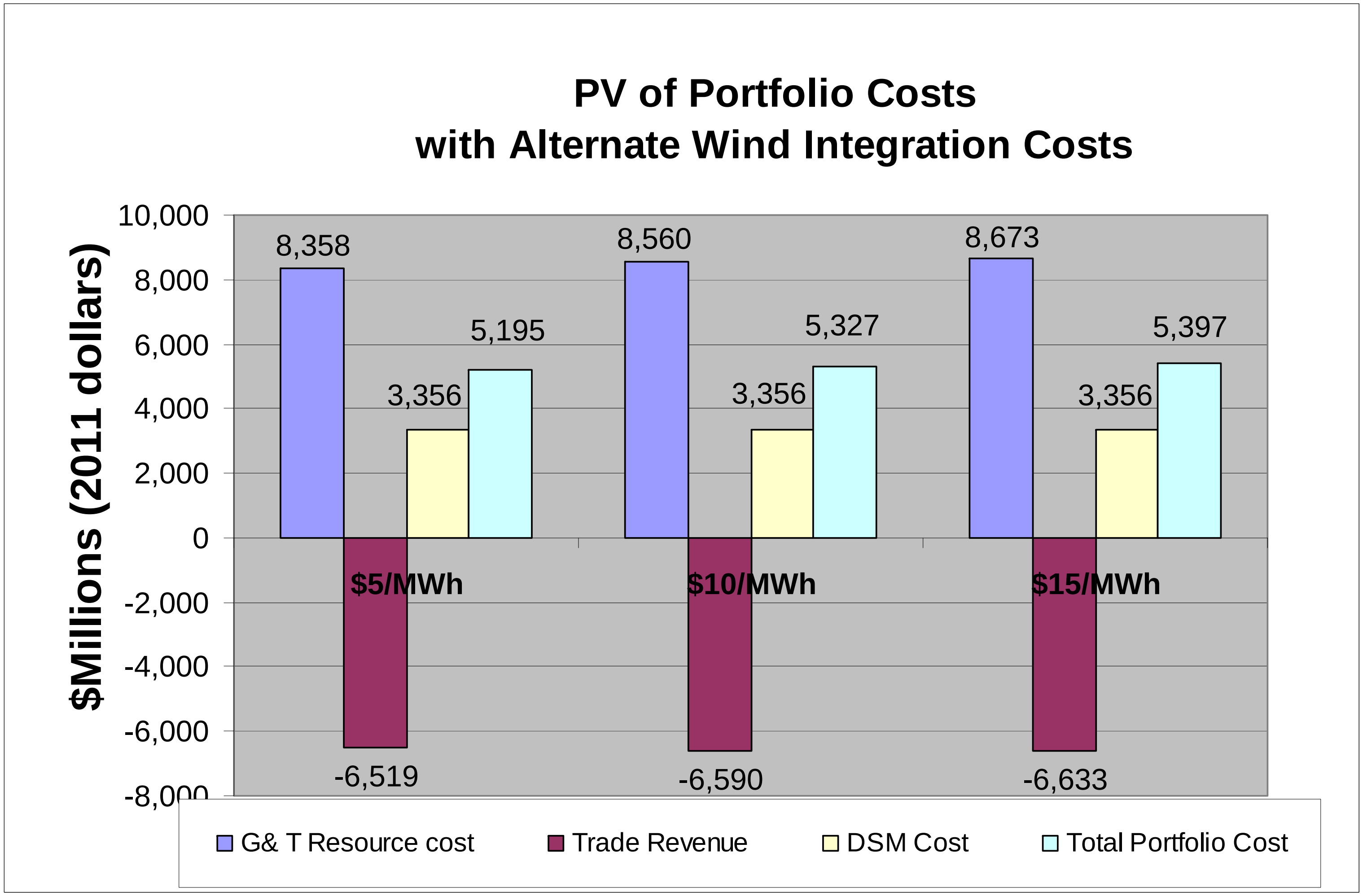
Thermal: Yes (TY) / No (TN) – considered as an option

Wind Integration Cost: $5, $10, $15 / MWh

ACQUISITION: WIND INTEGRATION COST

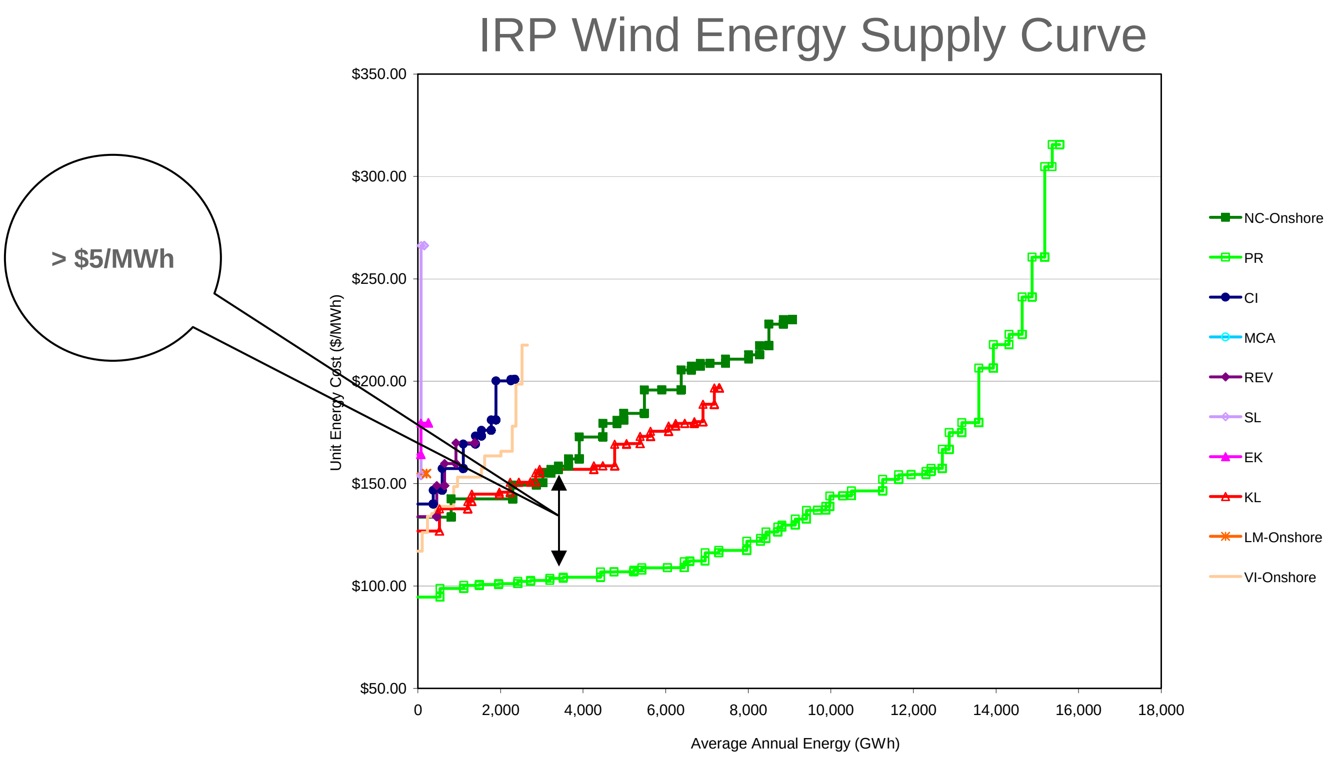


ACQUISITION: WIND INTEGRATION COST



ACQUISITION: WIND INTEGRATION COST

Wind geographical diversity benefits (~$5/MWh at full diversity) are lower than the increased cost of acquiring diversified wind projects, e.g., moving out of Peace Region.



ACQUISITION: WIND INTEGRATION COST

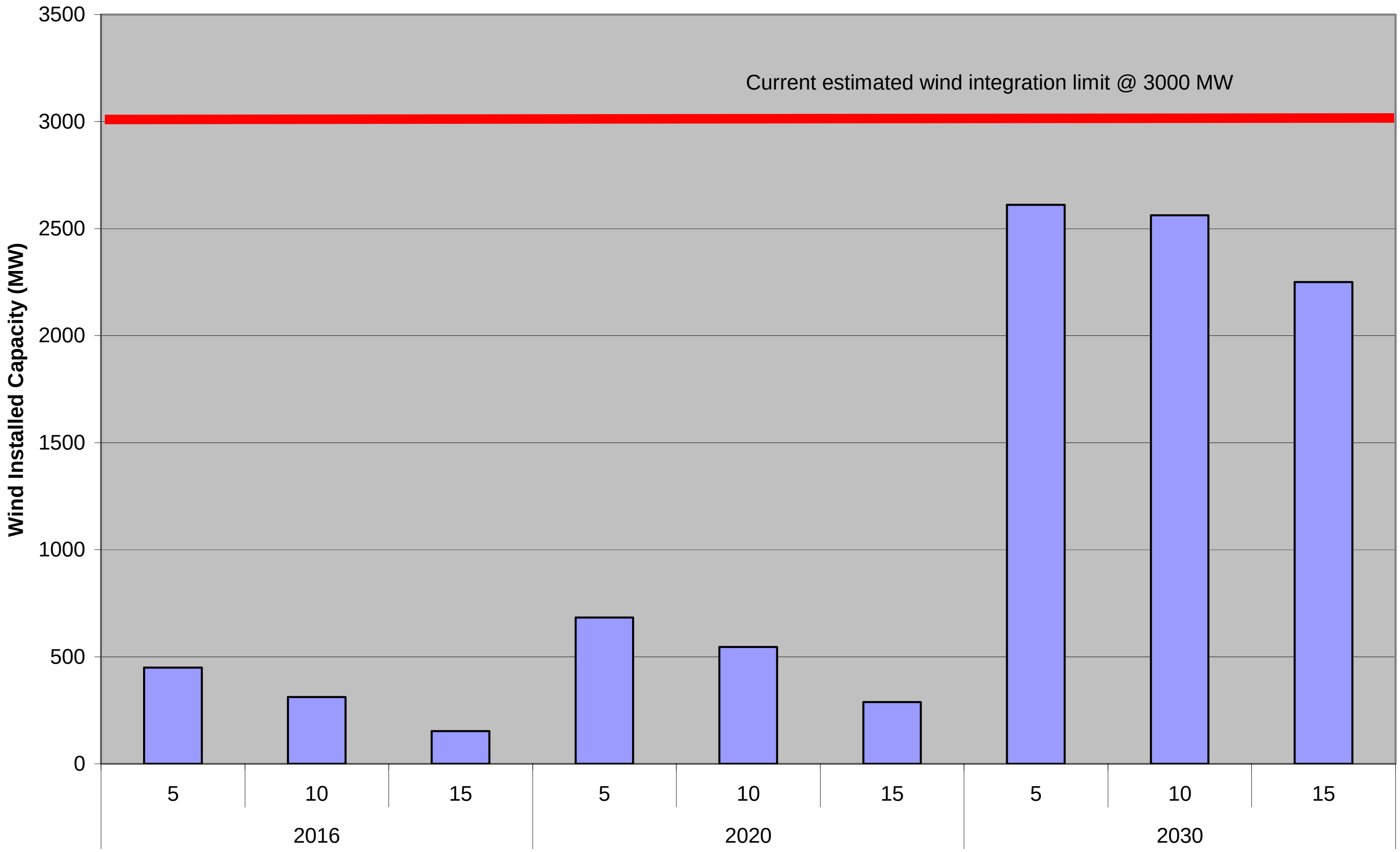
BC hydro FOR GENERATIONS

CONCLUSIONS

- Resource selection is sensitive to the wind integration cost adder, particularly in the 2016 and 2020 timeframes
- The wind integration cost adder mainly affects the proportion of wind and run-of-river resources
- For the next few thousands of GWh, the economic benefits of wind diversity on wind integration cost may be outweighed by the cost of acquiring diversified wind projects
- Wind integration costs are important to multi-resource acquisition processes and can play an important role in determining optimal acquisitions

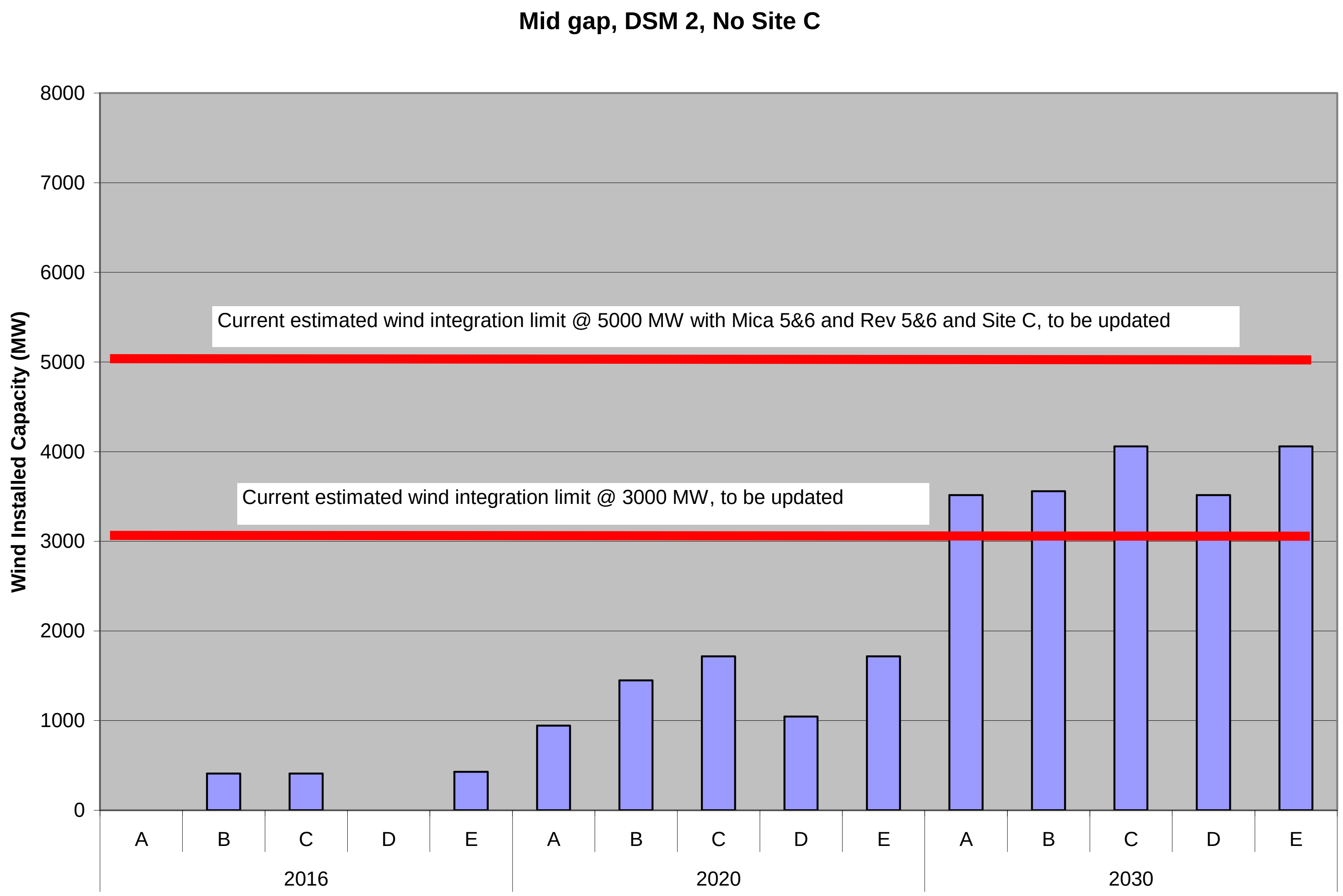
ACQUISITION: WIND INTEGRATION LIMIT

Mid Gap, DSM 2, With Site C



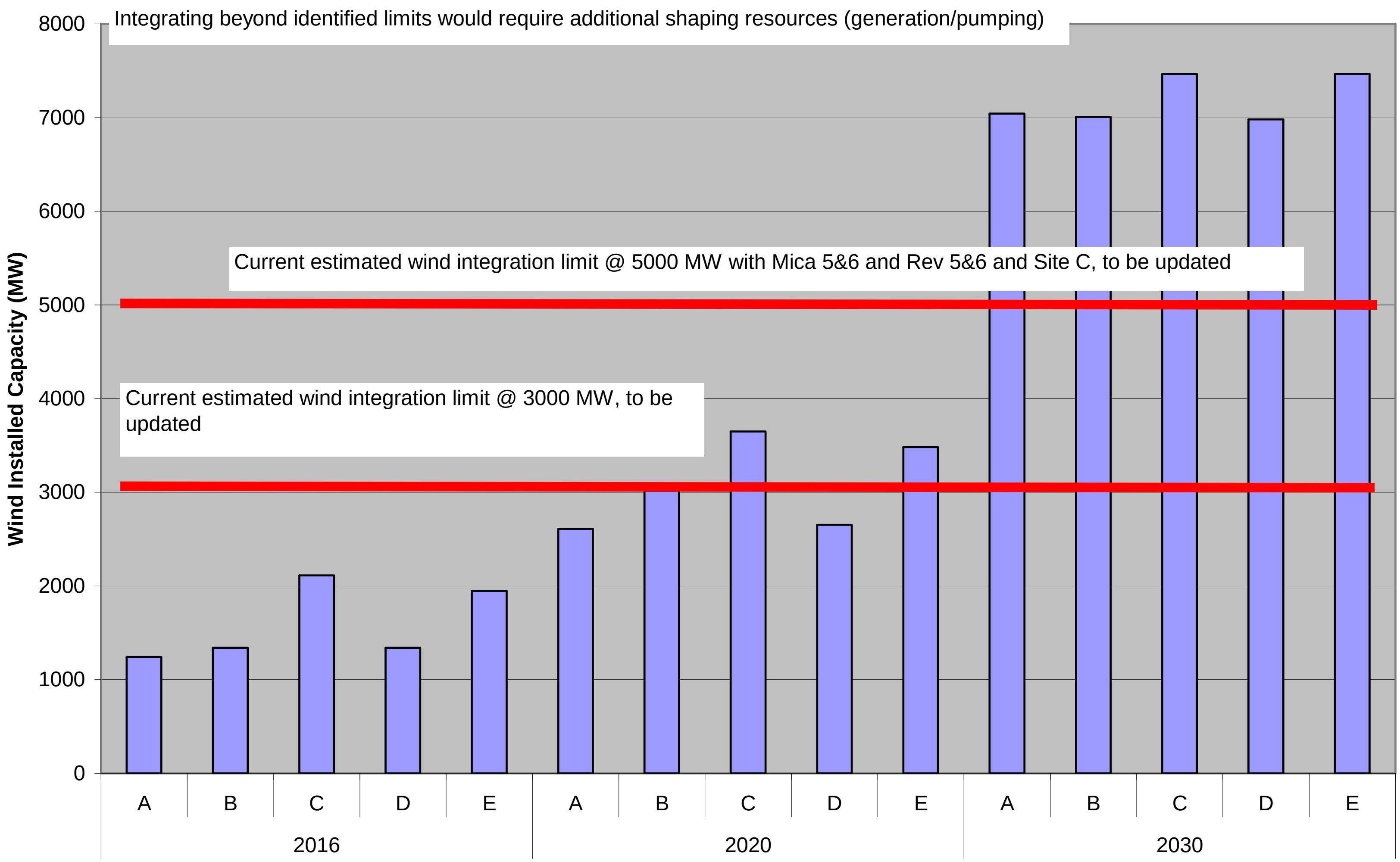
ACQUISITION: WIND INTEGRATION LIMIT

BC hydro FOR GENERATIONS



ACQUISITION: WIND INTEGRATION LIMIT

Large Gap, DSM 2, Without Site C



ACQUISITION: WIND INTEGRATION LIMIT

BC hydro FOR GENERATIONS

To be discussed later

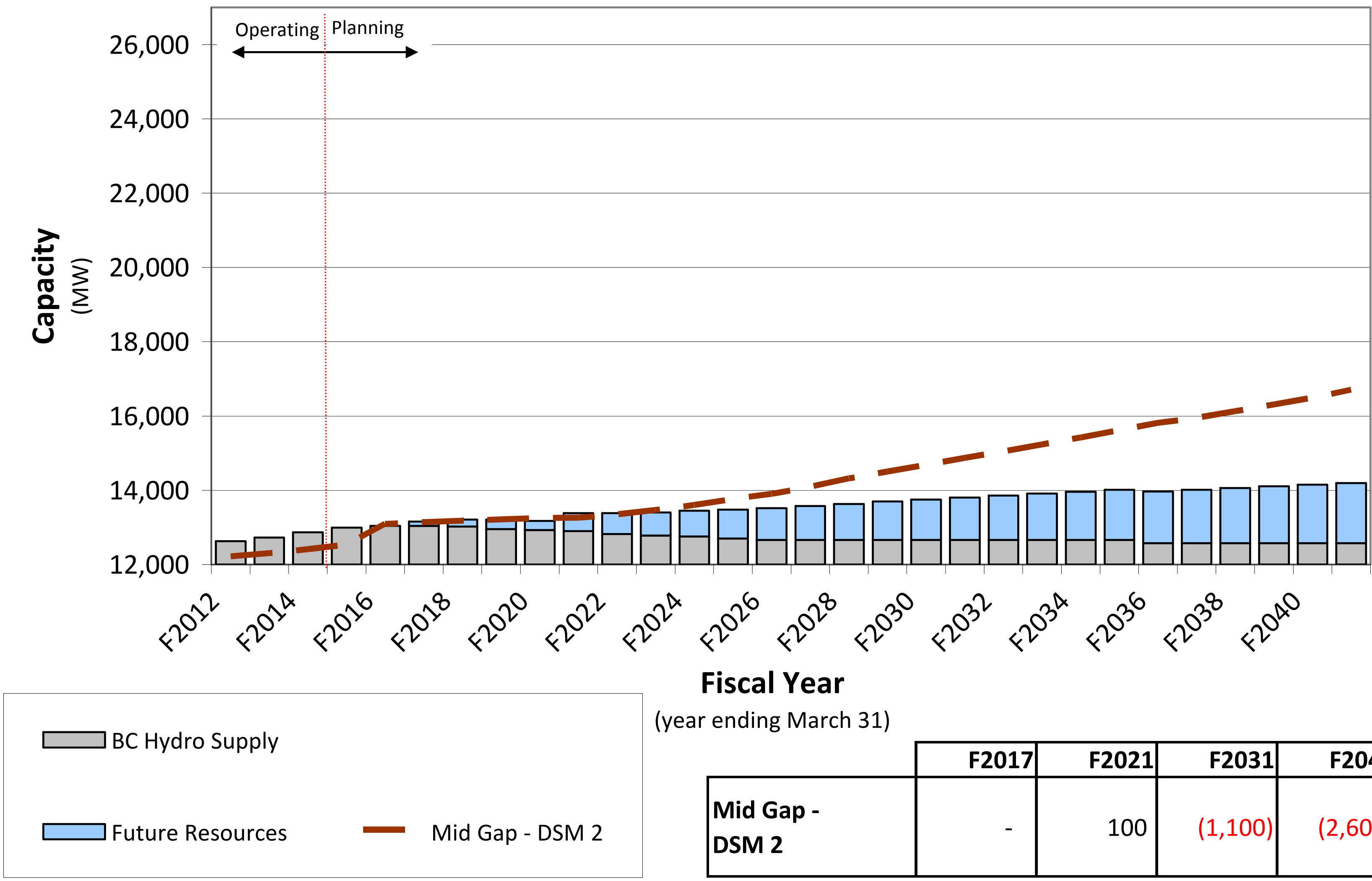
- Site C provides additional capacity allowing for more shaping and integration capability
- Updating wind limits
- What resources are available to integrate more wind, cost for those resources needs to be considered

CAPACITY ANALYSIS

KATHY LEE, LINDSAY FANE AND BASIL STUMBORG

CAPACITY: MID GAP WITHOUT SITE C (INTEGRATED SYSTEM)

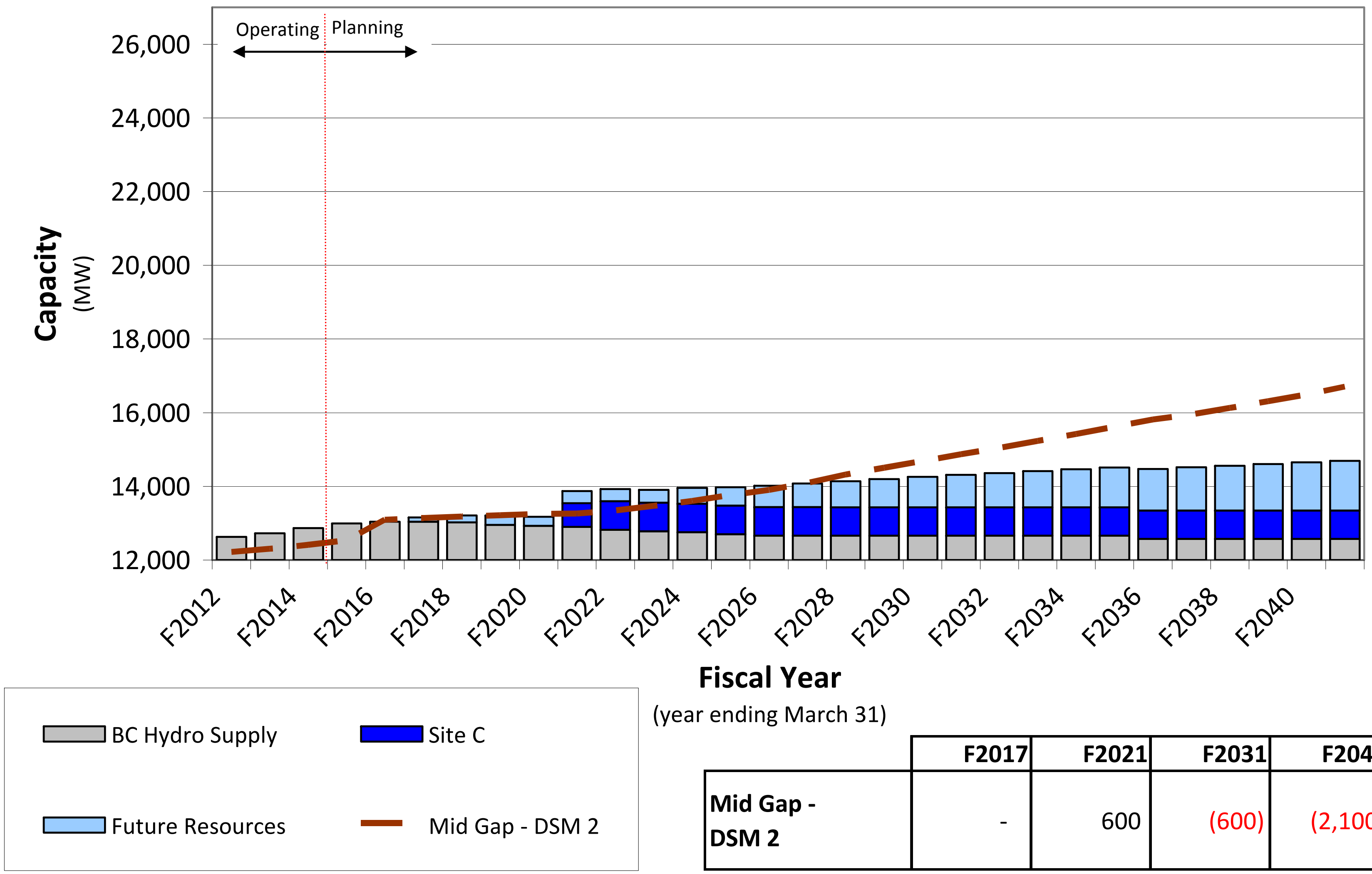
BChydro FOR GENERATIONS



	F2017	F2021	F2031	F2041
Mid Gap - DSM 2	-	100	(1,100)	(2,600)

CAPACITY: MID GAP WITH SITE C (INTEGRATED SYSTEM)

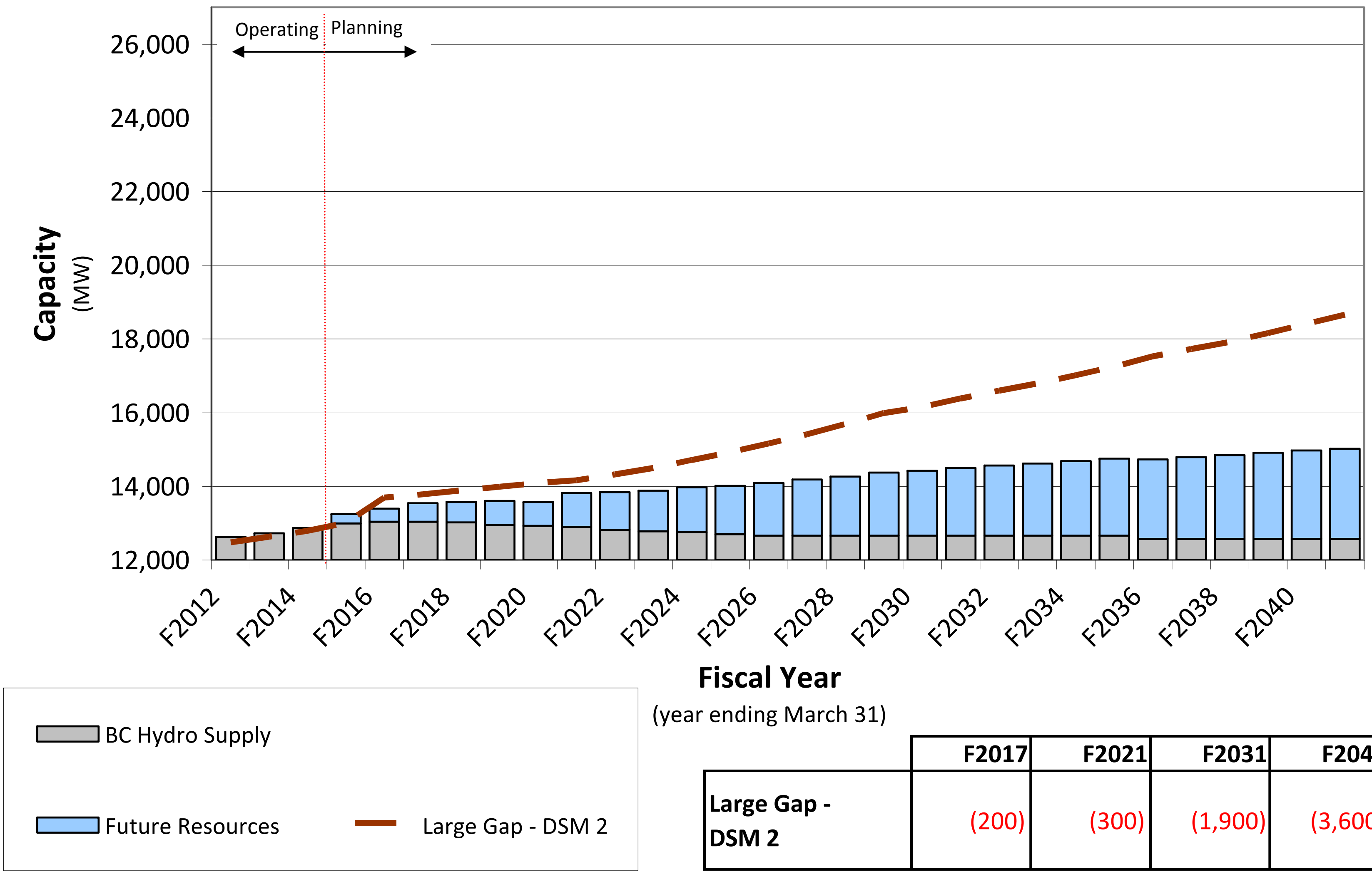
BC hydro FOR GENERATIONS



	F2017	F2021	F2031	F2041
Mid Gap - DSM 2	-	600	(600)	(2,100)

CAPACITY: CONTIGENCY RESOURCE PLAN (INTEGRATED SYSTEM WITHOUT SITE C)

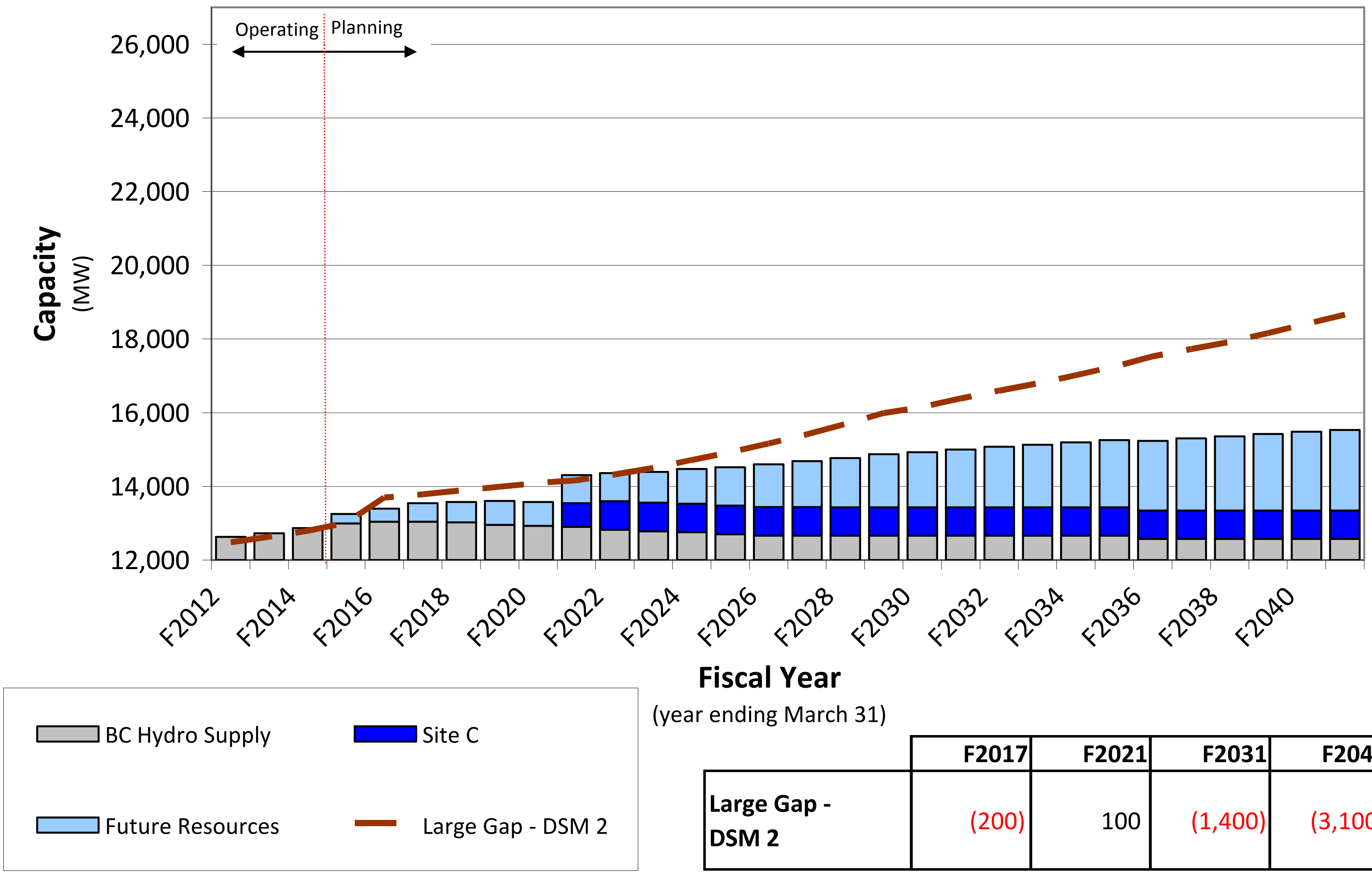
BC hydro FOR GENERATIONS



	F2017	F2021	F2031	F2041
Large Gap - DSM 2	(200)	(300)	(1,900)	(3,600)

CAPACITY: CONTIGENCY RESOURCE PLAN (INTEGRATED SYSTEM WITH SITE C)

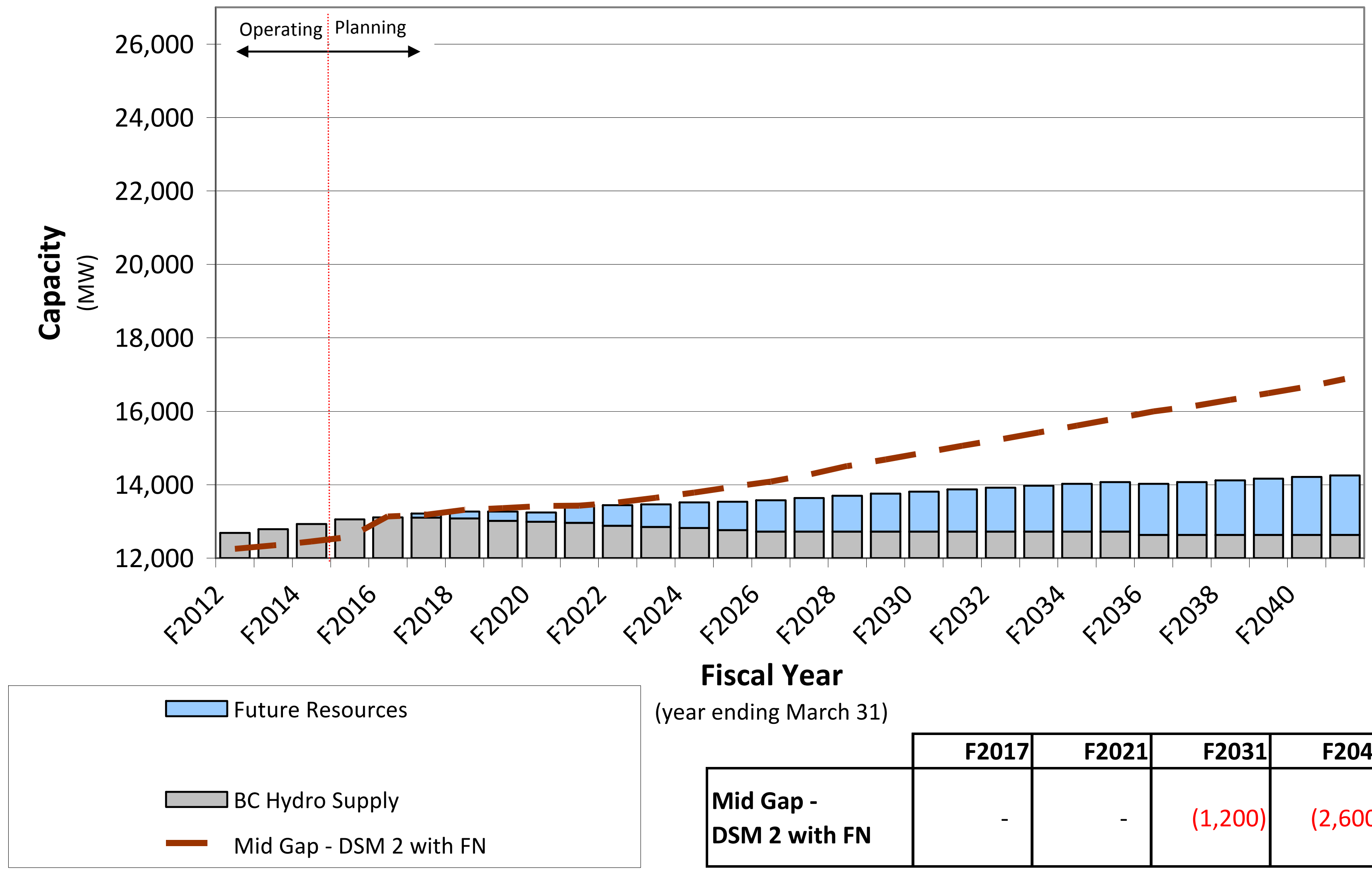
BChydro FOR GENERATIONS



	F2017	F2021	F2031	F2041
Large Gap - DSM 2	(200)	100	(1,400)	(3,100)

CAPACITY: MID GAP WITHOUT SITE C (INTEGRATE FORT NELSON)

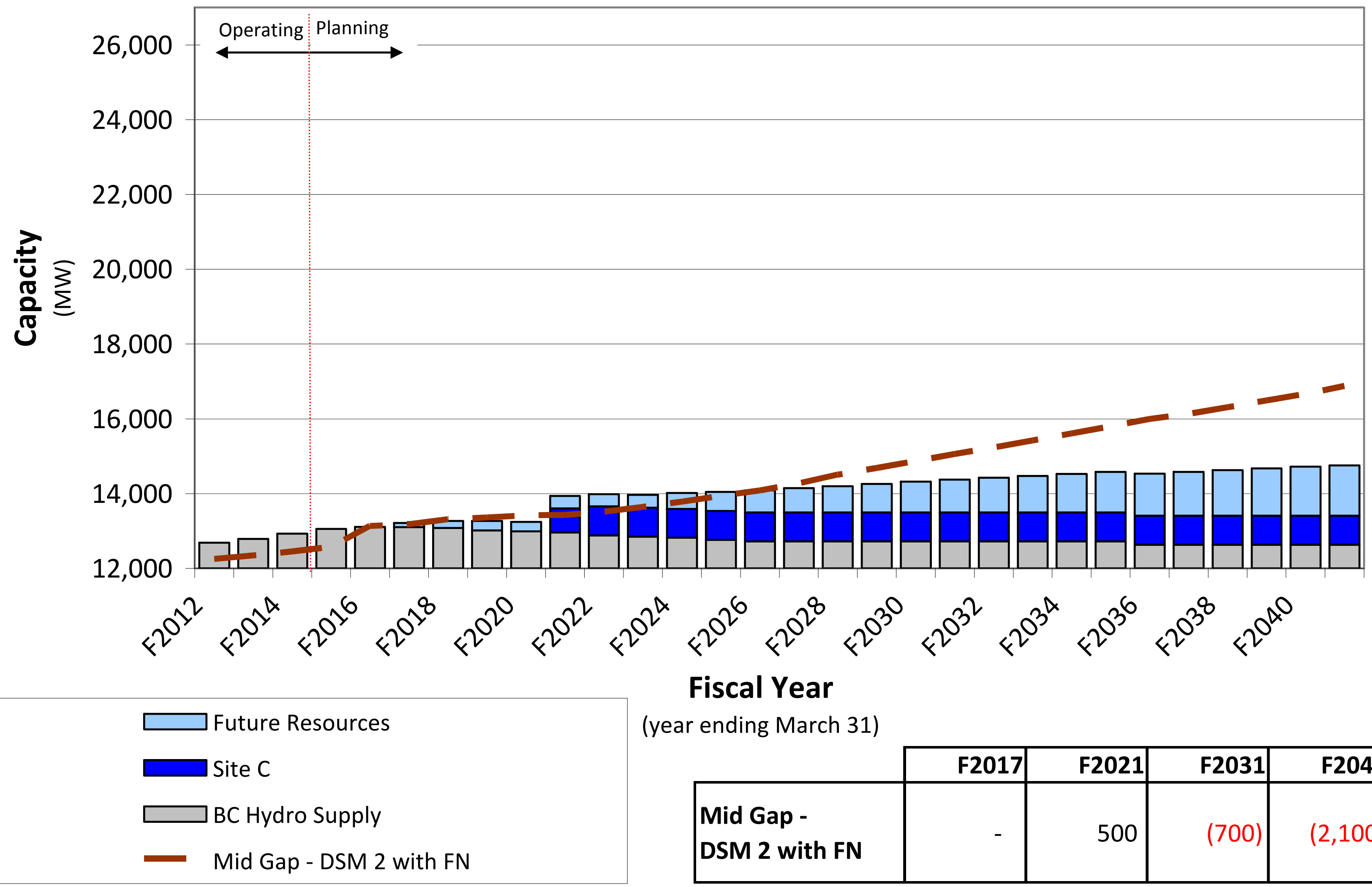
BChydro FOR GENERATIONS



	F2017	F2021	F2031	F2041
Mid Gap - DSM 2 with FN	-	-	(1,200)	(2,600)

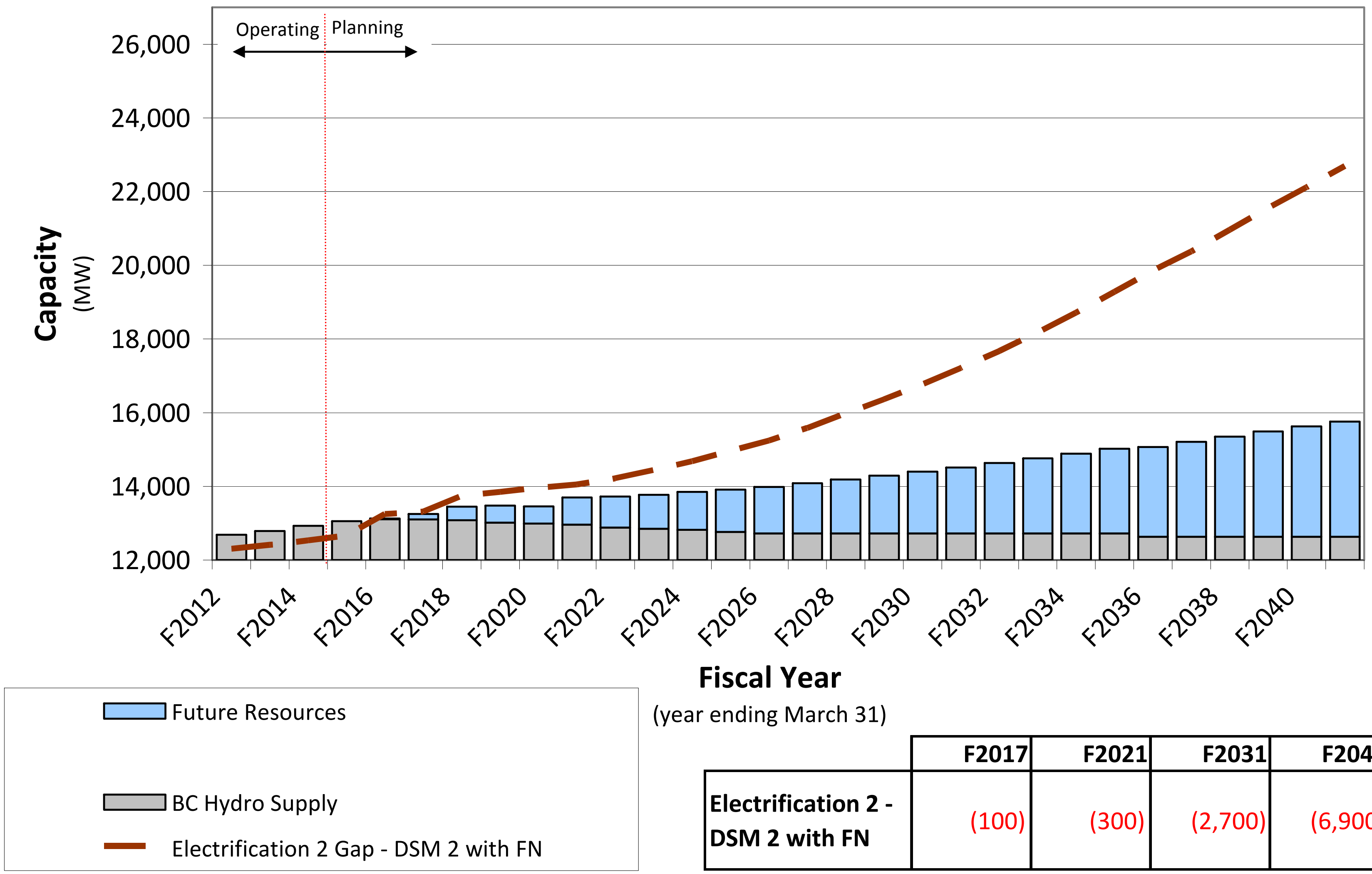
CAPACITY: MID GAP WITH SITE C (INTEGRATE FORT NELSON)

BChydro FOR GENERATIONS



	F2017	F2021	F2031	F2041
Mid Gap - DSM 2 with FN	-	500	(700)	(2,100)

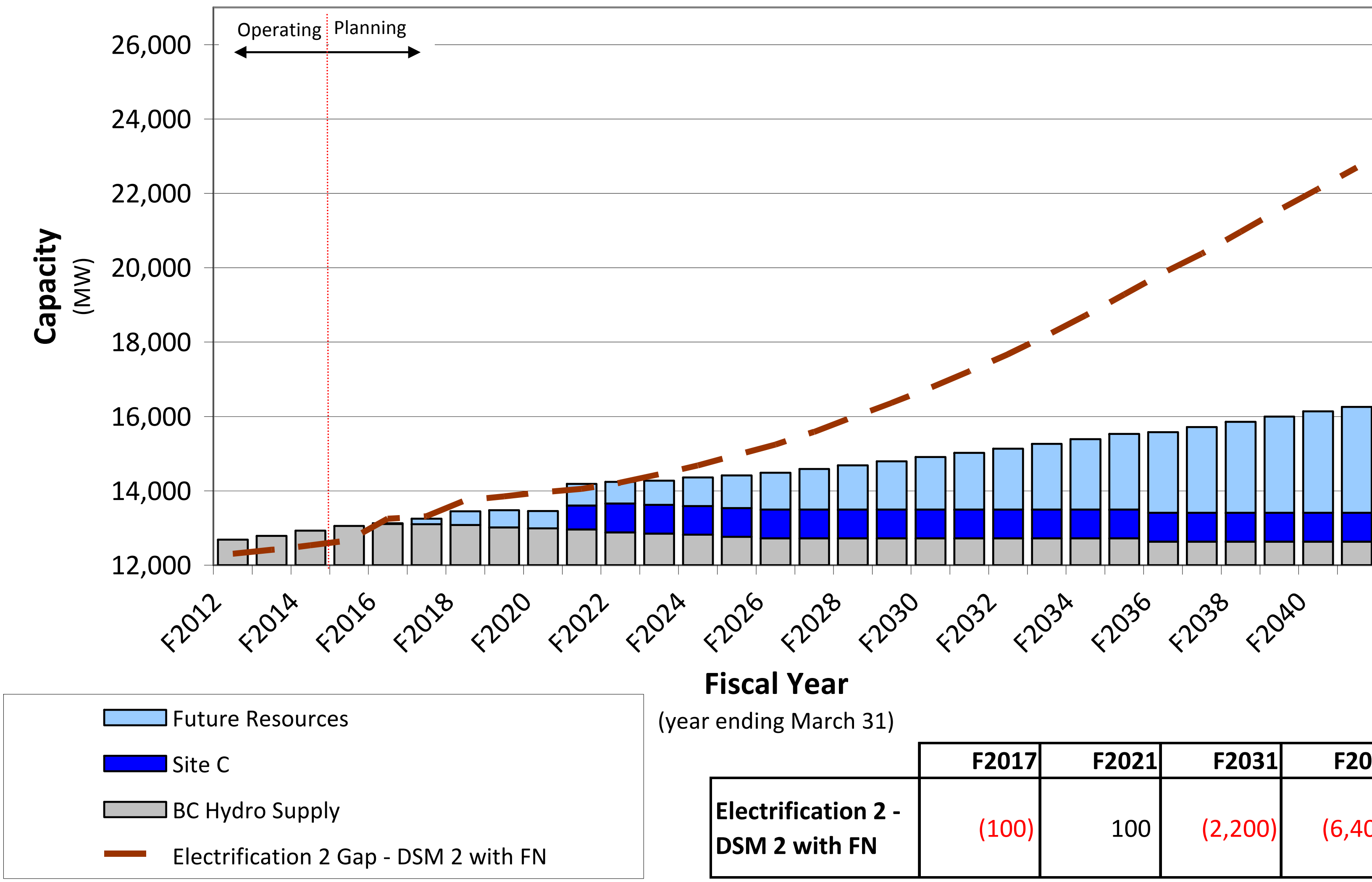
CAPACITY: ELECTRIFICATION 2 GAP (INTEGRATE FORT NELSON WITHOUT SITE C)



	F2017	F2021	F2031	F2041
Electrification 2 - DSM 2 with FN	(100)	(300)	(2,700)	(6,900)

CAPACITY: ELECTRIFICATION 2 GAP (INTEGRATE FORT NELSON WITH SITE C)

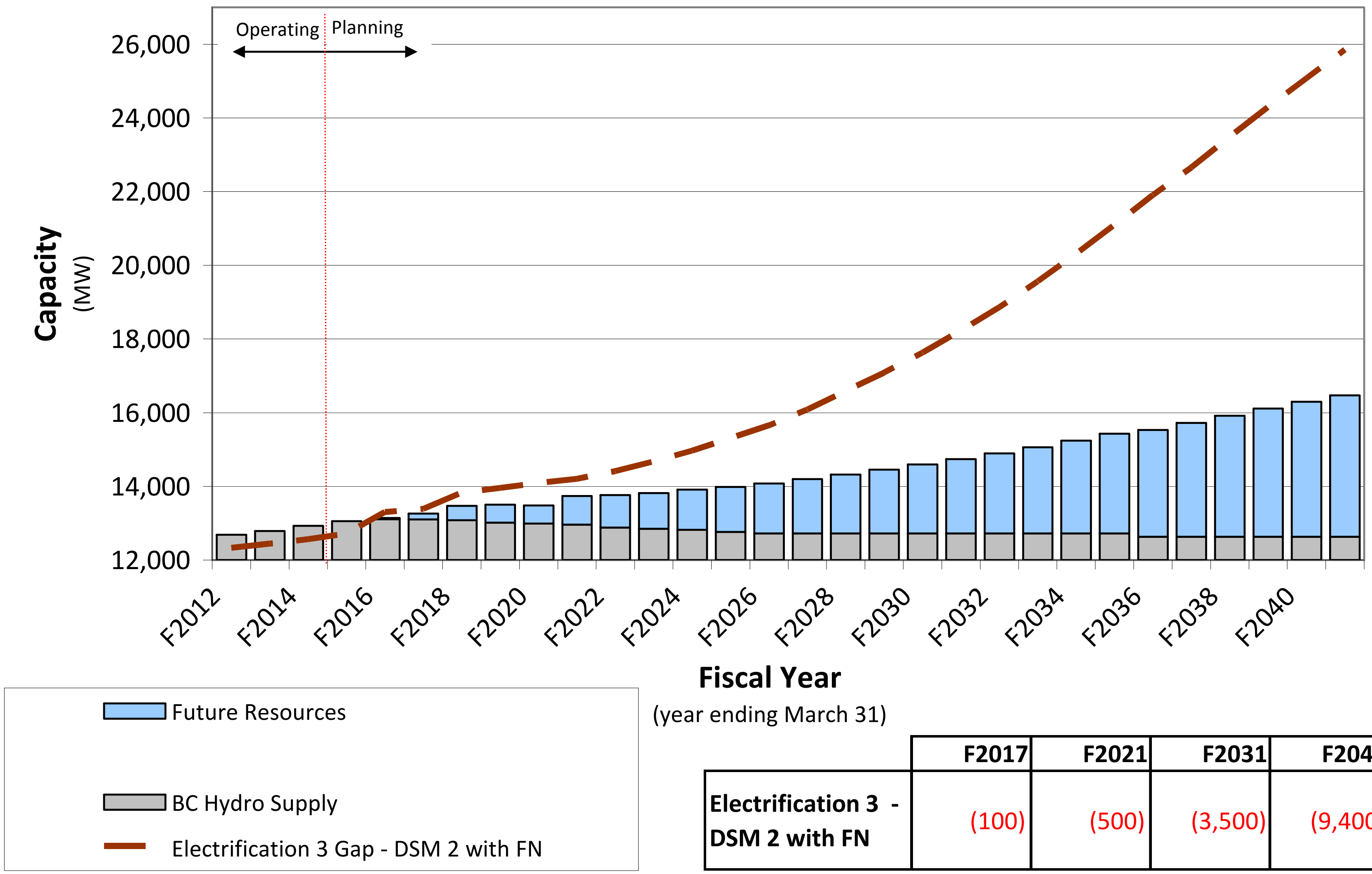
BC hydro FOR GENERATIONS



	F2017	F2021	F2031	F2041
Electrification 2 - DSM 2 with FN	(100)	100	(2,200)	(6,400)

CAPACITY: ELECTRIFICATION 3 GAP (INTEGRATE FORT NELSON WITHOUT SITE C)

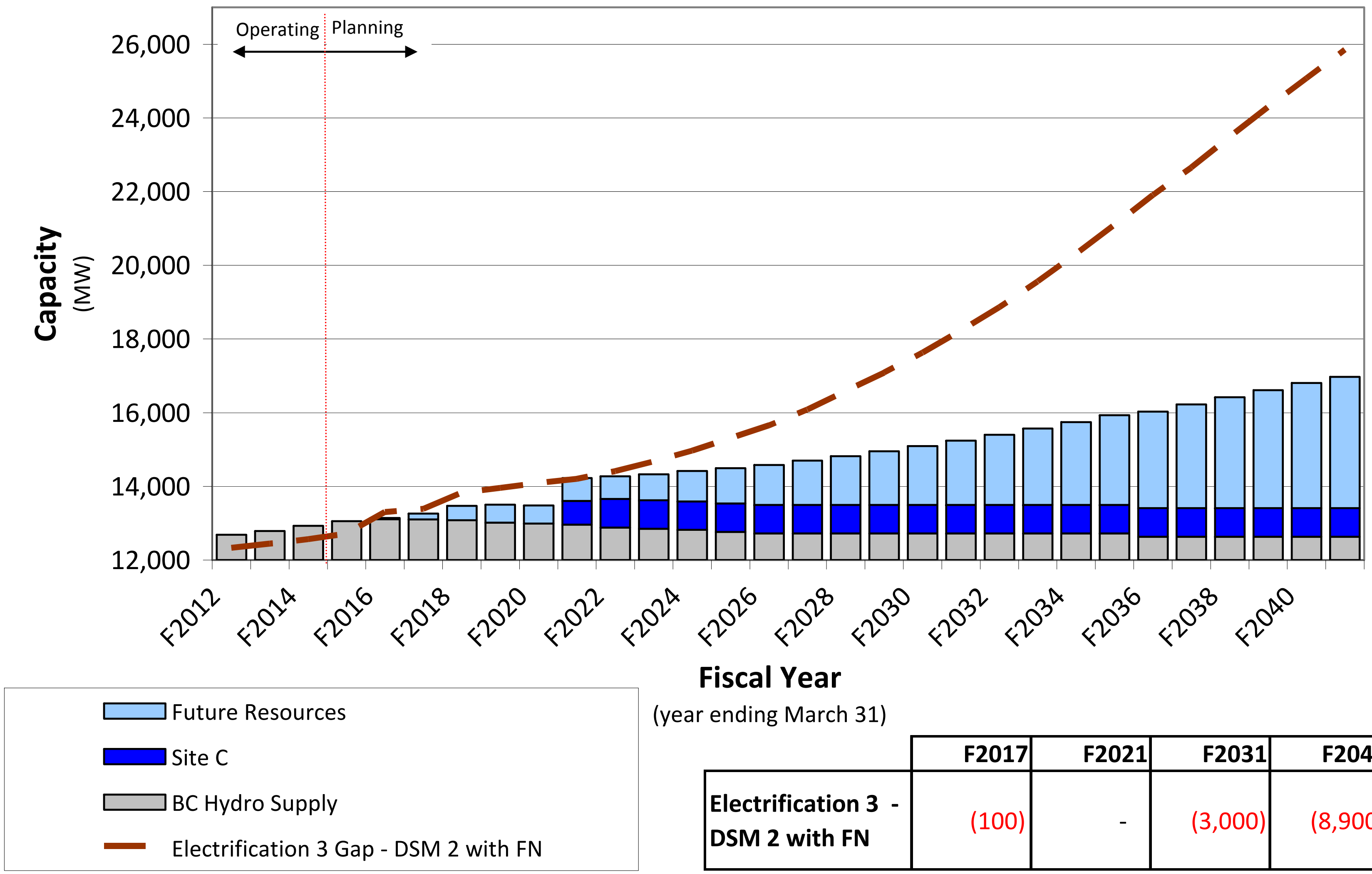
BC hydro FOR GENERATIONS



	F2017	F2021	F2031	F2041
Electrification 3 - DSM 2 with FN	(100)	(500)	(3,500)	(9,400)

CAPACITY: ELECTRIFICATION 3 GAP (INTEGRATE FORT NELSON WITH SITE C)

BC hydro FOR GENERATIONS

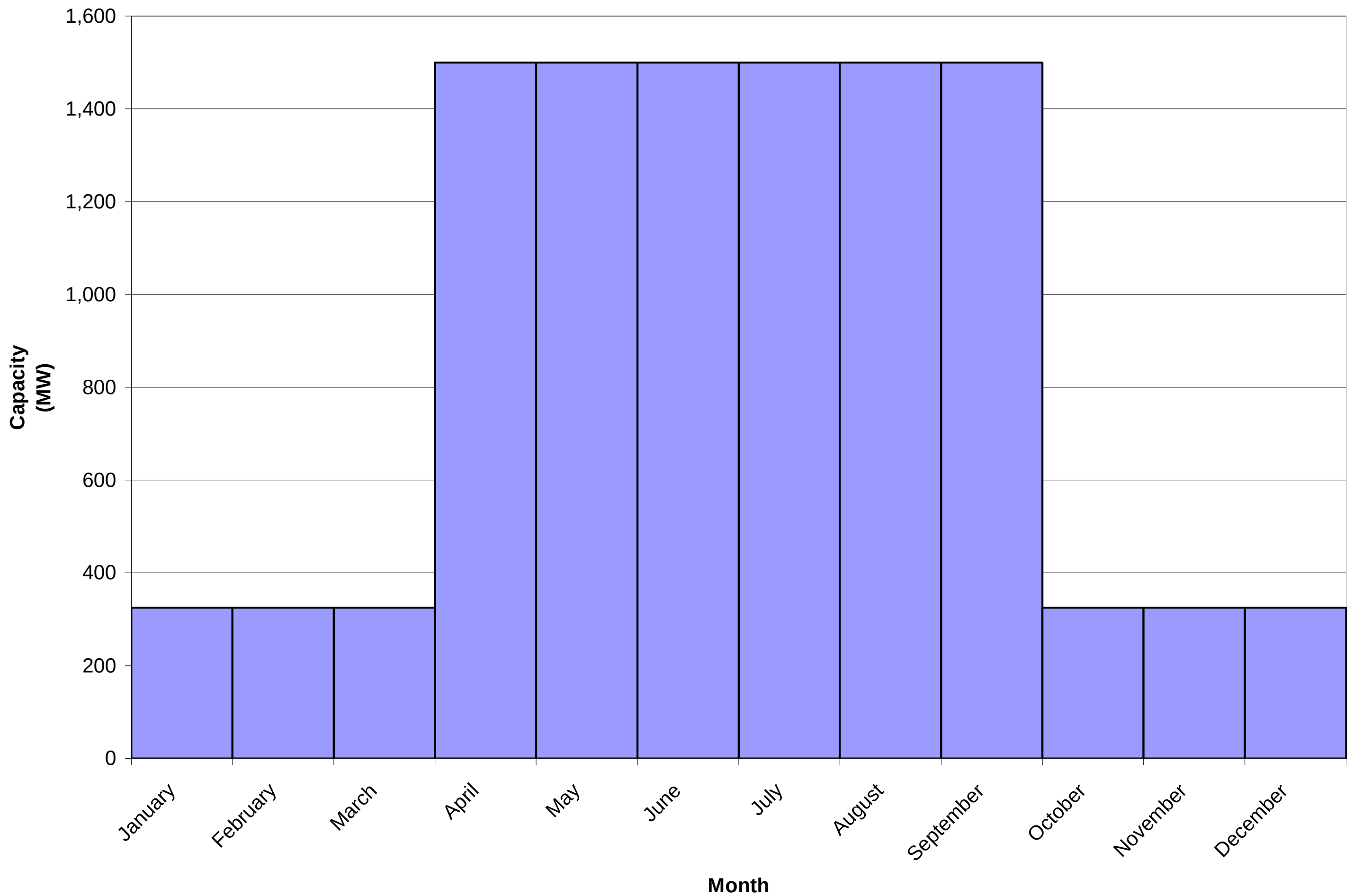


	F2017	F2021	F2031	F2041
Electrification 3 - DSM 2 with FN	(100)	-	(3,000)	(8,900)

EXPORT SHAPE
INCREMENTAL/AGGREGATED EXPORT

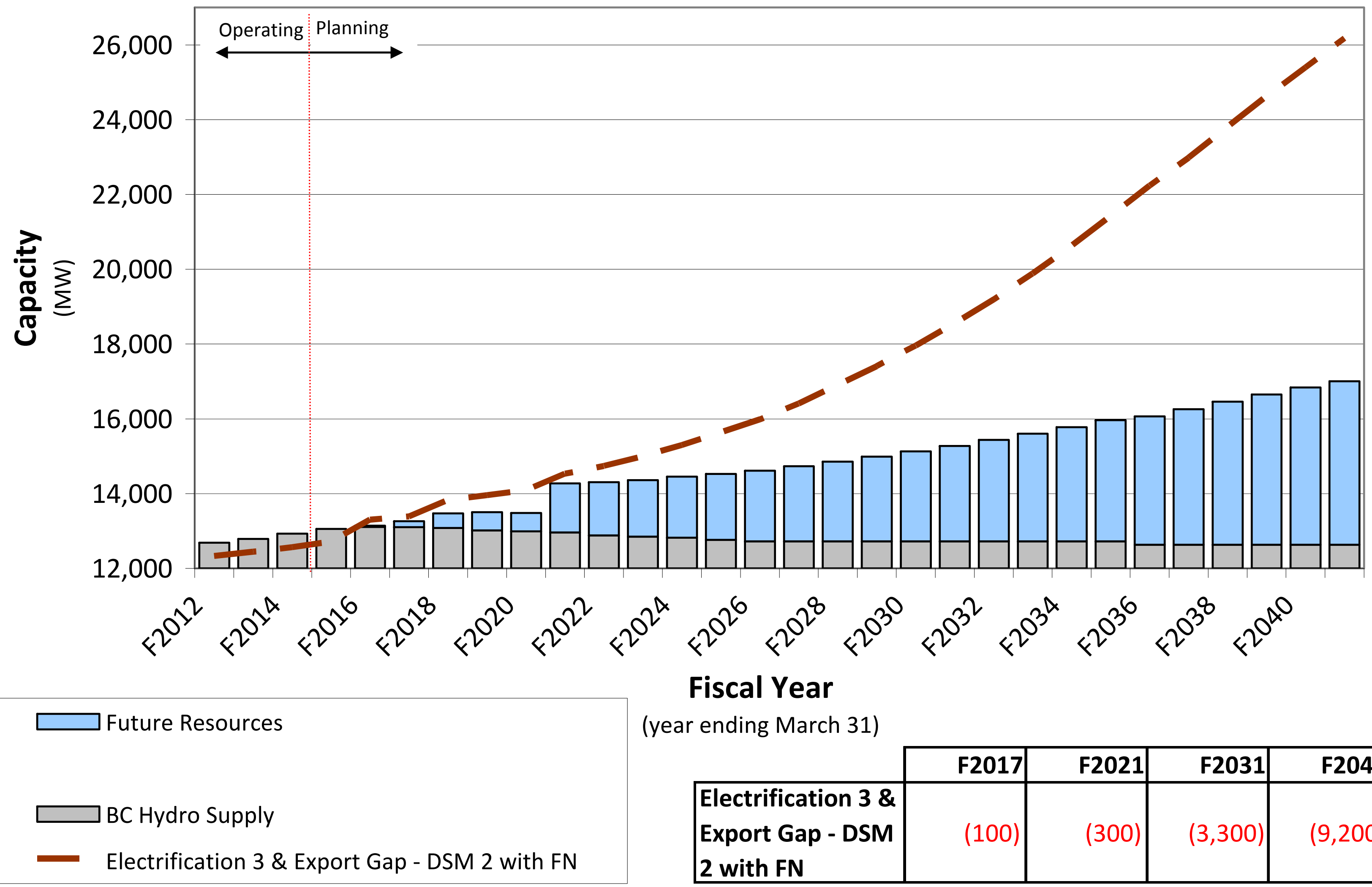
BC hydro FOR GENERATIONS

Export Shaped Profile: preferential profile to get rid of excess spring/early summer runoff and meet high demand in summer from biggest potential market buyer



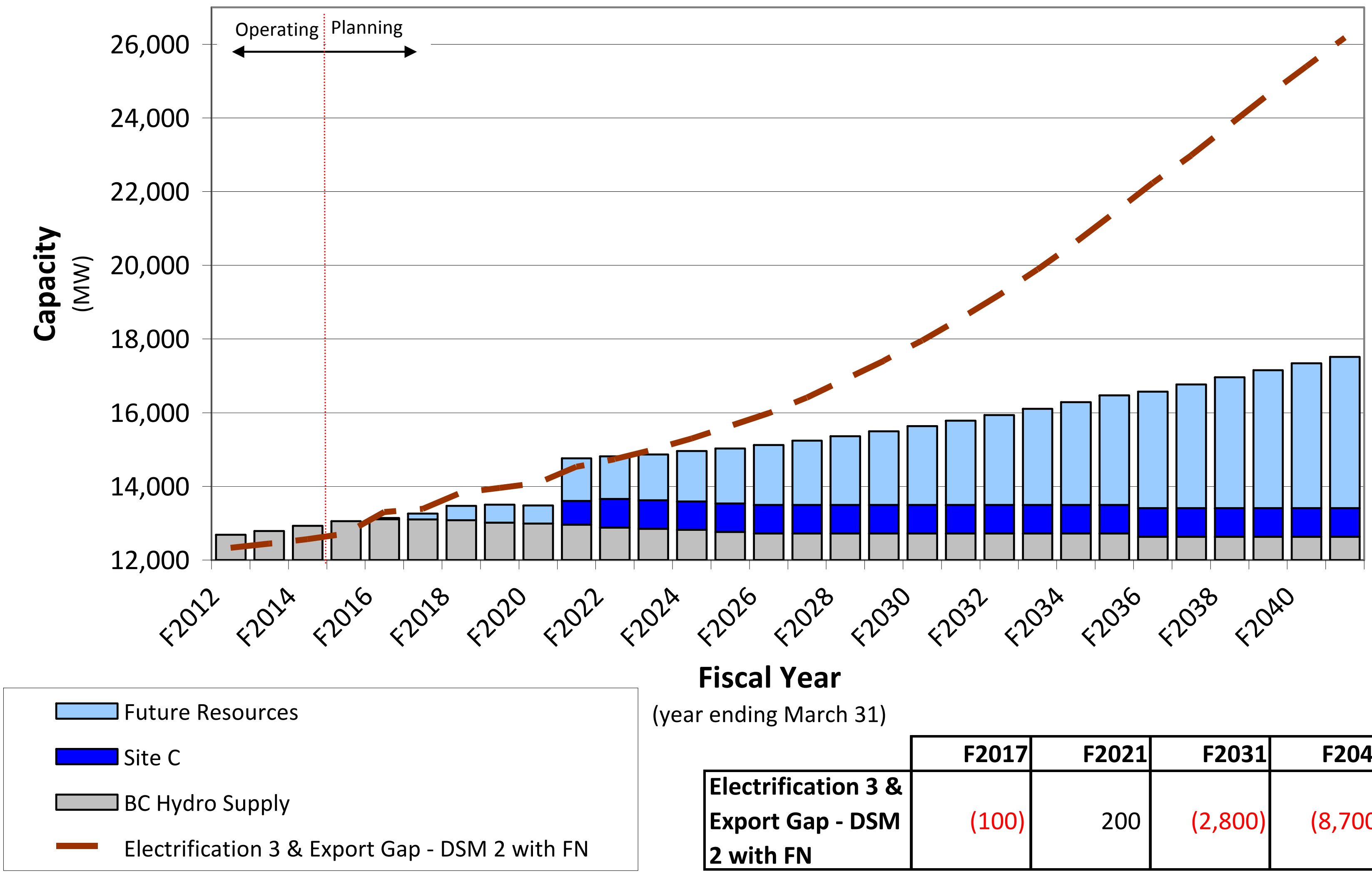
CAPACITY: ELECTRIFICATION 3 & EXPORT GAP (INTEGRATE FORT NELSON WITHOUT SITE C)

BC hydro FOR GENERATIONS



	F2017	F2021	F2031	F2041
Electrification 3 & Export Gap - DSM 2 with FN	(100)	(300)	(3,300)	(9,200)

CAPACITY: ELECTRIFICATION 3 & EXPORT GAP (INTEGRATE FORT NELSON WITH SITE C)



	F2017	F2021	F2031	F2041
Electrification 3 & Export Gap - DSM 2 with FN	(100)	200	(2,800)	(8,700)

CAPACITY: NEED

BC hydro FOR GENERATIONS

Uncertainties on need

- Peak load:
  - Typical load uncertainties (e.g. low and high load bands due to temperature and economic uncertainties)
  - electrification sensitivity
  - export
- Capacity savings from Energy Focused DSM
- Load shape changes
- Capacity from intermittent resources (e.g. wind)
- Wind integration
- Firming Tariff

CAPACITY OPTIONS

BChydro FOR GENERATIONS

Burrard

- No longer a reliance on energy
- Regulation M314: Burrard's capacity can be relied upon until Mica 5/6, ILM, 3rd Meridian transformer are in service
- Thereafter, Burrard capacity used for emergency only

- IRP: model full plant capacity (900 MW) until 2015 when all equipment expected to be in service

Canadian Entitlement

- Return of Canadian Entitlement capacity under provisions of Columbia River Treaty
- Does not qualify as a self sufficiency/generation facility in the province
- Agreement could be terminated in 2024

- IRP: 400 MW market reliance until 2015
  - Self Sufficiency requirement kicks in 2016, CE not considered as long term resource

CAPACITY OPTIONS

BC hydro FOR GENERATIONS

Supply side options (cost at project)

Option	Capacity (MW)	UCC * ($/kW-yr)	Description
Revelstoke Unit 6	500	55	Addition of 6th unit at Revelstoke GS
Mica Pumped Storage Unit	500	112	Addition of a pumped storage unit at Mica GS
SCGT – Kelly Nicola	100 (each unit)	71	New simple cycle gas turbine in Kelly Lake/Nicola region
Pumped Storage	500-1000 (each unit)	~100	New pumped storage developments at various sites, primarily in LM/VI region

* cost, not yet netted off benefits

CAPACITY OPTIONS

Demand side options (cost at customer's meter)

	Capacity Savings (MW)								UCC * ($/kW-yr)
	F2021				F2025				
	Initial est.	High	Mid	Low	Initial est.	High	Mid	Low	
Rates Incentives	203	250	168	96	385	475	320	183	25
Industrial Load Curtailment	395	446	383	312	395	446	383	312	47
Capacity Focused Programs	250	262	191	132	250	262	191	132	63

* based on initial est.

CAPACITY OPTIONS

BChydro FOR GENERATIONS

Key considerations:

- Cost and benefits
  - Supply side: Project cost, Transmission cost Vs Shaping benefits etc
  - Demand side: Cost Vs Benefits on the Regional Transmission and Distribution system etc
- Characteristics (availability, dispatchability, shaping capability, flexibility)
- Lead time
- Uncertainties:
  - Examples for Demand Side Options: Overlap savings between initiatives, Customer acceptance of many of the options etc.

CAPACITY OPTIONS: REV 6

Characteristics:

- Conventional technology (hydroelectric)
- Minimal footprint (incremental addition at existing GS)
- Long term source of supply (50+ years)
- Provides shaping (studies underway to quantify)
- Dispatchable with direct control
- Capable of automatic generation control operation

Lead time: 6 years (definition - 2 years, implementation - 4 years)

Uncertainties:

- Negligible uncertainty on the output
- Capital cost risk is medium, based on feasibility level study
- Overall development uncertainty is low

Possible next step:

- If need to hold earliest in service date of 2018 is identified, proceed with definition phase work.

CAPACITY OPTIONS: MICA PUMPED STORAGE

BChydro FOR GENERATIONS

Characteristics:

- Conventional technology (hydroelectric using reversible pump/turbines)
- Pump mode transfers water from Revelstoke reservoir to Mica reservoir
- Generate mode transfers water from Mica reservoir to Revelstoke reservoir
- 30% energy loss on pump/generate cycle
- Provides seasonal shaping and spill reduction (studies underway to quantify)
- Dispatchable with direct control
- Capable of AGC operation
- Negligible footprint (incremental addition at existing GS).
- Long term source of supply (50+ years)

Lead time: 6 years (definition - 2 years, implementation - 4 years)

CAPACITY OPTIONS: MICA PUMPED STORAGE

BC hydro FOR GENERATIONS

Uncertainties:

- Negligible uncertainty on the output
- Capital cost risk is high, based on pre-feasibility level of study
- Overall development uncertainty is medium

Possible next step:

- If needed, proceed with definition phase work (feasibility study) to firm up design and cost estimates.

CAPACITY OPTIONS: PUMPED STORAGE

BC hydro FOR GENERATIONS

Characteristics:

- Conventional technology (hydroelectric using reversible pump/turbines)
- Pump mode transfers water from lower watercourse to upper reservoir
- Generate mode transfers water from upper reservoir to lower watercourse
- 30% energy loss on pump/generate cycle
- Provides daily shaping
- Dispatchable with direct control
- Capable of AGC operation
- Greenfield sites, some with significant footprints
- Long term source of supply (50+ years).

Lead time: 8 years (identification/definition - 3 years, implementation - 5 years)

CAPACITY OPTIONS: PUMPED STORAGE

BC hydro FOR GENERATIONS

Uncertainties:

- Output uncertainty: Negligible
- Capital cost risk is high, based on survey level study.
- Permitting risks will likely vary considerably amongst sites but considered high because of no prior example in BC
  - Particularly high permitting risks in LM/VI areas where capacity is most valuable
- Overall development uncertainty is high

Possible next step:

- If needed, proceed with definition phase work (pre-feasibility studies) on a selected group of sites.

CAPACITY OPTIONS: SIMPLE CYCLE GAS TURBINE

BC hydro FOR GENERATIONS

Characteristics:

- Conventional technology (large aero-derivative gas turbines)
- Dispatchable on short notice with direct control
- Greenfield sites having small footprint
- GHG emissions of ~480 tonnes/GWh
- Can site near existing infrastructure (substations, water supplies, gas pipelines).
- Long term source of supply (30+ years)

Lead time: 5 years (definition - 2 years, implementation - 3 years)

Uncertainties: as discussed in Role of Gas section

Possible next step:

- If needed, proceed with definition phase work to firm up siting, design and cost estimates.

CAPACITY OPTIONS: RATE INCENTIVES

BC hydro FOR GENERATIONS

Characteristics:

- Concept:
  - Rate structures to encourage customers for reducing their electricity consumption during on-peak periods and/or shifting their electricity consumption to off peak periods
- Assumptions considered in IRP analysis:
  - Voluntary participation
  - Target winter months and evening peak hours
  - Saving estimates include residential, commercial and industrial components
  - Energy neutral – expects electricity consumption during off peak periods to go up
- Other:
  - Non-dispatchable, no direct control (passive)
  - Long term source of capacity (20+ years)

CAPACITY OPTIONS: RATE INCENTIVES

BC hydro FOR GENERATIONS

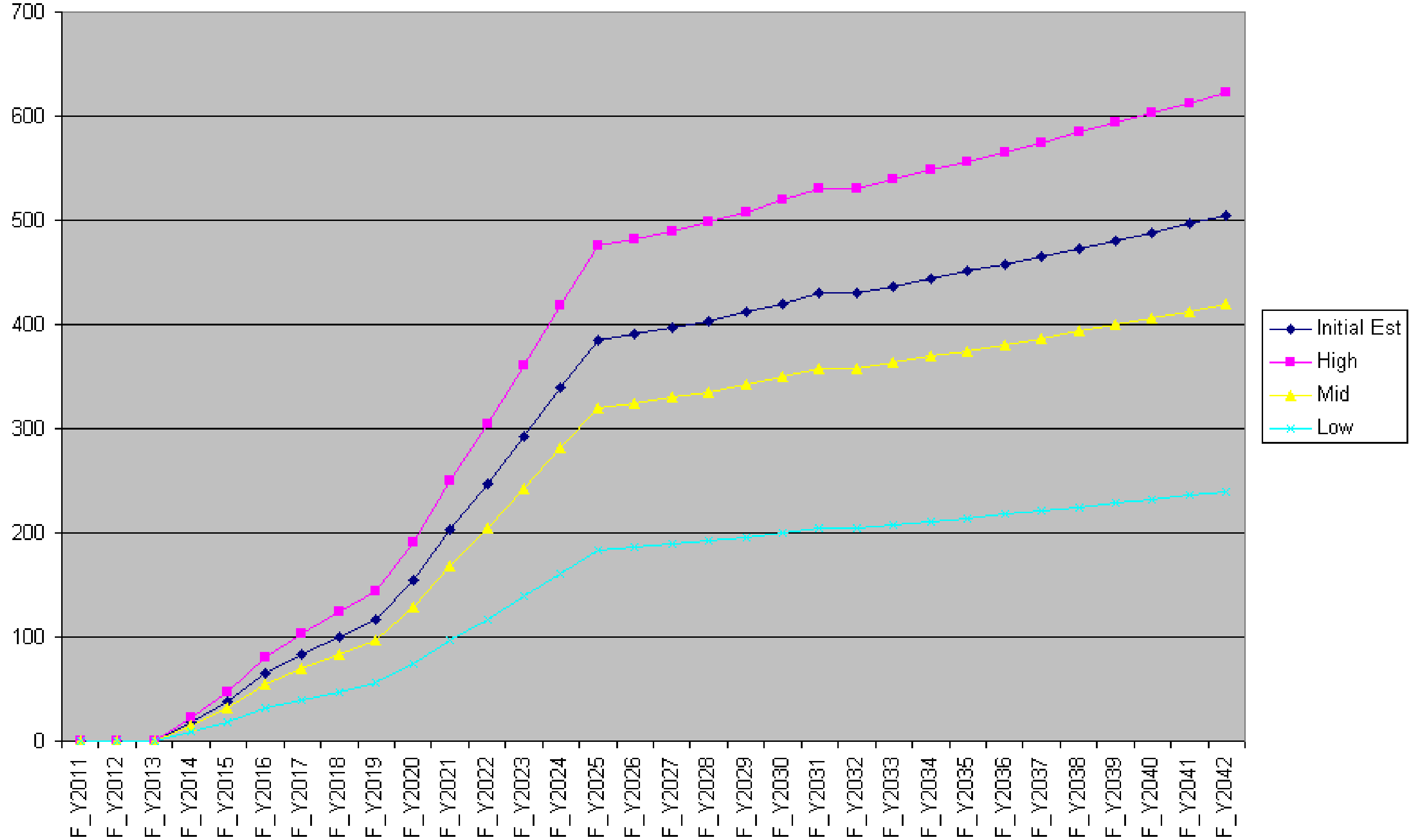
Key uncertainties assessed:

- Customer participation rates (difficult to predict for voluntary program)
- Savings per participant/ Participant response to rate structure (elasticity)
- Overlap with programs

CAPACITY OPTIONS: RATE INCENTIVES

BC hydro FOR GENERATIONS

Uncertainty assessment of Capacity Focused DSM Option A: Rate Incentives



CAPACITY OPTIONS: RATE INCENTIVES

Uncertainties continued:

- Risk adjusted values show large variations are possible (based on current assessment/ limited knowledge)
- Effectiveness:
  - Secondary system peaks might occur outside target period (e.g. AM peak) or due to load shifted
- Costs are based on preliminary planning estimates
- Further uncertainty on regional savings

Possible next step:

- If needed, could proceed with:
  - End use studies to refine estimates of achievable savings
  - Apply to BCUC to implement and assess customer response
  - Others?

CAPACITY OPTIONS: INDUSTRIAL LOAD CURTAILMENT

Characteristics

- Concept:
  - Load curtailment program:
    - Targets large industrial customers who agree to curtail load on short notice in return for a financial payment (in the context of a long term program, via contracts)
  - Modified demand rate (RS 1852):
    - Existing rate redesigned to encourage load curtailment during evening peak
- Other
  - Dispatchable
  - Customer imposed limitations on notice requirements, frequency/duration of curtailment calls, recovery times
  - Long term source of capacity (10-20 years)
  - No system shaping benefits anticipated

CAPACITY OPTIONS: INDUSTRIAL LOAD CURTAILMENT

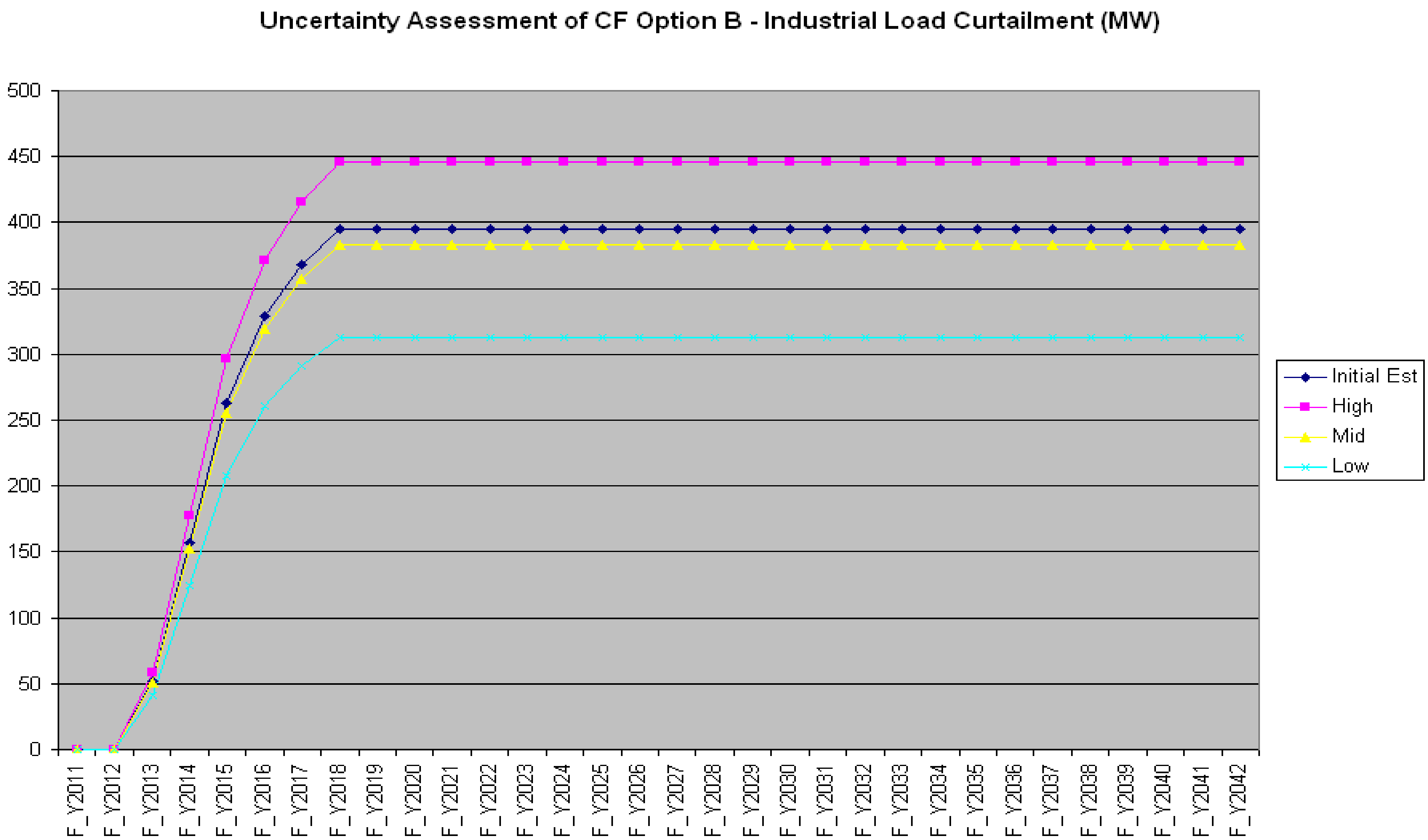
BC hydro FOR GENERATIONS

Key uncertainties assessed:

- Changes in the customer-mix over time
- Ability of the customers to provide demand relief over many years (needed for long-term planning purposes)

CAPACITY OPTIONS: INDUSTRIAL LOAD CURTAILMENT

BC hydro FOR GENERATIONS



CAPACITY OPTIONS: INDUSTRIAL LOAD CURTAILMENT

BC hydro FOR GENERATIONS

Uncertainties:

- Risk-adjusted values show moderate variations are possible (based on current risk assessment/limited knowledge)
- Participation:
  - Unclear on extent to which customers will commit to long term arrangements
- Effectiveness:
  - Customer-imposed limitations on notice/frequency/duration for curtailment calls may reduce effectiveness
- Costs and quantities uncertainty (preliminary estimates)

Possible next step:

- If needed, could proceed with:
  - Discussions with customers to define curtailment parameters (quantities, notice times, call frequency, call duration)
  - Further analysis of load profile changes and interaction effects with other capacity DSM programs
  - Refinement of cost estimates
  - Others?

CAPACITY OPTIONS:
CAPACITY FOCUSED PROGRAMS

BC hydro FOR GENERATIONS

Characteristics:

- Concept
  - Provide capacity savings via load control programs with customers
  - Mix of some local control (timers, thermostats) (passive controls) and some utility control via signals sent to smart meters (active controls)
  - Main end uses targeted include: water heating, space hearting, lighting and certain industrial loads
- Implementation
  - Payments will include costs for customer equipment plus participation incentives
  - Would complement rate incentives
  - Includes residential, commercial and industrial components

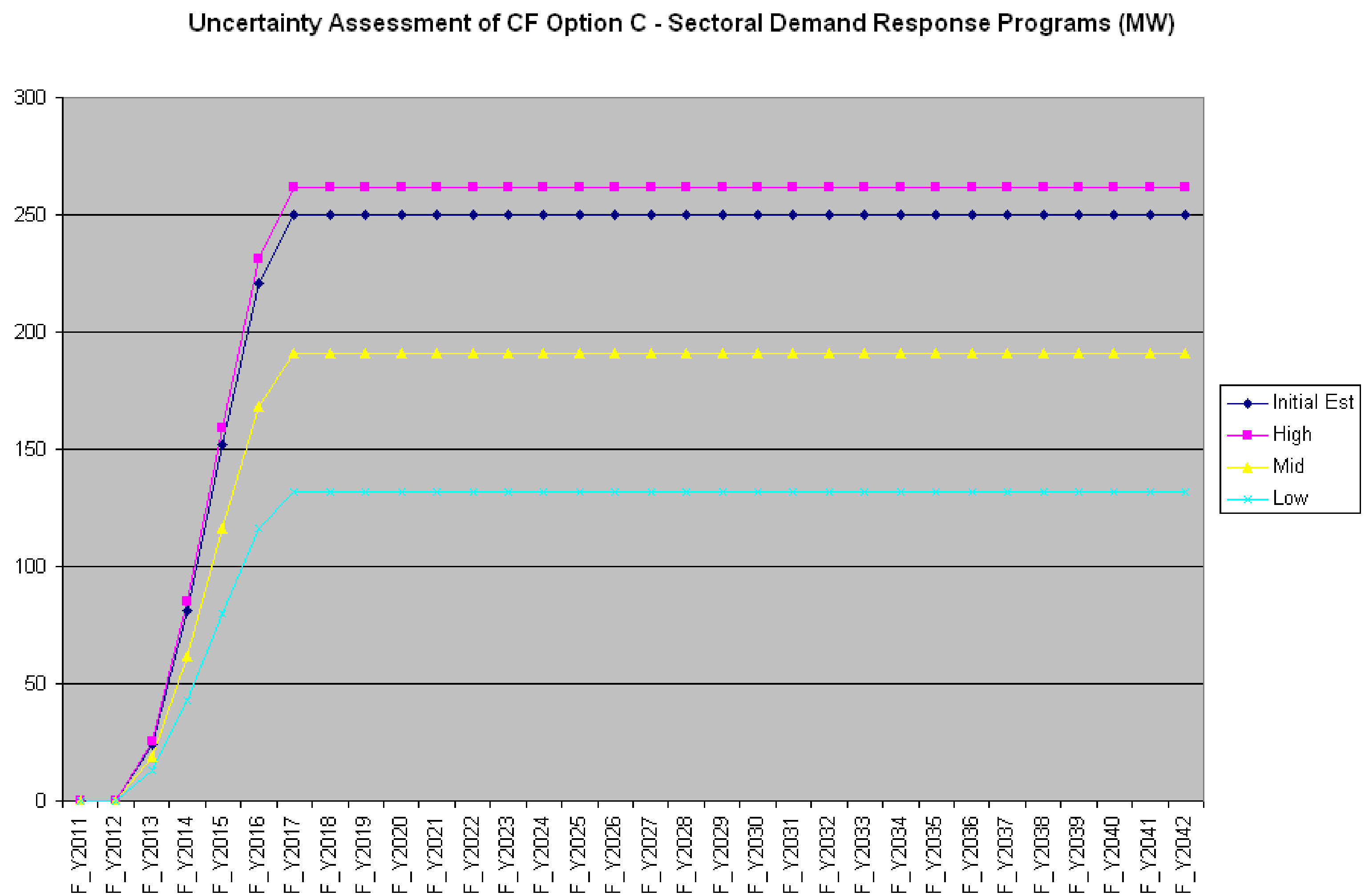
CAPACITY-FOCUSED PROGRAMS

Key uncertainties assessed:

- Residential Programs
  - Participation and savings for space heating
- Commercial
  - Lack of direct knowledge around exactly what activities would be undertaken by customers
  - Quantity of flexible load for shifting is not clear
- Industrial
  - Potential of processes / end-uses that can be controlled
  - Willingness of customers to participate

CAPACITY-FOCUSED PROGRAMS

BC hydro FOR GENERATIONS



CAPACITY OPTIONS: CAPACITY FOCUSED PROGRAMS

BC hydro FOR GENERATIONS

Uncertainties:

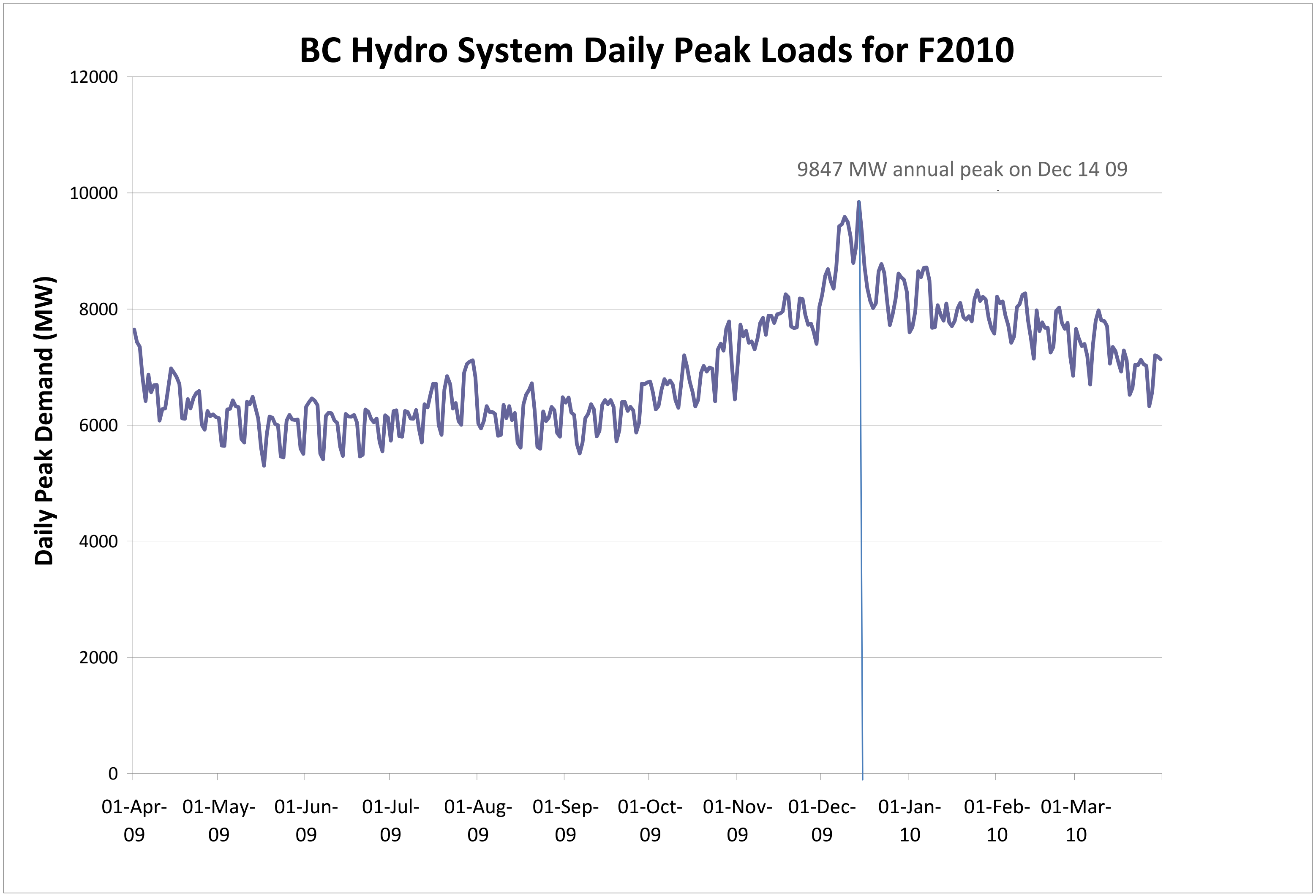
- Risk-adjusted values show large variations are possible (based on current risk assessment/limited knowledge)
- Participation:
  - Unclear on extent to which customers will commit to long term arrangements
- Effectiveness:
  - Analysis not completed to assess potential to reduce system peak loads when combined with other demand side options
- Cost and savings estimates are based on preliminary planning information
- Further uncertainty on regional savings

Possible next step:

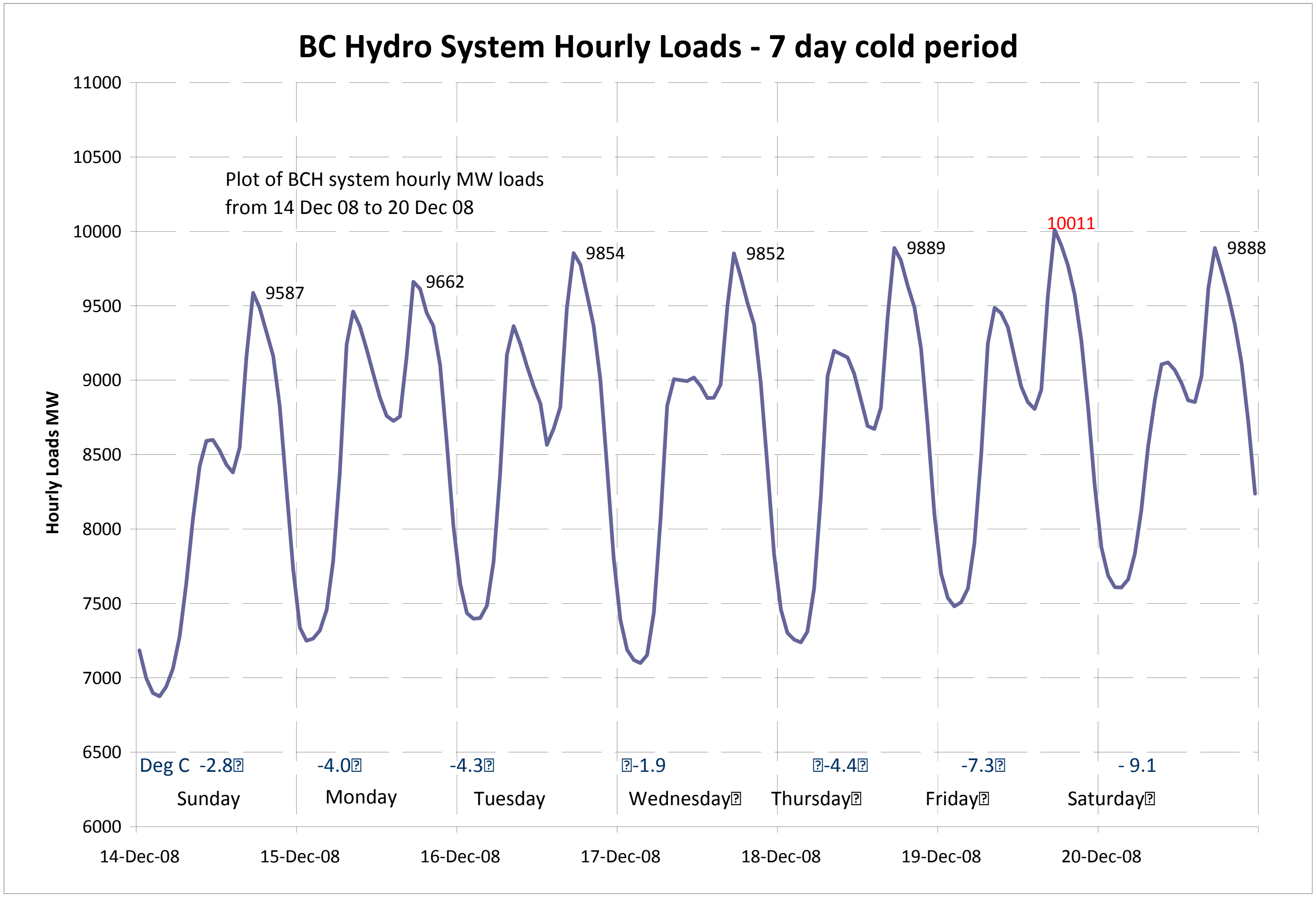
- If needed, could proceed with:
  - Discussions with customers to determine expected participation and refine information on types of end uses that may be controlled
  - Rolling out programs to assess customer response and facilitate planning
  - Others?

CAPACITY: DAILY PEAK

BC hydro
FOR GENERATIONS



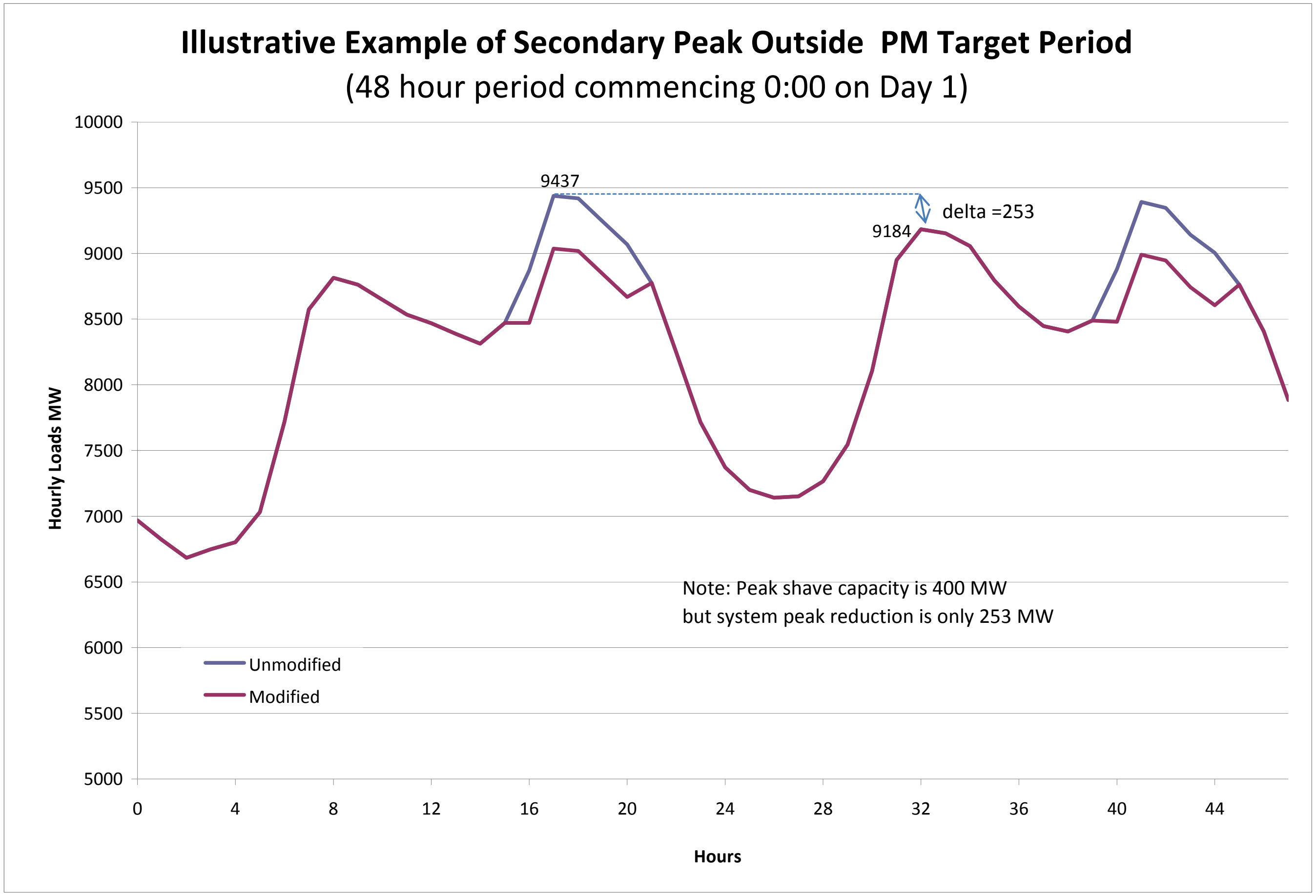
CAPACITY: COLD PERIOD



CAPACITY: EFFECTIVENESS SECONDARY PEAK

BC hydro FOR GENERATIONS

- Target period
- Load shape change



CAPACITY: EFFECTIVENESS, LIMITED CURTAILMENT CALLS

BChydro FOR GENERATIONS