Cascade Natural Gas Corporation

2018 Integrated Resource Plan
Technical Advisory Group Meeting #4

Thursday, Oct. 19th, 2017
Oregon Public Utility Commission
Offices
Salem, OR

Cascade Natural Gas Corporation
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Agenda

- **Introductions**
- **IRP Action Plan Update**
- **Fracking Presentation (NWIGU)**
- **SENDOUT® Optimization Modeling**
- **Alternative Resources**
- **Candidate Portfolios**
- **Monte Carlo Simulations**
- **Results**
- **Upcoming Schedule**
- **Questions**

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IRP Action Plan Update

2014 IRP Action Item	Update
1. Cascade will improve its demand forecast by developing a report to track the issuance of corrected bills and reclassifying therms from corrected bills to the month those therms were used. In its next IRP, Cascade will use its new Statistical Analysis Software (SAS) to test non-linear weather effects on natural gas, to perform analysis on potential serial correlation problems, and to create a time series autoregressive integrated moving average (ARIMA) model for customer forecasting.	On June 26th Cascade's Gas Supply Oversight Committee (GSOC) met and was provided an update on the 2017 portfolio procurement plan, which included recent market intelligence and updated pricing. In TAG 3 the company will discuss its supplies of varying lengths and pricing alternatives.
2. Cascade will continue to monitor outside determinants of natural gas usage, such as legislative building code changes and electrical "Direct Use" campaigns as they are determined to significantly affect the Company's forecast.	Since the 2014 Action Plan, Cascade has monitored the following legislation, campaigns, and other external actions with the potential to influence natural gas use in the States of Washington and Oregon: - National standard practice manual, Portland renewable energy goals, gas to electric fuel switching, HB-2711 moratorium on hydraulic fracturing for oil and gas exploration and production, several Washington state bills on Carbon taxes, deep decarbonization, and the clean air rule.
3. Cascade will continue to monitor the effectiveness of the Oregon Public Purpose Fund to ensure the funds are adequate to capture significant portions of achievable therm savings in Oregon.	Since the 2014 IRP, Cascade has made two filings to increase its public purpose charge to ensure funding would be sufficient to acquire the therm savings target established in the IRP as a least cost resource: Advice No. O15-12-01 on December 11th, 2015 to increase its public purpose charge from 1.85% to 3.7% (reduced to 3.4% before Commission approval) and Advice No. O16-10-01 on October 31st, 2016, in which the Company asked to increase the Public Purpose Charge from 3.4% to 4.87%.
4. The company will continue to follow and analyze the impacts of the Western Climate Initiative and proposed carbon legislation at both the state and federal level as they pertain to natural gas conservation, as well as other such acts that may arise from these efforts. The company will continue to monitor the timing and the costs associated with carbon legislation and analyze the impacts on the company's overall portfolio costs. As specific carbon legislation is passed, the company will update its avoided cost calculations, conservation potential and make modifications to its DSM incentive programs as necessary.	The Company has continued to monitor the Western Climate Initiative and proposed carbon legislation since the 2014 Action Plan. While no significant action has been taken on the WCI with impacts to the Company, the Company is actively following the current legislation and is monitoring the potential impacts to portfolio costs.

IRP Action Plan Update Cont'd

2014 IRP Action Item	Update
5. The company will continue to monitor the cost effectiveness of existing conservation measures and emerging technologies to ensure that the current mix of measures included in the Washington Conservation program is appropriate. Areas for further analysis include the impacts associated with modifications to building codes along with the cost effectiveness of newer technologies such as the next generation of high efficiency water heaters (.70 EF) and high-efficiency hybrid heat pumps. The applicability of these measures within Cascade's service territory will be analyzed and the company's Conservation Incentive Program will be modified as necessary.	Cascade continually monitors the region and natural gas industry on currently available technology advancements as part of our Washington incentive programs. We reevaluate the portfolio cost-effectiveness paired with current technology and update install costs to maintain viability and as robust of a program as feasible. The Company is also engaged with the Northwest Energy Efficiency Alliance market transformation collaborative in coordination with other local utilities and the Energy Trust of Oregon as well as the Gas Technology Institute's emerging technology program to stay abreast of new technologies and opportunities for additions and changes to the Company's offerings. The Company also maintains a Trade Ally network for our Washington programs and routinely connects with local contractors to gauge availability of product and costs associated with installs of rebate eligible equipment and measures. The landscape is constantly evolving and Cascade works with its partners and local agencies and builders (including home builder associations) to track building code updates as well as changes to industry standards.
6. The Company will continue to monitor the potential reporting, administrative and potential financial impacts of long term resources as a result of concerns surrounding fracking. In particular we are awaiting the EPA to reveal the results of their current study in alleged water contamination found in Wyoming as a result of fracking activities.	Cascade has included a slide in TAG 3 to address this action item. Additionally, Cascade has extended an invitation to NWIGU to discuss this item.

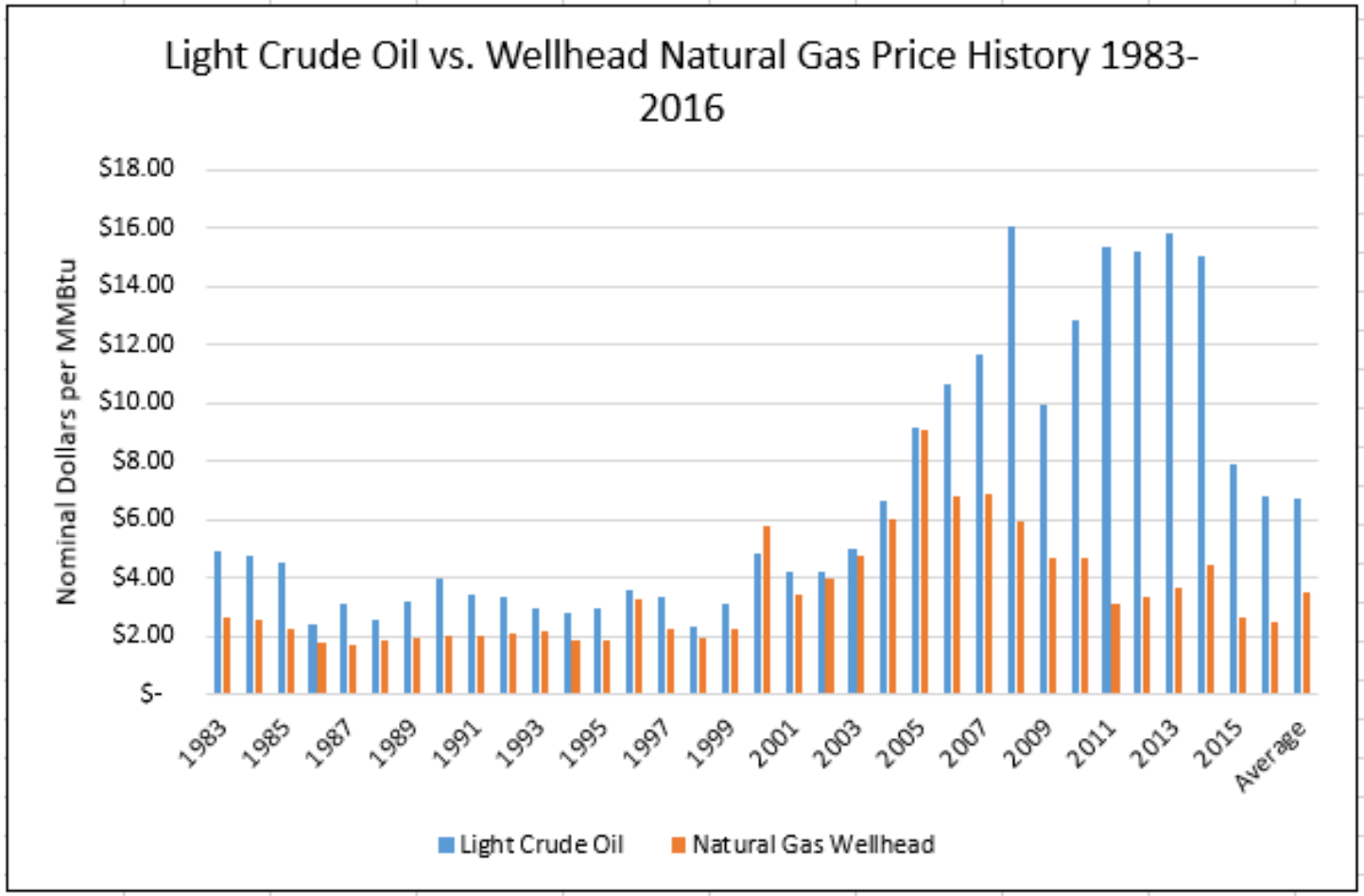
IRP Action Plan Update Cont'd

2014 IRP Action Item	Update
7. Cascade will continue to evaluate gas supply resources on an ongoing basis, including supplies of varying lengths (base, swing, peaking) and pricing alternatives. We will continue to analyze the uncertainties associated with supply and demand relationships.	Due to the robust nature of TAG 3, this will now be discussed in TAG 4.
8. The Company will continue to monitor the proposed pipeline expansion projects to access more supplies out of the Rockies. As cost estimates change, the company will analyze those resources under consideration to determine if modifications to the preferred portfolio are necessary.	NWP has provided an updated Wenatchee lateral expansion which is currently being considered for modeling.
9. As part of the Cascade's risk management policy and implementation, the Company will report on the status of the UM 1720 as well as related risk management policy enhancements to Cascade's risk management policy, at the first Purchased Gas Adjustment (PGA) quarterly meeting with OPUC Staff in early 2017. This docket is the Commission's Investigation into Long Term Hedging Policy.	Interested parties met on August 23rd, with the conclusion that an agreement could not be reached. The parties at this meeting (Staff, regional LDCs, NWIGU and CUB) will be requesting that this docket be closed. Cascade continues to work on enhancing its risk management policies in compliance with Washington's new hedging rules
10. The Company will continue to explore options to incorporate biogas into its portfolio, as specific projects are identified in our service territory. Price, location and gas quality considerations of the biogas supply will be evaluated.	Cascade has filed a Biomethane Reciept Services (Schedule 800) in Oregon to estabilsh biogas injection terms, conditions and gas quality requirements. Cascade continues to work with possible biomethane producers and evaluate those projects for possible future core supplies.
11. The Company will continue to monitor proposed LNG import facilities as information becomes available and will evaluate the various options that, if built, could result. Issues to monitor include specific cost, the availability of pipeline capacity and project timing.	Cascade is continuing to monitor the progress of import/export facilities such as the proposed Jordan Cove LNG terminal. The status of these projects are documented each month in Cascade's monthly internal market intelligence report
12. The Company will continue to monitor the futures market for price trends and will evaluate the effectiveness of its risk management policy. Implementation of Dodd- Frank in the coming year raises potential administrative challenges from a reporting standpoint; additionally it is unknown how the costs associated with the use of clearinghouses might impact prices of natural gas in the future.	Cascade has updated its price forecast to modify its weights based on a backcast of the accuracy of its sources. At this time the price impacts of Dodd-Frank and hedging related dockets such as UM 1720 and UG-132019 continues to be unknown. The Company will continue to provide updates in coming TAG meetings.

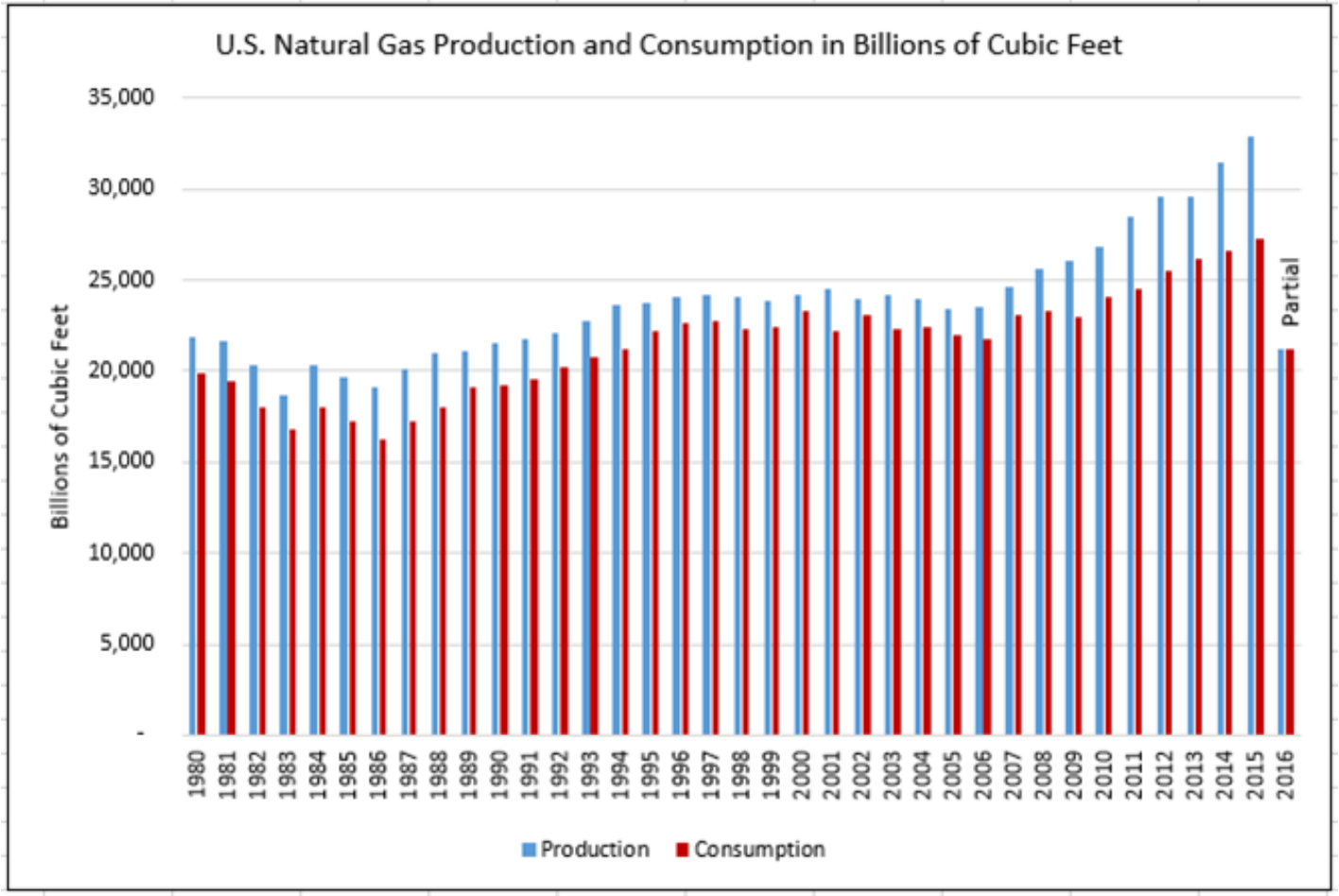
Consumer and Environmental Benefits of Shale Revolution

Ed Finklea
Northwest Industrial Gas Users
Presentation to Cascade TAG
October 19, 2017

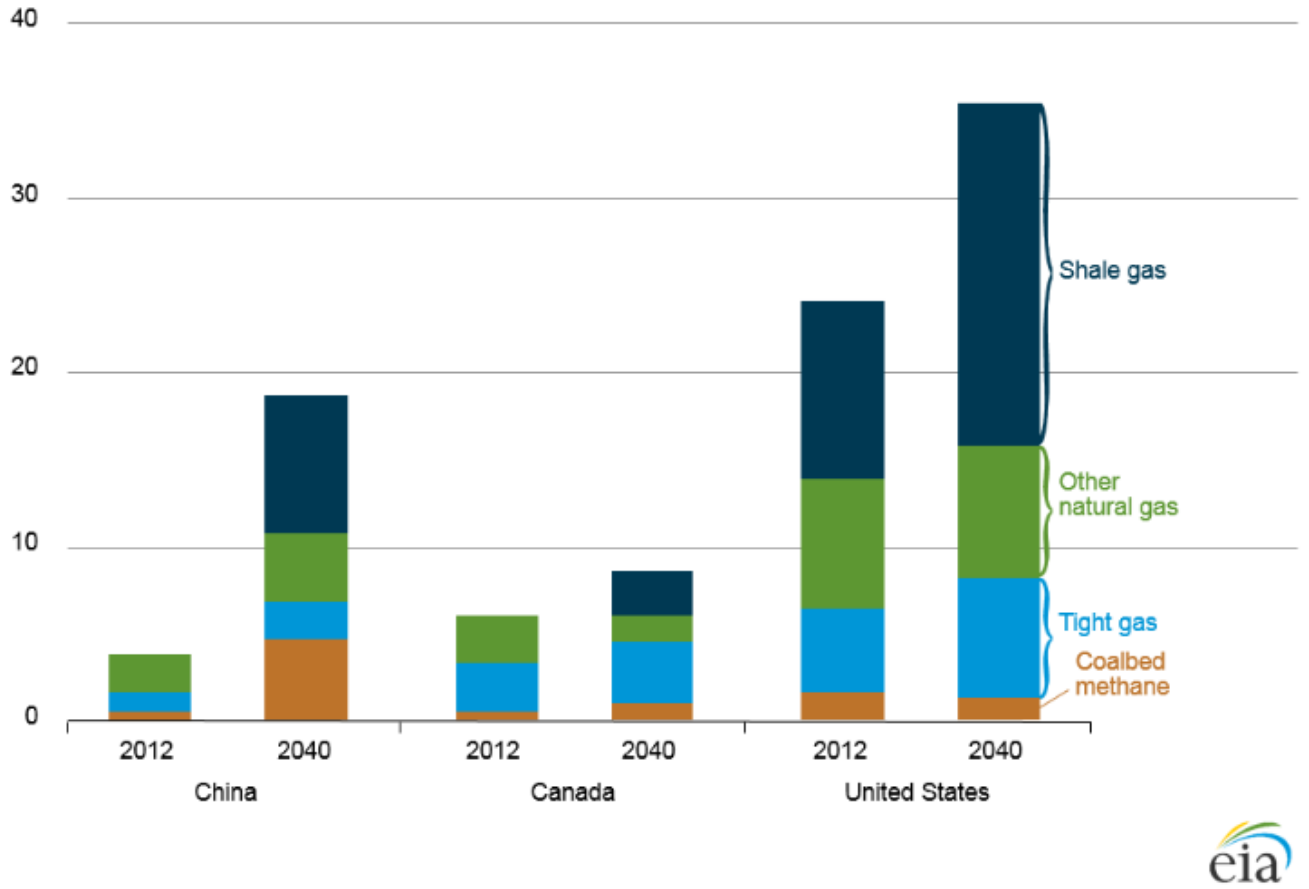
Oil and Natural Gas Price History 1983-2016



U.S. Natural Gas Production and Consumption in Billions of Cubic Feet 1980-2016

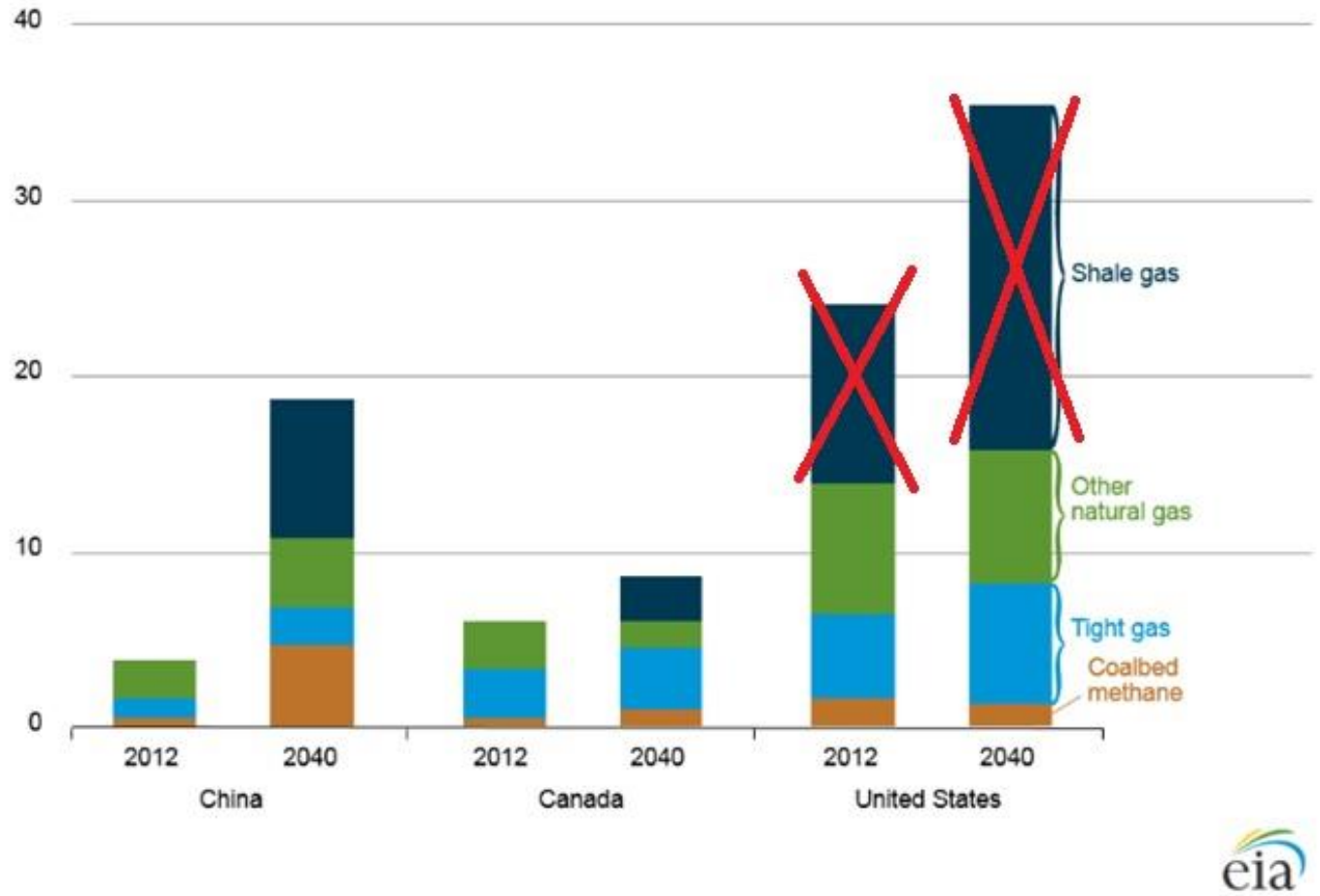


Natural Gas Production Outlook in North America, 2012-2040 in Trillion Cubic Feet

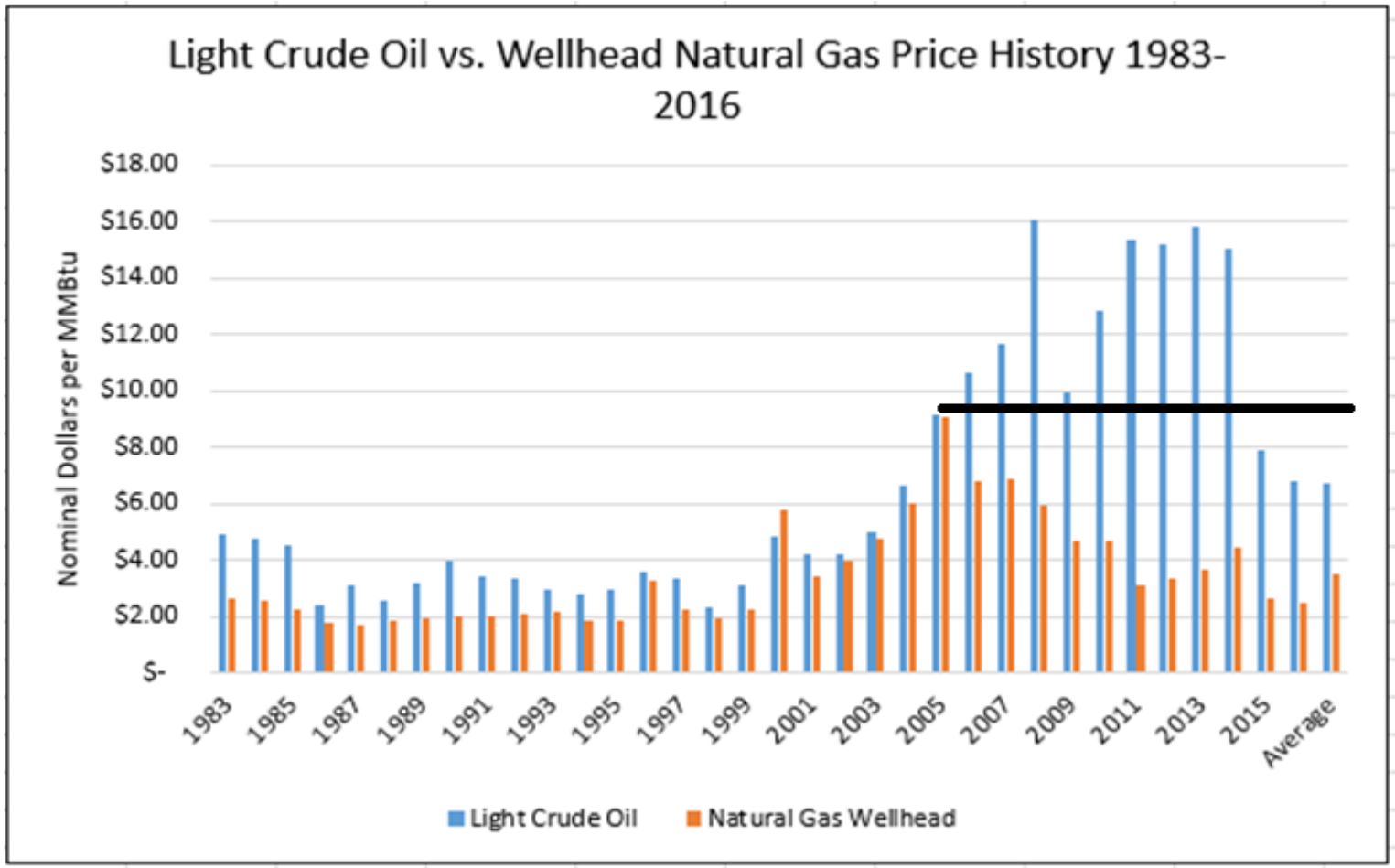



GOVERNOR CUOMO
IMAGINE THERE'S NO FRACKING...
YOKO & SEAN
WWW.ARTISTSAGAINSTFRACKING.COM

Eliminate Shale

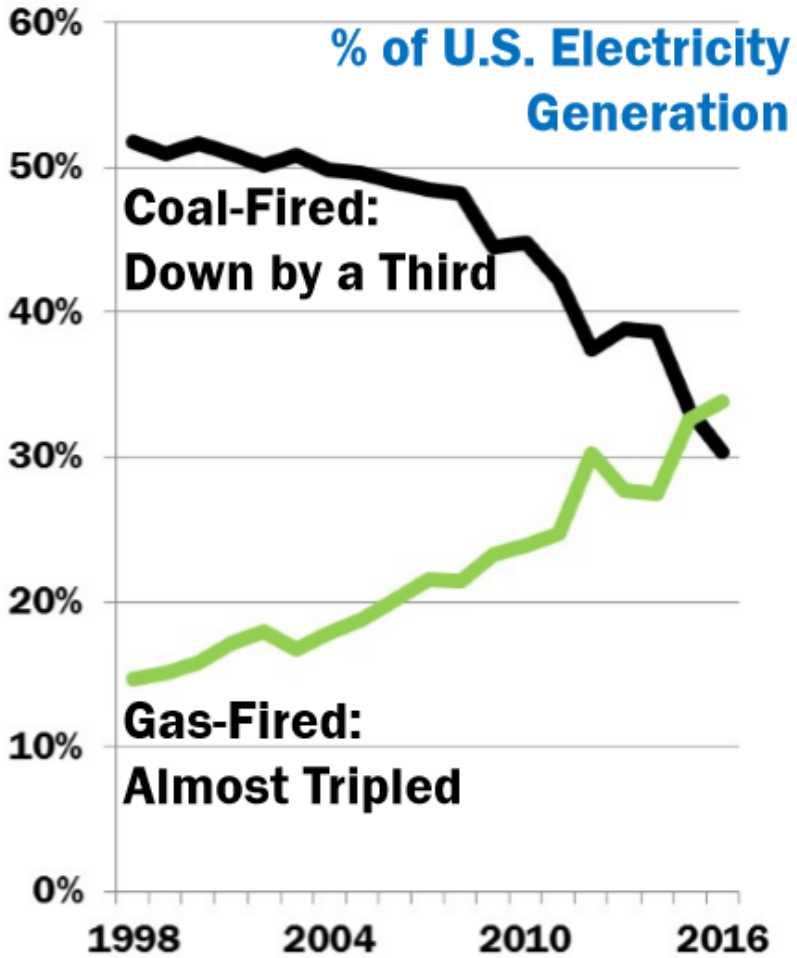


Prices Stay Above $8.00



No Fracking's Impact on Oregon Consumers

- Oregon Natural Gas Consumers Burned 239 million Dekatherm's in 2016.
- If no fracking raised natural gas prices by $5.00 per Dekatherm, staying at the pre fracking price of just above $8.00, Oregon consumers would have paid at least $1.1 billion more for natural gas in 2016.
- Every $1.00 per Dekaterm price reduction annually saves Oregon consumers $239 million on natural gas.
- US would have approximately a 10TCF shortfall to meet 2016 consumption levels without shale gas. How much LNG would US be importing? From where? Through what terminals? In Oregon, where would our natural gas be coming from? Would Canada be saving us at higher prices?



Source: Energy Information Administration

Total Carbon Emissions Reduction, 2007—2014 (Million Metric Tons per Year)

U.S.A	(590.8)
Spain	(118.1)
Italy	(109.6)
United Kingdom	(66.4)
Canada	(57.3)
Australia	(35.9)
France	(31.6)
Ukraine	(25.6)
Romania	(25.4)
Germany	(24.8)

Source: Global Carbon Atlas

SENDOUT® Optimization Modeling

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SENDOUT® Model

- Cascade utilizes SENDOUT® for resource optimization.
- This model permits the Company to develop and analyze a variety of resource portfolios to help determine the type, size, and timing of resources best matched to forecast requirements.
- SENDOUT® is very powerful and complex. It operates by combining a series of existing and potential demand side and supply side resources, and optimizes their utilization at the lowest net present cost over the entire planning period for a given demand forecast.

SENDOUT® Model (Cont'd)

- SENDOUT® utilizes a linear programming approach.
- The model knows the exact load and price for every day of the planning period based on the analyst's input and can therefore minimize costs in a way that would not be possible in the real world.
- Therefore, it is important to recognize that linear programming analysis provides helpful but not perfect information to guide decisions.

Modeling Transportation In SENDOUT® is a Balancing Act

- Start with a point in time look at each jurisdiction's resources
- Use the Nov17-Oct18 PGA portfolio
- Contracts –Receipt and Delivery Points
- We start with current transport contracts, using centralized receipts and approximately 66 delivery locations
- Rates - Current contractual, with CPI increase every 3 years
- Contractual vs. Operational
- Contractual can be overly restrictive
- Operational can be overly flexible
- Incorporating operational realities into our modeling can defer the need to acquire new resources.
- Gas Supply's job is to get gas from the supply basin to the pipeline citygate
- IRP focus is on the core
- Operations job is to take gas from the pipeline gate to our customers
- Operations focus is on the system, not just the core
- Limiting factor is receipt quantity –how much can you bring into the system?

Modeling Challenges

- Supply needs to get gas to the citygate.
- Many of Cascade's transport agreements were entered into decades ago, based on demand projections at that point in time.
- Sum of receipt quantity and aggregated delivery quantity can help identify resource deficiency depending on how rights are allocated.
- The aggregated look can mask individual citygate issues for looped sections, and the disaggregated look can create deficiencies where they don't exist.
- In many cases operational capacity is greater than contracted.
- SENDOUT® has perfect knowledge.

Supply Resource Optimization Process

- **Step 1: As-Is Analysis**
  - Run a deterministic optimization of existing resources with a three-day peak event to uncover timing and quantity of resource deficiencies.
- **Step 2: Introduce Additional Resources**
  - Include incremental supply, storage, and transportation to derive a deterministic optimal portfolio, additional portfolios.
- **Step 3: Stochastic Analysis of All Portfolios Under Existing Conditions**
  - Run all portfolios through a Monte Carlo weather simulation, using expected growth, supply and storage accessibility. Record the probability distributions of total system costs for each portfolio.
- **Step 4: Ranking of Portfolios**
  - Determine the preferred portfolio based on the mean and Value at Risk (VaR) of the total system cost and unserved demand of each portfolio. This resource mix will be the best combination of cost and risk for Cascade and its customers.

Supply Resource Optimization Process (Cont'd)

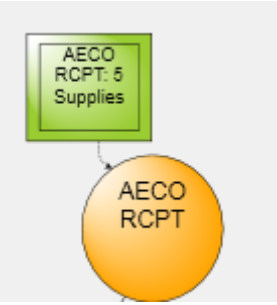
- **Step 5: Stochastic Analysis of Preferred Portfolio**
  - Run Monte Carlo simulations of various scenarios on preferred portfolio; comparing Mean and VaR to a managerial limit.
- **Step 6: Analysis of Preferred Portfolio**
  - Review data to confirm total system costs did not exceed Mean and VaR limits in any scenario. If limit is exceeded, repeat step 5 with next highest ranked portfolio.
- **Step 7: Sensitivity of Preferred Portfolio**
  - Run the preferred portfolio through Monte Carlo simulations on price. Review results to determine if total system cost is within the Mean and VaR limits across all sensitivities.
- **Step 8: Re-evaluation of Preferred Portfolio**
  - If the total system costs fall outside of the Mean and VaR limits in sensitivity analysis, select the next most optimal portfolio to run scenario and sensitivity analysis on. Repeat as needed.

Base Case Sendout Inputs

- Supply
- Storage
- Transportation
- Constraints
- Demand
- Weather
- Price Forecast

Supply

- Cascade can purchase gas at four markets; AECO, SUMAS, KINGSGATE and OPAL.
- At each market Cascade can purchase gas at different locations along the pipeline.
- For the first year, Cascade uses all current contracts for Supply inputs.
- For years 2-20, Cascade uses Base, Fixed, Winter base, Summer and Winter day gas, and Peak day incremental supplies as inputs.
- Over the planning horizon, the contracts are renewed in November and April.



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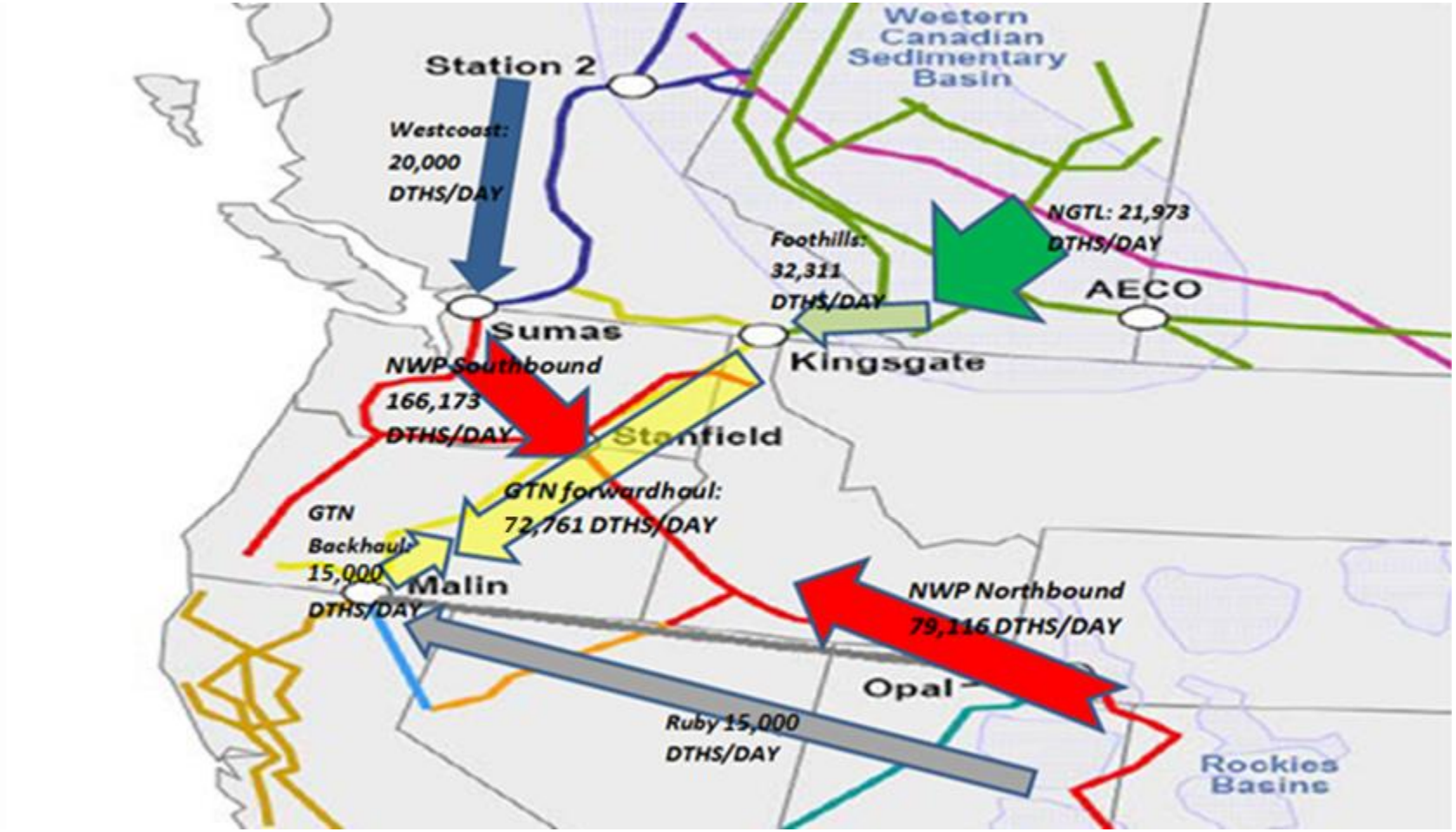
Supply



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Supply Base and Fixed

- Supply Base and Fixed are the baseline supply contracts that are entered into every 12 months.
- A base contract has a basis rate. This is defined as the price of gas at a given market (i.e., AECO base is the expected cost of gas at NYMEX plus the basis for AECO, for a given month).
- A fixed contract has a fixed rate.
- A penalty is applied to each contract when the gas is not taken for a day. This type of penalty forces these types of contracts to only take the optimal amount of gas to serve the base demand.

Supply Example

	JAN 2017	FEB 2017	MAR 2017	APR 2017	MAY 2017	JUN 2017	JUL 2017	AUG 2017	SEP 2017	Extension Option	Escalation Pattern	Monthly Multiplier	Index	Adder	Multiplier
*Daily MDQ	25000									Same					
*Daily Minimum Percent	100									Same					
Annual Maximum										Same					
Annual Minimum Percent										Same					
Monthly Maximum										Same					
Monthly Minimum Percent										Same					
Seasonal Maximum										Same					
Seasonal Minimum Percent										Same					
Known Take										Same					
*Rate - Commodity	2.5									Same	CPI				
Rate - Dispatch										Same					
Rate - Known Commodity Cost										Same					
Rate - Other Variable 1										Same					
Rate - Other Variable 2										Same					
Rate - Penalty Annual										Same					
Rate - Penalty Seasonal										Same					
Rate - Penalty Monthly										Same					
Rate - Penalty Daily	2.5									Same				-0.01	
Rate - D1										Same					
Rate - D2										Same					
Volume - D1 Volume										Same					
Volume - D2 Volume										Same					
Temp Cutoff Max Temperature										Same					
Available % Below Min/Above Max										Same					
Temp Cutoff Min Temperature										Same					
Apply Temperature Cutoff										Same					
Energy Conversion Factor										Same					
Process Indicator										Same					
Resource Mix Start\Stop Indicators	Start									Last Year					
Rmix MDQ Range Max	25000									Same					

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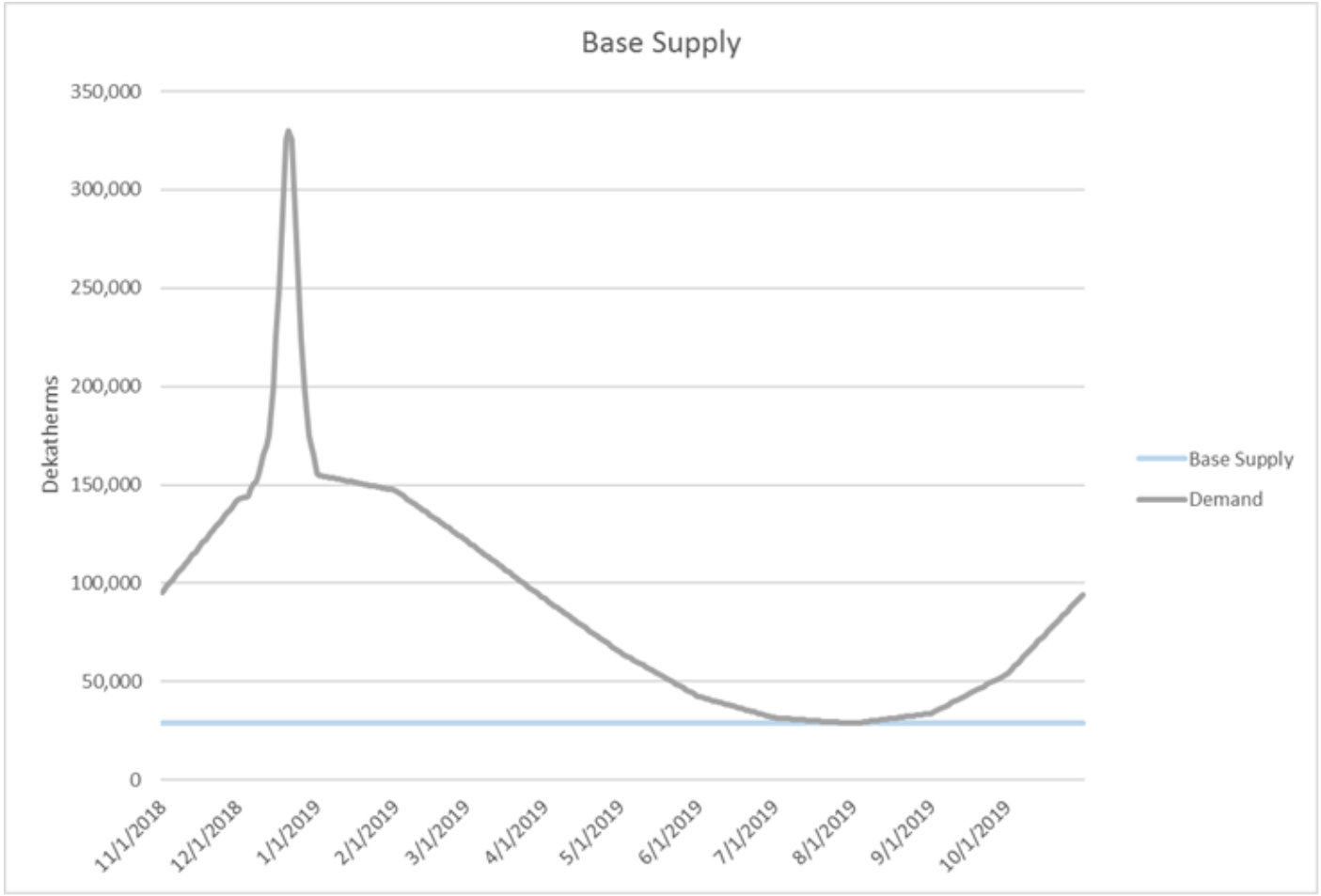
Base Supply (Cont'd)



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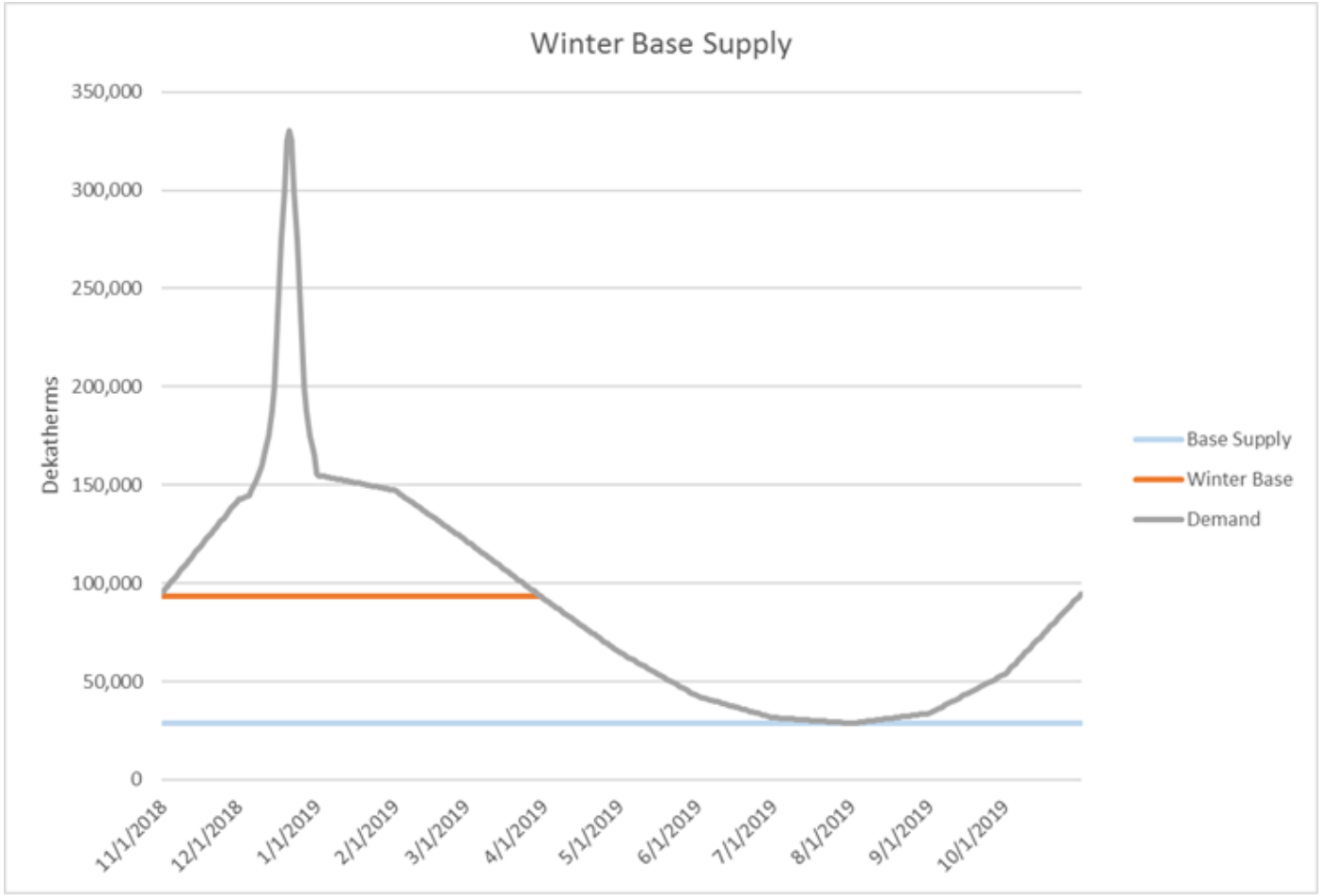
Winter base Supply

- Winter base supply is contracted supply with a premium charge that is slightly higher than base gas.
- The Maximum Daily Quantity (MDQ) is optimally set by SENDOUT.
- Winter supply is renewed every November and completes at the end of March.
- Winter Supply is additional baseline supply on top of the base or fixed supplies for the winter months.
- There is a penalty associated to this contract to force SENDOUT to take the optimal amount of additional winter base gas.

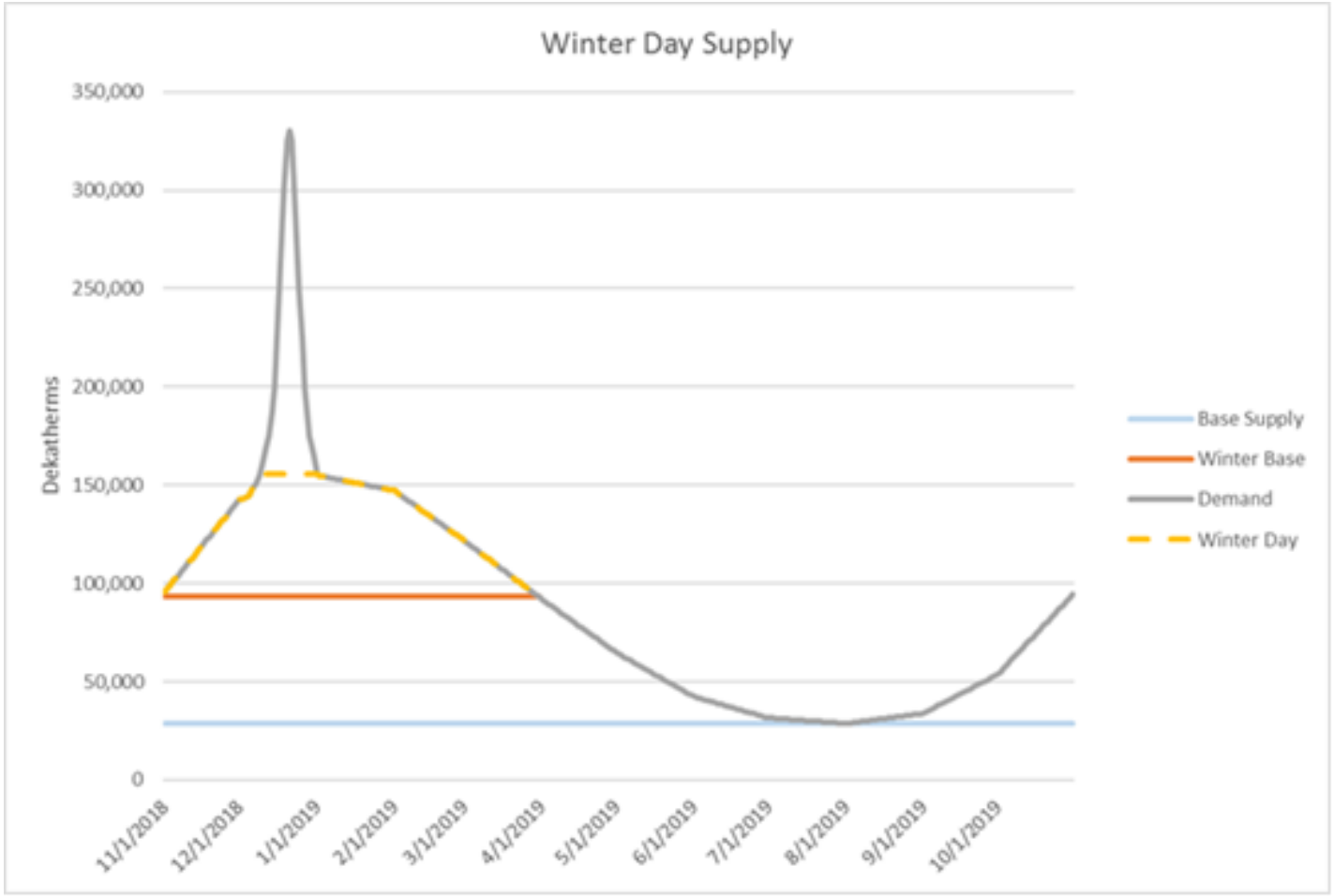
Winter Base Supply (Cont'd)



Day Supply (Winter)

- Winter Day supply is gas that is R-mixed at the beginning of November each year.
- The R-mix function takes into account the fixed and variable costs of a resource to determine the proper amount to take in a given period.
- Winter day gas has an MDQ cap but is not a must take supply.
- If a winter day supply has an MDQ of 10,000 dth then it can take anywhere from 0 to 10,000 dth of gas on any given day in the winter.
- Winter day supply has a slightly higher premium than winter base supply and it can be contracted from November to April.

Winter Day Supply (Cont'd)



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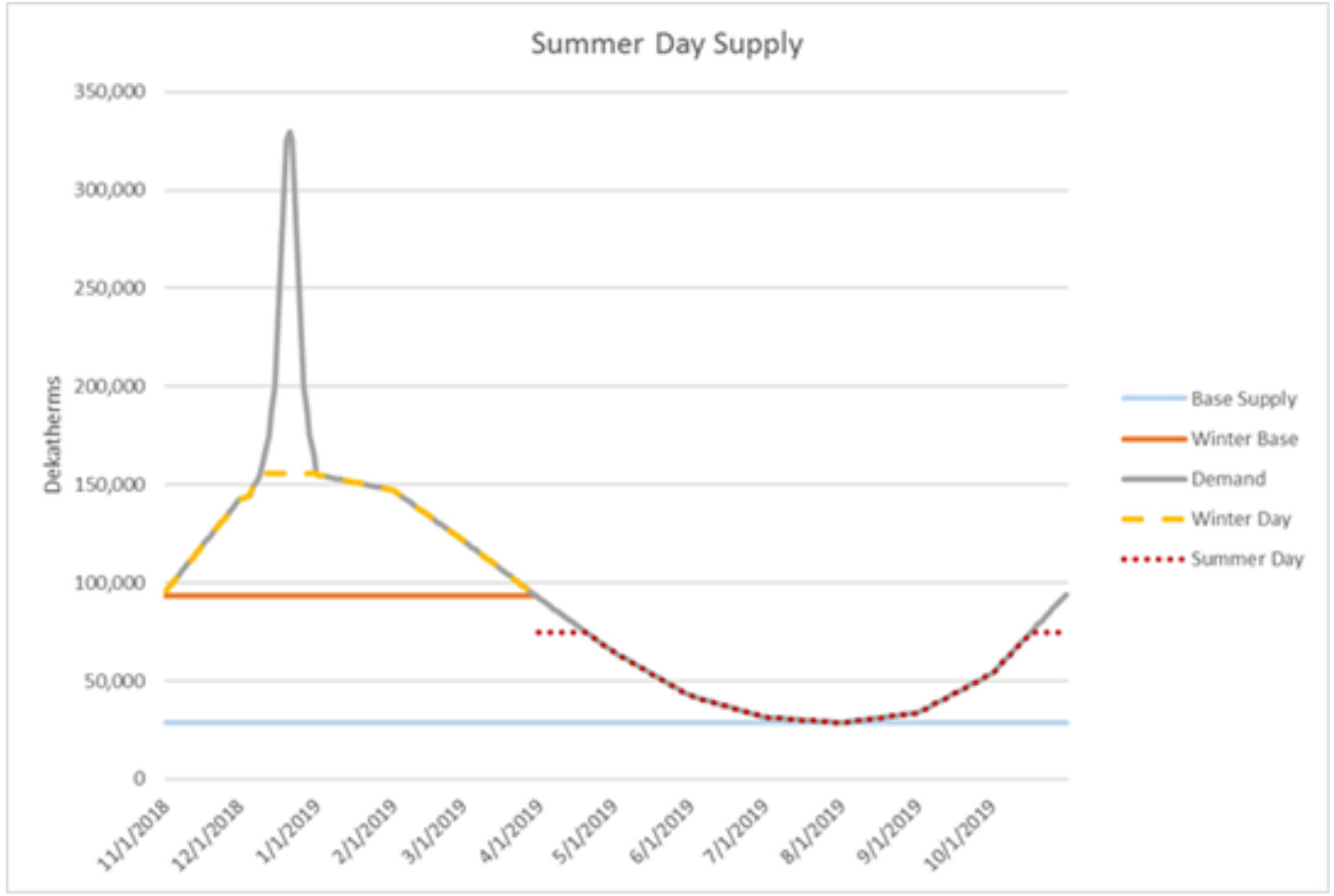
Day Supply (Summer)

- Summer day supply is gas that is R-mixed at the beginning of April each year.
- Summer day gas has an MDQ cap but is not a must take supply.
- If a summer day supply has an MDQ of 10,000 dth then it can take anywhere from 0 to 10,000 dth of gas on any given day in the summer.
- Summer day supply has a slightly higher cost than base supply and it can be contracted from April to November.

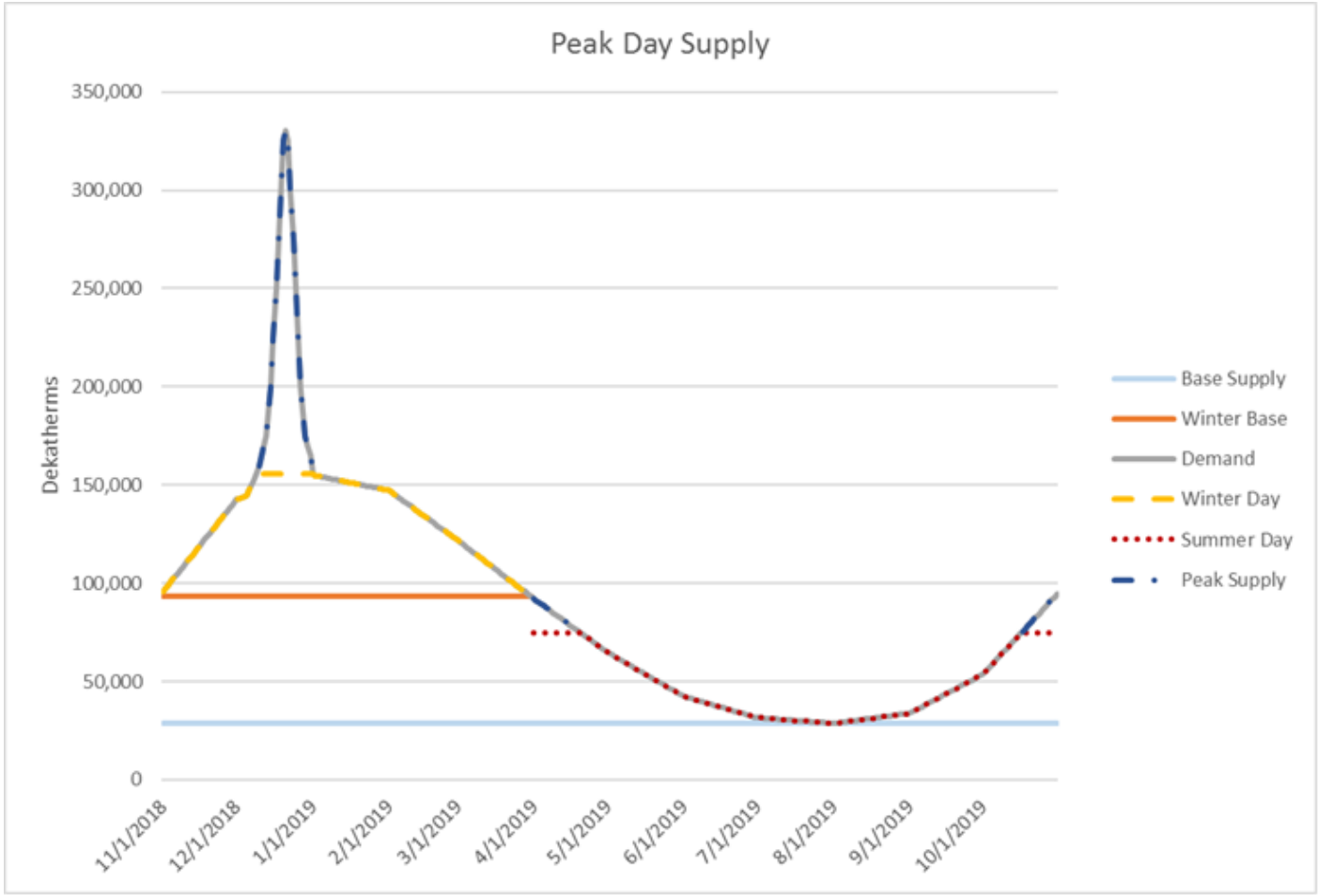
Day Supply (Summer)



Peak Supply

- Peak supply is gas purchased on high demand days where base, index, winter base, or day supply cannot accommodate.
- Peak supply has a slightly higher premium to buy than day supply.
- As long as Cascade has the transport capacity or can utilize a third party's transport capacity, we can purchase as much peak supply as needed to meet peak demand.

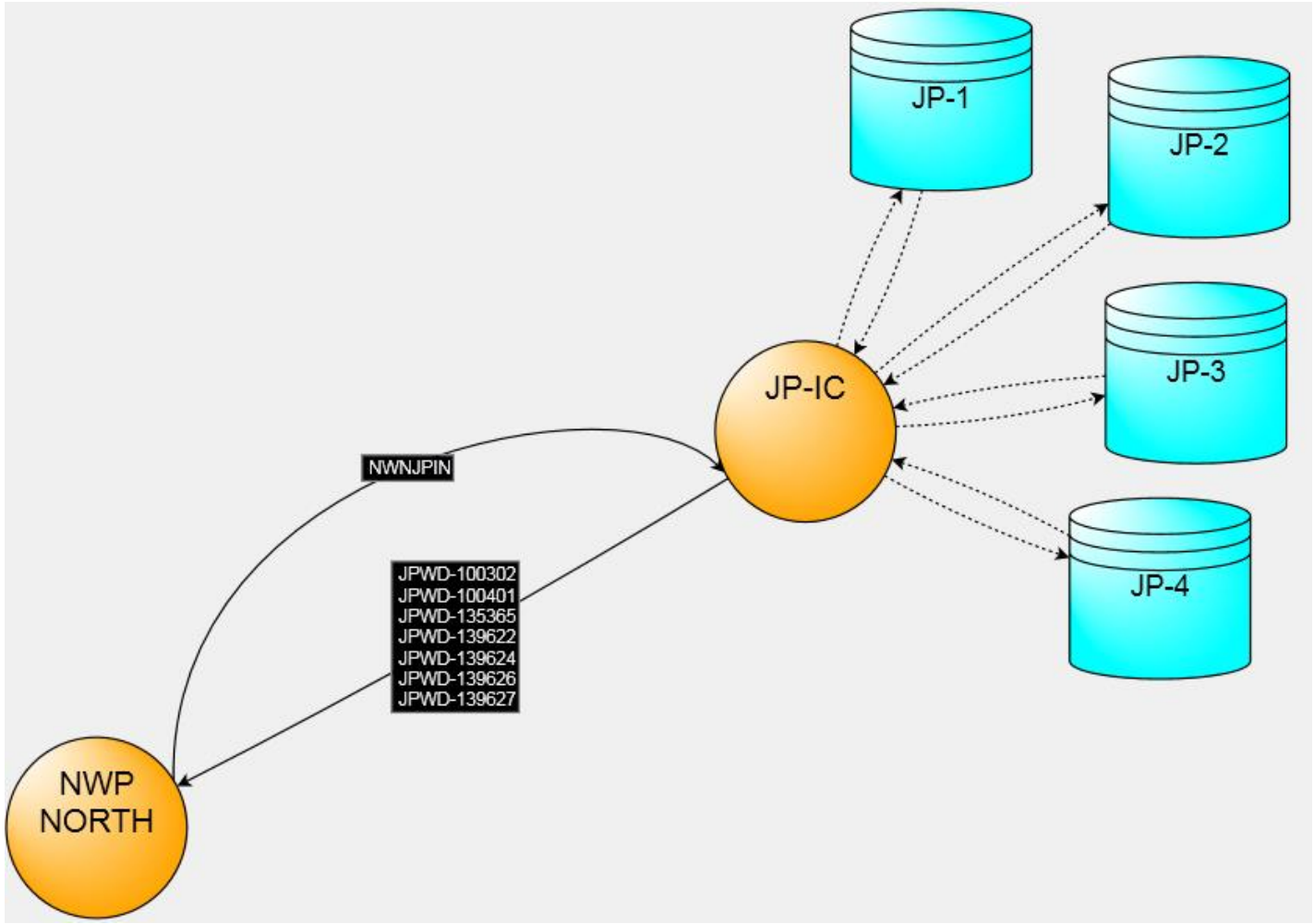
Total Supply



Storage

- Cascade leases storage at 2 locations: Jackson Prairie (JP) and Plymouth (Ply).
- Cascade has 4 storage contracts with JP and 2 contracts with Plymouth.
- Storage injections targets are set at 35% by the end of June, 80% by the end of August, and 100% by the end of September.
- These targets are set by our Gas Supply Oversight Committee.
- Cascade can withdrawal approximately 56,000 dth per day from JP and 78,000 dth per day from Plymouth for a total of approximately 134,000 dth per day.

Storage Example



Storage Example 2

	JAN 2017	FEB 2017	MAR 2017	APR 2017	MAY 2017	JUN 2017	JUL 2017	AUG 2017	SEP 2017	Extension Option	Escalation Pattern	Monthly Multiplier
Process Indicator										Same		
Inventory Maximum Physical Capacity	604351									Same		
Inventory Minimum Physical Percent										Same		
*Target Inv - End of Period Max Pct										Same		
*Target Inv - End of Period Min Pct						35		80	100	First Year		
*Inventory Adjustment - Value per Unit										Same		
*Inventory Adjustment - Volume										Same		
*Injection Daily MDQ				16789						First Year		
*Injection Daily Min Percent										Same		
*Withdrawal Daily MDQ				0						Last Year		
*Withdrawal Daily Min Percent										Same		
Fuel - Injection	0.15									Same		
Fuel - Withdrawal	0.15									Same		
Rate - Carry										Same		
Rate - Injection										Same		
Rate - Withdrawal										Same		
Rate - Other Injection										Same		
Rate - Other Withdrawal										Same		
Rate - Volume Charge										Same		
Rate - D1	.01558									Same		DaysInMonth
Rate - D2	.00057									Same		DaysInMonth
Volume - D1 Volume	16789									Same		
Volume - D2 Volume										Same		
Storage Ratchets Table	JP									Same		
Starting Inv Layer 1 Value per Unit	3									Same		
Starting Inv Layer 1 Volume	604351									Same		
Energy Conversion Factor										Same		
Injection Costing List - Transport										Same		
Injection Costing List - Source										Same		

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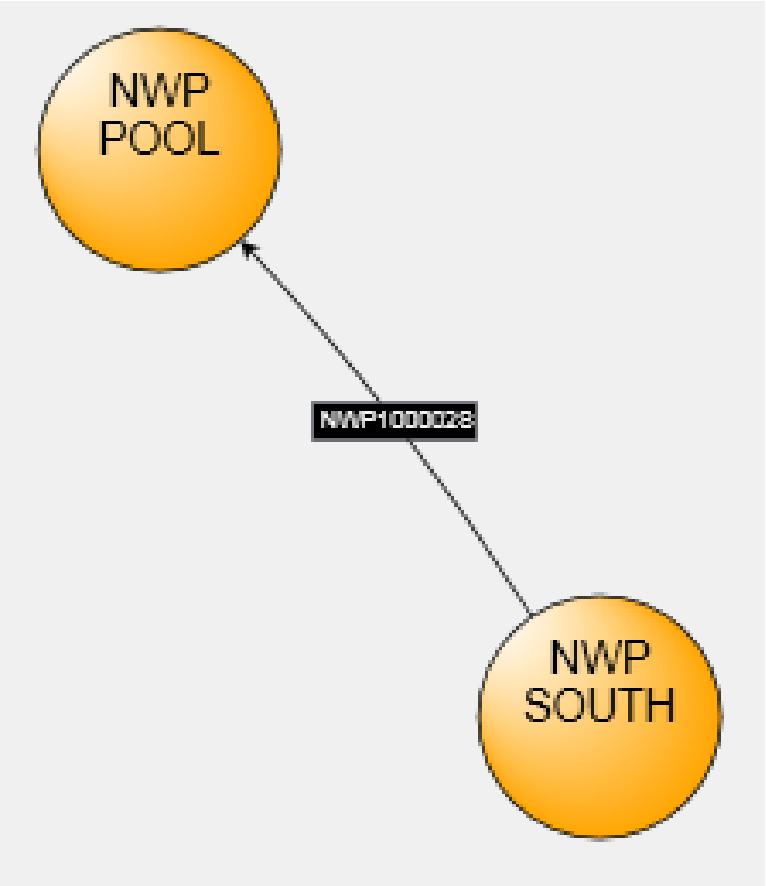
Transportation

- Transportation contracts are the means of how Cascade gets the gas from the supplier to the end user.
- Cascade has multiple types of transportation:
  - A single delivery point.
  - Multiple delivery points.
- The multiple delivery point contracts gives Cascade the flexibility to move the gas where it's most needed.
- On NWP, transportation goes to the zonal level because MDDO's can be reallocated within a zone to the citygate. Additionally, NWP typically issues constraint concerns at the zonal level.
- On GTN, transportation goes to the citygate level as MDDO's cannot be reallocated within the GTN zone.

Transportation (Cont'd)

- Transportation has an MDQ, a D1 rate, a transportation rate, and a fuel loss percentage.
- A maximum delivery quantity (MDQ) which is the maximum amount of gas Cascade can move on the pipeline on a single day.
- A D1 rate which is the reservation rate to have the ability to move the MDQ amount on the pipeline.
- A transportation rate which is the rate per dekatherm that is actually moved on the pipeline.
- The fuel loss percentage is the statutory percent of gas based on the tariff from the pipeline that is lost and unaccounted for from the point of where the gas was purchased to the citygate.

Transport Example



Transport Example

	JAN 2017	FEB 2017	MAR 2017	APR 2017	MAY 2017	JUN 2017	JUL 2017	AUG 2017	SEP 2017	Extension Option	Escalation Pattern	Monthly Multiplier
*Daily MDQ	116866									Same		
*Daily Minimum Percent										Same		
Fuel	1.28									Same		
Rate - Transportation	0.03									Same		
Rate - Other Variable										Same		
Rate - D1 Rate	0.39249									Same		DaysInMonth

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Delivery Rights vs Receipt Rights

- Cascade has more Delivery Rights than Receipt Rights.
- Approximately 457,000 Dth of Delivery Rights.
- Approximately 360,000 Dth of Receipt Rights.
- The excess Delivery Rights allow Cascade to be flexible with the 360,000 Dth of Receipt Rights.

Example of delivery right flexibility

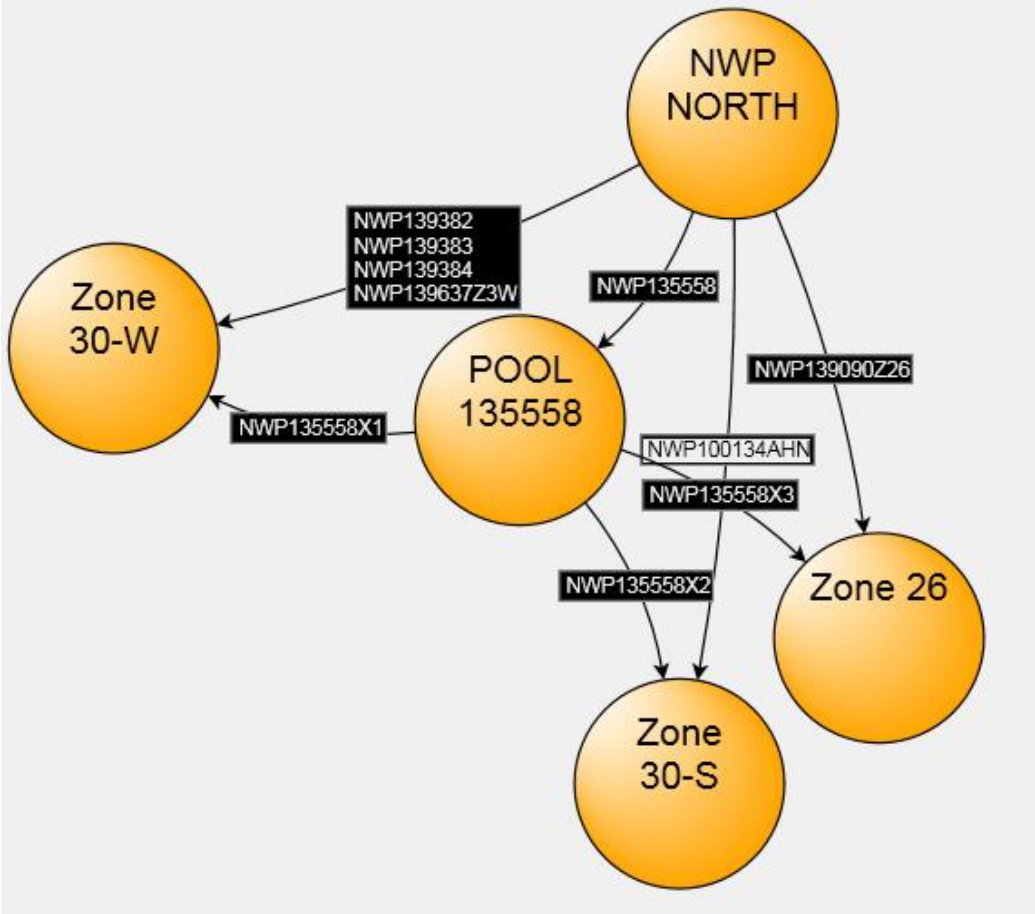
All of the following must be true

$X1 \leq 4\text{MDTs}$

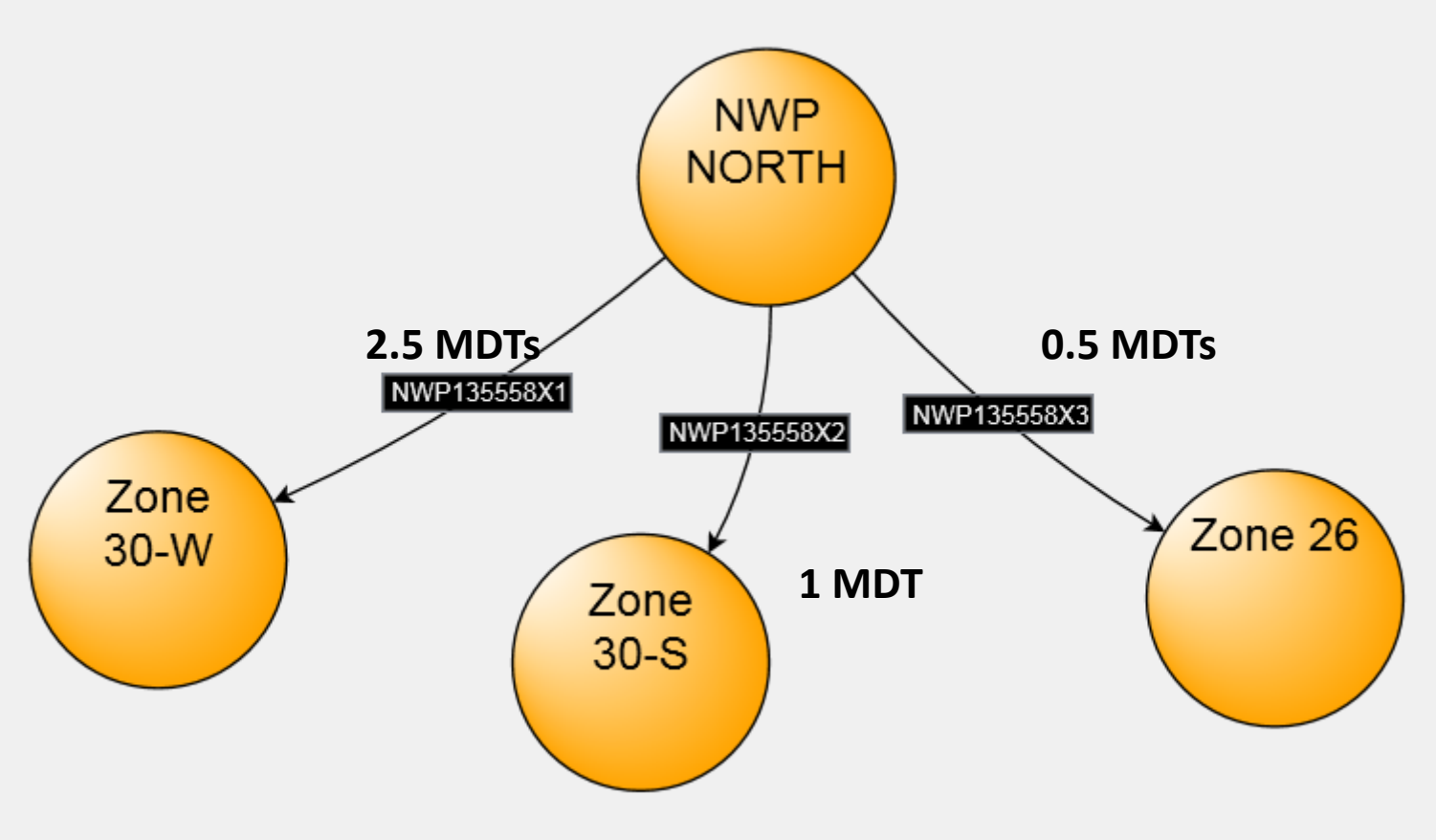
$X2 \leq 4\text{MDTs}$

$X3 \leq 4MDTs$

$X1 + X2 + X3 \leq 4MDTs$



Example of delivery right inflexibility



Transport Constraints

- To simplify modeling in SENDOUT®, the software allows the user to group multiple paths of one contract into a constraint group.
- This tells SENDOUT® to allow each path to take up to X Dekatherms, but not to exceed X Dekatherms for all paths of the contract.
- The analyst identifies which contracts should be in the group and assigns an MDQ for the constraint group.

Transport Constraints Example

	JAN 2017	FEB 2017	MAR 2017	APR 2017	MAY 2017	JUN 2017	JUL 2017	AUG 2017	SEP 2017	Extension Option
Annual Max										Same
Annual Min Percent										Same
Seasonal Max										Same
Seasonal Min Percent										Same
Monthly Max										Same
Monthly Min Percent										Same
*Daily Max	47603									Same
*Daily Min Percent										Same
Resource Mix Start\Stop Indicators										Same
RMIX MDQ Max										Same
RMIX MDQ Min										Same
Fixed Rate										Same
Demand Annual Max Percent										Same
Demand Annual Min Percent										Same
Demand Seasonal Max Percent										Same
Demand Seasonal Min Percent										Same
Demand Monthly Max Percent										Same
Demand Monthly Min Percent										Same
*Demand Daily Max Percent										Same
*Demand Daily Min Percent										Same

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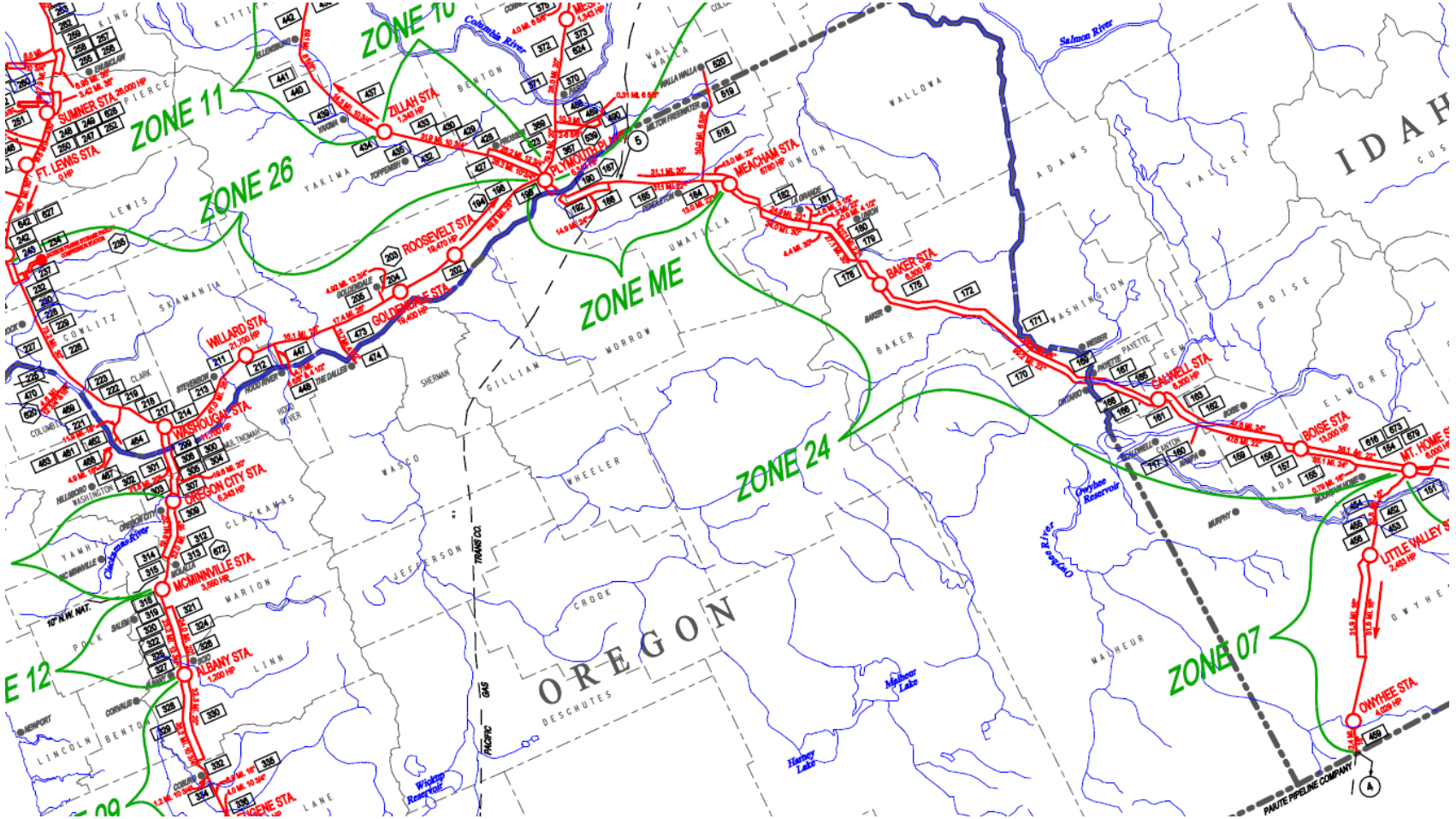
Location of Zones (Source: NWP)



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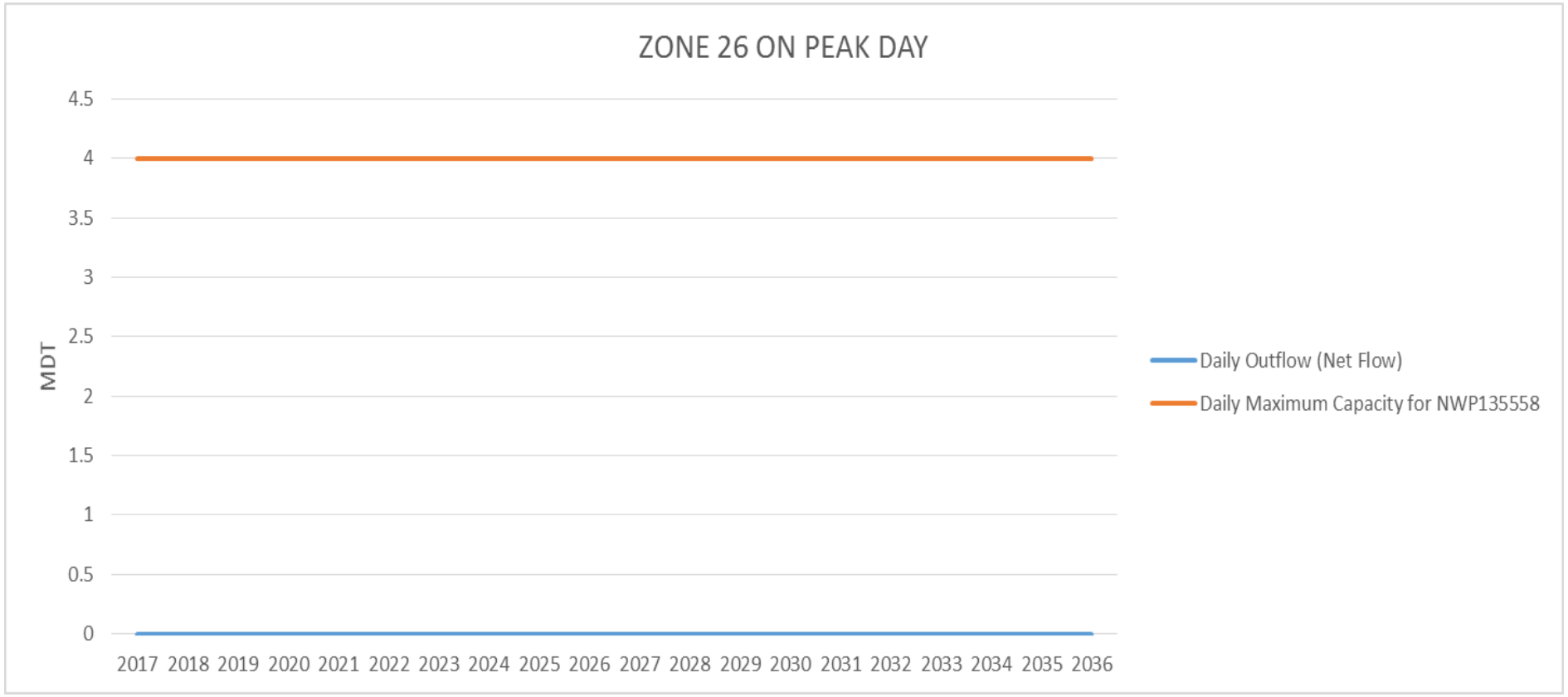
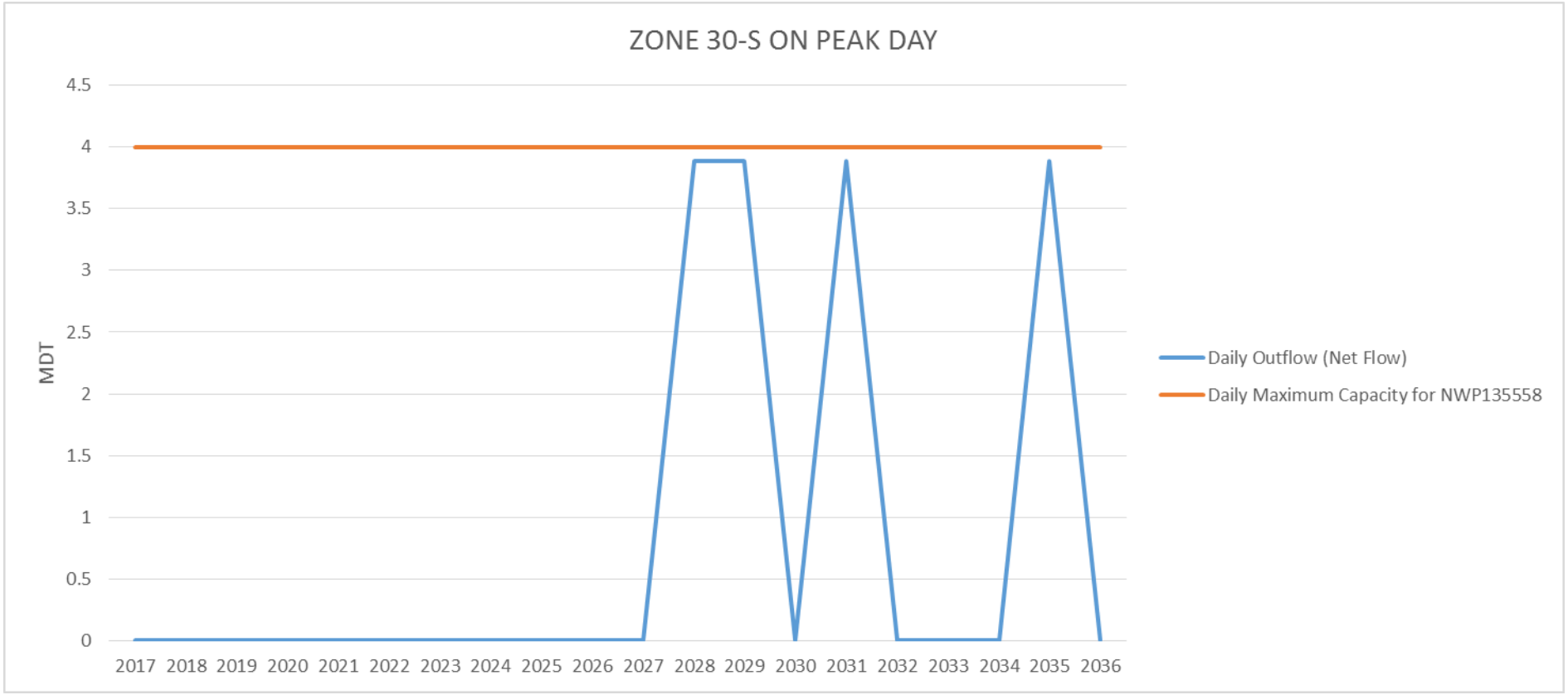
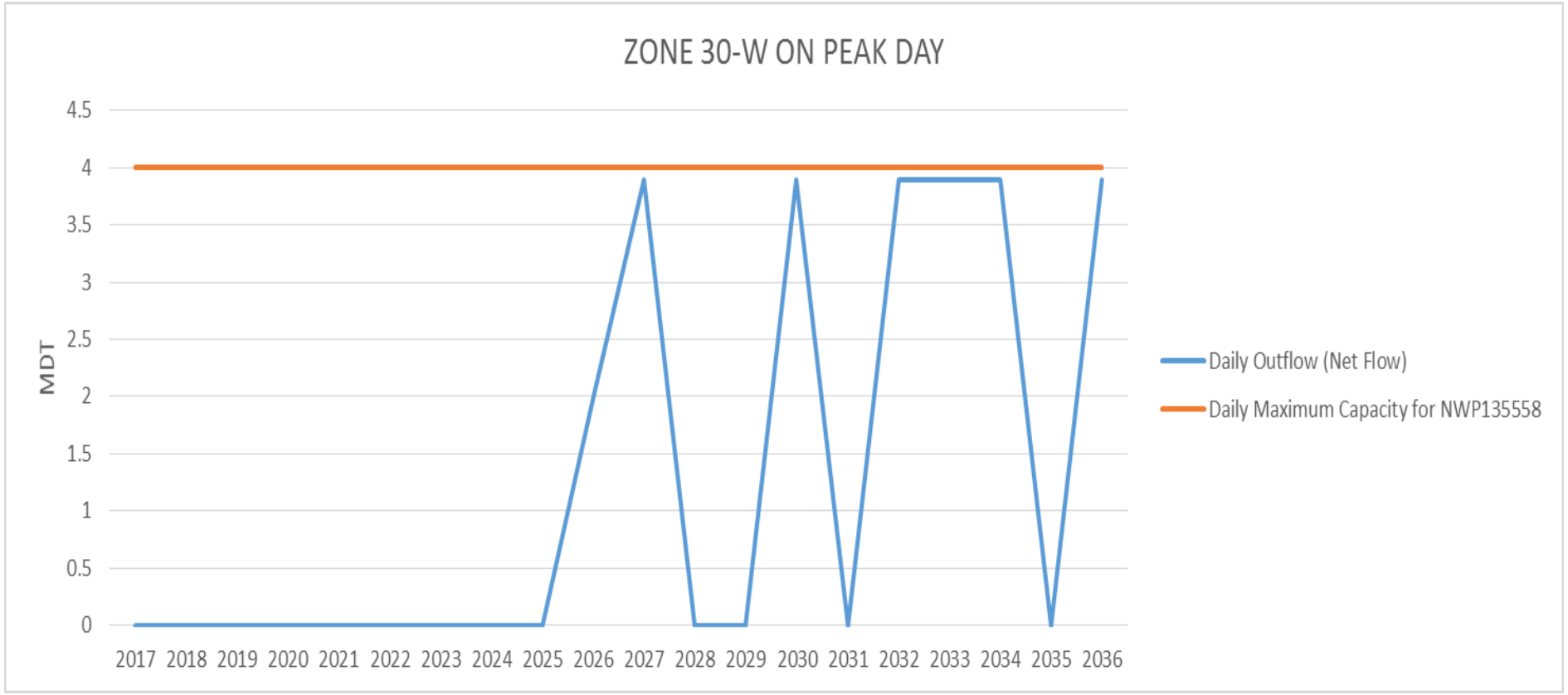
Zone 26 on Peak Day for Transport 135558



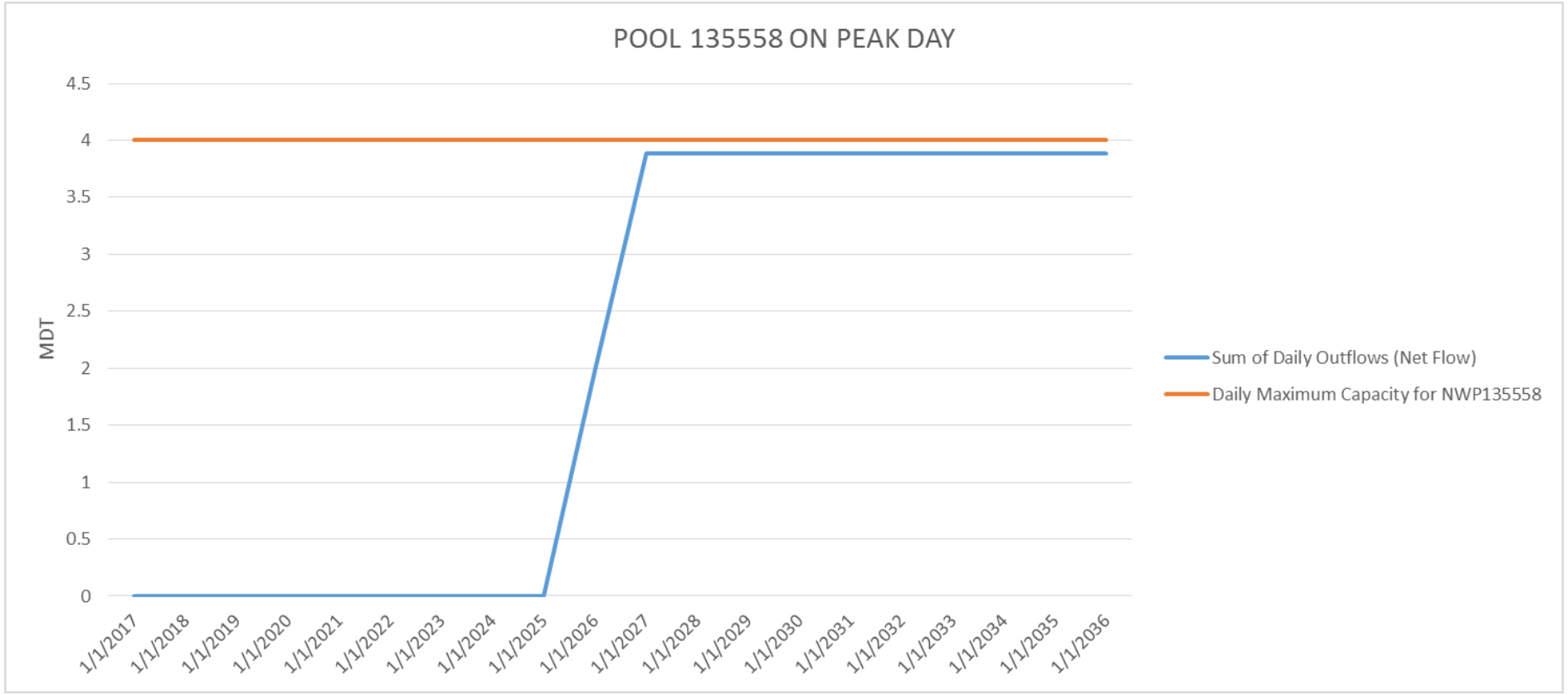
Zone 30-S on Peak Day for Transport 135558



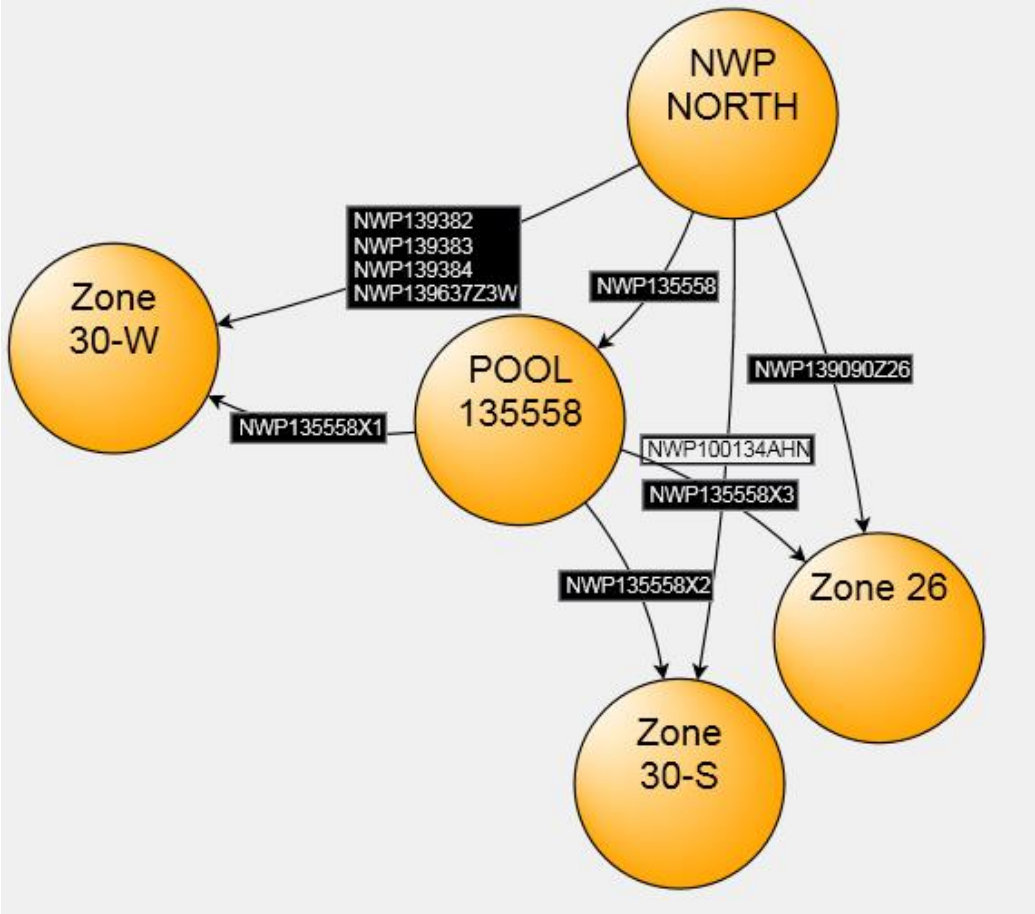
Zone 30-W on Peak Day for Transport 135558



Transport Contract 135558 on Peak Day



Example of delivery right flexibility



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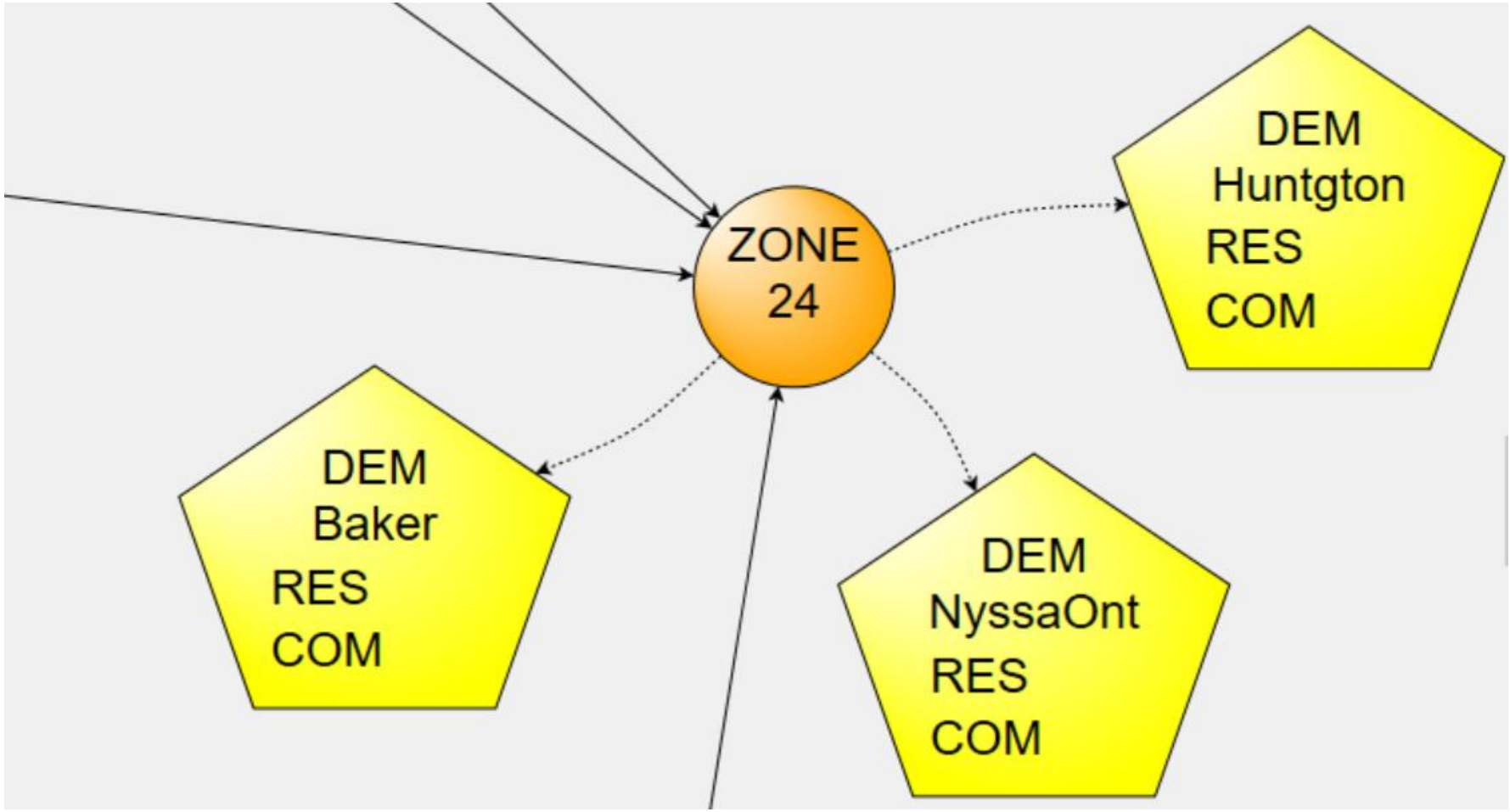
Demand Behind the Gate

- Cascade has strived over the last several years to enhance the IRP forecast and resource analysis to get to as granular a level as possible using the available data.
- Attempts to forecast demand behind the gate using existing forecasting methodology has been challenging.
- Customer billing data does not have daily meter reads for core customers making regression analysis on use per HDD per customer difficult.
- Given Cascade is not a contiguous system, DSM by citygate is currently is an ongoing complication:
  - This year we have added the Climate Zone.
  - Future IRPs will address the citygate level.
- Some towns can be served by multiple pipelines and the mix can change over time.

Demand

- Demand is forecasted at the citygate level by rate schedule.
- For NWP, each citygate's demand is associated with the zone.
- For GTN, each citygate's demand is associated with it's respective citygate interconnect.
- Demand Inputs
  - Forecast type (Monthly amount or Regressions).
  - Monthly projected customers for 20 years.
  - Regression coefficients if using the Regression forecast type.
  - If using a monthly number, it is the 2016 demand for that month with a growth factor.

Demand Example



Demand Example 2

	JAN 2017	FEB 2017	MAR 2017	APR 2017	MAY 2017	JUN 2017	JUL 2017	AUG 2017	SEP 2017	Extension Option	Escalation Pattern	Monthly Multiplier	Index	Adder	Multiplier
Forecast Method	Usage Fac									Same					
Customers	28347	28386	28429	28435	28456	28442	28450	28469	28489	Same					
*Demand - Daily										Same					
Demand - Monthly Base										Same					
Demand - Monthly Heat										Same					
Demand - Monthly Total										Same					
Demand - Percent Factor - non P non Q										Same					
Demand - Percent Factor - non Q										Same					
Usage Factors - Weekday Base	0.1919	0.1659	0.1396	0.0979	0.0741	0.0625	0.0589	0.0581	0.06	First Year					
Usage Factors - Weekday Heat	0.007448									Same					
Usage Factors - Weekend Base	0.186298	0.160298	0.133998	0.092298	0.068498	0.056898	0.053298	0.052498	0.054398	First Year					
Usage Factors - Weekend Heat	0.007448									Same					
*Rate - Unserved Dispatch (Pri 1)										Same					
*Rate - Unserved (Pri 2)	960									Same					

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Weather

- Weather inputs for SENDOUT include:
  - Monte Carlo
  - Historical
  - Normal
- Monte Carlo inputs include mean, standard deviation, max, minimum, and distribution.
- Historical data is used to build weather profiles for Monte Carlo.
- Normal weather is the daily average of the 30-year most recent history (1987-2016).

Weather Example – Monte Carlo

	JAN 2014	FEB 2014	MAR 2014	APR 2014	MAY 2014	JUN 2014	JUL 2014
HDD Mean	1031.8	804.1	639.6	453.9	254.2	92.6	10.3
HDD Std Dev	145.4	133.1	84.4	93.0	72.2	40.4	15.2
HDD Distribution	Normal						
HDD Max	1291	1242	841	641	426	170	75
HDD Min	772	568	448	254	92	19	0
CDD Mean							
CDD Std Dev							
CDD Distribution							
CDD Max							
CDD Min							
Scaling Year	Best Match						

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Long Range Price Forecast

- Cascade's long-term planning price forecast is based on a blend of current market pricing along with long-term fundamental price forecasts.
- The fundamental forecasts include Wood Mackenzie, EIA, the Northwest Power Planning Council (NPPC), Bentek and the Financial Forecast Center's long term price forecasts.
- While not a guarantee of where the market will ultimately finish, Henry Hub NYMEX is the most current information that provides some direction as to future market prices.
- Wood Mackenzie's long-term forecast is at a monthly level by basin. Cascade uses this to help shape the forecast's monthly basis pricing.
- The Company also relies on EIA's forecast; however, it has its limitations since it is not always as current as the most recent market activity. Further, the EIA forecast provides monthly breakdowns in the short-term, but longer term forecasts are only by year.

Long Range Price Forecast (Cont'd)

- CNGC assigns a weight to each source to develop the monthly Henry Hub price forecast for the 20-year planning horizon.
- Although it is impossible to accurately estimate the future, for trading purposes the most recent period has been the best indicator of the direction of the market. However, Cascade also considers other factors (historical constraints) which can lead to minor adjustments to the final long range forecast.

Price Forecast Weights

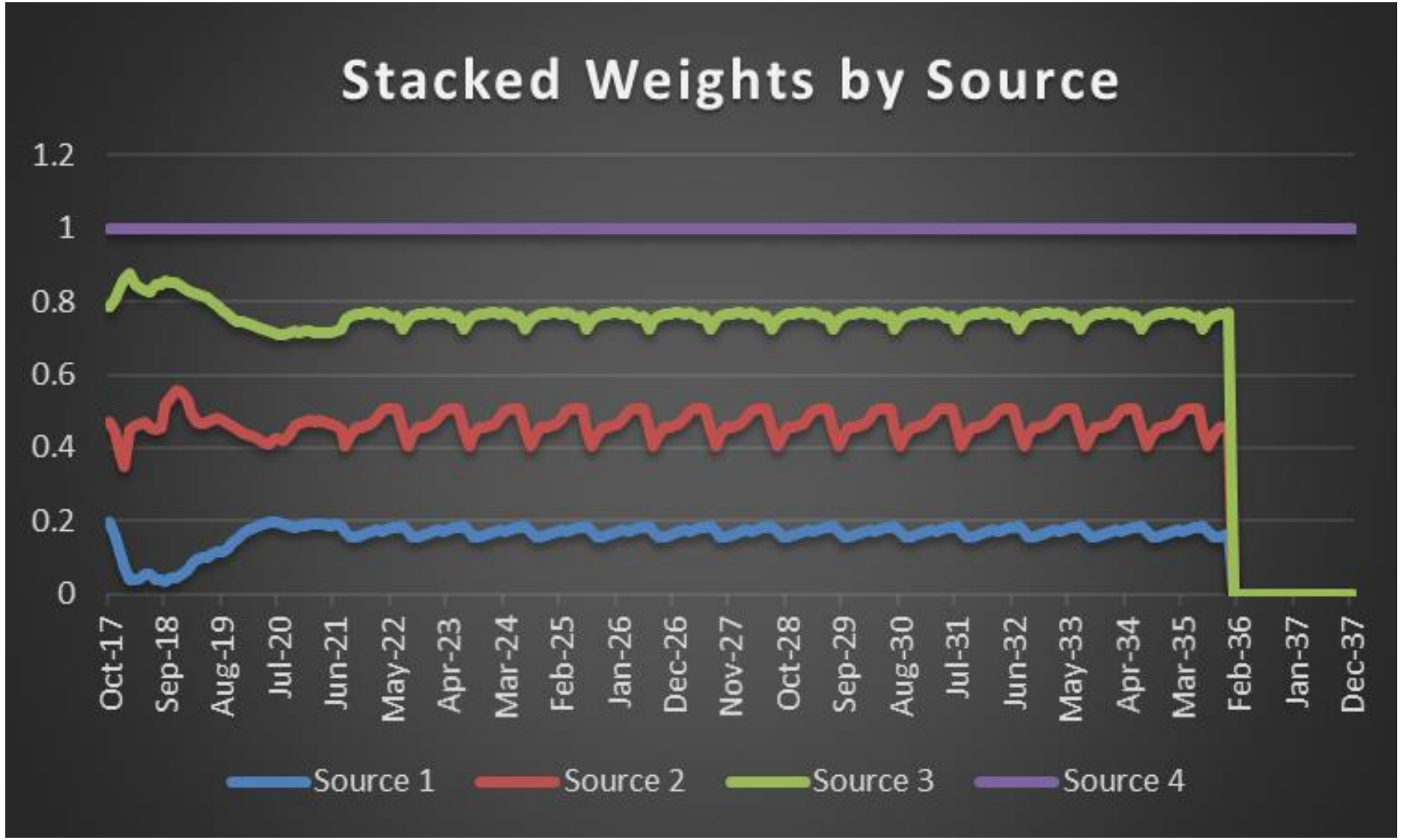
- Considerations in weight assignments
  - Cascade has modified its weighting system based on a backcast of the symmetric mean absolute percentage error (SMAPE) of its sources since 2010
    - Wood Mackenzie (monthly, covers all basins)
    - EIA (industry barometer, annual long term)
    - NPPC (regional perspective, but recognize it is also a blend)
    - NYMEX Henry Hub
  - EIA is the only source who produces a forecast after 2036
    - EIA typically forecasts higher than most other sources, so their forecast needs to be normalized based on their average error

Example of SMAPE Calculations by Source

	Source 1	Source 2	Source 3	Source 4
T+1	0.126033375	0.217301	0.1446299	0.152795
T+2	0.167033935	0.208055	0.1973402	0.193328
T+3	0.201221558	0.159752	0.1774237	0.180943
T+4	0.207867469	0.216499	0.0567454	0.206089
T+5	0.240209263	0.170581	0.0149917	0.203743
T+6	0.223763051	0.15863	0.0308552	0.178014
T+7	0.224086048	0.017803	0.160998	0.126166
T+8	0.173107419	0.108208	0.1654999	0.101882
T+9	0.22366183	0.182278	0.1409933	0.190653
T+10	0.197011026	0.171414	0.1373605	0.182815
T+11	0.232436816	0.198159	0.0881173	0.177821
T+12	0.235293955	0.064647	0.046813	0.169711

Example Weights Price Forecast For 2018

Date	Source 1	Source 2	Source 3	Source 4
18-Jan	7.443%	27.601%	51.155%	13.802%
18-Feb	4.103%	40.758%	43.028%	12.111%
18-Mar	4.142%	42.124%	38.518%	15.216%
18-Apr	4.619%	41.958%	37.283%	16.140%
18-May	5.469%	41.641%	36.015%	16.876%
18-Jun	5.248%	40.041%	37.548%	17.163%
18-Jul	3.654%	41.433%	39.335%	15.578%
18-Aug	3.970%	41.695%	38.973%	15.362%
18-Sep	3.324%	48.277%	34.266%	14.132%
18-Oct	4.354%	49.429%	31.572%	14.646%
18-Nov	4.459%	51.308%	29.570%	14.663%
18-Dec	5.599%	49.377%	29.287%	15.737%



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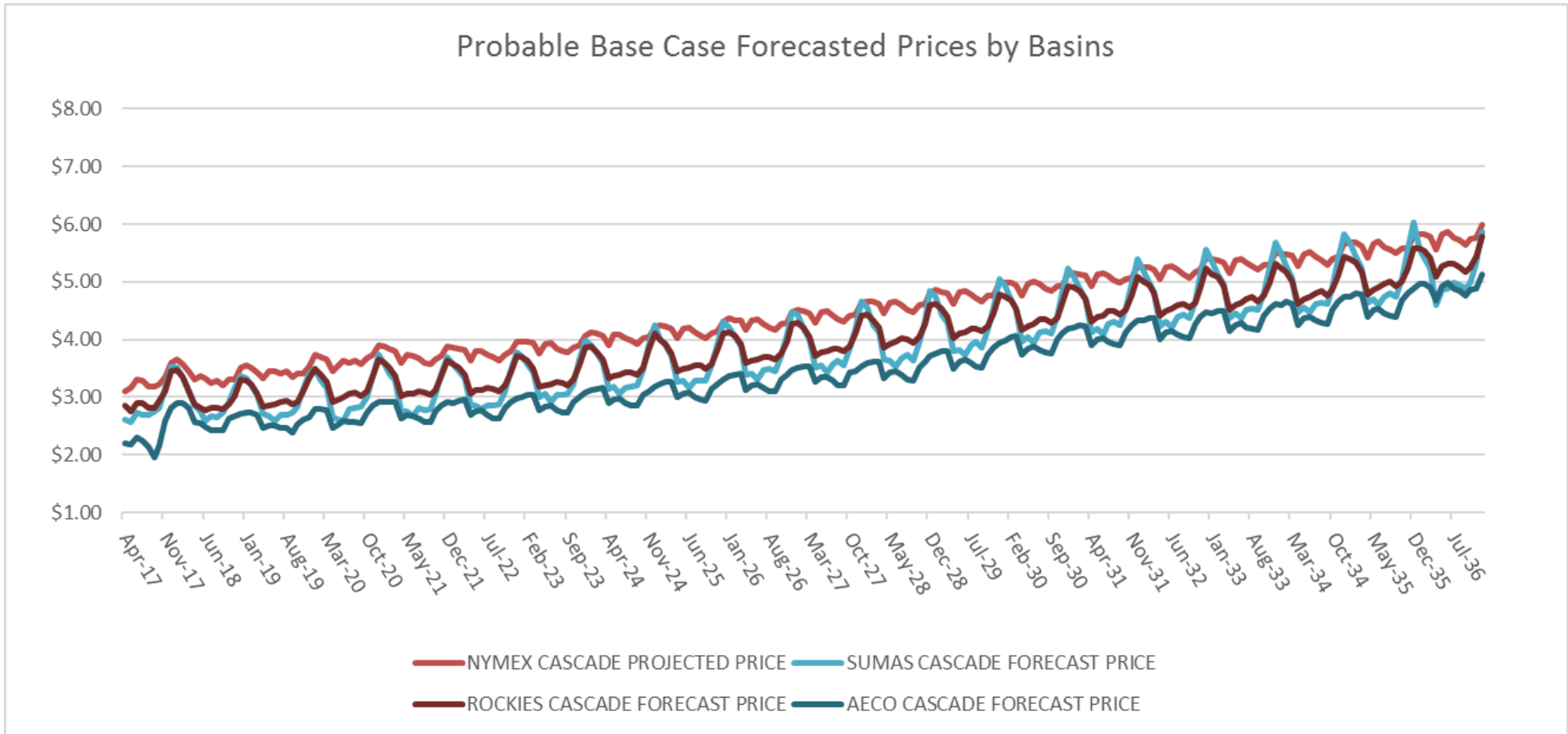

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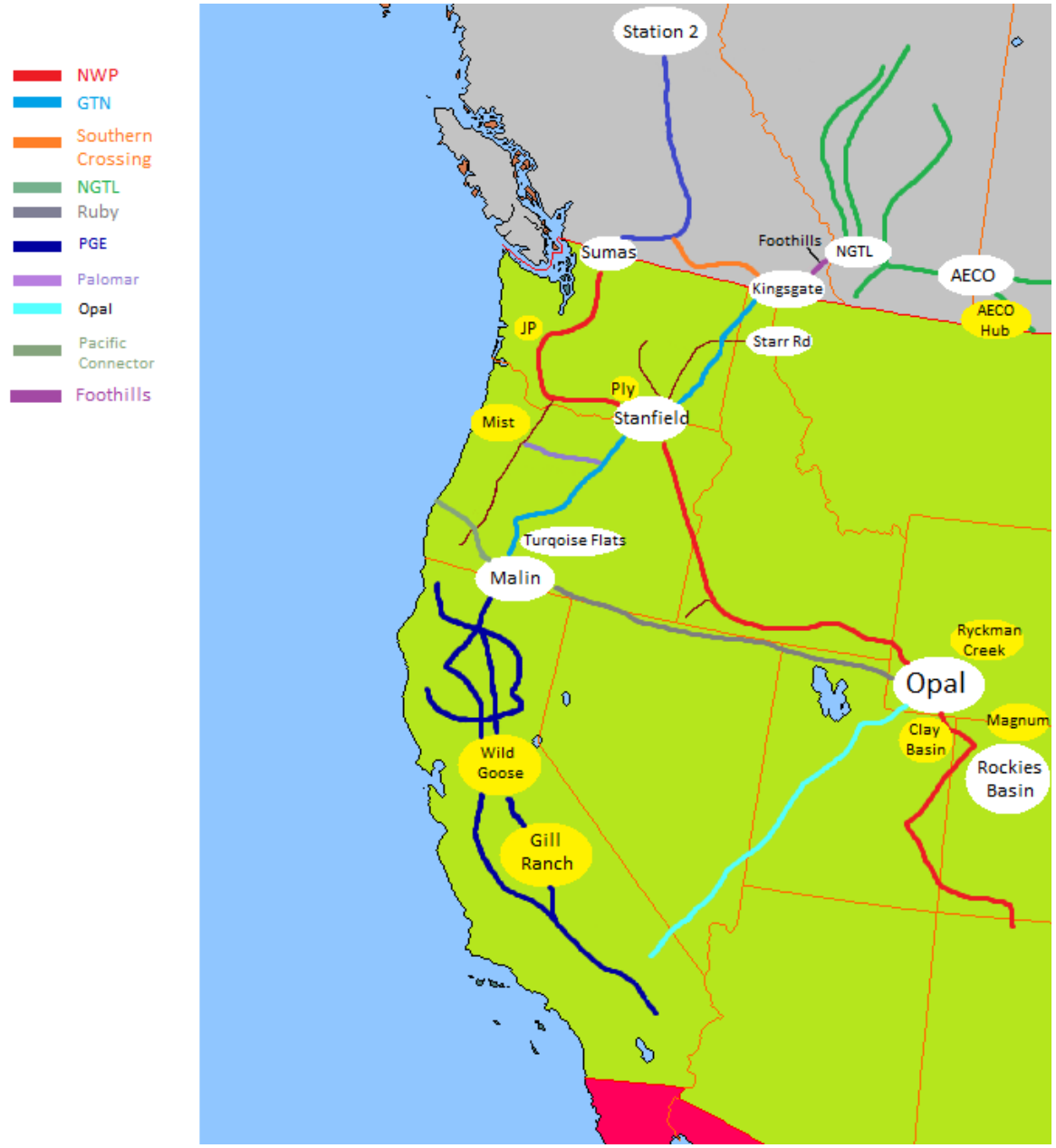
Alternative Resources

Major Resource Issues on the Horizon

- Once a deficiency is identified, Cascade must analyze potential solutions to ensure service over the planning horizon.
- Conversations with partners at various pipelines, storage facilities, new supply sources.
- SENDOUT® is used to ultimately derive the optimal mix of resources, referred to as the “preferred portfolio”.

Location of Current & Alternative Resources



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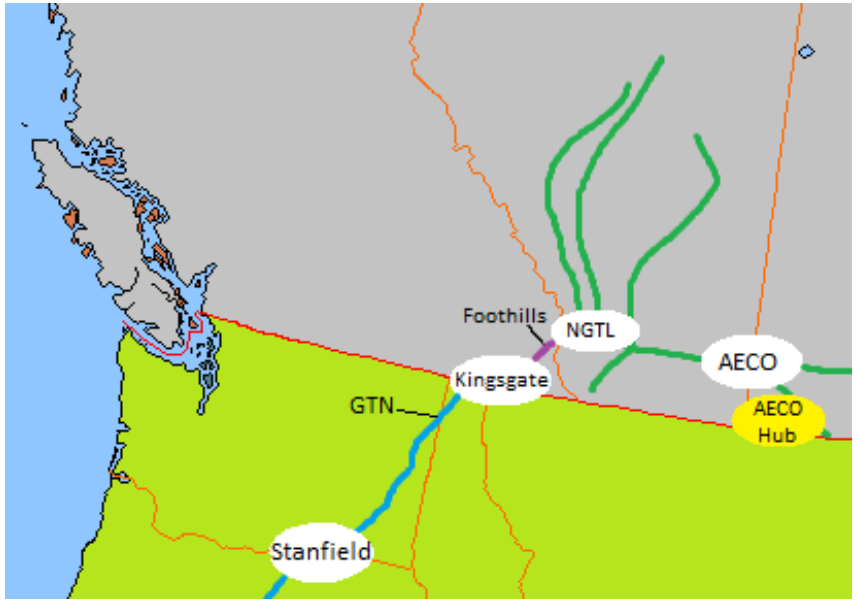
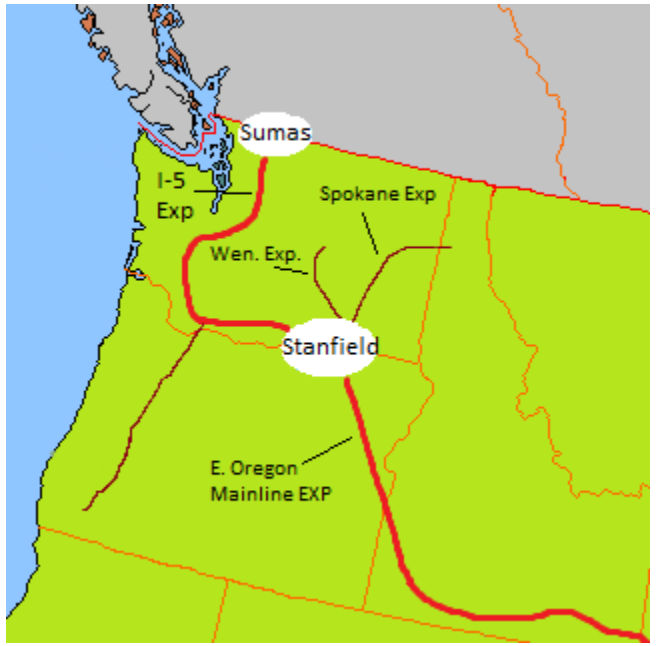
Incremental Transport – North to South

- Incremental NGTL – Additional capacity to move gas from AECO basin to Alberta/BC border
- Incremental Foothills – Additional capacity to move gas from Alberta/BC border to Kingsgate
- Incremental GTN N/S – Additional capacity to move gas from Kingsgate to various citygates along GTN



Incremental Transport – Northwest Pipeline

- I-5 Mainline Expansion – Additional capacity to move gas along I-5 corridor in western Washington
- Wenatchee Lateral Expansion – Additional capacity to move gas along Wenatchee Lateral to central Washington
- Spokane Lateral Expansion – Additional capacity to move gas along Spokane Lateral to eastern Washington
- Eastern Oregon Mainline Expansion – Additional capacity to move gas along Eastern Oregon Lateral to Oregon citygates



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Incremental Transport – South to North

Incremental Opal– Additional capacity to move gas from Utah to Opal
Incremental Ruby – Additional capacity to move gas from Rockies Basin to Turquoise Flats
Incremental GTN S/N – Additional capacity to move gas from Turquois Flats to various citygates along GTN

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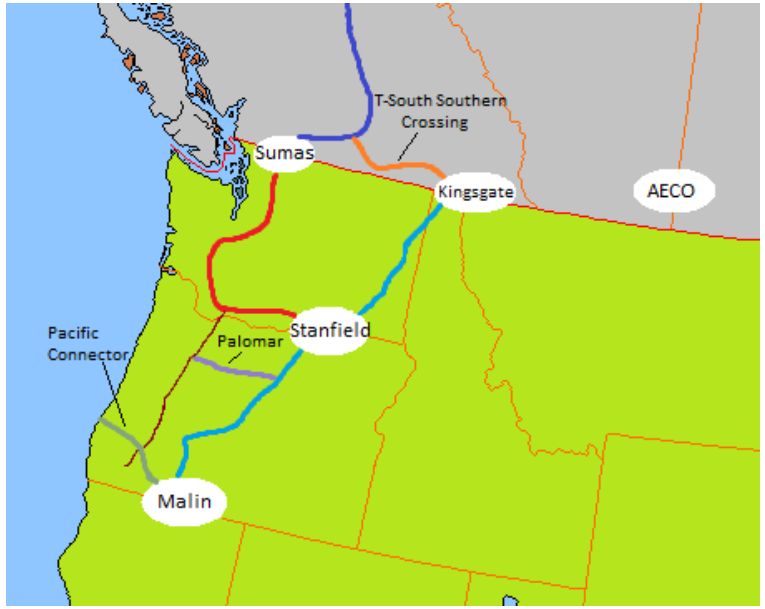
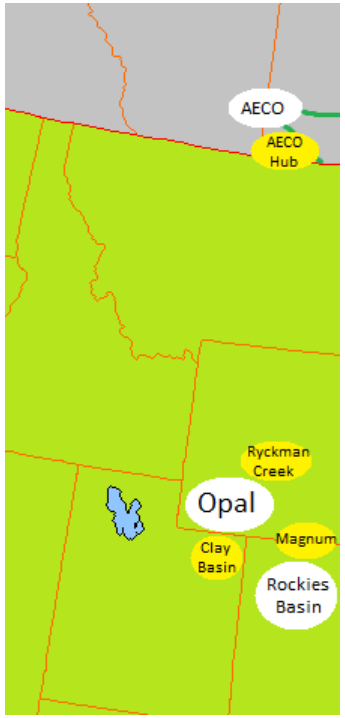
Incremental Transport – Bilateral

- T-South Southern Crossing – Price arbitrage opportunity to move gas between Sumas and AECO basins bilaterally
- Trails West (Palomar) – Additional capacity to move Rockies gas to the I-5 corridor
- Pacific Connector – Pipeline that will feed LNG facility on Oregon coast, increasing liquidity at Malin



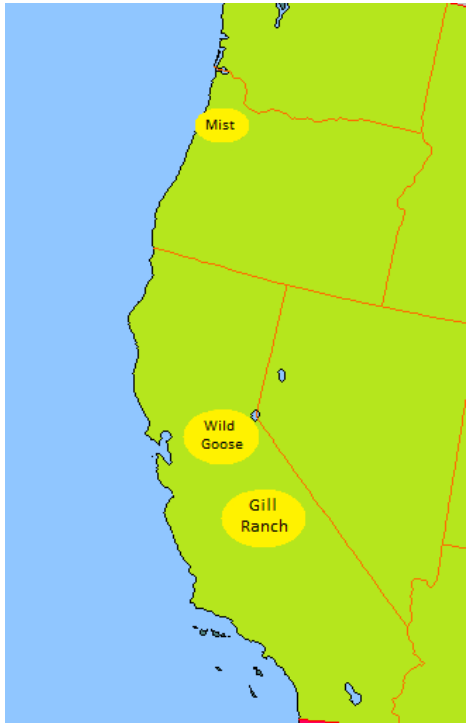
Incremental Storage - North and East

- Ryckman Creek Storage – Additional storage in southwest Wyoming serving the system, primarily Oregon
- Magnum Storage – Additional storage near Rocky Mountains, serving the system, primarily Oregon
- AECO Hub Storage – Additional storage near AECO Hub, serving the system
- Clay Basin Storage – Additional storage near Opal, serving the system



Incremental Storage - South and West

- Gill Ranch Storage – Additional storage in central California, serving the system, primarily Oregon
- Mist Storage – Additional storage in northern Oregon, serving the system, primarily Washington
- Wild Goose Storage – Additional storage in northern California, serving the system, primarily Oregon



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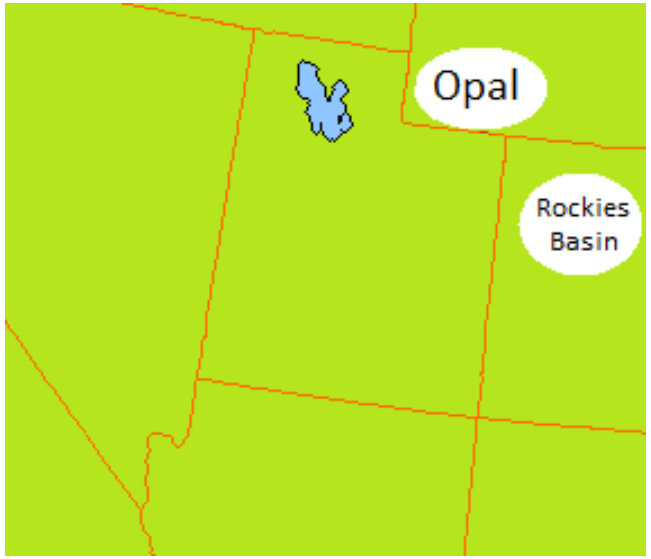
Incremental Supplies

- Incremental Opal Supply – Additional supply around the Rockies Basin
- Renewable Natural Gas – Incremental biogas supply directly to distribution system



Candidate Portfolios

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Portfolio Summary

	GTN	No GTN
NWP	• ALL-IN	• NWP Only • NWP Only w/ Storage
No NWP	• GTN Only • GTN Only w/ Storage	• Only Storage

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Portfolio Components

	All In	Incremental GTN	Incremental GTN & Storage	Incremental NWP	Incremental NWP & Storage	Storage Only
Incremental NGTL	X	X	X			
Incremental Foothills	X	X	X			
Incremental GTN N/S	X	X	X			
I-5 Expansion	X			X	X	
Wenatchee Lateral						
Spokane Expansion				X	X	
Eastern OR Expansion						
Incremental Opal						
Incremental Ruby						
Incremental GTN S/N						
T-South Southern Crossing						
Trails West (Palomar)						
Pacific Connector						
Ryckman Creek Storage			X		X	X
Magnum Storage						
AECO Hub Storage						
Clay Basin Storage						
Gill Ranch Storage						
Mist Storage						
Wild Goose Storage						
Incremental Opal Supply						
Renewable Natural Gas						

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All In Portfolio

- Deterministic optimum mix of all evaluated resources, including incremental transportation on NWP & GTN, and all regional storage facilities.
- Components:
  - Incrm GTN: 10,200 Dths by Nov. 2027, escalating to 25,021 Dths by Nov. 2037
  - Incrm Fthls: 25,908 Dths by Nov. 2037
  - Incrm I-5 Exp: 17,469 Dths by Nov. 2027, escalating to 41,035 Dths by Nov. 2037
  - Incrm Nova: 36,246 Dths by Nov. 2037

Incremental GTN & Storage Portfolio

- Deterministic optimum mix of incremental transportation on GTN and all regional storage facilities.
- Components:
  - Incrm GTN: 21,218 Dths by Nov. 2027, escalating to 43,490 Dths by Nov. 2037
  - Incrm Fthls: 48,783 Dths by Nov. 2027
  - Incrm Nova: 6,364 Dths by Nov. 2027, escalating to 59,121 Dths by Nov. 2037
  - Incrm Ryckman Creek: 1,000 Dths by Nov. 2027

Incremental GTN Only

- Deterministic optimum mix of incremental transportation on GTN .
- Components:
  - Incrm GTN: 21,218 Dths by Nov. 2027, escalating to 43,490 Dths by Nov. 2037
  - Incrm Fthls: 48,783 Dths by Nov. 2027
  - Incrm Nova: 6,364 Dths by Nov. 2027, escalating to 59,121 Dths by Nov. 2037

Incremental NWP & Storage Portfolio

- Deterministic optimum mix of incremental transportation on NWP and all regional storage facilities.
- Components:
  - Incrm I-5 Exp: 7,531 Dths by Nov. 2027, escalating to 37,321 Dths by Nov. 2037
  - Incrm Spokane Exp: 14,794 Dths by Nov. 2037
  - Incrm Ryckman Creek: 1,000 Dths by Nov. 2027

Incremental NWP Only

- Deterministic optimum mix of incremental transportation on NWP.
- Components:
  - Incrm I-5 Exp: 7,531 Dths by Nov. 2027, escalating to 37,321 Dths by Nov. 2037
  - Incrm Spokane Exp: 14,794 Dths by Nov. 2037

Incremental Storage Only

- Deterministic optimum mix of incremental regional storage facilities.
- Components:
  - Incrm Ryckman Creek: 1,000 Dths by Nov. 2027

Final Ranking – Mean and VaR

	Total System Cost		Unserved Demand	
Portfolios	**Mean ($000)**	**VaR ($000)**	**Mean (Mdts)**	**VaR (Mdts)**
All-In	3,730,375	3,761,824	0	0
Incrm GTN	3,605,874	3,636,062	36.04	92.46
Incrm GTN with Storage	3,607,897	3,638,312	36.04	92.46
Storage Only	3,741,640	3,772,235	46.35	86.65
Incrm NWP with Storage	3,763,508	3,794,217	46.06	86.64
Incrm NWP	3,763,540	3,795,170	46.06	86.55

Candidate Portfolio - All In Portfolio

- Deterministic optimum mix of all evaluated resources, including incremental transportation on NWP & GTN, and all regional storage facilities.
- Components:
  - Incrm GTN – 10,200 Dths by Nov. 2027, escalating to 25,021 Dths by Nov. 2037
  - Incrm Fthls – 25,908 Dths by Nov. 2037
  - Incrm I-5 Exp – 17,469 Dths by Nov. 2027, escalating to 41,035 Dths by Nov. 2037
  - Incrm Nova – 36,246 Dths by Nov. 2037

Scenarios and Sensitivities

Monte Carlo Simulations

- Monte Carlo Scenarios – Weather
- Monte Carlo Sensitivities – NYMEX price
- Why not Monte Carlo on both together?

Monte Carlo – Weather

- Using historical weather, we had SENDOUT run 200 simulations to stress test our candidate portfolio over a variety of different scenarios.
- In each scenario, we are testing to confirm that the mean and VaR are within acceptable limits as set by Cascade's Gas Supply Oversight Committee.
- This ensures that our expected resource portfolio is still the optimal choice even in extreme weather situations.

Low Growth and High Growth

	KEY ELEMENTS IN SENDOUT SCENARIO Low Load Growth, Medium Gas Price Forecast, Average weather with Peak Event. All elements considered. All items in RED mean those elements were excluded from the scenario. All items in BLUE mean those elements were dampened in the scenario.		
	Current Station2	**JP1**	**AECO Base/Fixed, Winter, Day W/S, Peak**
	Current NGTL	**JP2**	**SUMAS Base/Fixed, Winter, Day W/S, Peak**
	Current GTN	**JP3**	**ROCKIES Base/Fixed, Winter, Day W/S, Peak**
	Current NWP	**JP4**	**HUNT Base/Fixed, Winter, Day W/S**
	Current Foothills	**PLY-1**	**KINGSGATE Base**
	Current Ruby	**PLY-2**	**OPAL Base**
			STAT2 Base
	Incremental NGTL	***Ryckman Crk Storage***	***Opal Incrm Supply***
Low Growth	***Incremental GTN N-S***	***Gill Ranch Storage***	***BioNaturalGas***
	NWP I-5 Mainline EXP	***Mist Storage***	***Resource Mix - 3 Basins***
	Incremental Ruby	***Wild Goose Storage***	
	NWP Wen lateral EXP	***Aeco Hub Storage***	
	Incremental Foothills	***Magnum Storage***	
	NWP Z20 lateral EXP	***Clay Basin Storage***	
	T-South-So Crossing		
	Trails West (Palomar)		
	NWP East OR Mainline EXP		
	Incremental GTN S-N		
	Incremental Enbridge		
	Pacific Connector		

	KEY ELEMENTS IN SENDOUT SCENARIO High Load Growth, Medium Gas Price Forecast, Average weather with Peak Event. All elements considered. All items in RED mean those elements were excluded from the scenario. All items in BLUE mean those elements were dampened in the scenario.		
	Current Station2	**JP1**	**AECO Base/Fixed, Winter, Day W/S, Peak**
	Current NGTL	**JP2**	**SUMAS Base/Fixed, Winter, Day W/S, Peak**
	Current GTN	**JP3**	**ROCKIES Base/Fixed, Winter, Day W/S, Peak**
	Current NWP	**JP4**	**HUNT Base/Fixed, Winter, Day W/S**
	Current Foothills	**PLY-1**	**KINGSGATE Base**
	Current Ruby	**PLY-2**	**OPAL Base**
			STAT2 Base
	Incremental NGTL	***Ryckman Crk Storage***	***Opal Incrm Supply***
High Growth	***Incremental GTN N-S***	***Gill Ranch Storage***	***BioNaturalGas***
	NWP I-5 Mainline EXP	***Mist Storage***	***Resource Mix - 3 Basins***
	Incremental Ruby	***Wild Goose Storage***	
	NWP Wen lateral EXP	***Aeco Hub Storage***	
	Incremental Foothills	***Magnum Storage***	
	NWP Z20 lateral EXP	***Clay Basin Storage***	
	T-South-So Crossing		
	Trails West (Palomar)		
	NWP East OR Mainline EXP		
	Incremental GTN S-N		
	Incremental Enbridge		
	Pacific Connector		

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Limit JP and Limit Ply Storage

	KEY ELEMENTS IN SENDOUT SCENARIO Medium Load Growth, Medium Gas Price Forecast, Average weather with Peak Event. All elements considered. All items in RED mean those elements were excluded from the scenario. All items in BLUE mean those elements were dampened in the scenario.		
Limit Storage - JP	**Current Station2**	**JP1**	**AECO Base/Fixed, Winter, Day W/S, Peak**
	Current NGTL	**JP2**	**SUMAS Base/Fixed, Winter, Day W/S, Peak**
	Current GTN	**JP3**	**ROCKIES Base/Fixed, Winter, Day W/S, Peak**
	Current NWP	**JP4**	**HUNT Base/Fixed, Winter, Day W/S**
	Current Foothills	**PLY-1**	**KINGSGATE Base**
	Current Ruby	**PLY-2**	**OPAL Base**
			STAT2 Base
	Incremental NGTL	***Ryckman Crk Storage***	***Opal Incrm Supply***
	Incremental GTN N-S	***Gill Ranch Storage***	***BioNaturalGas***
	NWP I-5 Mainline EXP	***Mist Storage***	***Resource Mix - 3 Basins***
	Incremental Ruby	***Wild Goose Storage***	
	NWP Wen lateral EXP	***Aeco Hub Storage***	
	Incremental Foothills	***Magnum Storage***	
	NWP Z20 lateral EXP	***Clay Basin Storage***	
	T-South-So Crossing		
	Trails West (Palomar)		
	NWP East OR Mainline EXP		
	Incremental GTN S-N		
	Incremental Enbridge		
	Pacific Connector		

	KEY ELEMENTS IN SENDOUT SCENARIO Medium Load Growth, Medium Gas Price Forecast, Average weather with Peak Event. All elements considered. All items in RED mean those elements were excluded from the scenario. All items in BLUE mean those elements were dampened in the scenario.		
Limit Storage - Ply	**Current Station2**	**JP1**	**AECO Base/Fixed, Winter, Day W/S, Peak**
	Current NGTL	**JP2**	**SUMAS Base/Fixed, Winter, Day W/S, Peak**
	Current GTN	**JP3**	**ROCKIES Base/Fixed, Winter, Day W/S, Peak**
	Current NWP	**JP4**	**HUNT Base/Fixed, Winter, Day W/S**
	Current Foothills	**PLY-1**	**KINGSGATE Base**
	Current Ruby	**PLY-2**	**OPAL Base**
			STAT2 Base
	Incremental NGTL	***Ryckman Crk Storage***	***Opal Incrm Supply***
	Incremental GTN N-S	***Gill Ranch Storage***	***BioNaturalGas***
	NWP I-5 Mainline EXP	***Mist Storage***	***Resource Mix - 3 Basins***
	Incremental Ruby	***Wild Goose Storage***	
	NWP Wen lateral EXP	***Aeco Hub Storage***	
	Incremental Foothills	***Magnum Storage***	
	NWP Z20 lateral EXP	***Clay Basin Storage***	
	T-South-So Crossing		
	Trails West (Palomar)		
	NWP East OR Mainline EXP		
	Incremental GTN S-N		
	Incremental Enbridge		
	Pacific Connector		

Limit Both Storage and No JP

	KEY ELEMENTS IN SENDOUT SCENARIO Medium Load Growth, Medium Gas Price Forecast, Average weather with Peak Event. All elements considered. All items in RED mean those elements were excluded from the scenario. All items in BLUE mean those elements were dampened in the scenario.		
Limit Storage - Both	**Current Station2**	**JP1**	**AECO Base/Fixed, Winter, Day W/S, Peak**
	Current NGTL	**JP2**	**SUMAS Base/Fixed, Winter, Day W/S, Peak**
	Current GTN	**JP3**	**ROCKIES Base/Fixed, Winter, Day W/S, Peak**
	Current NWP	**JP4**	**HUNT Base/Fixed, Winter, Day W/S**
	Current Foothills	**PLY-1**	**KINGSGATE Base**
	Current Ruby	**PLY-2**	**OPAL Base**
			STAT2 Base
	Incremental NGTL	***Ryckman Crk Storage***	***Opal Incrm Supply***
	Incremental GTN N-S	***Gill Ranch Storage***	***BioNaturalGas***
	NWP I-5 Mainline EXP	***Mist Storage***	***Resource Mix - 3 Basins***
	Incremental Ruby	***Wild Goose Storage***	
	NWP Wen lateral EXP	***Aeco Hub Storage***	
	Incremental Foothills	***Magnum Storage***	
	NWP Z20 lateral EXP	***Clay Basin Storage***	
	T-South-So Crossing		
	Trails West (Palomar)		
	NWP East OR Mainline EXP		
	Incremental GTN S-N		
	Incremental Enbridge		
	Pacific Connector		

	KEY ELEMENTS IN SENDOUT SCENARIO Medium Load Growth, Medium Gas Price Forecast, Average weather with Peak Event. All elements considered. All items in RED mean those elements were excluded from the scenario. All items in BLUE mean those elements were dampened in the scenario.		
No Storage - JP	**Current Station2**	**JP1**	**AECO Base/Fixed, Winter, Day W/S, Peak**
	Current NGTL	**JP2**	**SUMAS Base/Fixed, Winter, Day W/S, Peak**
	Current GTN	**JP3**	**ROCKIES Base/Fixed, Winter, Day W/S, Peak**
	Current NWP	**JP4**	**HUNT Base/Fixed, Winter, Day W/S**
	Current Foothills	**PLY-1**	**KINGSGATE Base**
	Current Ruby	**PLY-2**	**OPAL Base**
			STAT2 Base
	Incremental NGTL	***Ryckman Crk Storage***	***Opal Incrm Supply***
	Incremental GTN N-S	***Gill Ranch Storage***	***BioNaturalGas***
	NWP I-5 Mainline EXP	***Mist Storage***	***Resource Mix - 3 Basins***
	Incremental Ruby	***Wild Goose Storage***	
	NWP Wen lateral EXP	***Aeco Hub Storage***	
	Incremental Foothills	***Magnum Storage***	
	NWP Z20 lateral EXP	***Clay Basin Storage***	
	T-South-So Crossing		
	Trails West (Palomar)		
	NWP East OR Mainline EXP		
	Incremental GTN S-N		
	Incremental Enbridge		
	Pacific Connector		

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No Ply Storage and No Storage

	KEY ELEMENTS IN SENDOUT SCENARIO Medium Load Growth, Medium Gas Price Forecast, Average weather with Peak Event. All elements considered. All items in RED mean those elements were excluded from the scenario. All items in BLUE mean those elements were dampened in the scenario.		
No Storage - Ply	**Current Station2**	**JP1**	**AECO Base/Fixed, Winter, Day W/S, Peak**
	Current NGTL	**JP2**	**SUMAS Base/Fixed, Winter, Day W/S, Peak**
	Current GTN	**JP3**	**ROCKIES Base/Fixed, Winter, Day W/S, Peak**
	Current NWP	**JP4**	**HUNT Base/Fixed, Winter, Day W/S**
	Current Foothills	**PLY-1**	**KINGSGATE Base**
	Current Ruby	**PLY-2**	**OPAL Base**
			STAT2 Base
	Incremental NGTL	***Ryckman Crk Storage***	***Opal Incrm Supply***
	Incremental GTN N-S	***Gill Ranch Storage***	***BioNaturalGas***
	NWP I-5 Mainline EXP	***Mist Storage***	***Resource Mix - 3 Basins***
	Incremental Ruby	***Wild Goose Storage***	
	NWP Wen lateral EXP	***Aeco Hub Storage***	
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	Incremental Enbridge		
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	KEY ELEMENTS IN SENDOUT SCENARIO Medium Load Growth, Medium Gas Price Forecast, Average weather with Peak Event. All elements considered. All items in RED mean those elements were excluded from the scenario. All items in BLUE mean those elements were dampened in the scenario.		
No Storage - Both	**Current Station2**	**JP1**	**AECO Base/Fixed, Winter, Day W/S, Peak**
	Current NGTL	**JP2**	**SUMAS Base/Fixed, Winter, Day W/S, Peak**
	Current GTN	**JP3**	**ROCKIES Base/Fixed, Winter, Day W/S, Peak**
	Current NWP	**JP4**	**HUNT Base/Fixed, Winter, Day W/S**
	Current Foothills	**PLY-1**	**KINGSGATE Base**
	Current Ruby	**PLY-2**	**OPAL Base**
			STAT2 Base
	Incremental NGTL	***Ryckman Crk Storage***	***Opal Incrm Supply***
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Monte Carlo Weather – Normal Distribution

	JAN 2014	FEB 2014	MAR 2014	APR 2014	MAY 2014	JUN 2014	JUL 2014
HDD Mean	1031.8	804.1	639.6	453.9	254.2	92.6	10.3
HDD Std Dev	145.4	133.1	84.4	93.0	72.2	40.4	15.2
HDD Distribution	Normal						
HDD Max	1291	1242	841	641	426	170	75
HDD Min	772	568	448	254	92	19	0
CDD Mean							
CDD Std Dev							
CDD Distribution							
CDD Max							
CDD Min							
Scaling Year	Best Match						

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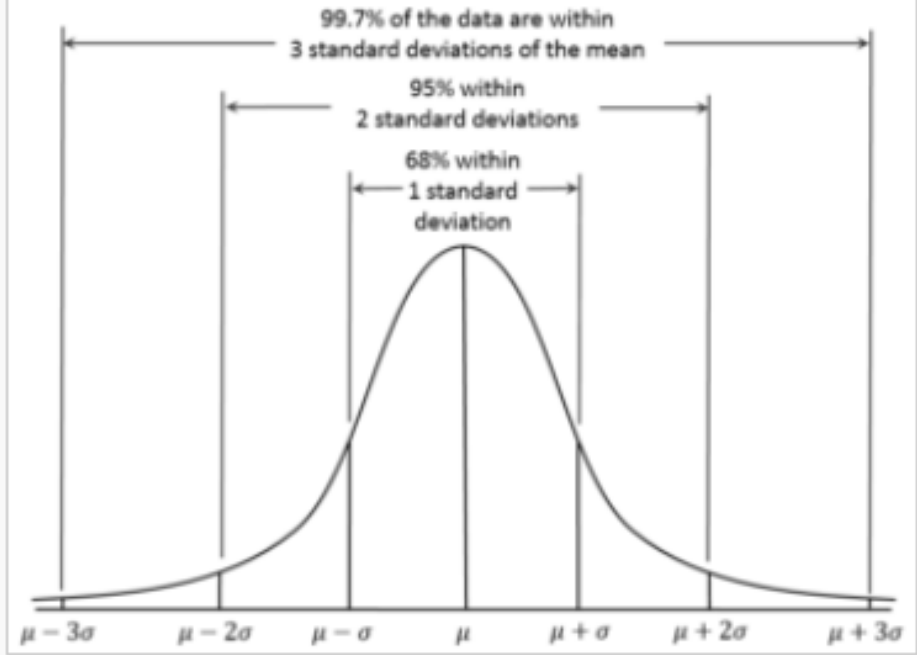
Monte Carlo Weather – Normal Distribution

- When following a normal distribution your data will follow the 68%, 95%, 99.7% rule like in the below diagram.



For the normal distribution, the values less than one standard deviation away from the mean account for 68.27% of the set; while two standard deviations from the mean account for 95.45%; and three standard deviations account for 99.73%.

Monte Carlo Weather – Normal Distribution

- To build our monthly inputs for SENDOUT we analyze our 30 data samples for each weather location which are the monthly HDD totals for the years 1987-2016. After getting the mean and standard deviation we can compute how many data samples fall within each range of standard deviations.

	All Months Combined
Within 1 Std Dev	69%
Within 2 Std Dev	96%
Within 3 Std Dev	99.4%

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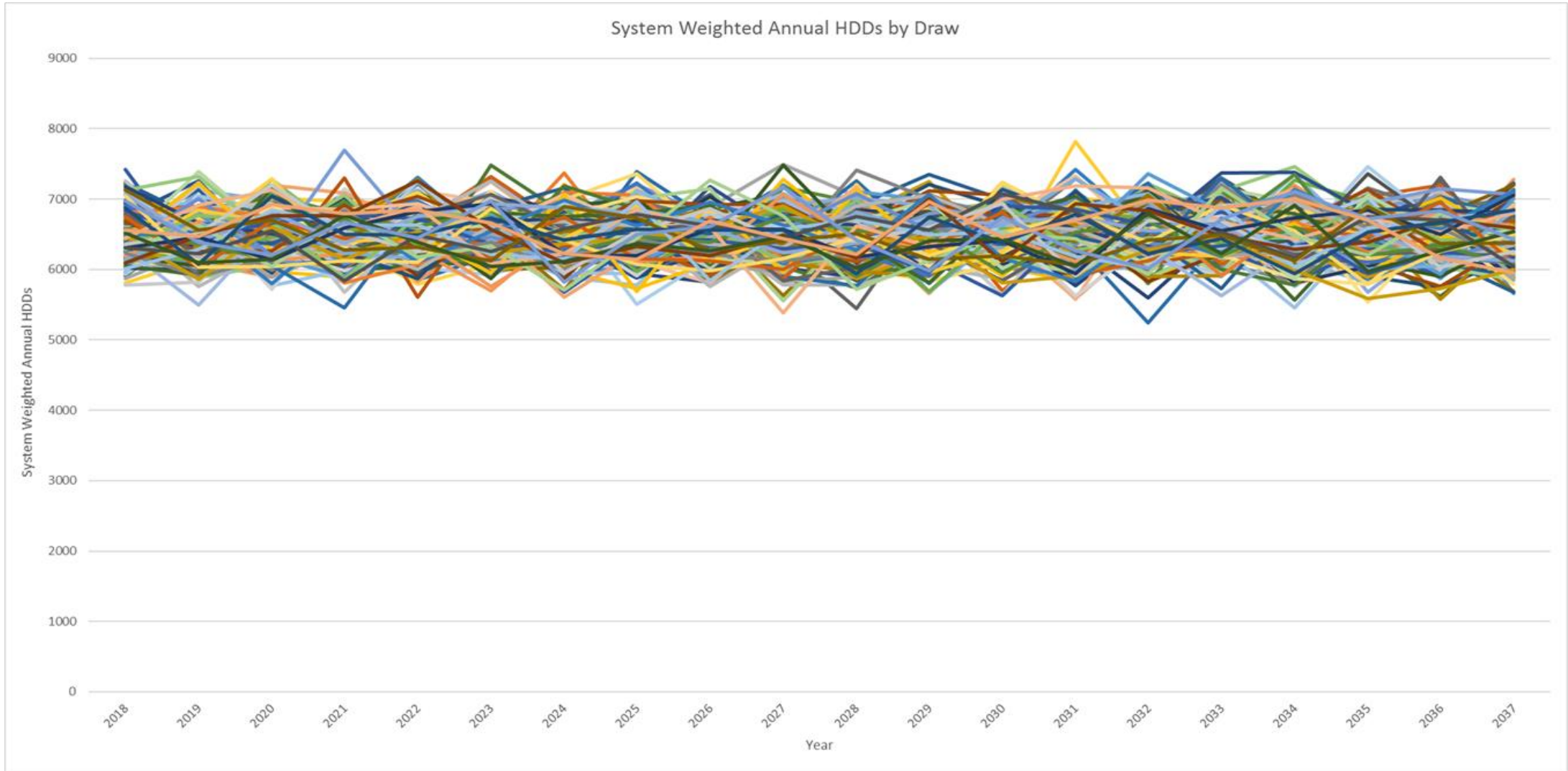

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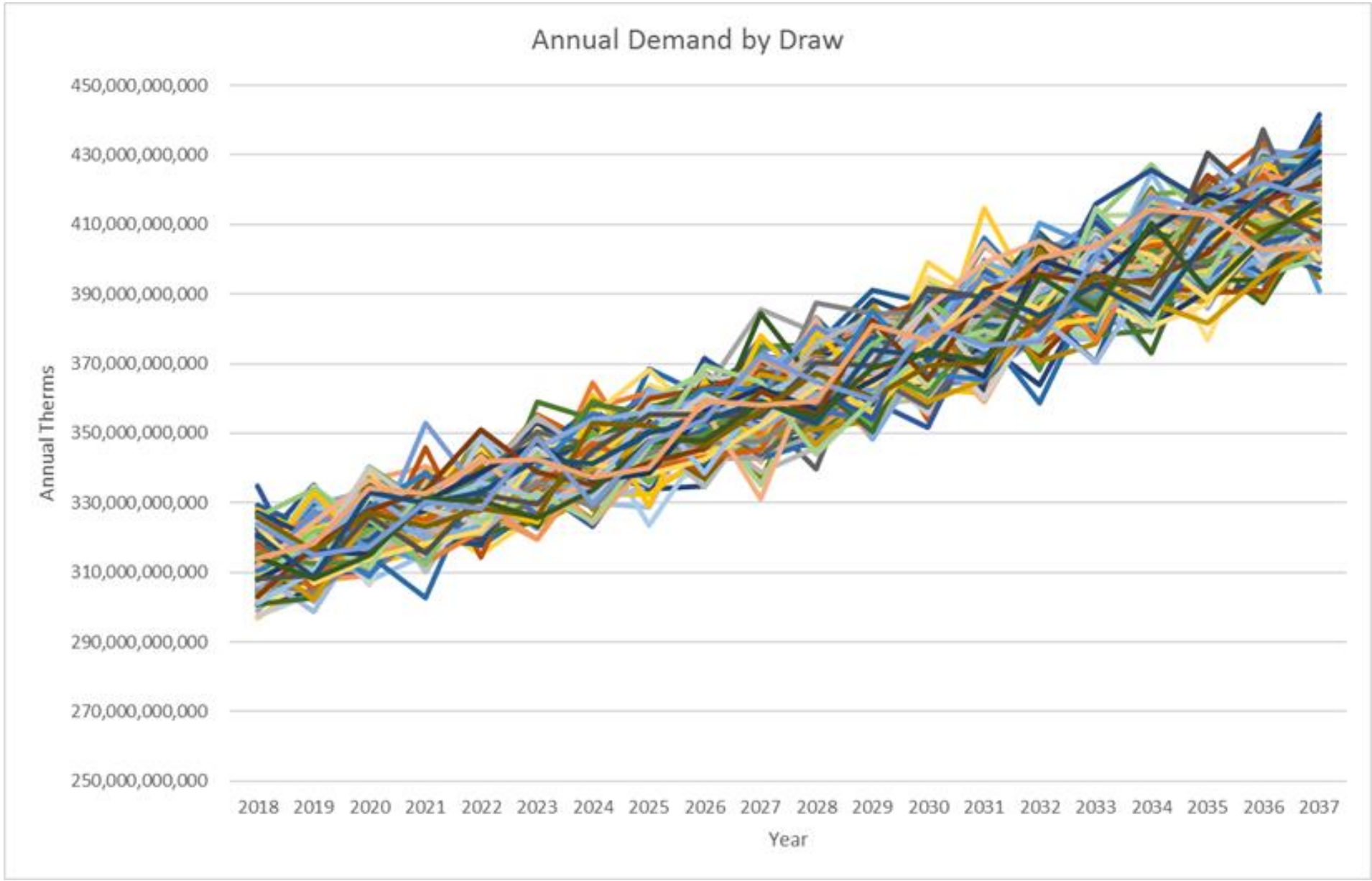

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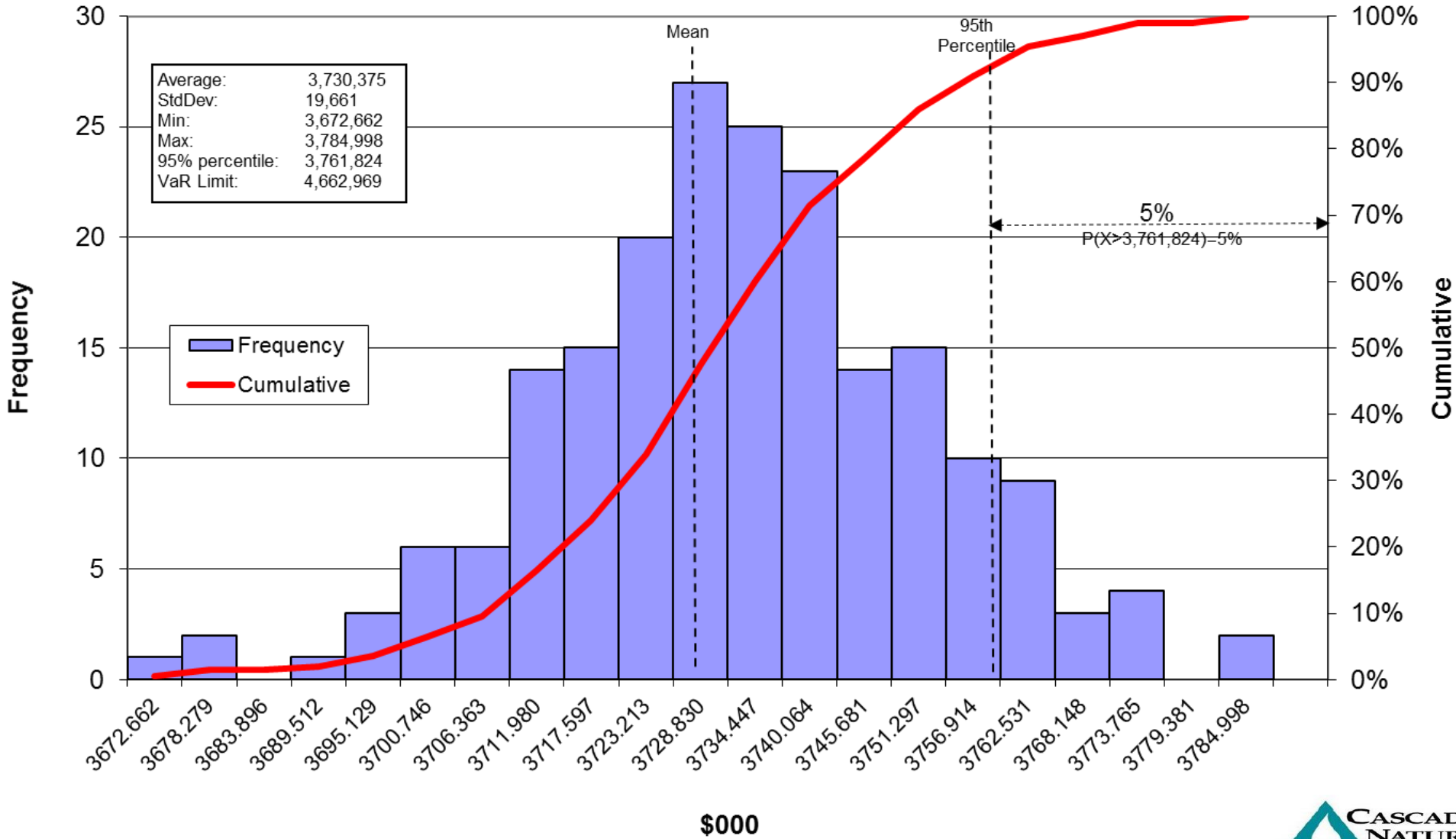
Total System Cost for All-in Portfolio



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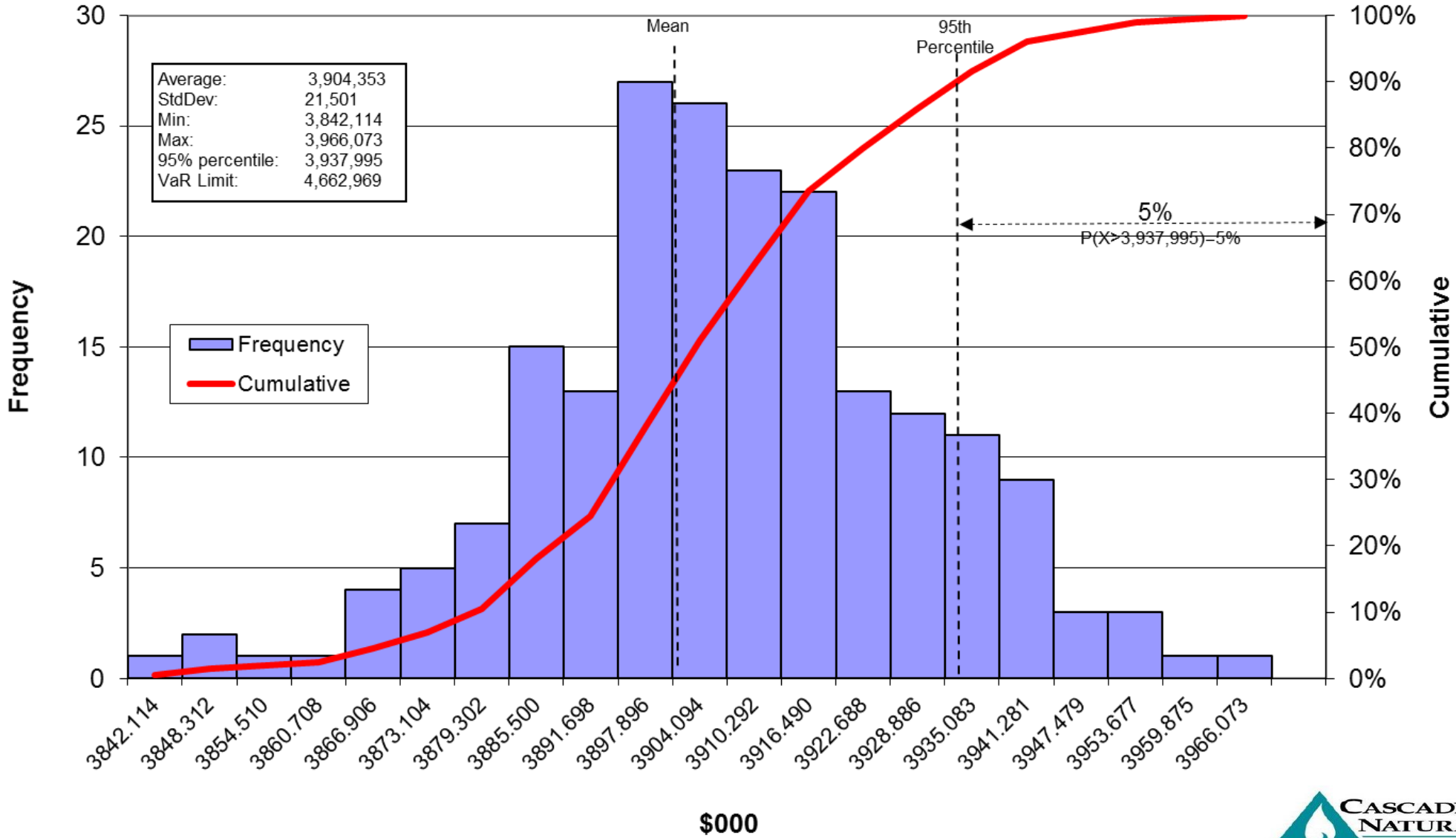
Total System Cost w/ High Growth



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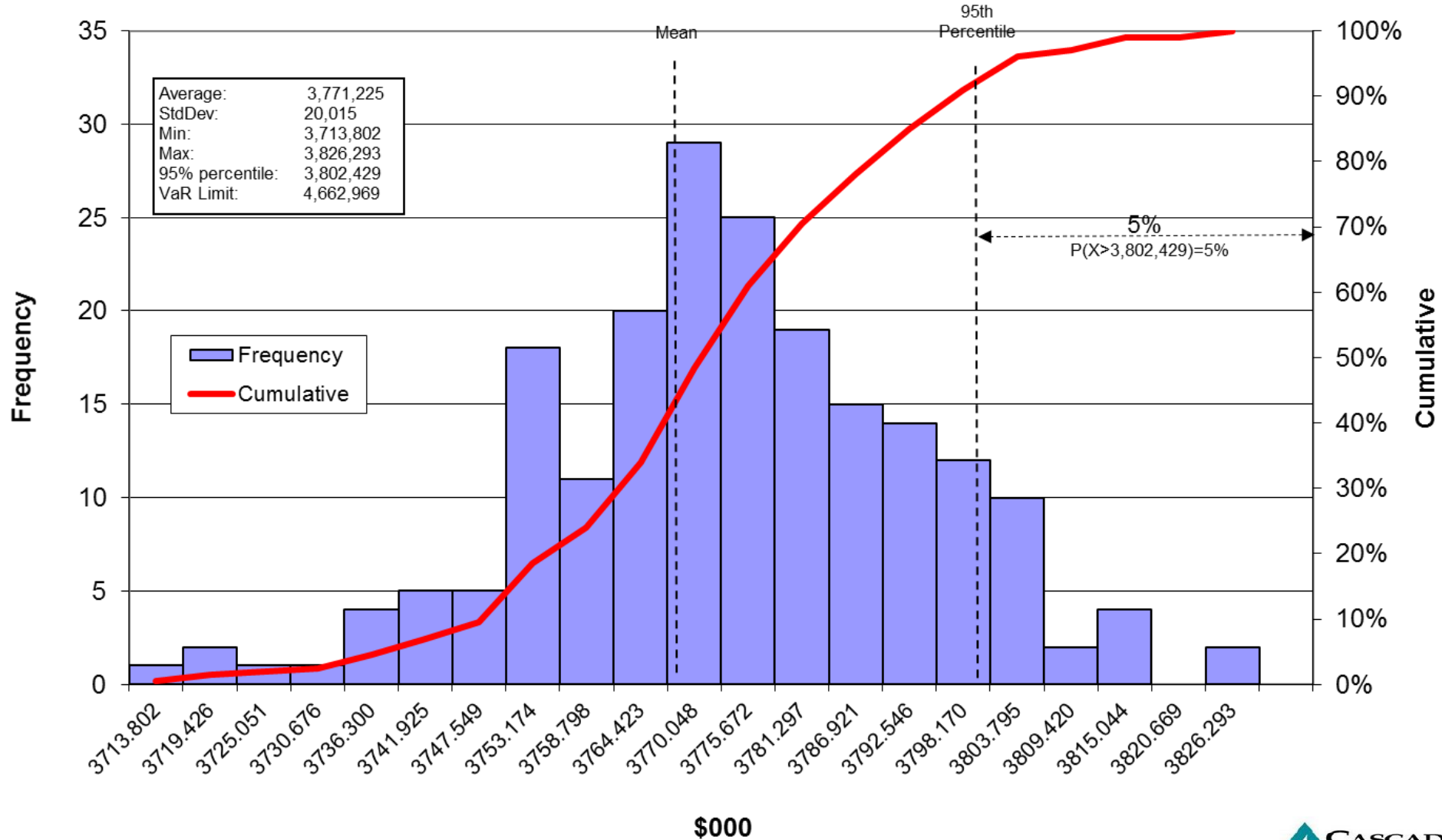
Total System Cost w/ limited JP Storage



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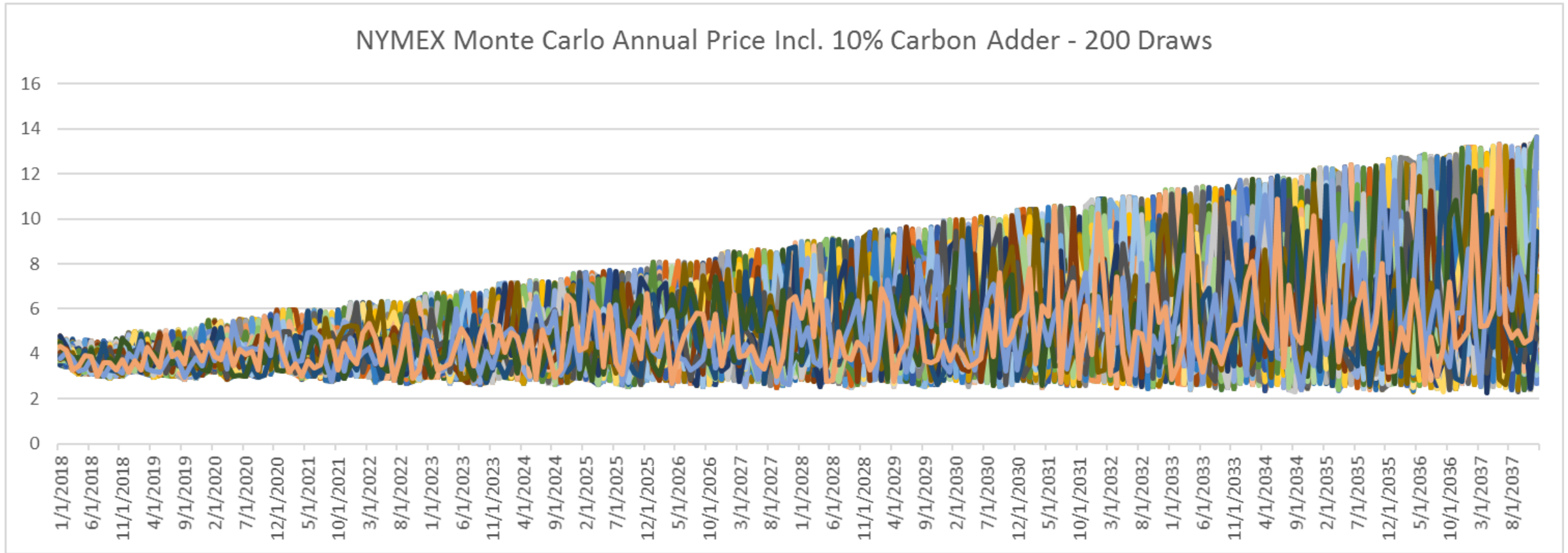
Monte Carlo – NYMEX Price

- Using our 20 year price forecast as the mean value for the NYMEX market, we had SENDOUT run 200 simulations to stress test our expected case over a variety of different pricing environments.
- In each sensitivity test, we are testing to confirm that the mean and VaR are within acceptable limits as set by Cascade's Gas Supply Oversight Committee.
- This ensures that our expected resource portfolio is still the optimal choice even in extreme pricing situations.

Sensitivities Analysis

Sensitivities		Assumptions
Price	High	Medium Load Growth, Average Weather with Peak Event, High Gas Price Environment
	Base	Medium Load Growth, Average Weather with Peak Event, Expected Gas Price Environment
	Low	Medium Load Growth, Average Weather with Peak Event, Low Gas Price Environment
Carbon Adder	10%	Medium Load Growth, Average Weather with Peak Event, Medium Gas Price Environment with 10% Adder for Unknown Regulatory Impacts
	20%	Medium Load Growth, Average Weather with Peak Event, Medium Gas Price Environment with 20% Adder for Unknown Regulatory Impacts
	30%	Medium Load Growth, Average Weather with Peak Event, Medium Gas Price Environment with 30% Adder for Unknown Regulatory Impacts
Per Ton	$10	Medium Load Growth, Average Weather with Peak Event, Medium Gas Price Environment with $10 per ton Carbon Tax
	$20	Medium Load Growth, Average Weather with Peak Event, Medium Gas Price Environment with $20 per ton Carbon Tax
	$30	Medium Load Growth, Average Weather with Peak Event, Medium Gas Price Environment with $30 per ton Carbon Tax



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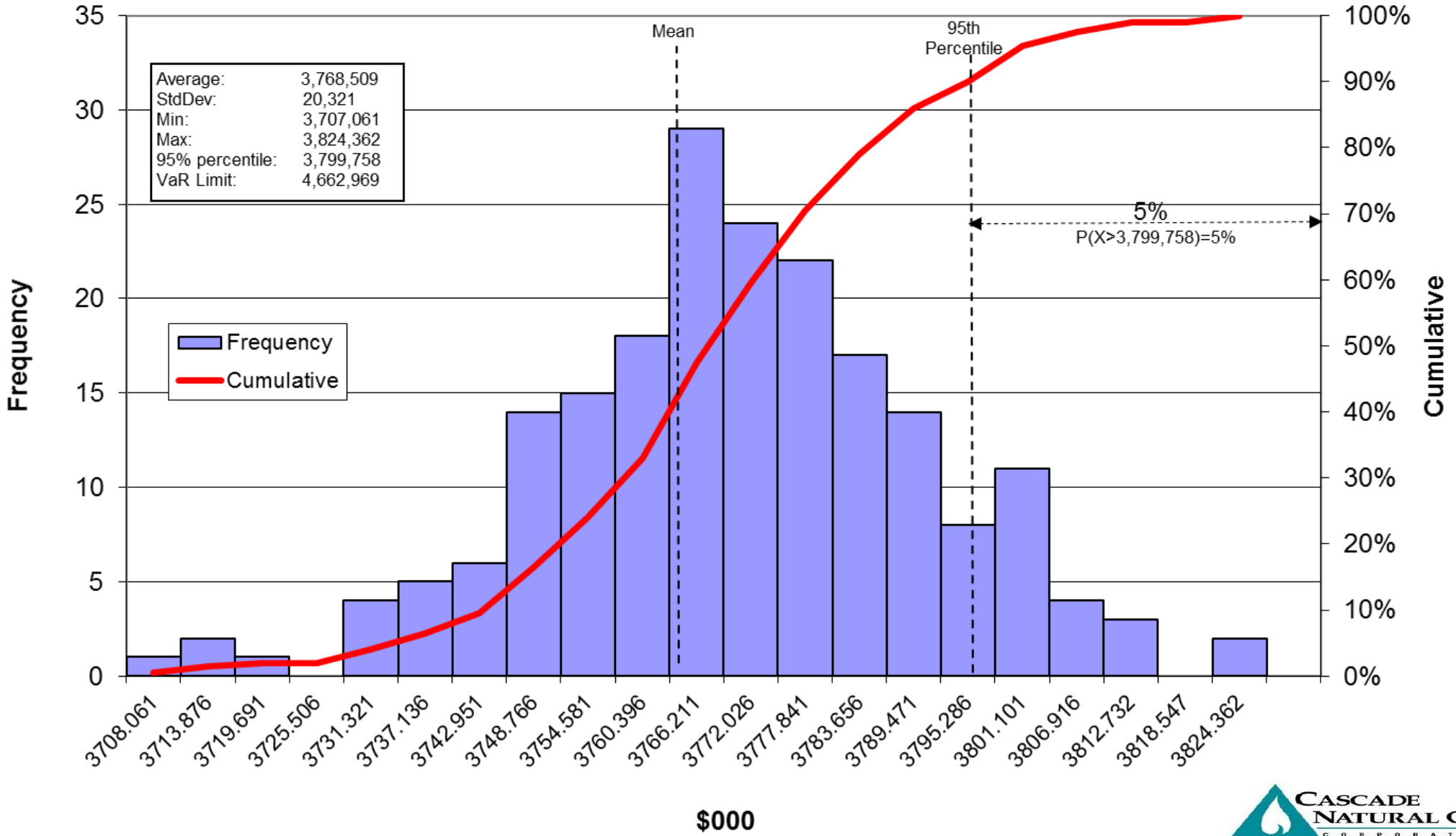
Total System Cost w/ High Price



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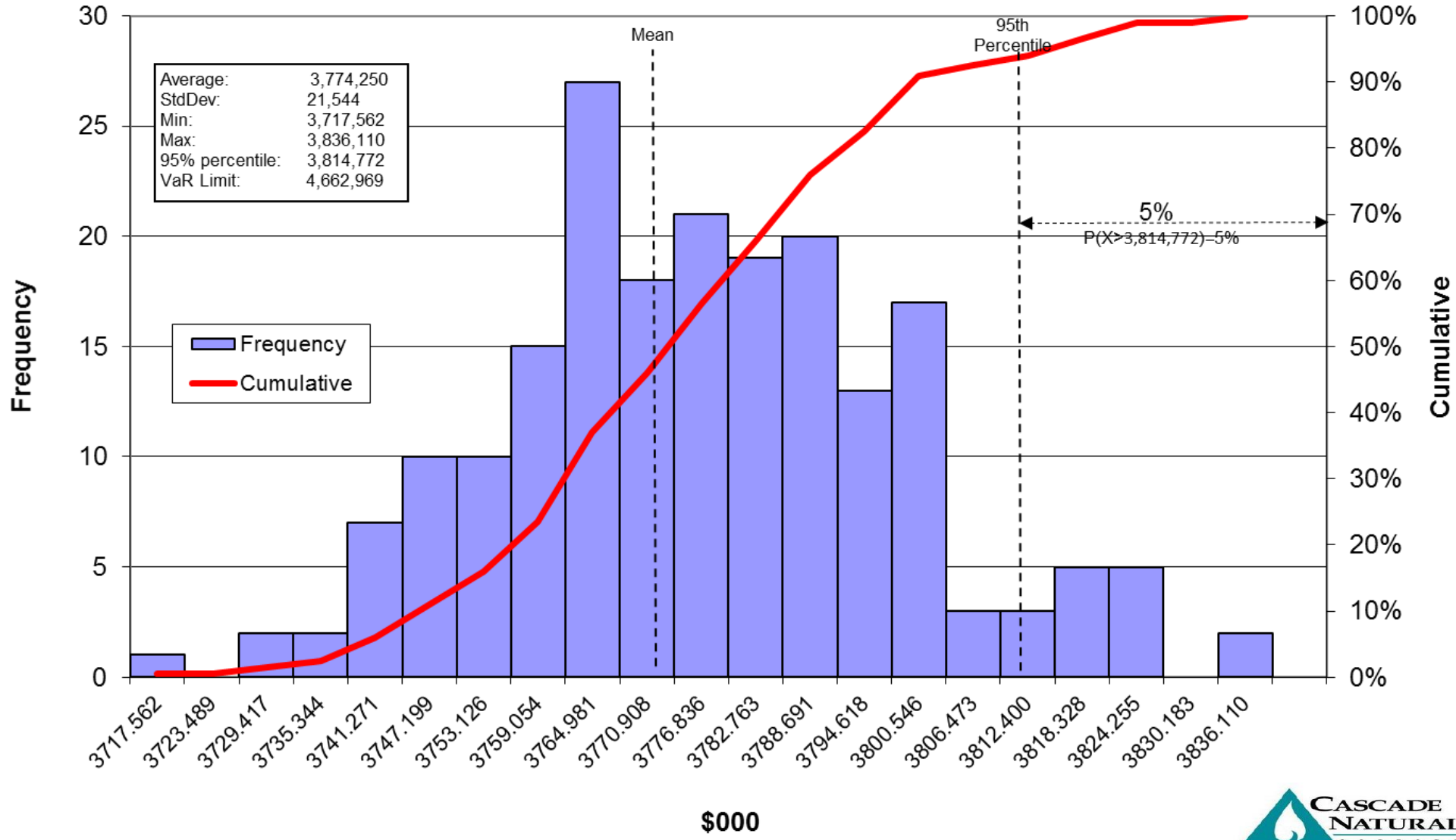
Total System Cost w/ 10% Carbon Adder



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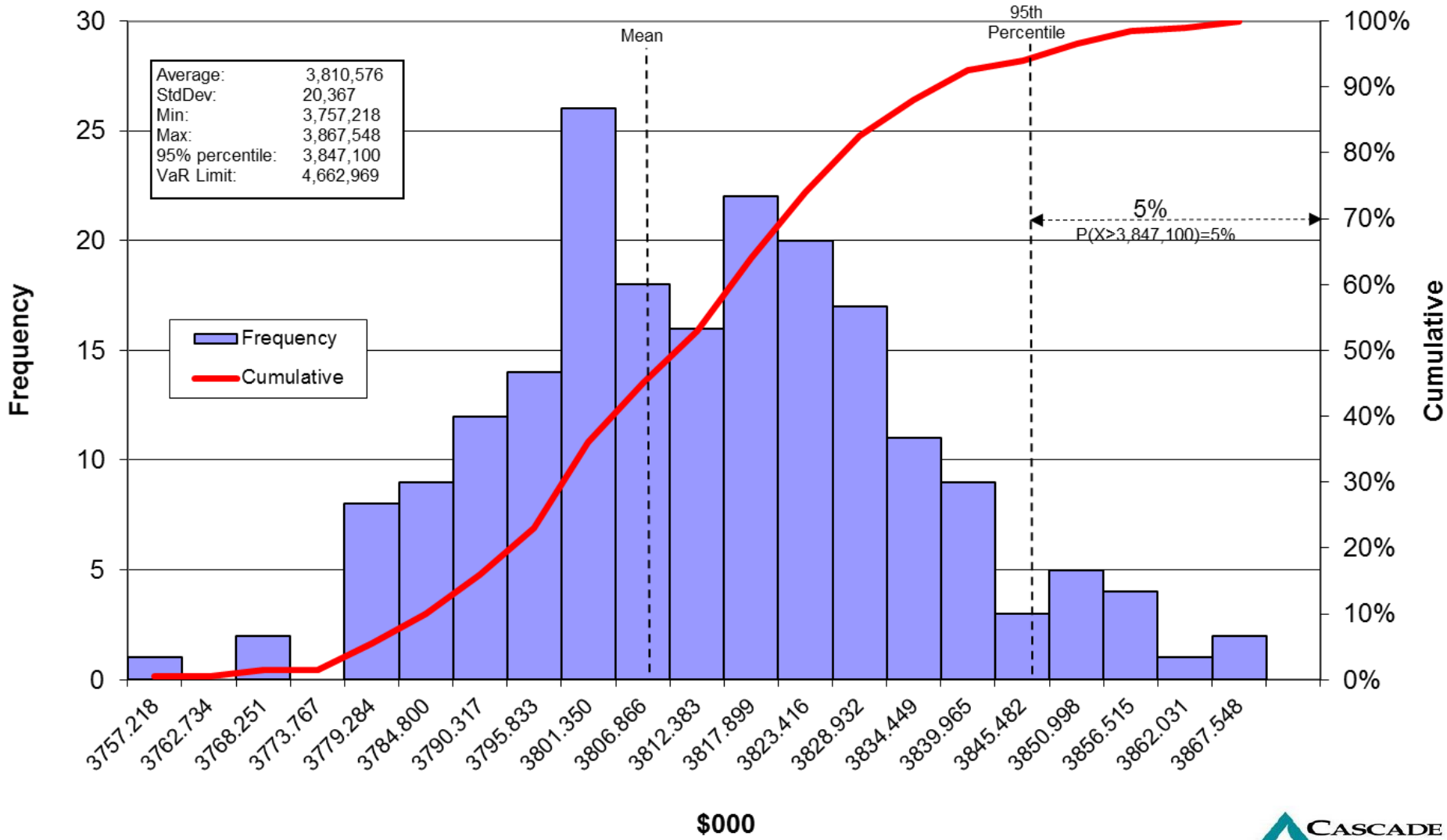
Total System Cost w/ 10$ per Ton Adder



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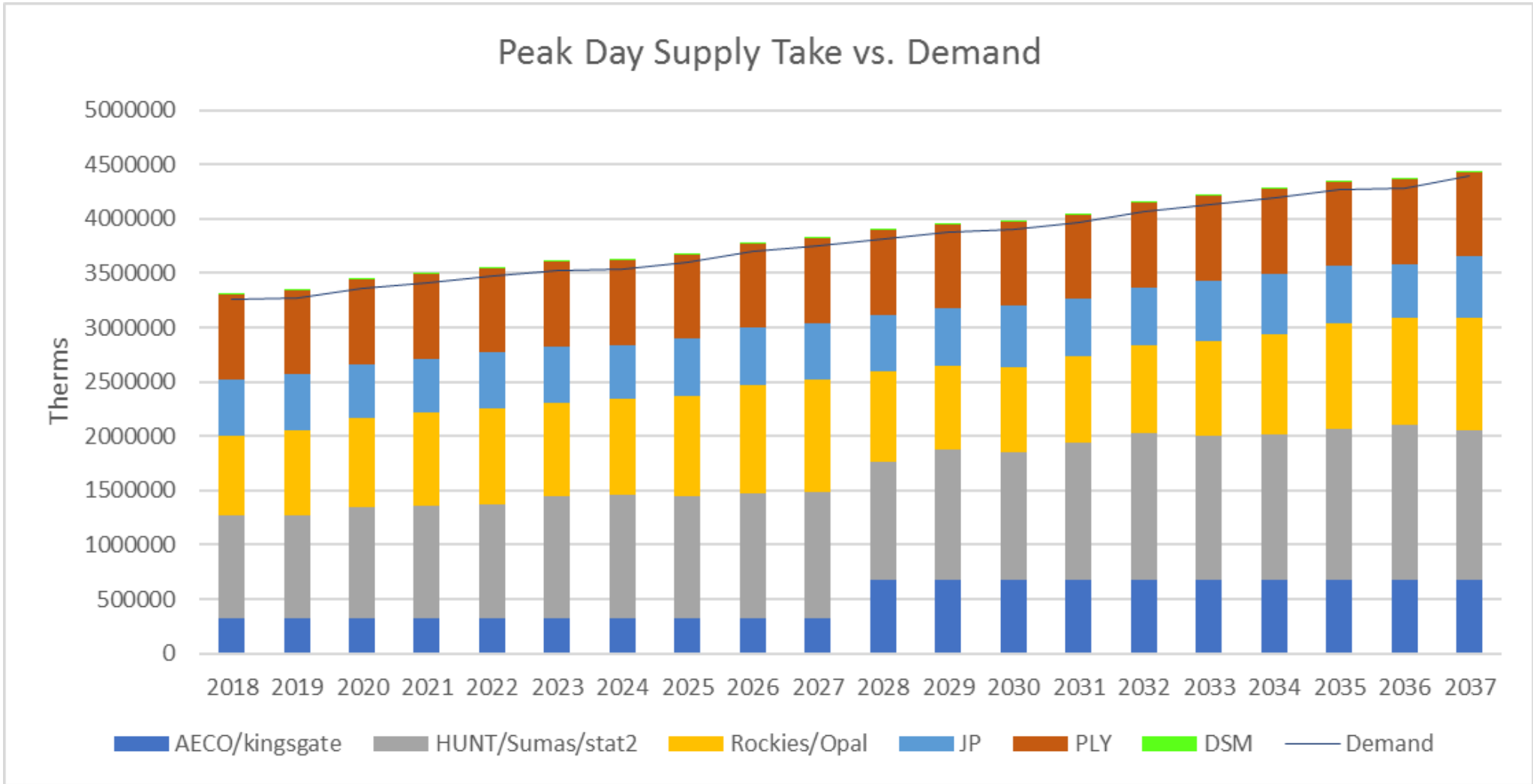
Scenario/Sensitivity Analysis ($000)

Scenarios and Sensitivities	Mean Total System Cost	VaR Total System Cost	Distance From VaR Limit
Low Growth	3,558,879	3,586,974	1,075,995
All-in Low Price	3,677,101	3,706,370	956,598
All-in Base Price	3,730,375	3,761,824	901,145
Limit Ply	3,735,878	3,767,042	895,927
No Storage - Ply	3,735,878	3,767,042	895,927
All-in High Price	3,768,059	3,799,758	863,210
Limit JP	3,771,225	3,802,429	860,540
10% Carbon Adder	3,774,250	3,814,772	848,196
Limit Both JP and Ply	3,781,513	3,813,037	849,932
No Storage - JP	3,786,551	3,817,561	845,408
No Storage - Both JP and Ply	3,806,273	3,843,720	819,249
10$ Per Ton Adder	3,810,576	3,847,100	815,868
20% Carbon Adder	3,845,766	3,880,357	782,612
20$ Per Ton Adder	3,901,711	3,933,235	729,733
High Growth	3,904,353	3,937,995	724,974
30% Carbon Adder	3,907,371	3,938,963	724,006
30$ Per Ton Adder	3,978,920	4,006,628	656,341



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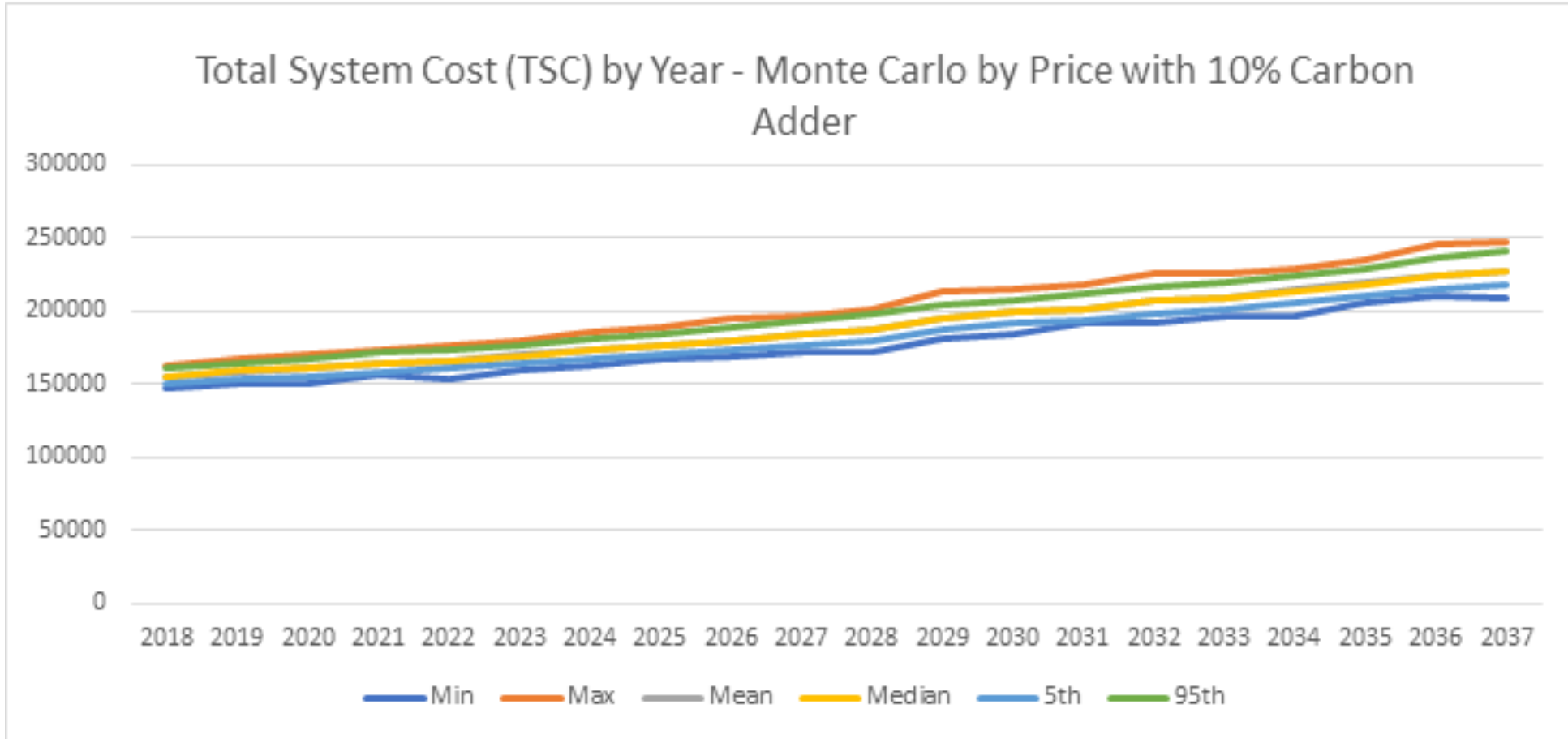
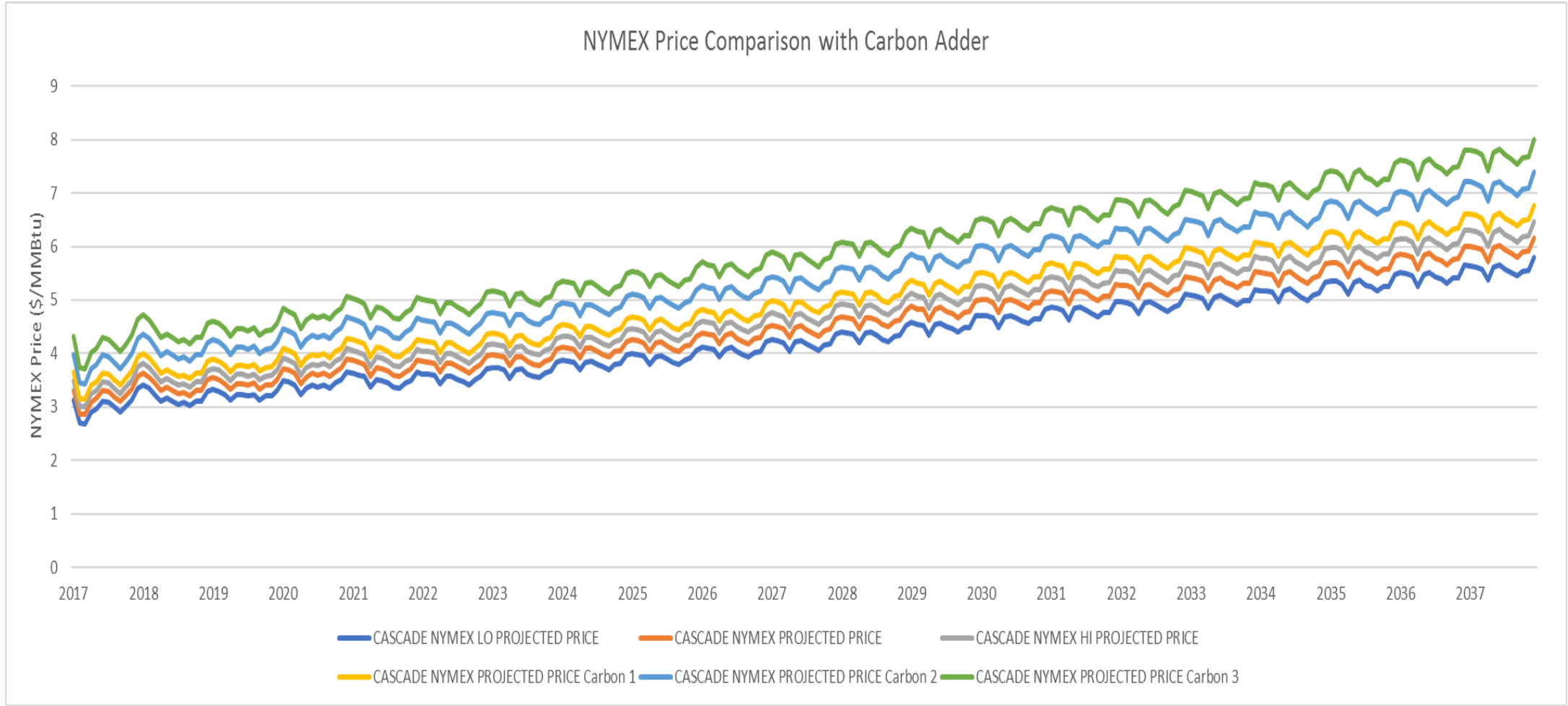

Total System Cost (TSC) by Year - Monte Carlo by Price with 10% Carbon Adder
300000
250000
200000
150000
100000
50000
0
2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037
Min
Max
Mean
Median
5th
95th



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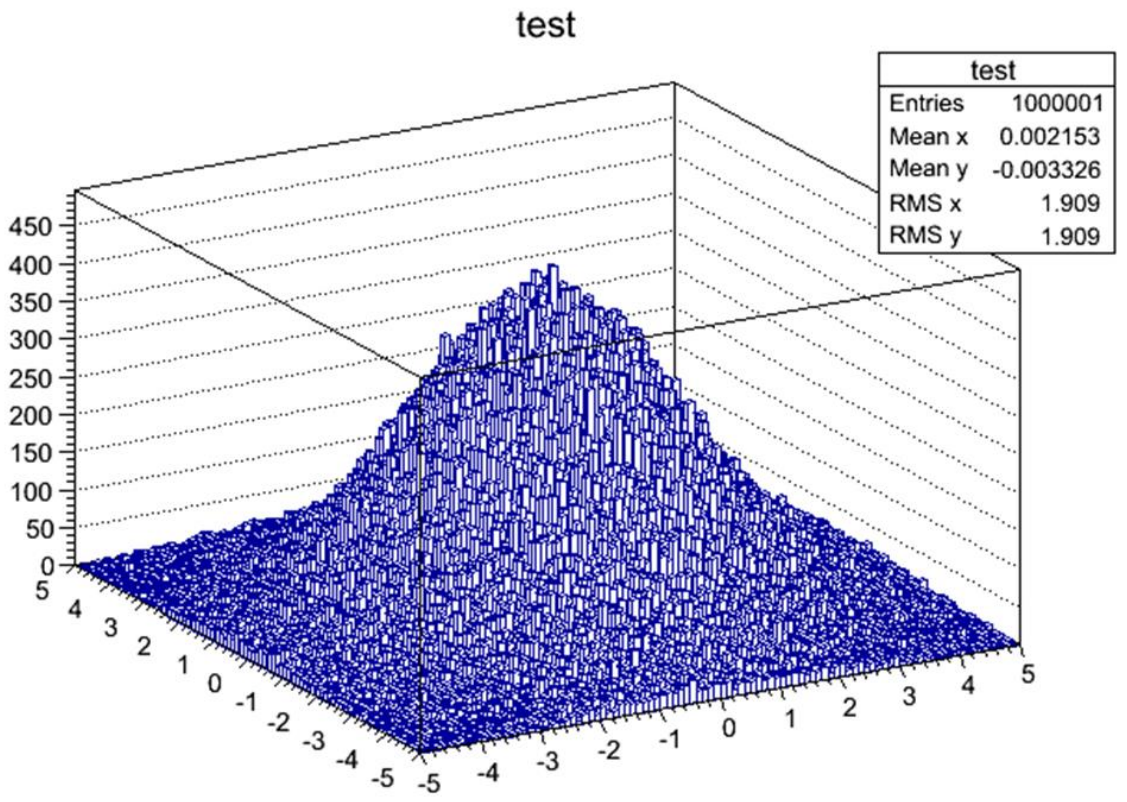
Why not Monte Carlo Price AND Weather?

- What happens when we look at drawing on both price and weather at the same time?

- We can imagine a 3 dimensional histogram, instead of the 2 dimensional histograms on the previous pages. Filling this in takes many more draws.

- 200 draws of weather on the X axis and 200 draws of price on the Y axis might need 200 x 200 = 40,000 draws to fill in a histogram like this…



2018 IRP Timeline

Monday, November 6, 2017	Draft of 2018 IRP distributed	
Tuesday, December 5, 2017	Comments due on draft from all stakeholders	
Wednesday, December 20, 2017	TAG 5, if needed	WebEx Only
Monday, January 22, 2018	Executive Summary Presentation to Senior Management	Kennewick, WebEx
Thursday, January 25, 2018	IRP filing in Oregon	

Questions?

Cascade Natural Gas Corporation

2018 Integrated Resource Plan
Technical Advisory Group Meeting #4

Thursday, Oct. 19th, 2017
Oregon Public Utility Commission
Offices
Salem, OR

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