Northwest **Power** and **Conservation** Council

March 5, 2015

MEMORANDUM

TO: Council Members

FROM: Tom Eckman

SUBJECT: Additional Background Materials for Scenario Input Assumptions

Attached are two PowerPoint presentations that will be used at the Power Committee meeting to provide additional background for the committee's discussion of scenarios and input assumptions for the 7th Plan. One PowerPoint presentation addresses the alternative assumptions that could be used for 7th Plan development regarding the potential impact of climate change on regional loads and hydro system output. The second PowerPoint summarizes the major inputs and policy assumptions to the RPM that could significant impact results. This PowerPoint lists those inputs on which the Council has already provided guidance and those the staff will request Council guidance on at the March meeting.

The final attachment, the "RPM Input Matrix" summarizes all of the primary inputs and decision criteria used by the RPM and the staff recommendations regarding these inputs. While these will also be discussed at the March meeting, they are largely for reference.

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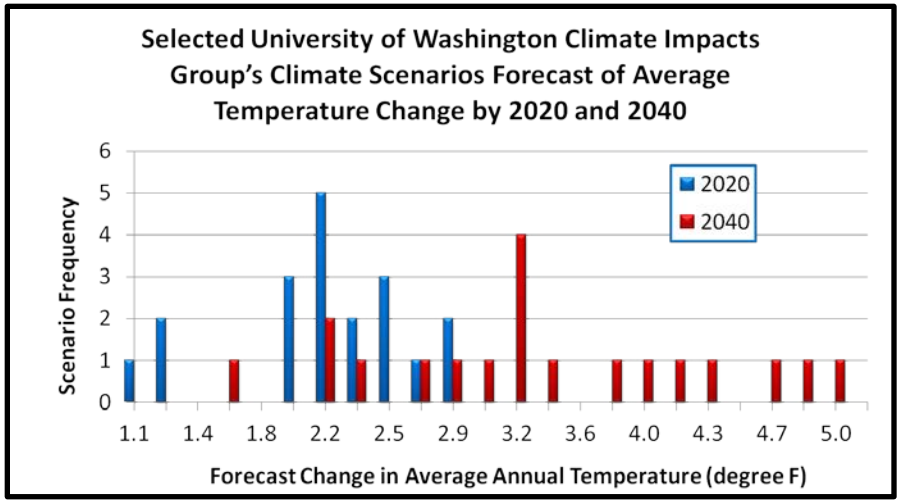
Options for Incorporating Potential Impacts of Climate Change in the 7th Plan Scenario Analysis

Issue:
How Should the 7th Plan Address Potential Climate Change in Scenario Analysis?

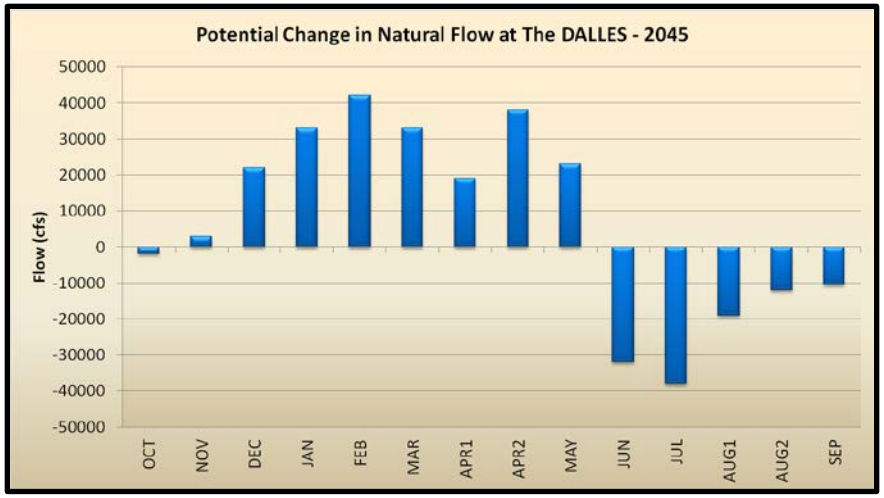
Tom Eckman
Massoud Jourabchi
John Fazio
Ben Kujala

Three Major Potential Impacts

Increased average annual temperatures



Changes in the timing of run-off



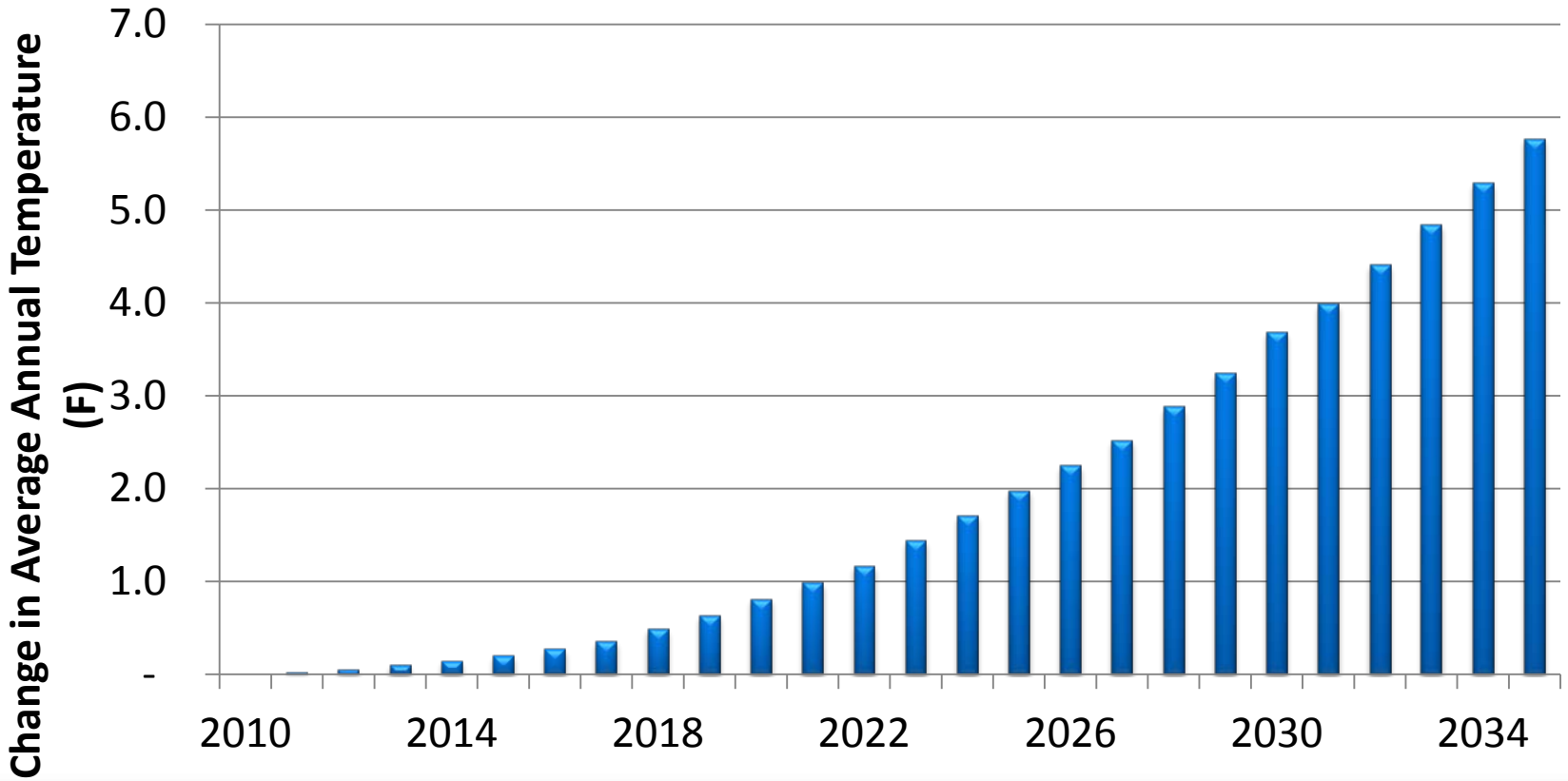
Increased in-migration and associated economic growth from "climate refugees."

A recent Op-Ed in LA Times may reveal an upcoming trend

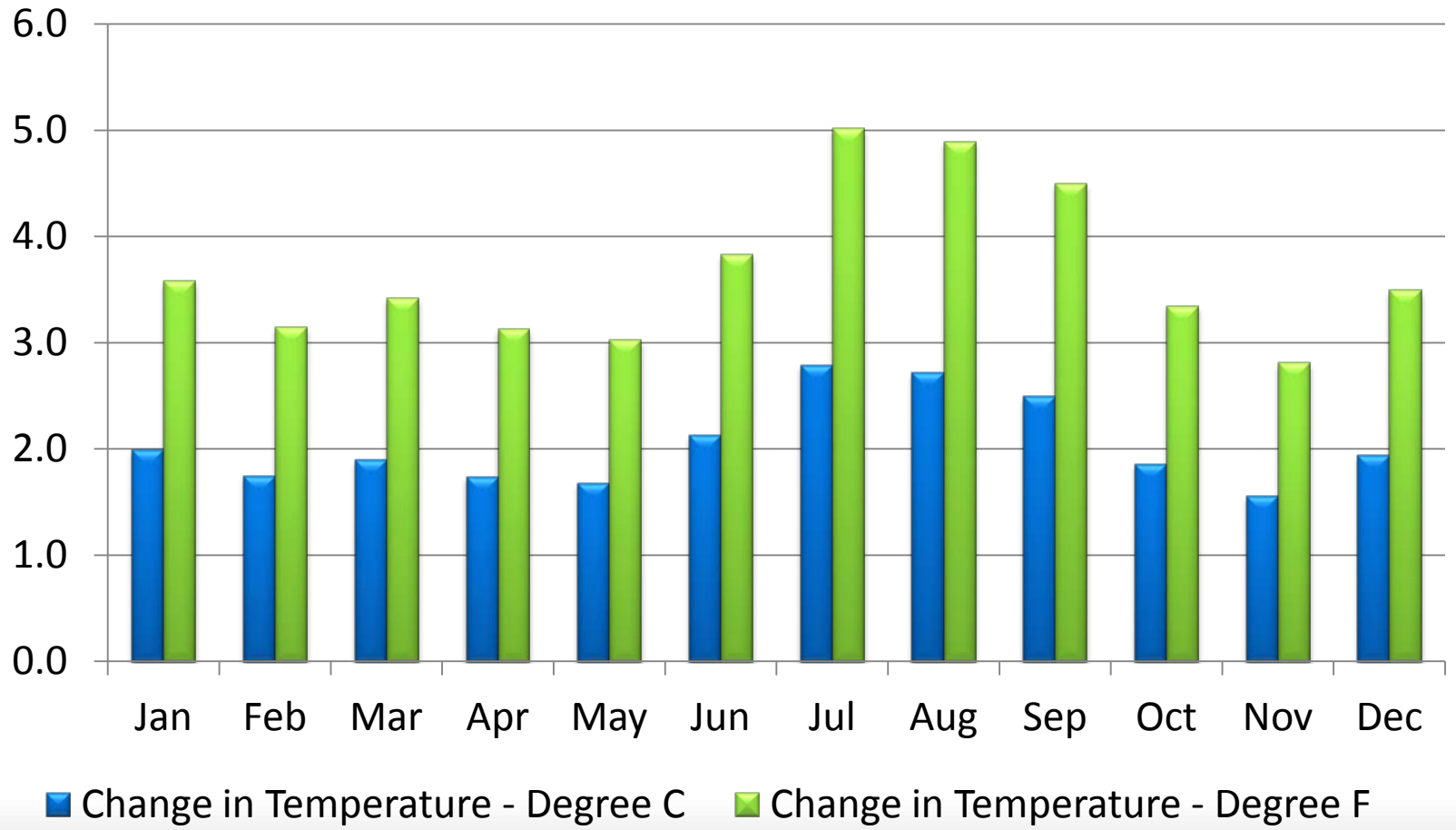
Potential Climate Change Impacts on Regional Loads and Load Shape

Potential Direct and Indirect Affects

Northwest Average Annual Temperature Are Forecast to Increase

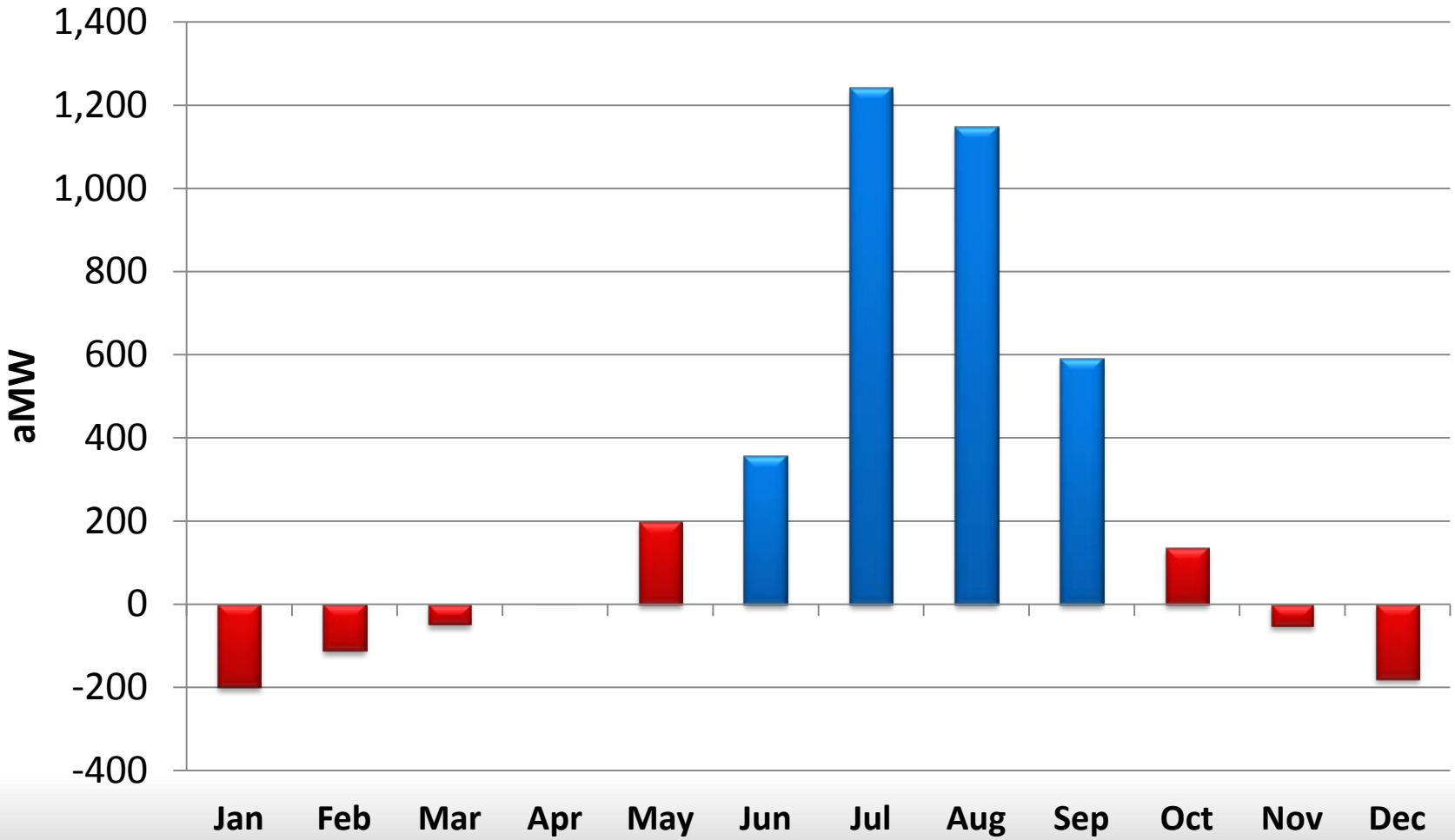


Summer Temperatures Are Projected To Increase More Than Winter Temperatures



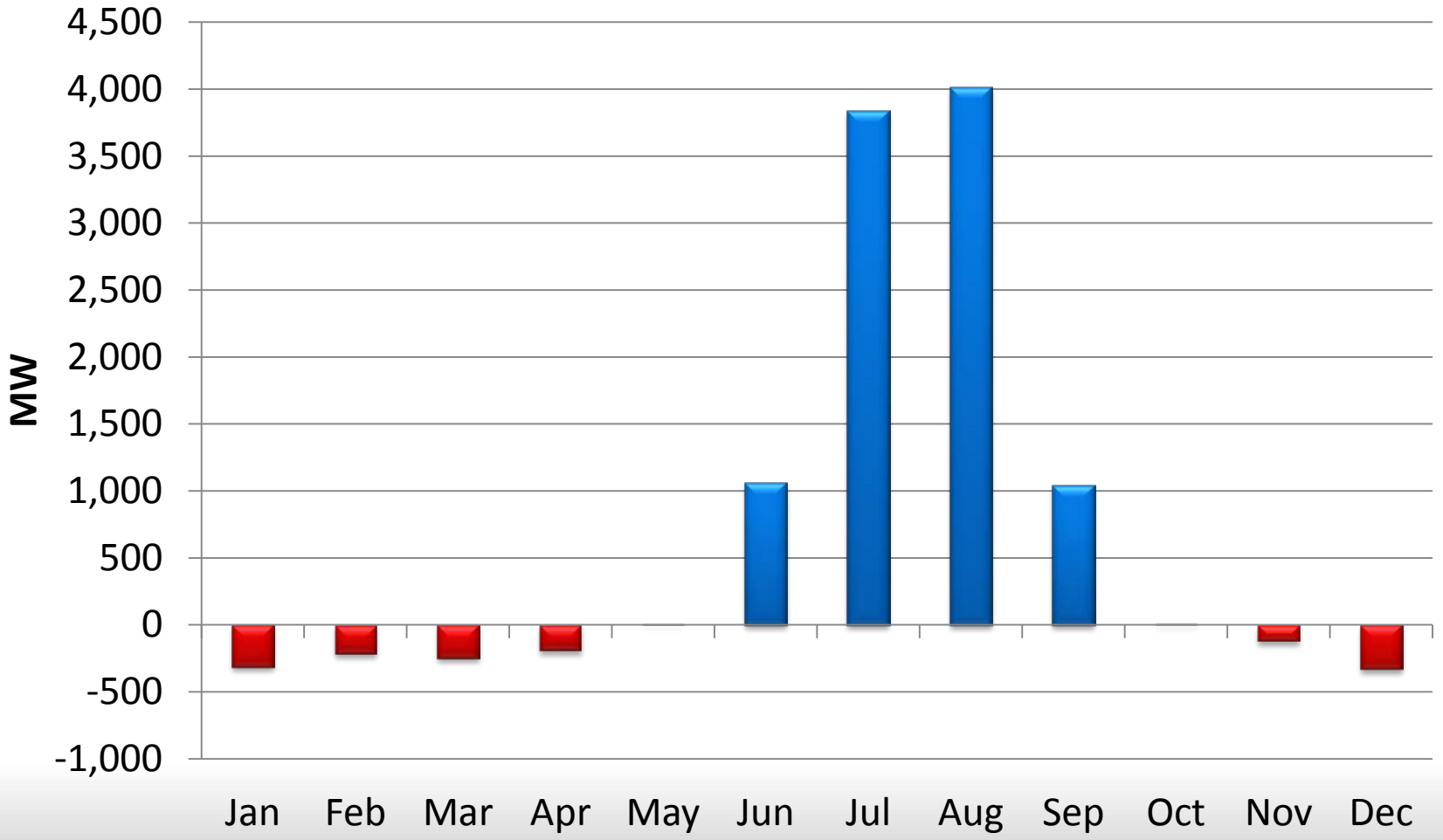
Potential Change in Monthly Energy By 2035 Due to Change in Temperature

Compared To Existing High Load Growth Frozen Efficiency Forecast



Potential Change in Monthly Peaks By 2035 Due to Change in Temperature

Compared To Existing High Load Growth Frozen Efficiency Forecast



In Addition To The Direct Affects of Climate Change There Are Potential "Indirect Affects" That May Impact Electricity Use

- Increased growing season length with early snowmelt period as winters become milder and minimum temperature increase.
- Increased fire occurrences (higher elevations)
- Decreased output from lumber industry
- Increased use of hospitals and healthcare facilities
- Increased use of refrigerated warehouses
- Increased load for air conditioning, electric vehicle and large data centers
- Increased use of environmentally friendlier transportation
- Increased environmental awareness

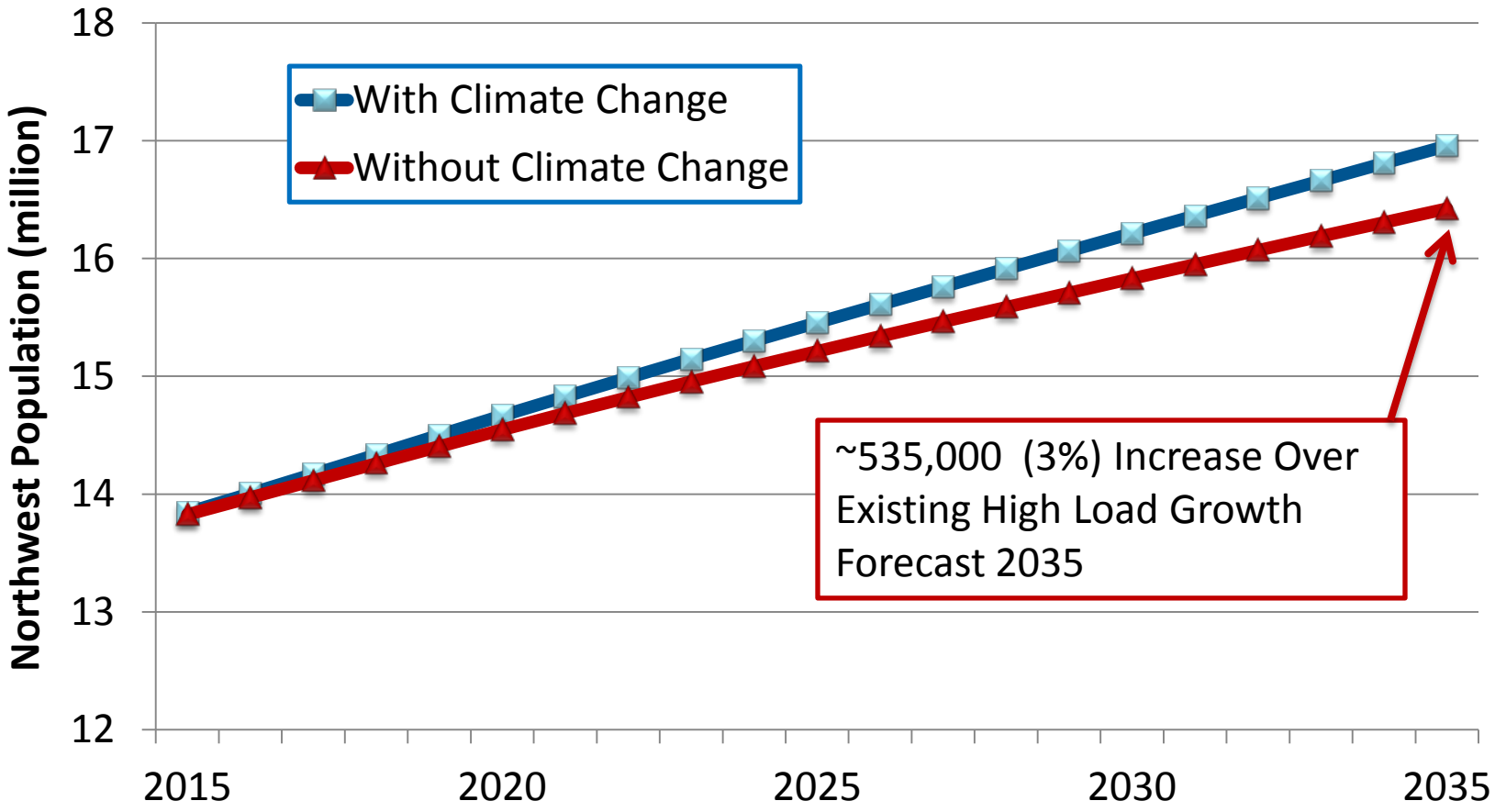
Potential Climate Change "Indirect Affects" Assumptions

Between 2015 and 2035

- Regional population increases by additional 535,000 people
- Residential housing stock increases by 2%
- Commercial & industrial output goes up by 2%
  - Health Care needs increase by 6%
  - Lumber products output decreases by 1%
  - Refrigerated food processing needs increase by 6%
- Irrigation/agriculture load increases by 50%
- Penetration rate of PHEV/EV increases by 50%
- Large Data Center load increases by 50% -post 2019
- Residential Saturation rate of AC increases by 50%

Potential Change in Regional Population By 2035 Due To Temperature and Economic Impacts

(Compared to High Frozen Efficiency Load Forecast)



Potential Change in Monthly Energy By 2035 Due To Temperature and Economic Impacts

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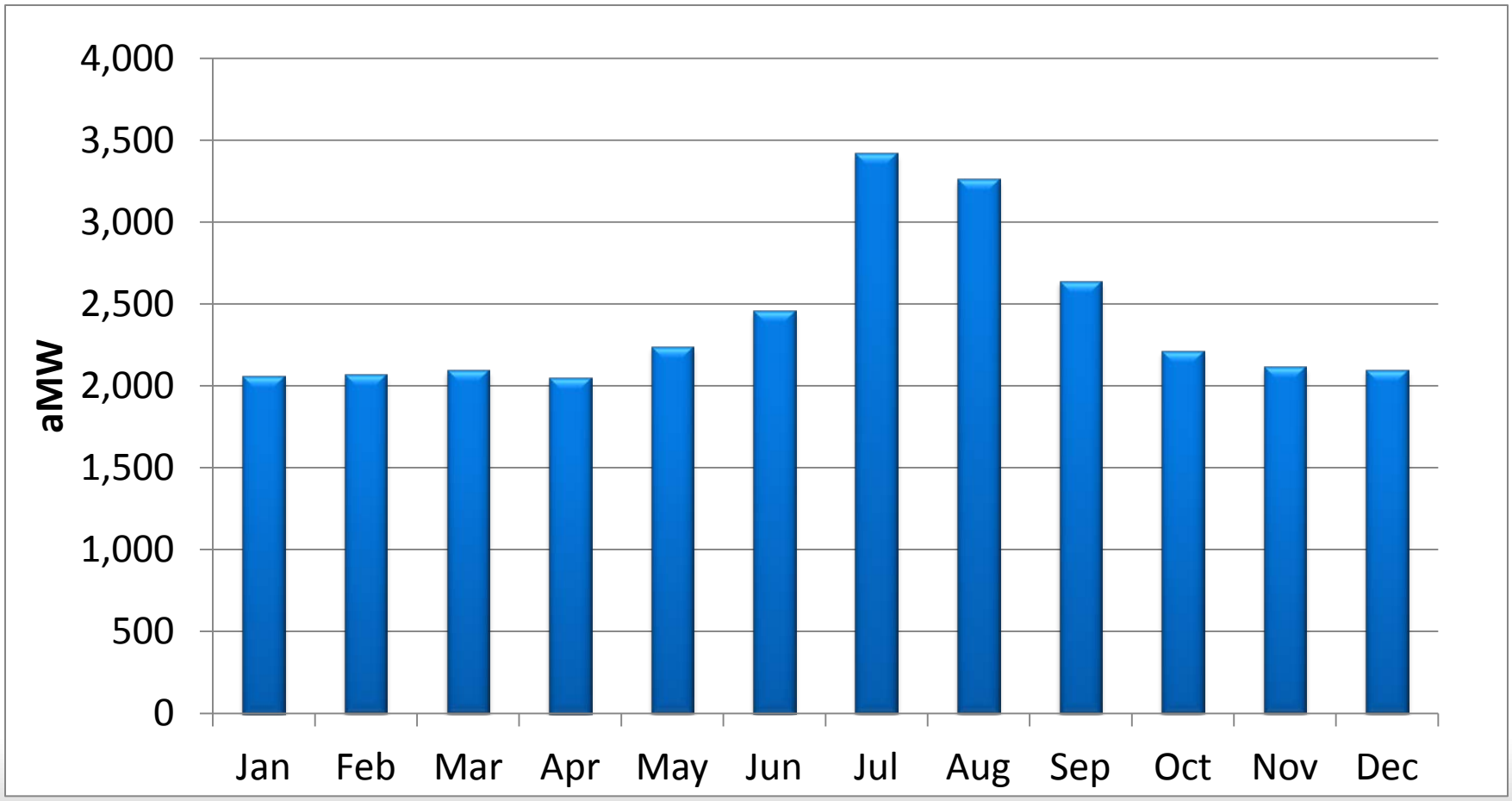

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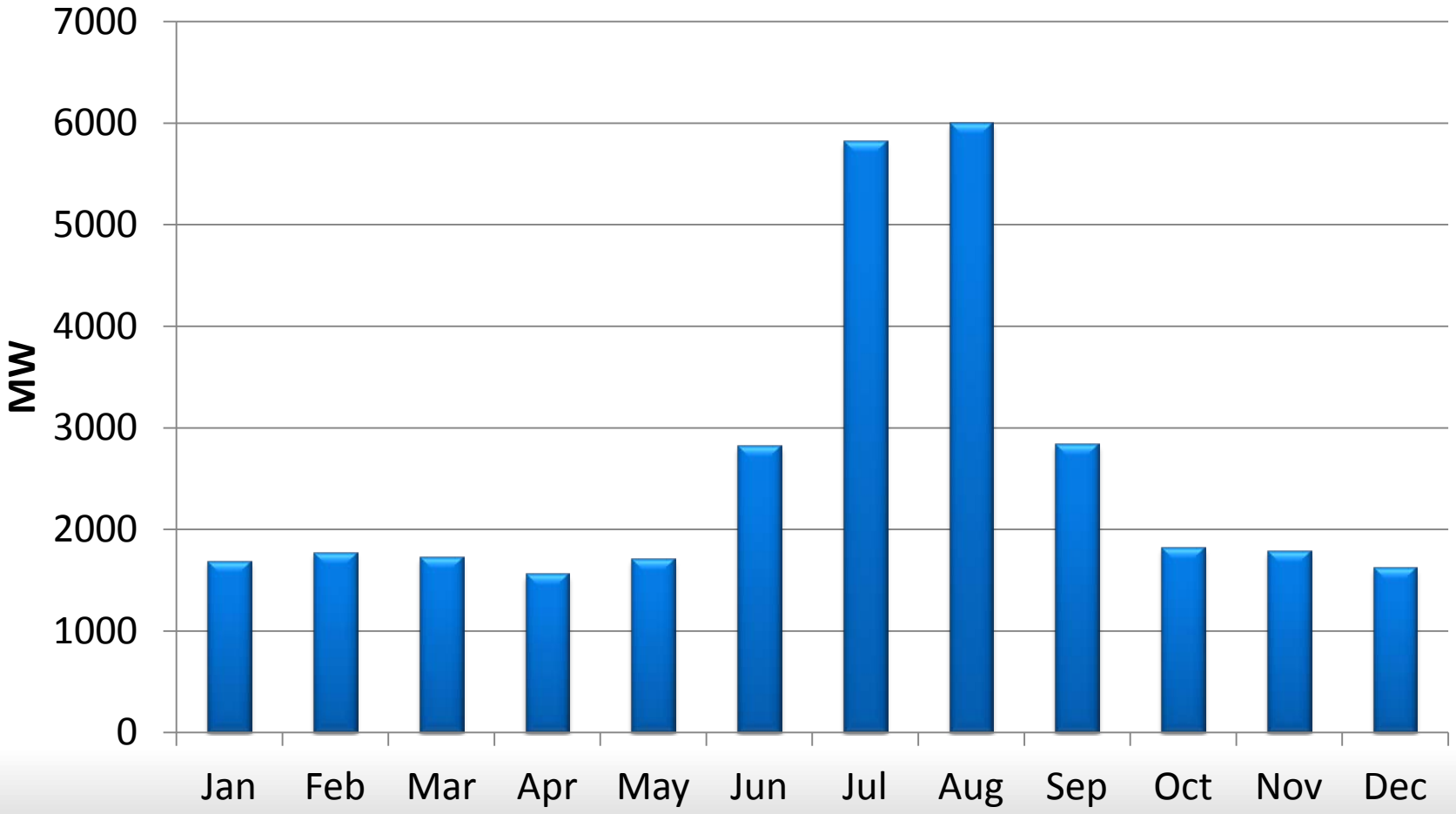
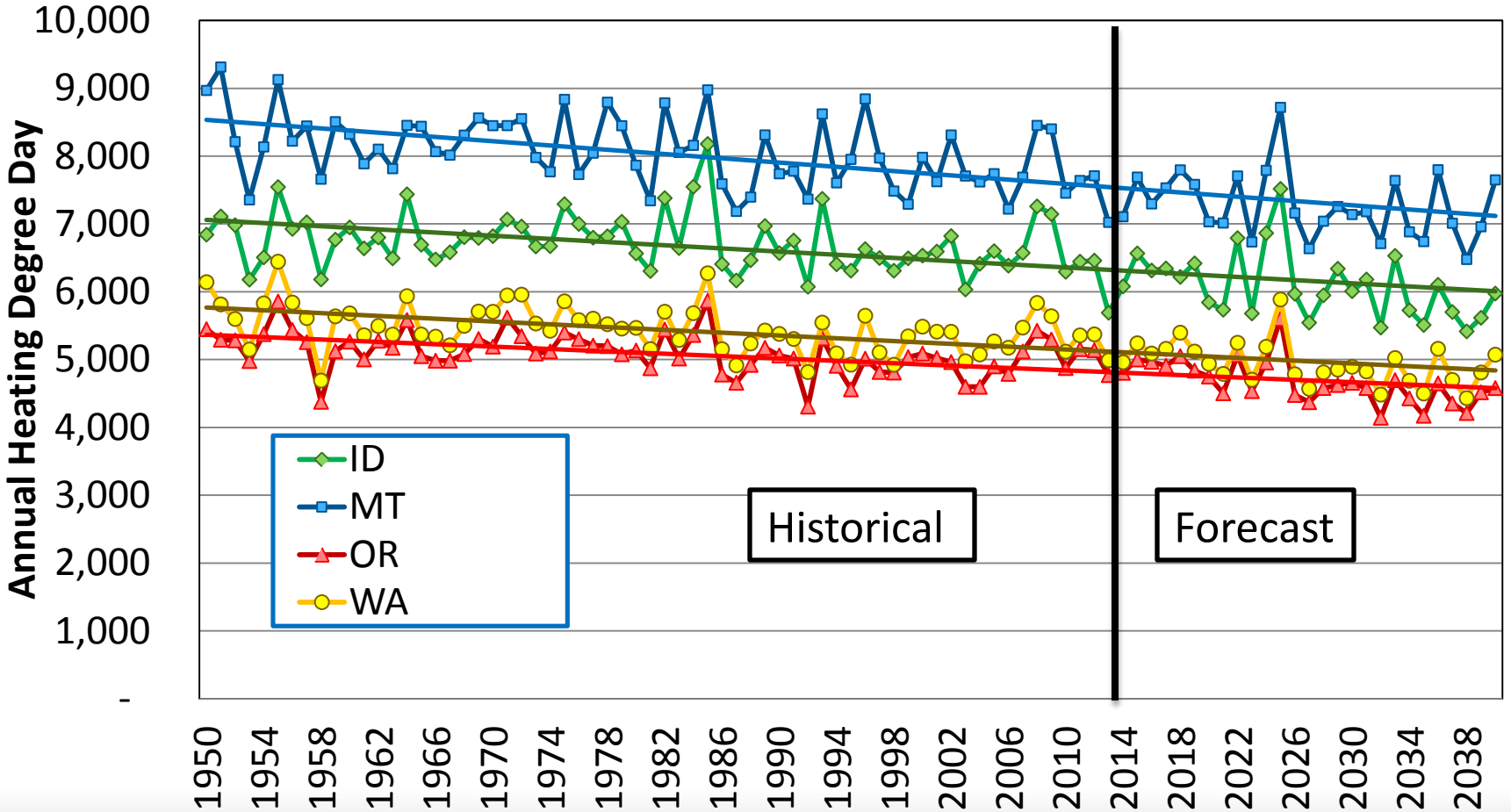
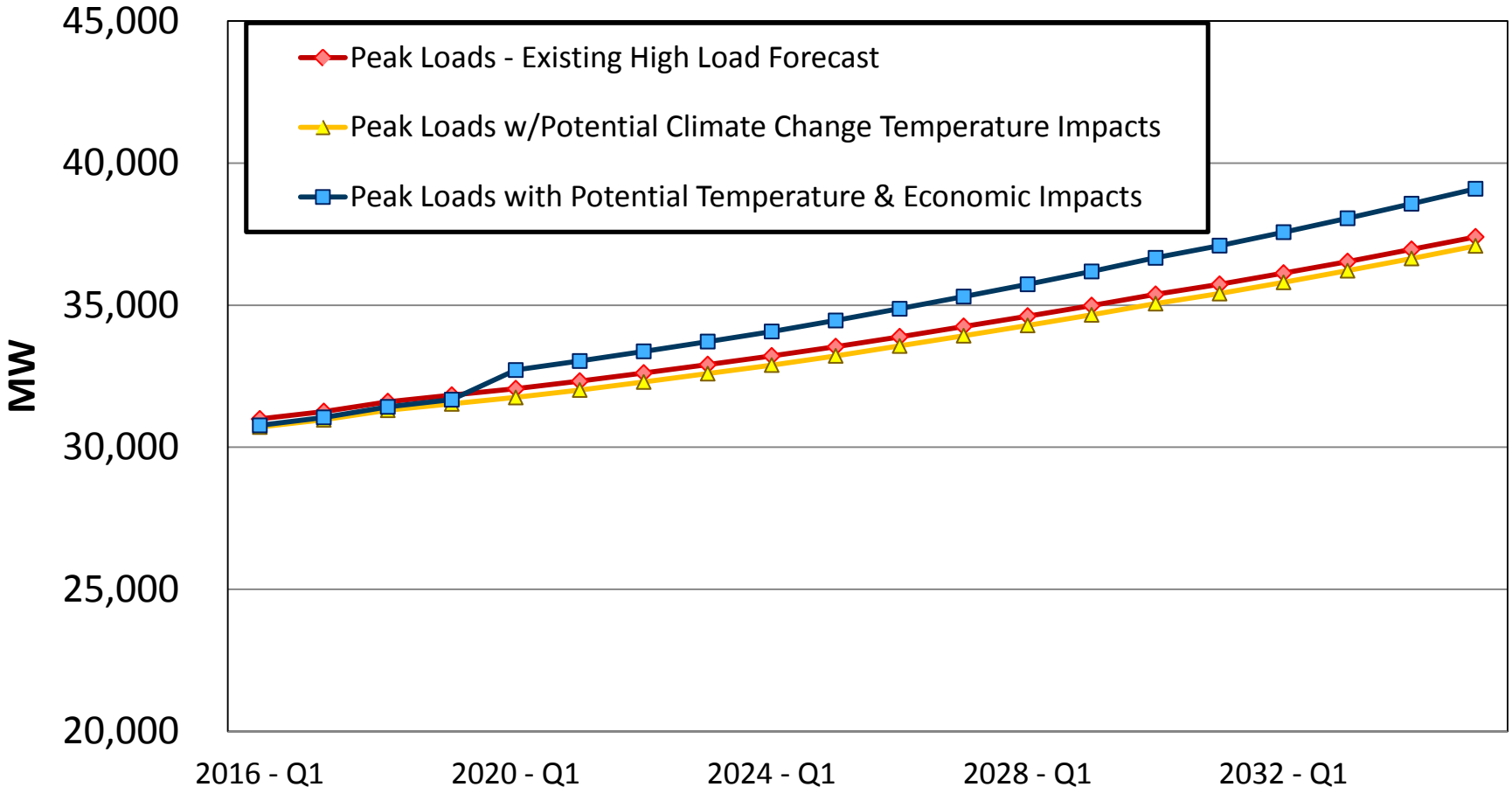


Historic and Potential Future Pattern in Annual Heating Degree Days 1950-2040



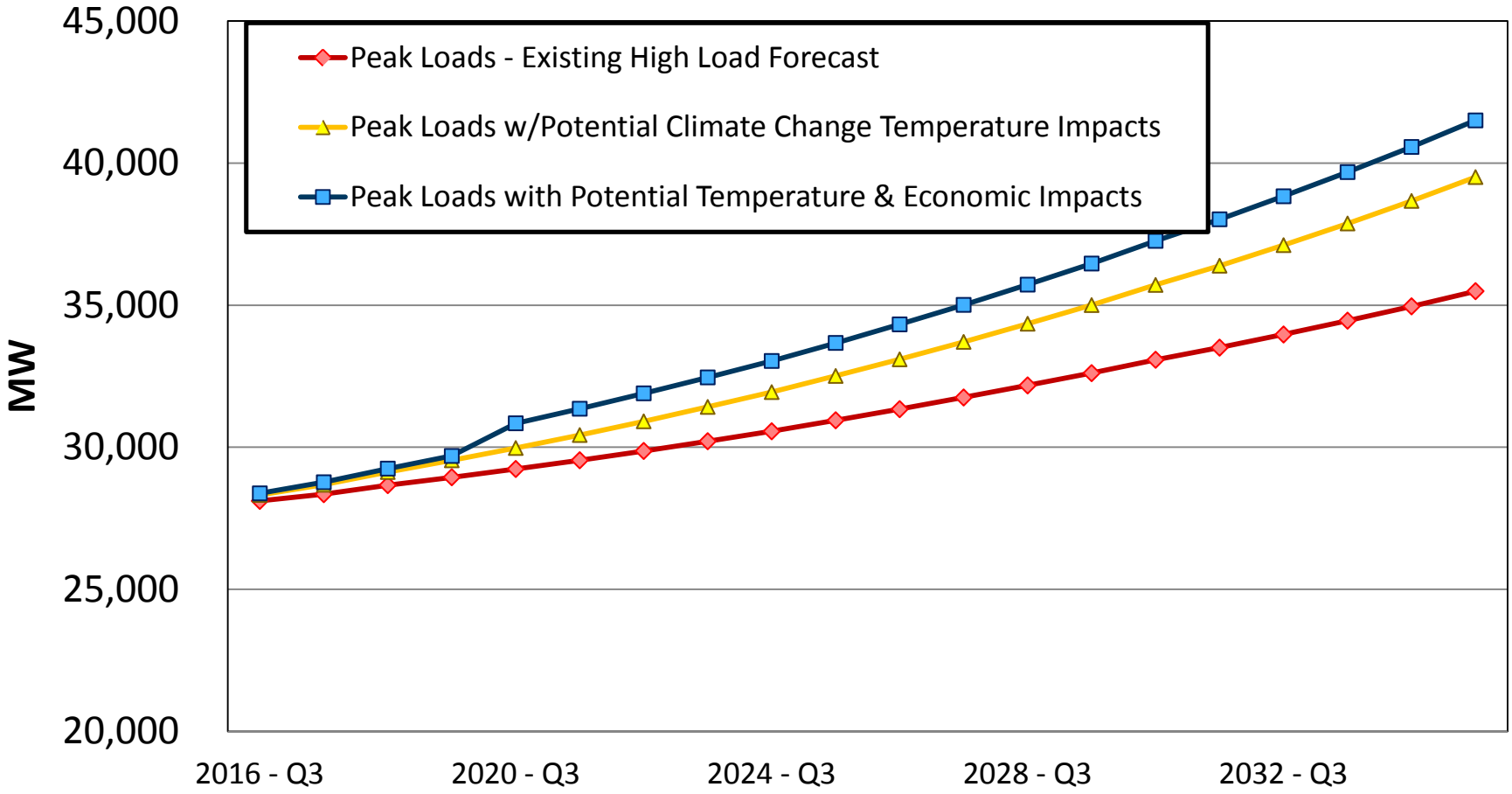
Winter Peak Loads With and Without Potential Climate Change Affects

(Compared to High Frozen Efficiency Load Forecast)



Summer Peak Loads With and Without Potential Climate Change Affects

(Compared to High Frozen Efficiency Load Forecast)



Staff Recommendation

Approach for the 7th Plan Scenario Analysis

- Incorporate direct impact of changes in temperature on forecast future loads (and load shapes) in all scenarios.

- Incorporate indirect effects on regional population and economic growth in all scenarios.

Potential Climate Change Impacts on Hydropower

Global Circulation Models

- Current data based on 2009 International Panel on Climate Change (IPCC-4) report
- Downscaled for the NW by the Climate Impacts Group (U of W) and others
- River Management Joint Operating Committee (RMJOC) has overseen data development
- IPCC-5 report data will not be processed in time for the 7th Power Plan

Summary GCM Results

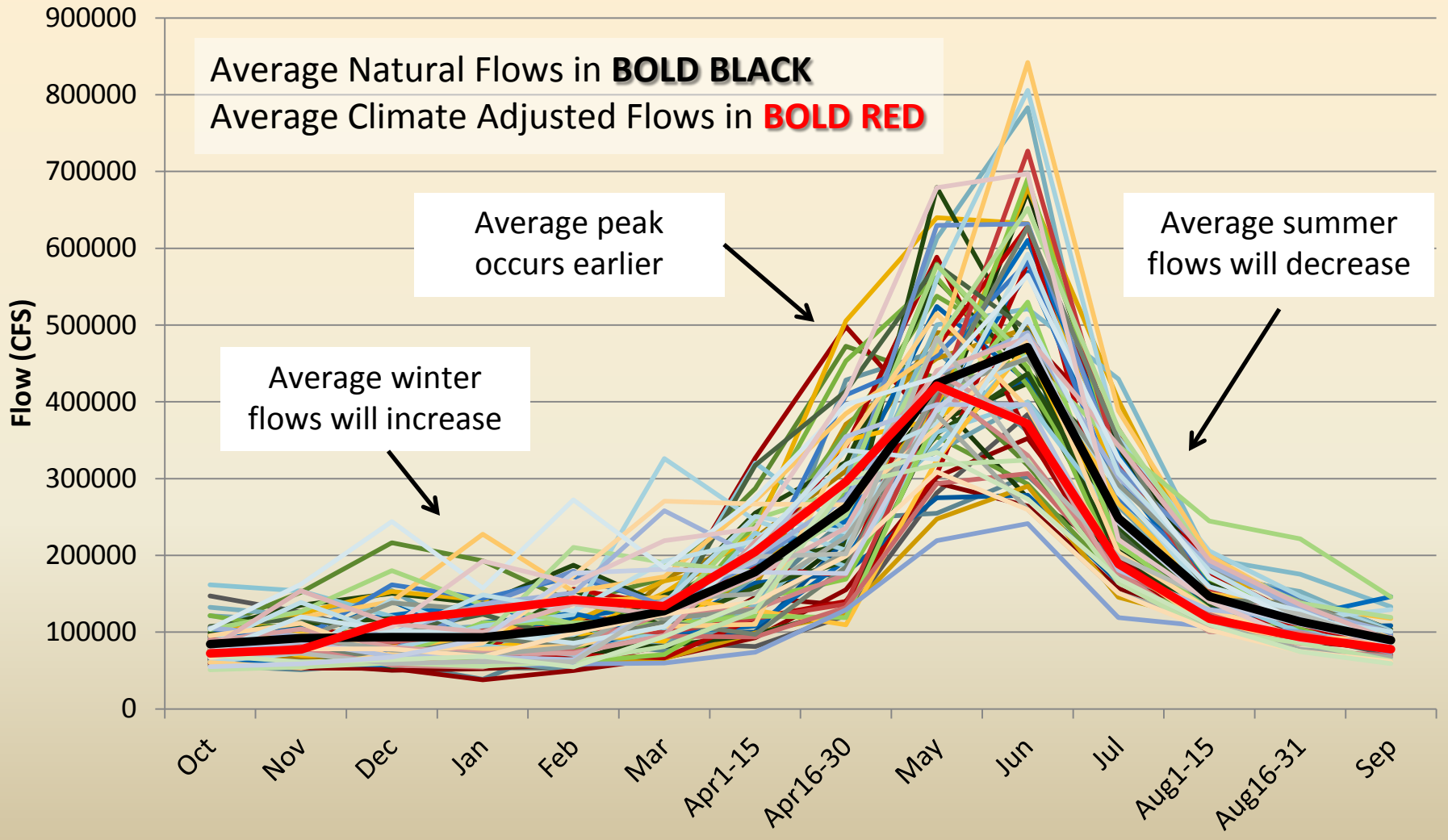
Increasing temps all months

Precipitation higher or lower

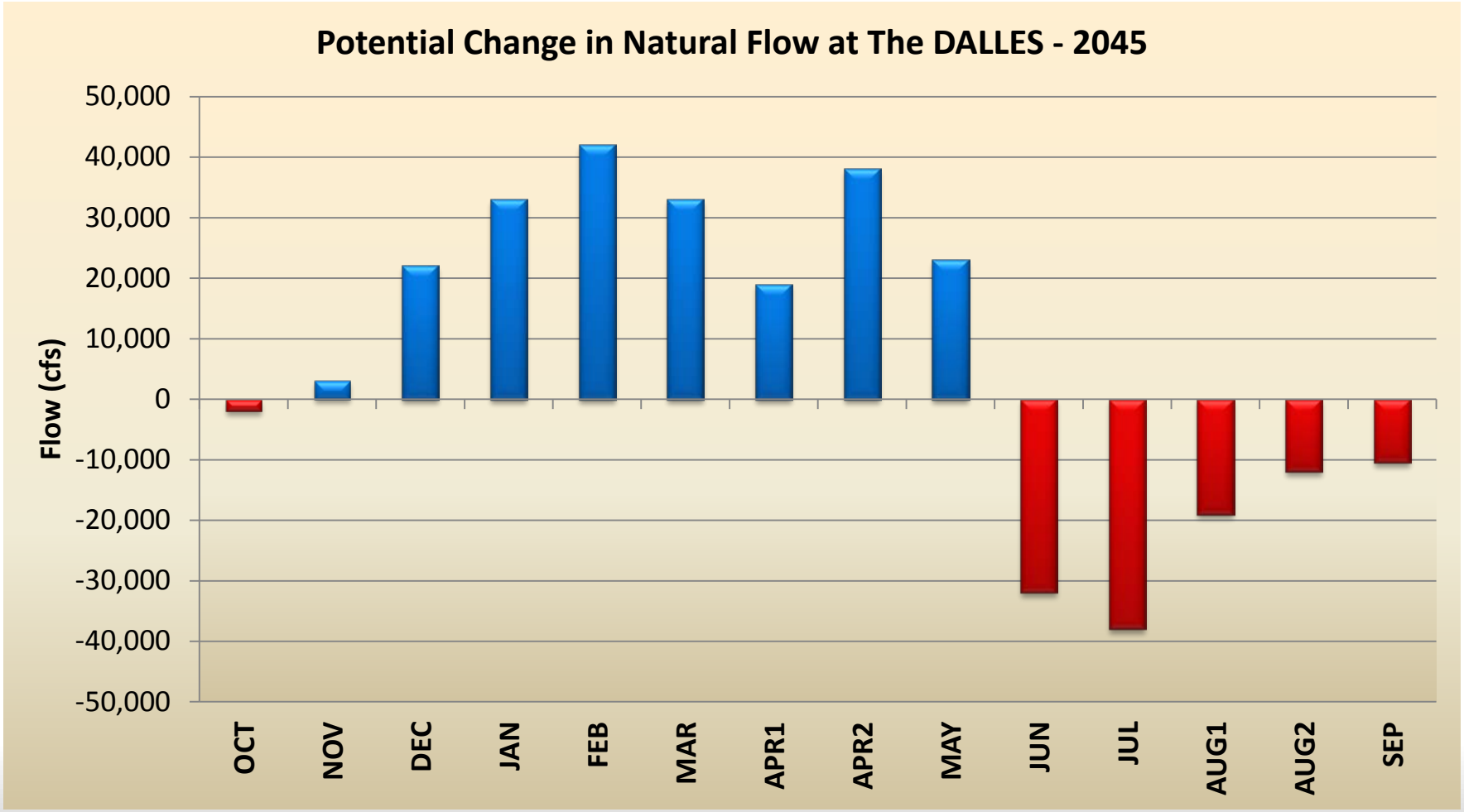
Shift in stream flows (on average)

- Higher winter flows
- Lower summer flows

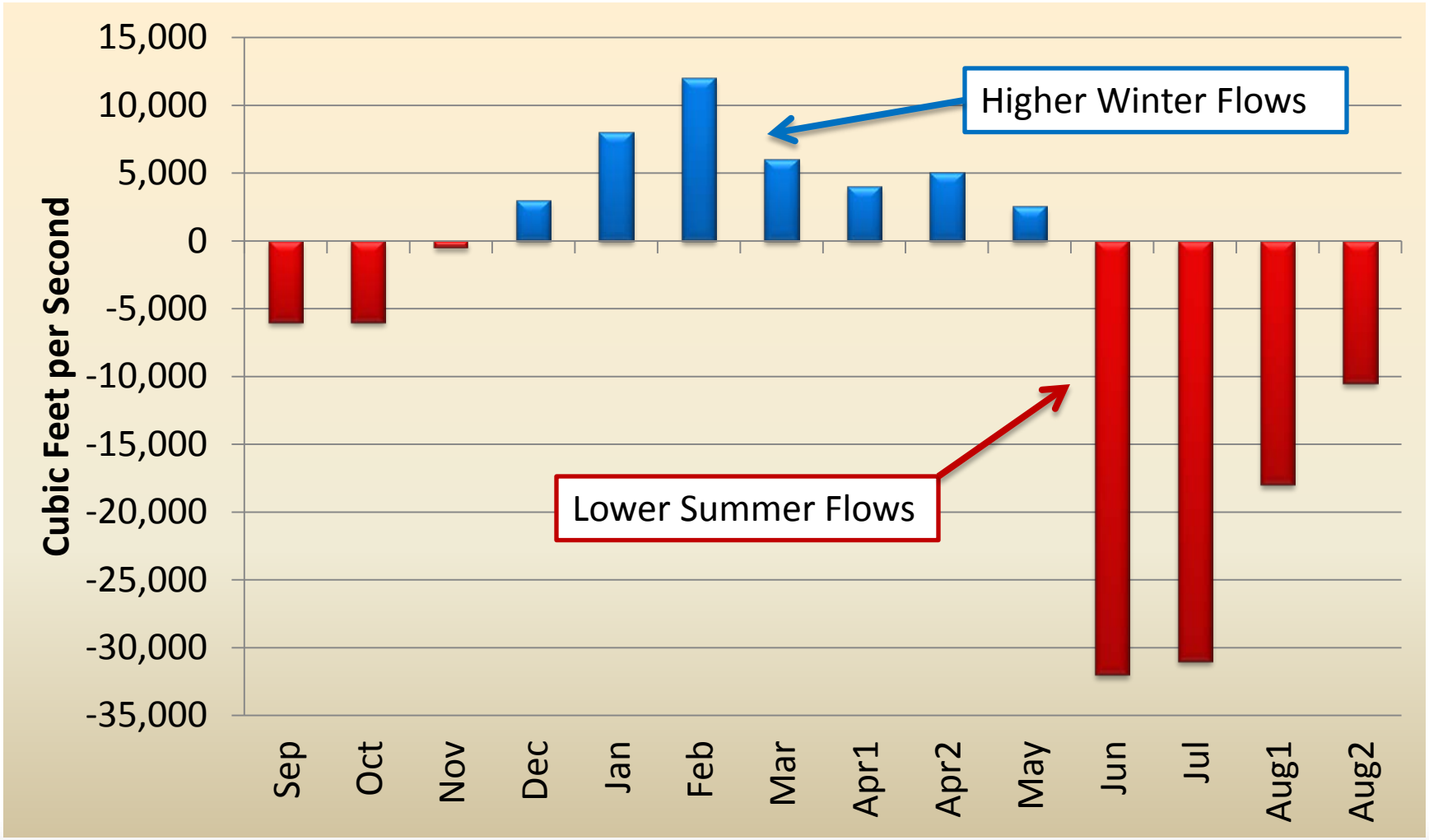
Normal Variation in Flows vs. Average Flows



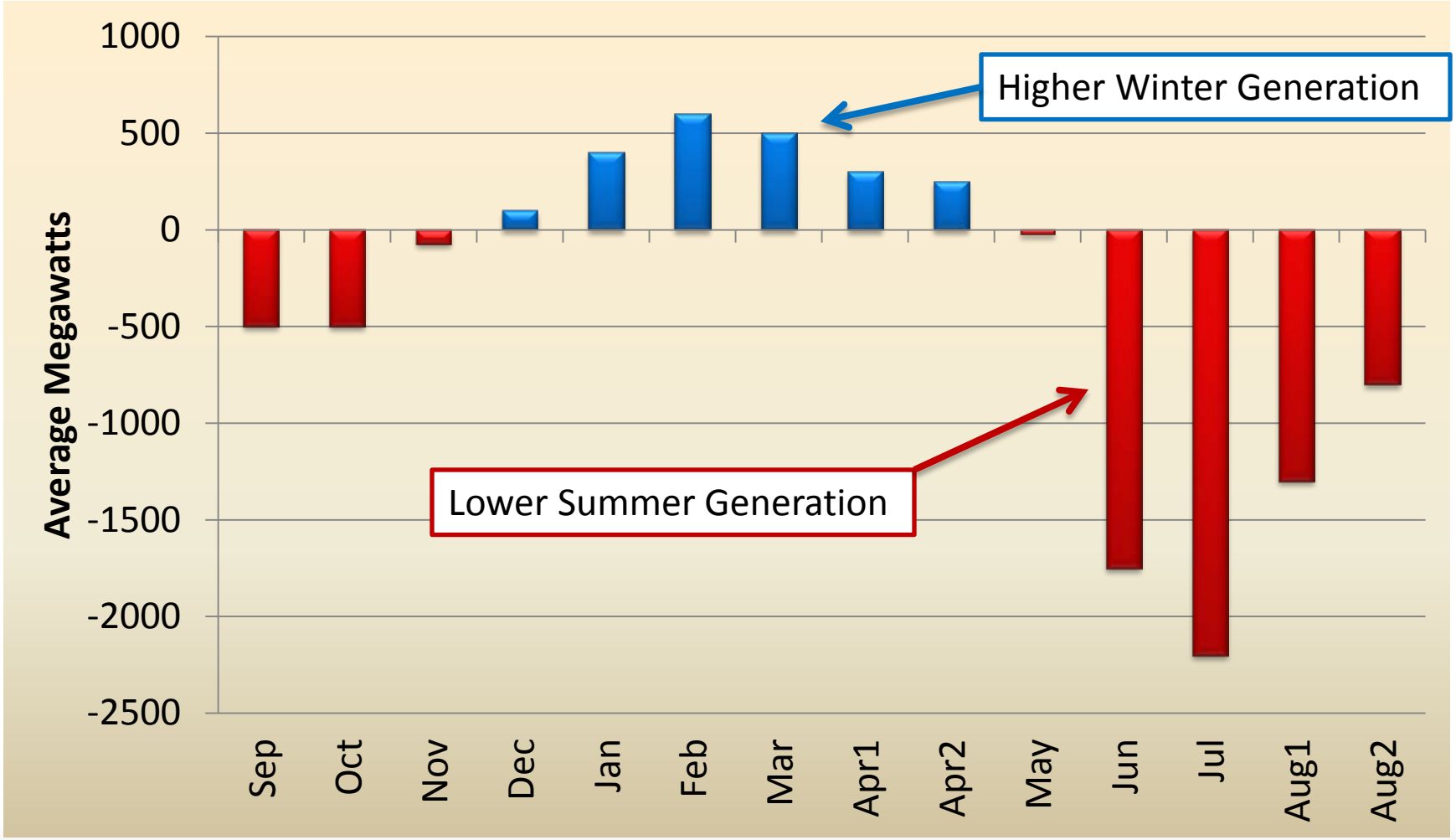
Potential Changes in Natural Flows at The Dalles



Average Change in Regulated Flows (~2045)



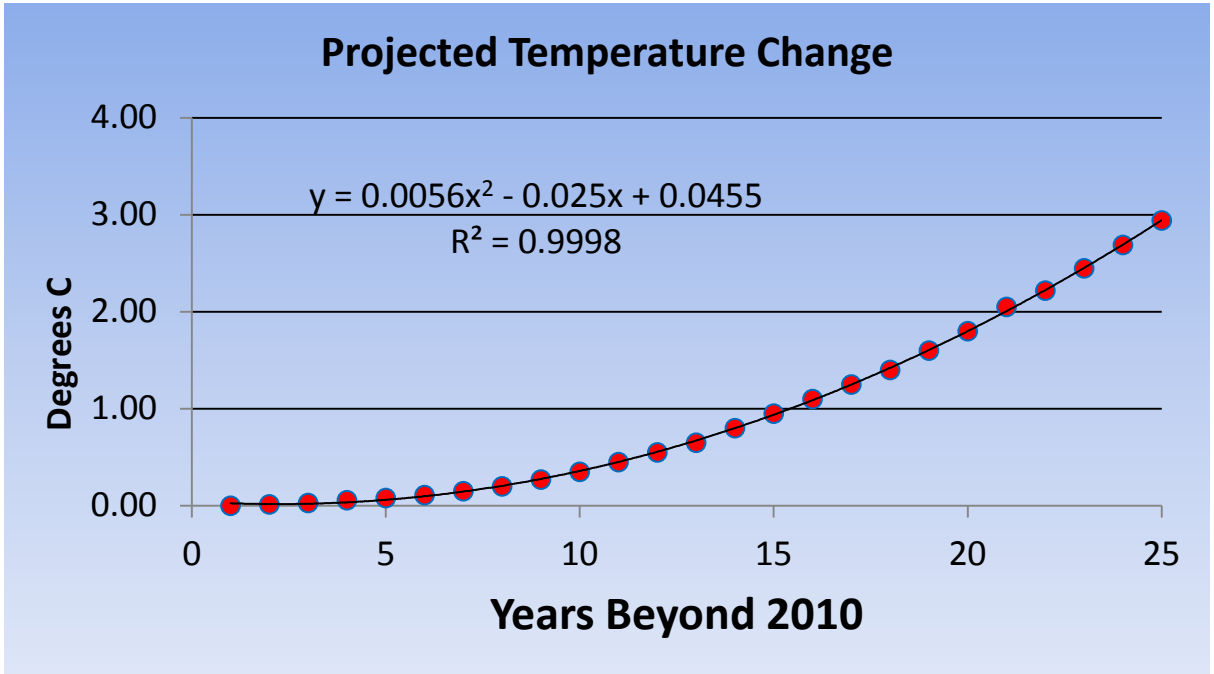
Average Change in Hydro Generation (~2045)

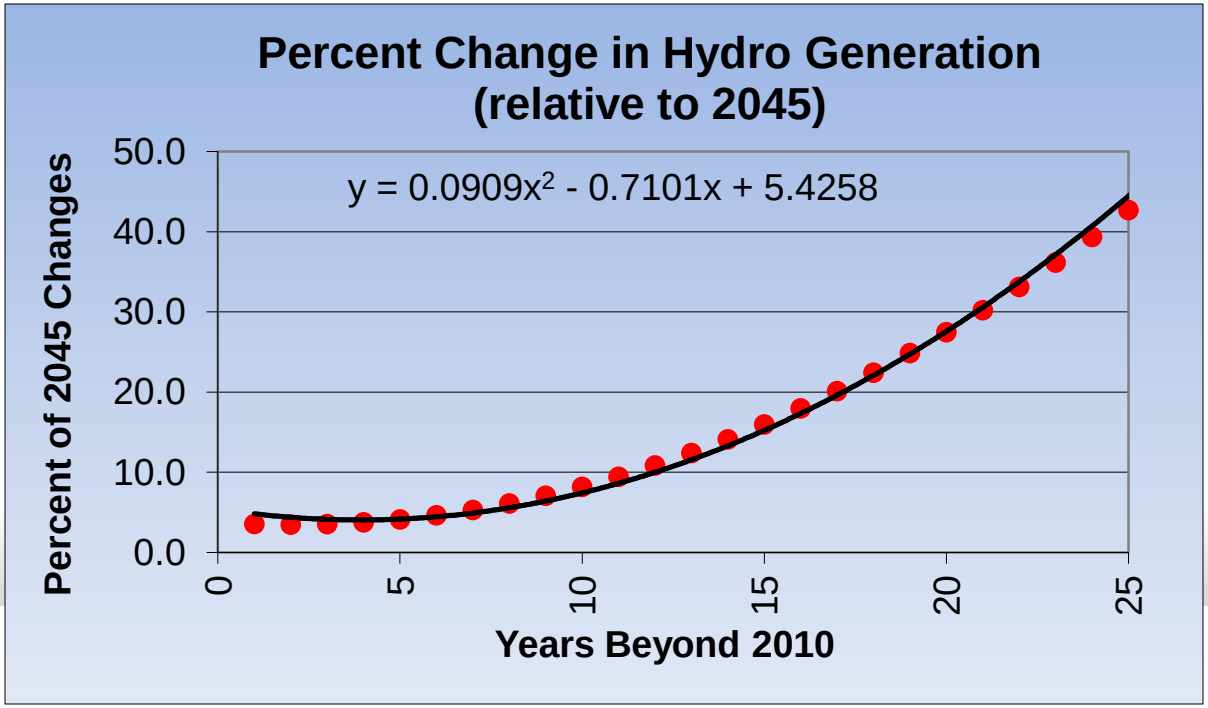


Changes are Non-Linear

More Rapid Changes in Later Years

Hydro generation changes assumed to follow same trend as temperature change

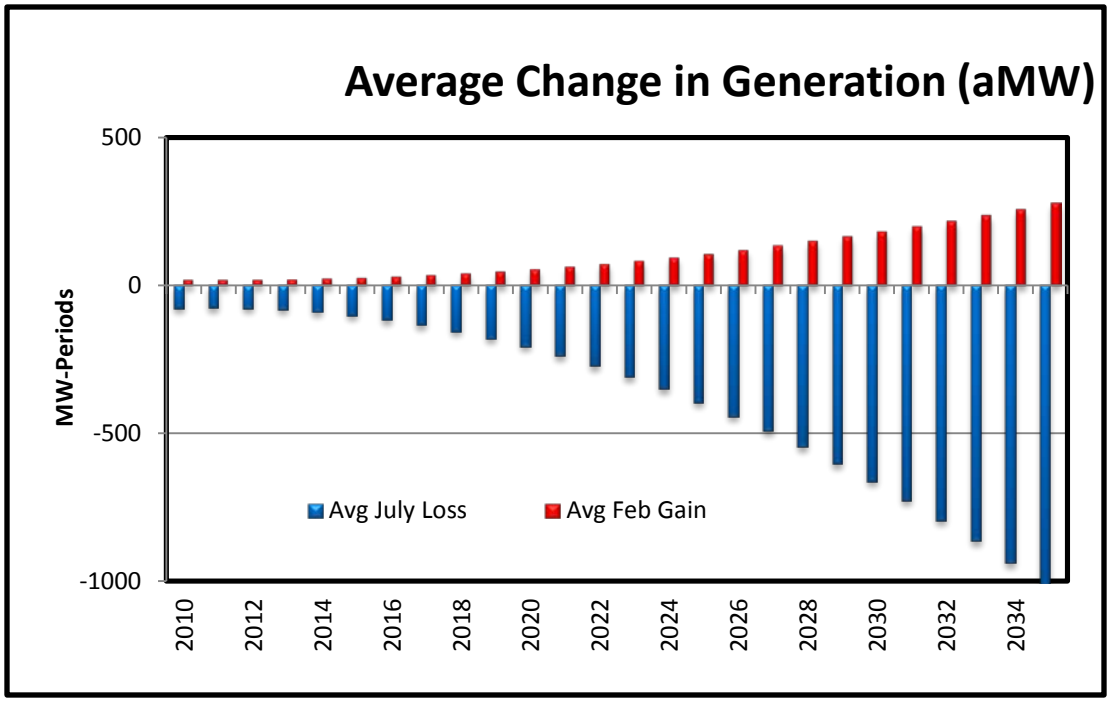


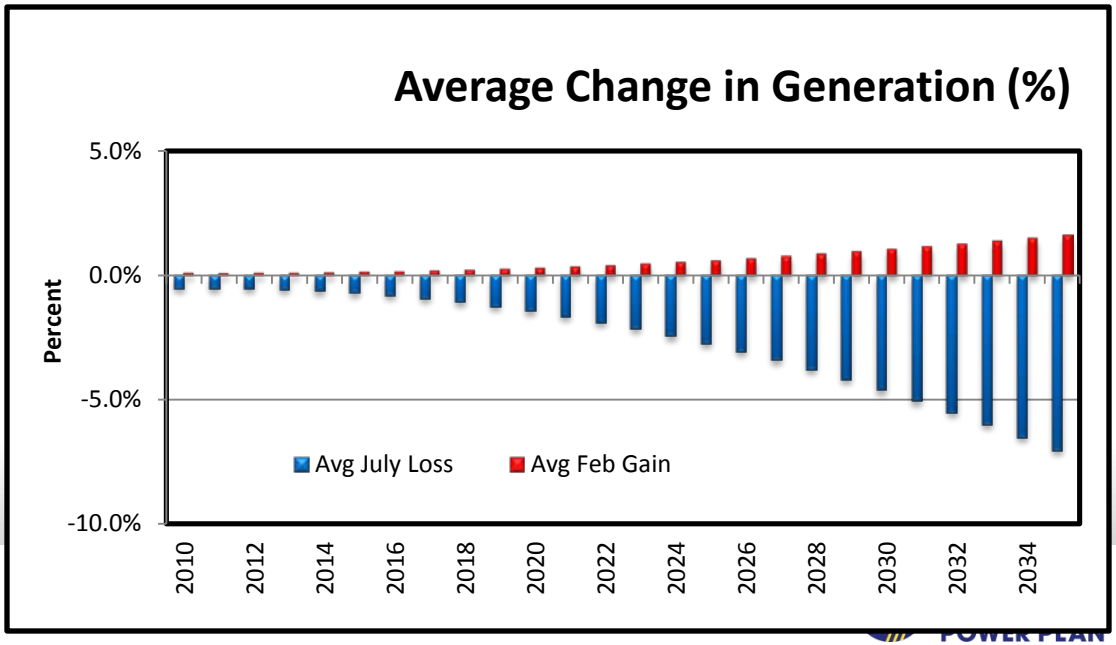


Changes are Non-Linear

More Rapid Change in Later Years

These values are estimates only for illustration



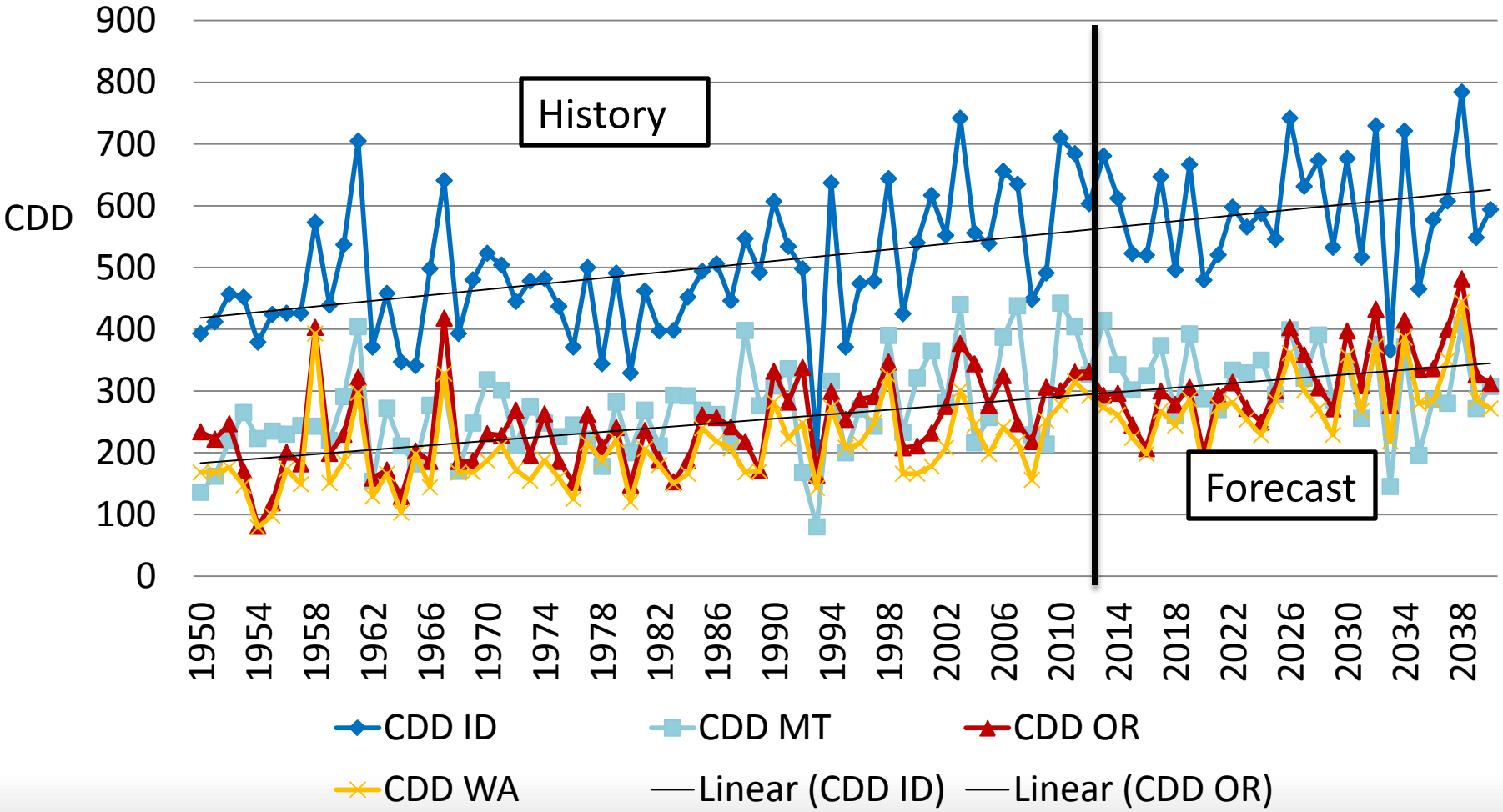


Staff Recommendation on Hydrogeneration

- Do not include climate-change modified hydro in all RPM scenarios
  - Current data (IPCC-4) is out of date
    - Based on a 70-year water record with identified errors
  - Only one of many climate change scenarios for run-off patterns
- Treat potential changes in hydro system run-off in single scenario analysis (6B)
- Include 7th Plan Action Items
  - Monitor climate change data development
  - When IPCC-5 data (next year) is available run climate change scenario

Backup

Historic and Possible Future Pattern of unfolding Change in Cooling Degree Day 1950-2040



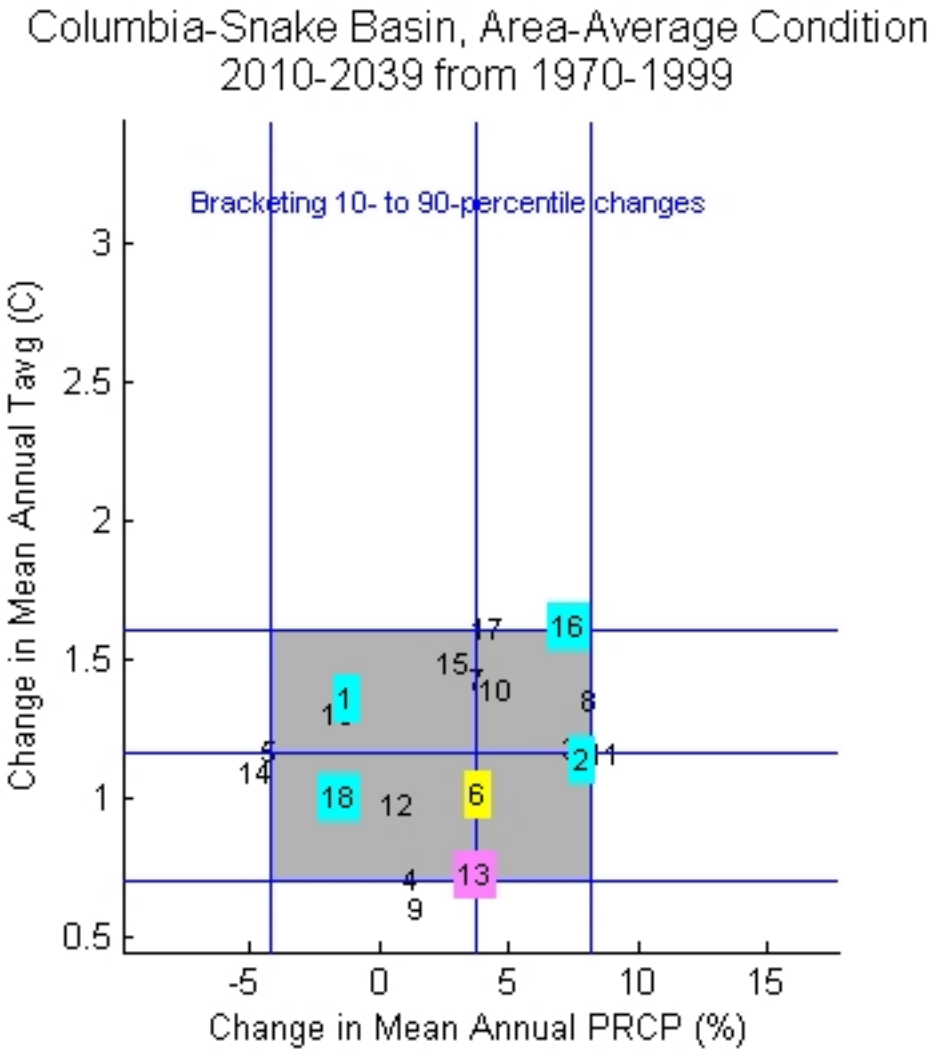
Climate Change with Temperature and Economic Drivers Compared to High Frozen Efficiency Load Forecast

2035	Energy MWa	Peak MW	Percent Energy	Percent Peak
January	2,049	1,687	7%	5%
February	2,061	1,774	8%	5%
March	2,087	1,725	8%	5%
April	2,040	1,557	8%	5%
May	2,233	1,705	9%	6%
June	2,451	2,822	10%	9%
July	3,414	5,825	13%	17%
August	3,257	6,001	12%	17%
September	2,634	2,840	10%	9%
October	2,206	1,820	8%	6%
November	2,111	1,787	8%	5%
December	2,092	1,625	7%	4%

Temp and Precipitation Changes for Various GCM Studies

Precipitation can be higher or lower

Temperature is always higher



Source:
Climate and Hydrology Datasets for Use in the RMJOC Agencies' Longer-Term Planning Studies: Part I - Future Climate and Hydrology Datasets

RMJOC - Summary of Projections Selected

				Hybrid Selections						
				2020s			2040s			
Number		GCM [2]	Emissions Scenario	Selected (Labels) [3]	Change in P (in) [4]	Change in T (°C)	Selected (Labels)	Change in P (in)	Change in T (°C)	Transient (x = selected, o = not selected)
1	√	ccsm3	B1	MW/D	-1.2	1.4		-0.8	1.8	x
2	√	cgcm3.1 t47	B1	LW/W	7.9	1.1	LW/W	11.5	1.3	x
3		cnrm cm3	B1		7.5	1.2		5.3	1.2	o
4		echam5	B1		1.3	0.7		5.9	1.2	o
5	√	echo g	B1		-4.2	1.2	LW/D	-7.9	1.8	x
6	√	hadcm	B1	C	3.8	1.0	C	3.7	1.7	x
7		ipsl cm4	B1		3.8	1.4		6.9	2.1	
8		miroc 3.2	B1		8.1	1.3		10.4	2.3	
9		pcm1	B1		1.5	0.6		3.6	0.8	o
10		ccsm3	A1b		4.6	1.4		2.0	2.4	o
11		cgcm3.1 t47	A1b		8.8	1.2		13.4	1.8	o
12		cnrm cm3	A1b		0.8	1.0		4.1	1.6	o
13	√	echam5	A1b	MC	3.7	0.7	MC	3.7	1.5	x
14		echo g	A1b		-4.7	1.1		0.9	1.9	o
15		hadcm	A1b		3.0	1.5		6.7	2.2	o
16	√	ipsl cm4	A1b	MW/W	7.4	1.6		11.2	2.6	
17	√	miroc 3.2	A1b		4.2	1.6	MW/W	14.2	2.7	
18	√	pcm1	A1b	LW/D	-1.5	1.0		-0.2	1.8	x
19 [1]	√	hadgem1	A1b		-1.5	1.3	MW/D	-2.5	2.8	

RPM Input and Drivers and Their Impact on Results Update

March 10, 2015

Presentation Purpose

This presentation is intended to:

- Present the list of major inputs needed to build scenarios in the RPM
- Request Council Member guidance on the inputs/parameters for the Draft 7th Plan

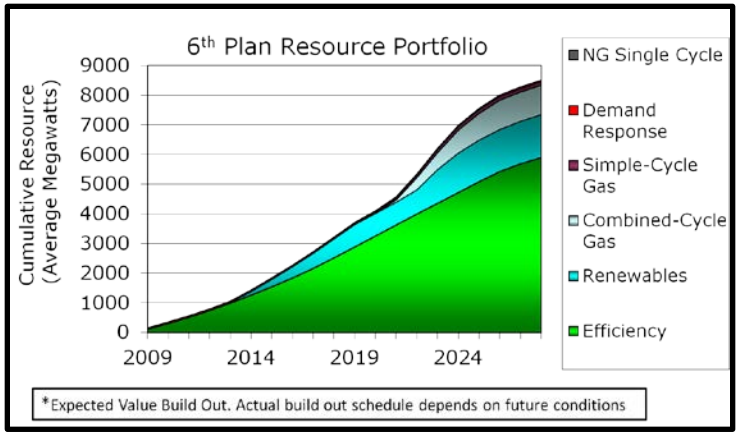
This presentation is NOT intended to:

- Be a final assessment of the RPM inputs "that matter most."

Policy-Based Drivers Are Found In Both Resource Strategies and Futures

Resource Strategies – actions and policies over which the decision maker *has control* that will affect the outcome of decisions

Futures – circumstances over which the decision maker *has no control* that will affect the outcome of decisions



- Load Uncertainty
- Resource Uncertainty
  - Output
  - Cost
  - Construction Lead Times
- Wholesale Electricity Market Price Uncertainty

Scenarios – Combinations of *Resource Strategies* and *Futures* used to "stress test" how well what we control performs in a world we don't control

“Big Knobs” Data Inputs

We Are Revisiting These Inputs Today

These Inputs Have Been Agreed to at Prior Meetings

- Electricity/Natural Gas Price Forecast Range
  - Including Upper/Lower Bound Wholesale Electricity Prices
- Load Forecast Range
- Hydro Generation (Use 80 Water Years)
- Existing Resource Characteristics, Including Regulatory Compliance Costs and Announced Closures

The Full Council Will Consider These Tomorrow

- Conservation Resource Characteristics
- Demand Response Resource Characteristics
- New Generating Resource Characteristics, e.g. Heat Rate, Capital Cost, Variable Operation and Maintenance Cost, Planning Cost, etc.

"Big Knobs" Model Resource Strategy Constraints

Guidance Is Needed Today on These Inputs

- Energy and Capacity Reliability (i.e., Planning Reserve) Requirements (derived from GENESYS)
- Limits on Imports
- Carbon Price/Emission Limits
- Climate impacts assumptions on future loads and hydro system
- Cost of Curtailment
- Transmission system impacts of DR, EE and Generation

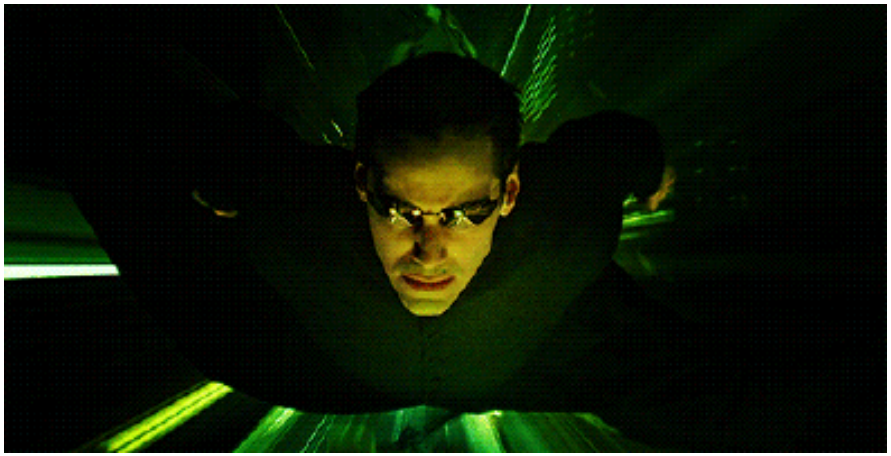
The Full Council Will Consider These Tomorrow

- RPS Target Achievement Rate (i.e., share of RPS actually achieved with resources)
- Limits on Conservation Acquisition
  - Maximum Annual Conservation
  - Maximum Conservation Available Over 20 years
  - Maximum Change Year-over-Year Conservation Acquisitions (i.e., Program Ramp Rates)

"Big Knobs" Model Logic

- Energy/Capacity Adequacy Resource Construction Decision Rules
  - Implements Council guidance on "resource adequacy"
- RPS Resource Construction/Acquisition Decision Rules
  - Implements Council guidance on share of RPS Target met by resource development vs. RECS

Now Let's Enter



The Matrix

RPM Input Matrix

Element	Source	Resource Strategy OR Future?	Rule Summary Description	Details	Impact on RPM Results	Proposed Assumptions
Markets	RPM Policy Input OR Derived by RPM	Resource Strategy	Limits on Electricity Imports/Exports	How much out-of-region market electricity can be imported and how much regional electricity can be exported	High	Staff proposes using the historic Available Transfer Capability (ATC) from BPA Transmission for the COI + DC lines
Conservation	RPM Policy Input	Resource Strategy	Annual Limits on Conservation Resource Acquisition	How much conservation can be acquired in each year	High	EE ramp rates will be based on Council guidance at March meeting. Scenario's 4C and 4D are designed to test sensitivity of resource strategy to alternative pace/achievement of EE.
Conservation	RPM Policy Input	Resource Strategy	Annual Limits on Change in Conservation Resource Acquisitions	How much the potential acquisition of conservation can be accelerated/decelerated	High	EE ramp rates will be based on Council guidance at March meeting. Scenario's 4C and 4D are designed to test sensitivity of resource strategy to alternative pace/achievement of EE.
Markets	RPM Policy Input	Resource Strategy	Upper Bound (Backstop) Electricity Price	Cost of curtailment.	High	Based on Council guidance at March meeting. Staff recommends $10,000 MWh to ensure that resource strategies do not rely on curtailment.

Generation	RPM Policy Input	Resource Strategy	RPS Target Achievement Rate	This factor sets the fraction of state RPS obligations that are assumed to be achieved by the region	High	Based on Council guidance at March meeting. Staff recommendation will be based on analysis of state RPS requirements and utility positions relative to those requirements.
Conservation	RPM Policy Input	Resource Strategy	Resource Acquisition Decision Criteria	What are the economic criteria used to determine whether additional conservation resources are acquired	High	Economic build decisions are based on whether a generating resource has a lower levelized cost than a forecast of future wholesale electricity market prices. Forecast furture market prices are based on recent historical price trends.
Generation	RPM Policy Input	Resource Strategy	Resource Acquisition Decision Criteria	What are the economic criteria used to determine whether additional generating resources proceed with construction	High	Economic build decisions are based on whether additional EE acquisitions have lower levelized cost than a forecast of future wholesale electricity market prices. Forecast furture market prices are based on recent historical price trends.
Conservation and Generation	RPM Data Input	Resource Strategy	Adequacy Reserve Margins	What are the criterion used to determine whether additional conservation, demand response or generating resources are acquired to maintain system reliability	High	Staff recommends that Adequacy Reserve Margins for Energy and Capacity (ARM-E and ARM-C) for all scenarios, except 5B, derived from GENESYS using Regional Adequacy Assessment limits on imports by season (e.g., 2500 MW during winter). See 5B for description of alternative assumptions

Load Forecast	RPM Data Input	Futures	Load Forecast Range	Establishes lower and upper bounds for load growth (pre-conservation)	High	Based on Council guidance at December 2014 and March 2015 meetings
Markets	RPM Data Input	Futures	Wholesale Market Price Forecast Range	Establishes lower and upper bounds for wholesale electricity prices	High	Based on Council guidance at November 2014
Markets	RPM Data Input	Futures	Natural Gas Market Price Range	Establishes lower and upper bounds for wholesale natural prices	High	Based on Council guidance at July 2014
Generation	RPM Data Input	Resource Strategy	New Generating Resource Characteristics	Determines the acquisition cost, dispatch cost, forced outage rate, fixed O&M, contribution of a resource to meet energy and peak, and . of new generating resources	High	Based on Council guidance at March 2015 meeting
Conservation	RPM Data Input	Futures	Conservation Resource Characteristics/Supply Curve	Determines the acquisition cost and load shape of energy efficiency resources	High	Based on Council guidance at March 2015 meeting

Markets	RPM Data Input	Futures	Carbon Price/Emissions Limits	Sets either the market clearing price of carbon emissions or the upper limit on emissions.	High	Based on Council guidance on inputs for Scenarios 2-6. Staff recommends scenario 2C test carbon prices between $0 - $110 (in 2012$) and that these carbon prices also be used in all scenarios except 1A, 1B, 2A, 2B,3A and 3B.
Conservation	RPM Data Input	Resource Strategy	Conservation Availability Load Growth Scalar	This factor scales conservation potential with the load growth pattern occurring in each future tested.	Medium	Based on staff analysis of change in conservation potential between high, medium and low frozen efficiency load forecast
Conservation and Generation	RPM Policy Input	Resource Strategy	Electricity Price Smoothing Time	How much price history within a future should be used to evaluate cost-effectiveness for both conservation and generation	Medium	Staff recommends that RPM use 2 years
Generation	RPM Data Input	Resource Strategy	Existing Generating Resource Characteristics	Determines the dispatch cost, forced outage rate, fixed O&M, contribution of a resource to meet energy and peak needs of existing generating resources	Medium	Based on staff analysis of existing resource data
Demand Response	RPM Data Input	Futures	Demand Response Resource Characteristics/Supply Curve	Determines the acquisition cost, operating costs and load (capacity) impact of demand response resources	High	Based on Council guidance at March 2015 meeting

Generation	RPM Policy Input	Resource Strategy	Maximum Optioned Capacity per Period	The maximum amount of capacity that can be added within a period	Low	Based on assessment of generating resources
Generation	RPM Policy Input	Resource Strategy	Maximum Optioned Capacity Total	The maximum capacity that can be optioned over the planning horizon	Low	Staff will run the model and look at trade-offs between feasibility of total builds and model outcomes
Markets	RPM Policy Input	Resource Strategy	Lower Bound Electricity Price	Cost of spill	Low	Staff proposes using $325 which is consistent with the Sixth Plan assumption.
Conservation	RPM Policy Input	Resource Strategy	Conservation Acquisition Cost Range	Limits the range of values that can be tested to determine the maximum acquisition cost for Lost Opportunity and Discretionary Conservation resources	Low	Staff recommends testing between -$100/MWh and +$100/MWh. This range may be expanded if the model results in close to optimal outputs at either boundary.
Generation	RPM Policy Input	Resource Strategy	Resource Addition Periods	Establishes the frequency at which resource addition decisions are considered by the model	Low	Staff recommends annual evaluation for first 7 years then biennial evaluation after that
Generation	RPM Data Input	Futures	Hydro-System Output (80 years)	Establishes hydro-system output	Low	Staff recommends using existing hydro run-off patterns from 80 years with no adjustment for climate change, except in scenario 6B